ANNUAL REPORT

2017-18

Bangladesh Institute of Nuclear Agriculture
BAU Campus, Mymensingh-2202

October 2018

CONTENTS

BINA'S OBJECTIVES

- *To develop high yielding and better quality crop varieties using both mutation and conventional breeding techniques.*
- *To assess the fertilizer status of the soils of Bangladesh and efficiency of utilization of applied nutrients by crop plants using radioisotopic techniques.*
- *To develop means of water use efficiency for optimization of crop yields through radioisotopes and radiation techniques.*
- *To evolve control measure against major pests and diseases of crop plants.*
- *To assist national and international research programmes through cooperative support.*
- *To provide facilities to students of the Bangladesh Agricultural University for carrying out research leading to Masters and Ph.D. degree in Agriculture.*
- *To arrange training programmes for the research scientists on the peaceful use of atomic energy in agriculture.*

Plant Breeding Division

Research Highlights

Rice

Proposed Varieties Trial (PVT) of NERICA mutant, N_{10}-350-P-5-4 (derived from NERICA-10) in Aus season has been completed and application was done for variety release. Two advanced dual tolerant (salinity and submergence) rice lines were tested in on-farm and on-station trials in tidal flood prone areas. Some promising lines were selected from different yield trials for abiotic stresses and higher yield. The mutant RM-Kas-80(C)-1 derived from the phosphorus use efficient local Aus rice cultivar Kasalath by irradiating its seeds with 80 Gy carbon ion beams matured one week earlier than the check variety BRRI dhan49 and produced average yield of 4.40 t/ha which is little more than the check variety. Eight M_7 mutants of deepwater rice which were developed by irradiating the seeds of the local cultivar Laksmi digha with 200 Gy dose of gamma rays produced higher yield and their plant height ranged between 152 cm to 174 cm have been selected for preliminary yield trial in the next Aman season. Six M_5 mutants of BR-11 have been selected which were almost free of bacterial leaf blight or with minimum symptoms in the last Aman season. Five M5 mutants of Biroi rice with shorter and lodging resistant plant, early maturity, red and long fine grains have been selected. The mutant RM-40©-4-2-8 with extra long fine grains developed by irradiating the seeds of BRRI dhan29 with 40 Gy dose of carbon ion beams produced 4.8 – 6.9 t/ha grains over 11 locations which was 0.6-1.3 t/ha more than the mega variety BRRI dhan28. This mutant took one week more time to mature than BRRI dhan28. Additionally, 13 plant progenies were selected from the M_2 populations of NERICA-1, NERICA-4 and NERICA-10 irradiated with nitrogen ion beams.

Rapeseed-mustard

Two mustard mutants and seven rapeseed mutants have been selected and found promising in respect of maturity period along with some others improved yield components. Some other early maturing and high yielding mutants/lines in different generations have also been selected, which need further trials.

Sesame

Five advanced mutants (SM-08, SM-067, SM-001, SM-004 and SM-006) were found promising in respect to seed yield and other agronomic characters. Some other early maturing and high yielding mutants/lines in different generations have also been selected, which need further trials.

Soybean

Three advanced mutants were found promising regarding maturing period along with improved yield components. Two soybean genotypes were also found tolerant to salinity at vegetative stage.

Groundnut

The mutant D1/15/69, having comparatively shorter plant height, significantly higher pod yield (0.21 to 0.29 t/ha higher) than the popular check variety, Binachinabadam-4 will be applied for registration as a variety soon. Moreover, six mutants having comparatively shorter plant height, higher shelling percentage and significantly higher pod yield than the parent, Binachinabadam-6 has been selected for preliminary yield trial in the next year.

Mungbean

Two promising mutants of mungbean were selected for earliness, disease tolerant and higher yield from regional yield trial and one yellow seeded mutant was selected from advanced yield trial.

Chickpea

Two promising mutants /lines with bolder seed size, higher seed yield and tolerant to gray mold were selected from Zonal yield trial.

Lentil

Two mutants were found promising in respect of seed yield and disease reactions. Apart from these lines, other three lines found promising which are under trials. Moreover, a good number of mutants were selected for earliness, better yield and erect plant type.

Grasspea

Five advanced mutants have been selected for higher yield and shorter maturity period. A good number of M_3 mutant lines were developed which will be grow in the next season for further selection.

Blackgram

Two advanced mutants were found promising in respect of seed yield which will be evaluated in the next season. Some other early generation mutants will be evaluated in the coming season.

Onion

Two summer onion mutants, BP2/75/2 and BP2/75/2, having higher seed and bulb yield potential were registered as Binapiaz-1 and Binapiaz-2, respectively in 2018 for commercial cultivation in all onion growing areas throughout the country. The main characteristics of two varieties are as follows:

Binapiaz-1: Annual type because it produces seeds from seeds in the same season. It is suitable for growing in Kharif-I. It takes 200-210 days for seed to seed production and 100-120 days for bulb production. Shelf life of bulb is around two months and above at ambient condition. It has 8-11 leaves/plant at vegetative stage with individual bulb weight: 15-20 g. Plant height is 39-42 cm at maturity. Bulb size and colour are purple and flat. Average bulb yield is 8.21 t/ha and seed yield is 635 kg/ha.

Binapiaz-2: Annual type because it produces seeds from seeds in the same season. It is suitable for growing in Kharif-I. It takes 210-215 days for seed to seed and 110-115 days for bulb production. Shelf life of bulb is two months and above at ambient condition. It has 5-6 leaves/plant at vegetative stage with individual bulb weight 14-19g. Plant height is 38-42 cm at maturity. Bulb colour and shape are purple and round with long neck. Average bulb yield is 8.68 t/ha and seed yield is 698 kg/ha.

Rice

Evaluation of high yielding irrigated (Boro) rice lines (IIRON)

Seventy five rice lines along with two check varieties BRRI dhan28 and Binadhan-8 were tested in Boro season 2017-18 at BINA Substation farm, Rangpur. Seeds were sown on 3 December 2017 and transplanted to the field on 15 January 2018. The experiment was laid out in RCBD with two replications. Unit plot size was 1m x 1m and spacing between hills and rows were 15 cm and 20 cm, respectively. Data on days to 1^{st} flowering**,** days to maturity, plant height, total tillers plant^{-1}, effective tillers hill-^{1}, panicle length (cm), grain yield m_2-^{1}(g) and phenotypic performance were recorded from five randomly selected plants from each plot. From the Table 1, it is observed that IIRON-29 line had the highest plant height whereas IIRON-52 had the lowest. First flowering observed earlier in four lines than check variety BRRI dhan28. First flowering was observed IIRON-47 (122.5 days), IIRON-51(125.5 days), IIRON-11(127.5 days), IIRON-36(128.00 days) while check variety BRRI dhan28 (128.5 days). But only one line IIRON-11(154.5 days) matured earlier than Check variety BRRI dhan28 (155 days) followed by IIRON-52(158 days), IIRON-38(157 days) and IIRON-7(157.5 days). The highest effective tillers/hill (22) was observed in three lines (IIRON-7, IIRON-9, and IIRON-14) and lowest effective tillers/hill (6) in IIRON-21. The highest number of total tillers/hill (22.5) was observed in IIRON-14 and IIRON-17 while lowest number of total tillers/hill (8.5) in IIRON-21. Other check variety Binadhan-8 had the highest panicle length (26.00 cm) followed by IIRON-33 (25.50 cm) and IIRON-48 (24.90 cm). This IIRON-15 line produced the highest seed yield (2215.5 g/m^2) followed by IIRON-55 (2182.5 g/m^2) and IIRON-14 (2182.5 g/m^2).

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

Table 1 : Mean performance of IIRON rice lines along with check varieties of rice at BINA substation, Rangpur during boro season 2017-18

Entry name	Days to 1^{st} flowering	Days to maturity	Plant height (cm)	Panicle length (cm)	No. of total tillers hill^{-1}	No. of effective tillers hill^{-1}	Grain yield/m^2 (g)	Phenotypic acceptability
IIRON-4	129.00	161.00	91.90	24.3	15.1	14.7	1685.5	5
IIRON-25	134.50	168.50	96.10	24.7	17.2	16.3	1906.0	3
IIRON-13	134.00	175.00	94.50	22.7	18.6	**18.0**	1830.5	5
IIRON-6	135.50	165.50	96.30	15.4	16.7	15.6	1709.5	3
BRRI dhan 28 (check)	128.50	155.00	95.84	22.6	13.1	12.3	1208.5	3
IIRON-52	134.50	158.00	**80.00**	22.9	13.76	12.5	1821.0	1
IIRON-31	144.00	174.50	98.80	21.8	14.2	13.2	1756.0	3
IIRON-30	138.00	161.50	100.40	24.0	13.5	13.3	1891.0	3
IIRON-27	136.00	161.00	99.10	14.2	16.1	15.1	1649.5	3
IIRON-24	149.00	168.00	108.10	24.6	17.0	16.7	2005.0	0
IIRON-48	134.50	161.50	95.00	**24.9**	13.3	13.1	1675.0	3
IIRON-38	129.50	157.00	96.10	23.5	15.7	14.9	1788.0	0
IIRON-18	137.50	164.50	100.40	21.1	15.3	14.7	2014.0	0
IIRON-16	136.50	165.50	100.90	11.4	12.6	11.6	1631.5	3
IIRON-11	**127.50**	**154.50**	103.65	22.8	11.5	10.6	1476.0	1
IIRON-3	132.50	159.00	93.60	23.0	14.1	13.5	1674.0	3
IIRON-50	143.00	171.50	98.30	15.9	14.0	12.9	1760.0	0
IIRON-14	130.50	159.50	96.90	23.5	**22.5**	**22**.0	2157.5	1
IIRON-51	**125.50**	159.00	96.40	22.9	12.1	11.5	1365.5	1
IIRON-17	132.50	159.00	92.10	22.7	**22.5**	**22**.0	2028.5	1
IIRON-23	140.00	167.00	97.20	21.8	18.05	17.7	2046.5	3
IIRON-9	131.50	161.50	93.90	22.4	22.4	22.0	2171.0	1
IIRON-5	141.00	162.50	95.10	22.6	13.8	12.6	1399.5	3
IIRON-47	**122.50**	157.50	97.00	21.8	14.3	13.1	1417.5	1

Entry name	Days to 1st flowering	Days to maturity	Plant height (cm)	Panicle length (cm)	No. of total tillers hill^{-1}	No. of effective tillers hill^{-1}	Grain yield/m^2 (g)	Phenotypic acceptability
IIRON-7	**128.50**	158.50	93.50	24.1	15.5	13.7	1635.0	3
IIRON-55	133.50	163.50	**84.50**	**17.4**	14.9	14.4	2182.5	1
Binadhan-8 (check)	131.50	158.50	95.50	26.0	11.5	10.4	1371.0	3
IIRON-32	135.50	174.50	103.50	24.8	11.9	10.7	1772.0	5
IIRON-29	147.00	180.00	**106.00**	23.5	13.6	13.0	1968.0	5
IIRON-10	132.50	164.50	93.50	20.0	14.6	13.5	1747.5	3
IIRON-22	131.50	167.00	85.20	21.9	13.3	11.6	1568.5	1
IIRON-1	133.50	165.50	95.40	21.9	14.9	13.8	1490.0	3
IIRON-12	134.00	164.00	94.20	23.0	15.8	15.2	1945.0	1
IIRON-37	131.50	165.50	93.40	22.0	14.1	13.0	1482.5	3
IIRON-28	135.50	166.00	96.60	20.7	10.0	9.1	1983.0	1
IIRON-8	133.50	164.50	91.50	23.0	15.0	13.6	1314.5	5
IIRON-35	139.50	159.00	80.40	21.0	15.1	12.5	1216.0	3
IIRON-33	141.00	167.00	105.50	25.5	15.8	15.5	2047.5	1
IIRON-20	133.00	163.50	84.50	24.5	16.6	15.1	2065.0	3
IIRON-2	132.00	161.50	94.50	21.8	13.9	13.3	1622.5	3
IIRON-56	132.00	162.50	95.50	20.5	12.3	11.3	1687.5	1
IIRON-53	134.00	163.50	95.80	21.7	11.5	10.5	1822.0	1
IIRON-19	144.00	168.50	95.80	21.4	14.8	14.6	2041.5	1
IIRON-36	**128**.00	157.00	84.20	21.9	14.5	13.3	1280.0	3
IIRON-49	132.50	161.50	94.00	22.0	13.3	12.8	1528.5	5
IIRON-39	135.50	172.00	96.50	21.3	10.7	9.5	1611.0	3
IIRON-40	141.50	175.00	93.40	23.0	18.7	18.4	1922.0	3
IIRON-34	141.00	172.50	101.20	23.0	17.6	17.4	1998.0	3
IIRON-54	141.00	177.00	95.50	23.2	10.8	9.2	1683.0	5
IIRON-15	134.50	165.00	107.20	24.5	16.8	16.7	2215.5	5
IIRON-26	144.00	172.50	106.10	23.9	15.9	15.4	1964.0	5
IIRON-21	133.50	164.00	96.70	20.6	8.5	6.8	1638.5	5
Mean	**135.05**	**164.64**	**95.72**	**22.99**	**0.87**	**13.93**	**1747.48**	
SD	**5.48**	**5.96**	**6.13**	**6.62**	**0.50**	**3.12**	**264.96**	

***1= Excellent, 3= Good , 5 = Fair, 7= Poor, 9 = unacceptable**

Evaluation of high yielding irrigated (Boro) rice lines (IBNN)

Fourty IRBN rice lines along with one check variety BRRI dhan28 tested in Boro season 2017-18 at BINA Headquarter farm, Mymensingh. Seeds were sown on 28 November 2017 and transplanted to the field on 8 January 2018.The experiment was laid out in RCBD with two replications. Unit plot size was 1m x 1m and spacing between hills and rows were 15 cm and 20 cm, respectively. Data on plant height, total tillers/plant, effective tillers hill-^{1}(no.), panicle length (cm), grain yield m^2 (g) and phenotypic performance were recorded from five randomly selected plants from each plot.

From the Table 2, it is observed that IIBN-13 line had the highest plant height (107.0 cm) whereas IRBN-38 and IRBN-41 had the lowest. The highest number of effective tillers/hill (16.67) was observed in IRBN-32 and lowest number of effective tillers/hill (5.50) in IRBN-12. The highest number of total tillers/hill (18.33) was observed in IRBN-72 and lowest number of total tillers/hill (5.67) in IRBN-12. The rice line IRBN-29 had the highest panicle length (30.50 cm) while IRBN-41 had the lowest panicle length (20.33). This IRBN-2 line produced the highest seed yield (1166 g/m^2) followed by IRBN-32 (1125 g/m^2) and IRBN-19 had the lowest yield. Based on early maturity and higher seed yield and phenotypic acceptability 27 rice lines were selected and will be evaluated in next growing season.

Table 2. Mean performance of IRBN lines along with check variety of rice at BINA Hqs, Mymensingh during boro season 2017-18

Entry name	Plant height (cm)	Panicle length (cm)	No. of effective tillers hill^{-1}	No. of Total tillers hill^{-1}	Grain yield/m^2 (g)	*Phenotypic acceptability
IRBN-1	**84.83**	**23.17**	**10**.00	11.50	**1000.00**	**3**
IRBN-2	90.34	26.34	13.17	14.33	1166.50	3
IRBN-3	93.00	26.33	11.00	12.00	962.00	1
IRBN-4	84.00	24.58	8.83	9.50	775.50	5
IRBN-5	**88.84**	**23.75**	**8.33**	8.83	**962.50**	**5**
IRBN-6	**96.34**	**25.92**	**8**.00	8.34	**883.50**	**1**
IRBN-7	89.00	25.16	10.00	10.33	796.50	5
IRBN-9	96.17	27.67	10.50	10.67	980.50	5
IRBN-10	**90.67**	**26.50**	**8.67**	9.34	**740**.00	**5**
IRBN-**11**	89.84	27.33	8.54	9.00	1000.00	5
IRBN-12	101.67	23.34	5.50	5.67	713.00	4
IRBN-13	107.33	24.33	13.67	15.34	917.50	5
IRBN-14	**98.00**	**25.16**	**5.67**	7.00	**800**.00	**5**
IRBN-15	106.00	25.33	7.33	7.33	852.50	5
IRBN-16	107.17	25.67	9.00	9.34	899.50	5
IRBN-17	81.00	23.33	10.33	11.33	827.50	5
IRBN-18	103.00	25.33	6.00	6.00	829.50	5
IRBN-19	92.34	26.67	9.17	10.67	572.50	4
IRBN-20	**101.00**	**24.67**	**7.67**	9.00	**800**.00	**5**
IRBN-21	89.50	25.33	9.33	12.00	785.50	5
IRBN-22	97.00	24.83	8.33	8.33	745.00	5
IRBN-23	102.33	29.00	11.33	11.66	770.00	5
IRBN-25	90.00	27.33	7.67	7.67	925.00	3
IRBN-26	87.00	23.83	9.00	9.33	950.00	5
IRBN-27	90.00	26.83	9.335	10.17	779.00	3
IRBN-28	**91.67**	**25.16**	**8.33**	8.33	**1000**.00	**3**
IRBN-29	101.67	**30.5**	10.00	10.67	1002.00	3
IRBN-30	**85.67**	**23.67**	**7.67**	8.34	**925**.00	**5**
IRBN-31	96.67	24.67	6.00	6.00	812.00	5
IRBN-32	106.67	26.67	16.67	17.34	1125.00	3
IRBN-33	95.335	24.42	9.67	10.67	814.00	3
IRBN-34	84.17	24.17	9.17	9.83	945.00	3
IRBN-35	**106.67**	**25**.00	**7.67**	8.00	**710**.00	**5**
IRBN-38	75.33	25.33	9.33	10.33	937.50	3
IRBN-41	**75.33**	**20.33**	**11.67**	15.34	**605**.00	**5**
IRBN-67	95.67	25.33	6.67	6.67	858.00	7
IRBN-69	79.33	26.33	9.33	9.33	695.00	7
IRBN-70	83.33	24.33	10.67	13.00	795.00	5
IRBN-72	76.67	24.67	15.00	18.33	650.00	5
IRBN-73	81.50	25.67	12.17	13.50	900.00	3
BRRI dhan28 (check)	81.67	21.83	8.07	8.55	650.00	5
Mean	**92.30**	25.35	9.40	10.26	**855.18**	
SD	**9.16**	1.73	2.40	2.95	**129.54**	

***1= Excellent, 3= Good , 5 = Fair, 7= Poor, 9 = unacceptable**

Evaluation of high yielding irrigated (Boro) rice lines (IRBPHN)

This experiment was carried out to assess the yield attributes of fifty eight rice lines along with one check variety BRRI dhan28 tested in Boro season 2017-18 at BINA Headquarter farm, Mymensingh. Seeds were sown on 11 December 2017 and transplanted to the field on 8 January 2018. The experiment followed RCB design with three replications. The size of a unit plot was 1.0

m × 1.0 m. Plant to plant distance was 15 cm and row to row distance was 20 cm. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. Data on plant height, number of effective tiller, panicle length, filled and unfilled grains panicle^{-1} and phenotypic performance were recorded after harvesting from 5 randomly selected competitive hills. Maturity was assessed plot basis. Recorded data were finally subjected to proper statistical analyses and are presented in Table 3.

The average range of plant height among the lines was 75.50 cm to 128.67cm with a mean value of 95.54 cm. IBPHN-53 had the lowest plant height and IBPHN-63 had the highest plant height. In this study, the average number of total tillers per hill ranged from 5.84 to 11.5 with a mean value of 8.55. IBPHN-4 had maximum number of total tillers per hill and IBPHN-6 had minimum number of total tillers per hill. The number of effective tillers per hill ranged from 5.84 to 11.33 with a mean value of 8.07. IBPHN-27 had maximum number of effective tillers per hill which was followed by IBPHN- 4 (11.00). . IBPHN-6 had minimum number of effective tillers per hill. Panicle length among the rice lines ranged from 21.00 cm to 33.00 cm with a mean value of 24.97 cm. IBPHN- 41 had the longest panicle (33.00 cm) followed by IBPHN- 65 (31.33 cm) and IBPHN- 16 had the lowest panicle length (21.00 cm). Yield per plant (g) ranged from 100.00 g to 1172.5 g with a mean value of 698.4 g. IBPHN- 5 had maximum yield per m^2 (1172.5 g) which was followed by IBPHN- 21 (1110.00 g). IBPHN- 65 had minimum yield per m^2 (100.0 g) followed by IBPHN- 66 (115.0 g).
Based on higher seed yield and phenotypic acceptability 22 lines were selected and will be evaluated in the preliminary yield trial in next growing season.

Table 3. Mean performance of IBPHN rice lines along with check variety at BINA Hqs, Mymensingh during boro season 2017-18

Entry name	Plant height (cm)	No. of effective tillers hill^{-1}	No. of Total tillers hill^{-1}	Panicle length(cm)	Grain yield (g)/m^2	Phenotypic acceptability
IRBPHN-1	94.67	6.33	8.33	21.67	625.00	5
IRBPHN-2	90.00	8.00	8.67	25.67	850.00	5
IRBPHN-3	85.67	7.50	7.50	24.17	647.50	5
IRBPHN-4	87.17	**11.00**	11.5	23.08	787.50	5
IRBPHN-5	93.50	7.00	7.50	24.42	**1172.5**	5
IRBPHN-6	102.00	**5.84**	**6.18**	24.84	729.00	5
IRBPHN-7	91.67	7.67	8.17	**26.83**	444.00	5
IRBPHN-8	96.50	8.17	8.67	25.67	700.00	5
IRBPHN-9	98.33	8.67	8.67	23.00	820.00	5
IRBPHN-11	90.00	8.00	8.33	26.00	627.00	5
IRBPHN-12	94.50	7.84	8.01	**27.84**	669.00	5
IRBPHN-13	90.00	6.67	6.67	24.00	334.00	5
IRBPHN-14	87.17	6.67	7.01	24.34	650.00	5
IRBPHN-15	77.67	7.33	7.66	24.83	525.00	7
IRBPHN-16	100.67	9.33	9.66	**21.00**	745.00	5
IRBPHN-17	87.83	8.33	8.83	23.09	767.00	5
IRBPHN-18	96.67	7.51	8.01	24.84	900.00	5
IRBPHN-19	95.67	7.00	7.00	23.50	925.00	7
IRBPHN-20	88.34	8.17	8.34	**26.25**	1025.00	5
IRBPHN-21	96.50	9.84	10.34	24.92	**1110.00**	**3**
IRBPHN-22	87.33	7.33	7.66	25.67	648.00	5
IRBPHN-23	**105.33**	10.33	10.33	24.33	920.00	5
IRBPHN-24	103.17	8.67	9.34	23.75	740.00	5
IRBPHN-25	85.67	9.34	9.51	25.00	735.00	5
IRBPHN-26	91.67	8.00	8.33	22.33	840.00	5
IRBPHN-27	105.67	11.33	11.33	26.17	820.00	5
IRBPHN-28	85.33	8.00	9.67	24.33	775.00	7

Entry name	Plant height (cm)	No. of effective tillers hill-1	No. of Total tillers hill-1	Panicle length(cm)	Grain yield (g)/m2	Phenotypic acceptability
IRBPHN-29	98.00	6.33	6.66	23.33	842.00	5
IRBPHN-30	86.17	7.17	7.66	24.42	500.00	7
IRBPHN-31	89.00	9.33	9.66	**21.83**	660.00	5
IRBPHN-32	94.34	8.83	9.33	24.59	1050.00	5
IRBPHN-33	96.33	8.00	8.33	25.33	737.50	5
IRBPHN-34	97.67	8.67	9.00	24.33	750.00	7
IRBPHN-35	91.83	8.17	8.67	**26.77**	765.00	5
IRBPHN-36	84.67	8.33	9.66	24.33	505.00	5
IRBPHN-37	90.67	10.34	10.67	22.92	850.00	7
IRBPHN-38	84.67	7.83	8.33	23.67	800.00	5
IRBPHN-39	84.17	7.50	8.67	23.25	650.00	5
IRBPHN-40	95.84	7.00	7.00	**27.09**	1000.00	5
IRBPHN-41	79.84	8.00	8.17	**33.00**	852.50	5
IRBPHN-42	92.00	8.00	8.33	26.67	740.00	5
IRBPHN-43	98.17	8.17	8.51	22.84	475.00	5
IRBPHN-44	101.33	9.33	9.66	24.83	739.00	5
IRBPHN-45	97.34	8.17	9.50	25.09	930.00	5
IRBPHN-46	96.67	6.67	7.67	26.33	875.00	5
IRBPHN-47	84.5	7.83	8.00	23.27	805.00	5
IRBPHN-50	91.00	7.67	7.67	23.67	787.50	5
IRBPHN-52	91.00	7.67	7.67	23.67	458.50	7
IRBPHN-53	**128.67**	7.00	7.00	26.50	398.00	7
IRBPHN-55	90.67	7.84	9.01	25.25	836.00	7
IRBPHN-56	109.67	7.42	8.01	25.88	650.00	5
IRBPHN-57	120.83	7.67	9.67	28.84	180.00	7
IRBPHN-59	137.84	7.50	7.84	27.17	193.00	5
IRBPHN-60	89.00	9.33	10.00	27.67	600.00	7
IRBPHN-63	**75.50**	9.00	9.67	21.92	735.00	7
IRBPHN-65	**127.33**	8.00	8.00	31.33	**100.00**	7
IRBPHN-66	**123.00**	8.33	8.66	30.67	**115.00**	5
IRBPHN-68	**119.00**	8.67	8.67	23.67	490.00	7
BRRI dhan28 (check)	81.67	6.33	8.00	21.83	650.00	5
Mean	**95.54**	**8.07**	8.55	**24.97**	**698.44**	**-**
SD	**12.54**	**1.12**	1.61	**2.29**	**228.31**	**-**

***1= Excellent, 3= Good , 5 = Fair, 7= Poor, 9 = unacceptable**

On-farm and on-station yield trial of two dual tolerant rice lines for tidal flood prone areas

This experiment was conducted to evaluate rice lines for salinity and submergence tolerance in tidal flood prone areas **.**This experiment has been conducted at 4 locations (Saline and Flood prone areas). Mutant RC-251 has been selected for its best performance. This mutant can tolerate 8 dS/m in saline soil and can also survive 18-20 days of under complete submergence and its life cycle is 110 days, yield is 5.0 t/ha at T. Aman season which is more than the check variety, BRRI dhan78 (Table 4) .

Table 4: Mean performance of different morphological traits related to yield

Locations	Mutants/ varieties	Plant height (cm)	Duration (Days)	No off effective tiller/ hill	Panicle length (cm)	Filled grain/ panicle	Unfilled grain/ panicle	Yield (t/ha)
Amtoli, Borguna	BRRI dhan78 (check)	113	130	14	23	125	65	4.2
	RC-251	110	120	18	27	140	30	4.8
	RC-249	105	127	12	19	118	95	3.9
Taltoli, Borguna	BRRI dhan78 (check)	112	131	13	23	121	66	4.1
	RC-251	109	119	19	28	144	44	4.9
	RC-249	104	126	12	18	112	112	3.5
Kalapara, Patuakhali	BRRI dhan78 (check)	113	129	14	22	125	86	4.3
	RC-251	108	118	20	28	168	33	5.1
	RC-249	104	125	13	21	123	114	3.7
Bashkhali, Chattagram	BRRI dhan78 (check)	115	133	15	21	124	88	4.4
	RC-251	111	122	21	27	176	23	5.3
	RC-249	102	126	11	20	123	134	3.4
Combined over four locations	BRRI dhan78 (check)	113	130	14	22	123	76	4.25
	RC-251	109	119	19	27.5	157	32	5.02
	RC-249	103	126	12	19.5	119	113	3.62

Regional yield trial of five promising NERICA M_7 mutants for drought

This experiment was conducted to select desirable mutants having drought tolerance, short duration, higher grain, quality grain and suitable for Aman seasons. This experiment has been conducted at 4 locations. Mutant N_{10}/300/P-2-3-5-2 and N_4/250/P-2(5)-26 have been selected for its higher yield (5.5 t/ha) and short duration (97 days) respectively which showed the better performance than that the check variety (Table 5).

Table 5: Mean performance of different morphological traits related to yield

Locations	Mutants/ Varieties	Plant height (cm)	Duration (Days)	No off effective tiller/ hill	Panicle length (cm)	Filled grain/ panicle	Unfilled grain/ panicle	Yield (t/ha)
BINA HQ	BRRI dhan56 (check)	113	115	10	24	475	225	4.1
	N_{10}/300/P-2-3-5-1	124	125	9	24	704	184	4.25
	N_4/250/P-2(5)-11-2	106	135	10	25	844	145	5.2
	N_4/250/P-2(5)-26	100	100	10	25	562	141	4.2
	N_4/250/P-1(2)	102	102	10	25	438	112	4.0
	N_{10}/300/P-2-3-5-2	121	128	13	27	882	241	5.3
Godagari, Rajshahi	BRRI dhan56 (check)	116	114	11	25	460	220	4.2
	N_{10}/300/P-2-3-5-1	123	122	10	26	710	189	4.3
	N_4/250/P-2(5)-11-2	104	129	12	24	840	143	5.1
	N_4/250/P-2(5)-26	102	97	11	26	522	130	4.3
	N_4/250/P-1(2)	102	102	11	27	432	122	4.0
	N_{10}/300/P-2-3-5-2	121	128	14	29	885	241	5.4
Nachole, Chapaina wabganj	BRRI dhan56 (check)	114	117	11	25	450	222	4.3
	N_{10}/300/P-2-3-5-1	122	123	10	28	660	122	4.1
	N_4/250/P-2(5)-11-2	108	134	9	26	810	141	5.0
	N_4/250/P-2(5)-26	99	96	11	24	520	152	4.2
	N_4/250/P-1(2)	99	98	12	24	411	115	4.2
	N_{10}/300/P-2-3-5-2	122	129	13	27	661	277	5.4
Sadar, Chapaina wabganj	BRRI dhan56 (check)	117	113	12	26	420	222	4.1
	N_{10}/300/P-2-3-5-1	126	124	11	27	666	128	4.2
	N_4/250/P-2(5)-11-2	109	132	10	24	772	252	5.0
	N_4/250/P-2(5)-26	100	97	12	25	665	171	4.3
	N_4/250/P-1(2)	98	98	13	23	462	118	4.1
	N_{10}/300/P-2-3-5-2	119	128	12	28	662	119	5.5
Combined over four locations	BRRI dhan56 (check)	115	114	11	25	451	222	4.1
	N_{10}/300/P-2-3-5-1	123	123	10	26	685	128	4.2
	N_4/250/P-2(5)-11-2	106	132	10	25	816	252	5.0
	N_4/250/P-2(5)-26	100	97	11	25	567	171	4.25
	N_4/250/P-1(2)	100	100	12	24	435	118	4.07
	N_{10}/300/P-2-3-5-2	120	128	13	28	772	119	5.4

Advanced yield trial of introgressed bacterial leaf blight resistant rice lines in Aman season

Four BLB introgressed lines along with one check Near isogenic pyramided BLB resistant lines (IRBB60) were put into advanced yield trial during aman season, 2017 at BINA HQs Mymensingh, Nokla and Nalitabari, Sherpur . 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 x 20 cm. Data on days to maturity, plant height, days to 1st flowering, no. of total tillers plant^{-1} , effective tillers hill^{-1}(no.), panicle length, filled grains panicle^{-1}(no.), 1000 grain weight (gm) and grain yield plot^{-1}(kg) were recorded from five randomly selected plants from each plot. Plot yield was converted to t/ha. Beside this two seedlings of each line/strain were inoculated at maximum tillering stage (40 days after transplanting) to evaluate their reaction to bacterial blight. Inoculation was done by clipping the leaves 2-3 cm from the tip with sterilized scissors dipped in bacterial suspension of 3 day-old culture of *X. oryzae* pv *oryzae* growing on Modified Wakimoto's Medium. Two isolates of *X. oryzae* pv *oryzae* (*Xoo*) were used to inoculate each line to test for bacterial blight resistance genes *Xa4, xa5, Xa7, xa13* and *Xa21*. The plants were assessed at 14 days after inoculation. The agronomic performance is shown in Table 6.

From the Table 7, it is observed that among the four test entries SSB-22 matured earlier followed by SSB-25. SSB-02 produced the highest filled grains/ panicle. Another entry SSB-24 produced the highest panicle length and seed yield (6.5 t/ha).

Table 6: Agronomic performance of four *Swarna sub1* BLB resistant rice lines during aman season, 2017

Entry name	Days to Maturity (Days)	Plant height (cm)	Days to flowering	No. of tillers /plant	No. effective tillers/ plant	Panicle length (cm)	Filled grains / panicle^{-1}	Unfilled grains/ panicle^{-1}	1000 seed wt.	Seed yield (t/ha)
SSB-02	137	100.5	100	11	10	26.66	183	41	19.57	5.83
SSB-22	107	98.21	80	12	11	27.06	110	19	25.79	3.73
SSB-24	125	105.71	85	10	10	28.16	176	39	23.48	6.51
SSB-25	112	101.96	82	10	10	24.75	153	21	22.40	4.17
IRBB60	105	95.91	78	10	8	25.88	119	19	22.03	3.99

Preliminary yield trial with some rice mutants of NERICA-10

This experiment was carried out to assess the yield attributes of five mutant lines derived from NERICA-10. Seeds of the five mutants along with parent NERICA-10 were sown on 30 July 2017 and transplanted to the field on 23 August 2017. The experiment followed RCB design with three replications. The size of a unit plot was 2.0 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, number of effective tillers/hill, panicle length, and filled and unfilled grains panicle^{-1}, 1000 seed weight and were recorded after harvesting from 10 randomly selected competitive hills. Maturity was assessed plot basis. Recorded data were finally subjected to proper statistical analyses and are presented in Table 7.

Table 71: Yield and yield attributes of some rice mutant lines along with the parent variety NERICA-10

Mutants/ parent	Days to maturity	Plant height (cm)	No. of effective tillers $hill^{-1}$	Panicle length (cm)	No. of filled grains $Panicle^{-1}$	No. of unfilled grains $panicle^{-1}$	1000 Seed weight (g)	Grain yield $/m^2$ (g)
N_{10}/300/pn-1	112	105.13	7.07	23.73	108.0	92.0	26.07	883.33
N_{10}/300/pn-4	104	83.27	6.73	22.00	77.07	56.60	20.17	583.33
N_{10}/300/pn-5	107	109.94	5.33	26.07	105.33	106.13	26.90	775.00
N_{10}/300/pn-7	126	108.47	5.33	25.80	111.80	84.87	27.20	883.33
N_{10}/300/pn-8	106	112.83	4.67	25.93	107.47	103.53	25.50	841.67
NERICA-10	122	88.17	5.47	22.87	90.73	54.27	25.50	540.00
Mean	112.83	131.8	5.77	24.40	100.07	82.90	25.22	751.11
SD	**9.13**	**14.45**	**0.93**	**1.77**	**13.41**	**22.64**	**2.57**	**152.61**

The mutant lines and the parent differed significantly for plant height, filled and unfilled grain $panicle^{-1}$ and grain yield. All the mutants produced taller plant height and panicle length than parent except N_{10}/300/pn-4.

Effective tiller number of the plants ranged from 4.67 to 7.07 with N_{10}/300/pn-1 being the highest and N_{10}/300/pn-8 the lowest. Filled grains panicle-1 ranged from 77.07 to 111.80 g with N_{10}/300/pn-7 being the highest while N10/300/pn-4 the lowest. Unfilled grains $panicle^{-1}$ ranged from 54.27 to 106.13g with N_{10}/300/pn-5 being the highest while NERICA-10 the lowest. All the mutants took 104-126 days to mature, while their parent NERICA-10 took long time to mature (122days) and N_{10}/300/pn-4 took shortest time (104 days) to mature. Filled grains $panicle^{-1}$ was the highest in the mutant N_{10}/300/pn-7 while the lowest in the mutant N_{10}/300/pn-4. All the mutants produced higher yield than their parent. Based on seed yield/plant four mutants (N_{10}/300/pn-1, N_{10}/300/pn-7, and N_{10}/300/pn-8) were selected for next year evaluation.

Growing of M_1 generation of Sylhet-21, Joria, Shatta, and Moinashail

With a view to improve yield potential, shortening of maturity period and induction of lodging resistance, dry seeds of the land races Sylhet-21, Joria, Shatta, and Moinashail were irradiated with 150, 200, 250 300 and 350 Gy doses of gamma rays from the ^{60} Co source of BINA. For each dose 100 g seeds of Sylhet-21, Joria, Shatta, and Moinashail were used. Immediately after irradiation, the seeds were sown in pots dose and variety wise, separately, on 30 July and transplanted on 30 August 2017 at BINA HQ farm, Mymensingh following non replicated design at 15 cm distance within rows of 20 cm apart. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied0 in the form of Urea, TSP, MoP, Gypsum and Zinc sulphate. Cultural and intercultural practices were followed as and when necessitated. At maturity, seeds of all plants were massed together dose and variety wise separately to screen and evaluate in the next generation.

T. AMAN

Advance yield trial with M_6Kasalath mutants

Seeds of two carbon ion beams irradiated M_6 mutants of Kasalth, derived from 60 and 80Gy doses, respectively, were sown at four locations during 06 July to 14 July 2017and seedlings were transplanted during 31 July to 21August 2017 (Table 1) along with a check variety BRRI dhan49 at 15 cm distance within rows of 20 cm apart. The experiment followed RCB design with three replications. The size of the unit plots were 5.0 m × 4.0 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, number of effective tiller, 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 8.

Table 8. Date of sowing and transplanting of two M_6Kasalath mutants and check variety at different locations of Bangladesh

Location	Date of sowing	Date of transplanting	Seedling age (days)
BINA HQ farm, Mymensingh	6 July 2017	31 July 2018	26
BINA sub-station farm, Cumilla	14 July 2017	21 August 2017	39
BINA sub-station farm, Rangpur	13 July 2017	7 August 2017	26
BINA sub-station, Chapainawabganj	-	-	-

It appeared that both the mutants had taller plant heights and longer panicle lengths at all locations than the check variety, BRRI dhan49 (Table 9) although the plant height of the mutants did not differ significantly with the check variety at any location except BINA sub-station farm, Rangpur. At Rangpur, the plant height of the mutant RM-Kas-60(C)-1 was significantly taller than the check variety but at par with the other mutant. But panicle differed at all locations except Chapainwabganj. At Chapainawabganj, panicle length of the mutants and check variety was statistically indifferent. Effective tiller number of the mutants differed significantly at Mymensingh and Rangpur,

Table 9. Yield and yield attributes of two M_5Kasalathmutants along with BRRI dhan49 in T. aman season, 2017-18

Variety/Line	Days to maturity	Plant height (cm)	Effective tillerplant^{-1} (no.)	Panicle length (cm)	Filled grain panicle^{-1} (no.)	Unfilled grain panicle^{-1}(no.)	Yield (tha^{-1})
BINA HQ farm, Mymensingh							
RM-Kas-60(C)-1	136	118.67	10.87	28.00	112.33	75.93	4.28
RM-Kas-80(C)-1	136	116.80	10.53	27.60	114.20	68.60	3.91
BRRI dhan49	143	112.33	8.67	24.20	175.70	41.47	4.30
$LSD_{(0.05)}$		NS	1.59	1.78	32.81	18.12	NS
BINA Sub-station farm, Cumilla							
RM-Kas-60(C)-1	134	100.40	11.40	23.07	124.53	41.67	3.50
RM-Kas-80(C)-1	134	102.33	15.07	24.40	127.07	41.79	3.99
BRRI dhan49	132	92.40	15.27	20.93	137.37	24.30	3.28
$LSD_{(0.05)}$		NS	NS	2.41	12.61	14.59	0.35
BINA Sub-station farm, Rangpur							
RM-Kas-60(C)-1	134	128.73	9.27	24.93	150.40	22.07	5.22
RM-Kas-80(C)-1	135	121.80	10.13	24.47	147.00	19.40	5.20
BRRI dhan49	144	109.00	12.33	19.87	126.13	10.67	5.15
$LSD_{(0.05)}$		8.32	2.07	3.57	NS	8.00	NS
BINA Sub-station farm, Chapainawabganj							
RM-Kas-60(C)-1	128	101.77	9.07	25.45	138.80	33.78	3.67
RM-Kas-80(C)-1	129	101.67	8.53	27.62	127.20	33.07	3.78
BRRI dhan49	131	94.62	8.80	22.53	134.07	25.80	2.77
$LSD_{(0.05)}$		NS	NS	NS	NS	NS	NS
Combined means over 4 locations							
RM-Kas-60(C)-1	-	129.57	11.55	25.36	134.96	38.24	4.18
RM-Kas-80(C)-1	-	127.65	12.42	26.02	128.68	36.31	4.41
BRRI dhan49	-	117.69	12.62	21.88	142.81	23.32	3.88

$LSD_{(0.05)}$	4.05	NS	NS	NS	NS	NS
LSD(0.05) for mutant × location interaction	NS	NS	NS	NS	NS	NS

At Mymensingh both the mutants had significantly higher number of effective tiller than the check variety but at Rangpur, the check variety had significantly higher number of effective tiller.

Number of filled grains panicle^{-1} differed significantly among the mutants and the check variety at Mymensingh and Cumilla (Table 2). But at the other two locations number of filled grains of the mutants and the check variety was statistically indifferent. Number of unfilled grains panicle $^{-1}$ differed significantly among the mutants and the check variety at all locations except Chapainawabganj. At Chapainawabganj, Number of unfilled grains panicle^{-1} did not differ significantly among the mutants and the check variety.

Finally, grain yield of the mutants and the check variety did not differ much with the check variety at any location although the mutant RM-KAS-80(C)-1 had produced some more yield at three locations than the check variety and the other mutant. Therefore, in the next year, this experiment will be conducted with RM-KAS-80(C)-1 for further confirmation of its yield performance.

Screening and Evaluation of Deepwater Rice Segregating Mutant Population for High Yield under Natural Deepwater Conditions

Seeds of ninety seven mutant populations and the parent cv. Laksmi digha were sown on 13 April 2017 at BINA Farm, Mymensingh. Seedlings were transplanted on 17 May 2017 at BINA sub-station farm, Gopalgonj following plant- progeny-rows at 20 cm distance within rows of 30 cm apart. A unit plot comprised a row of 3 m length. 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. Urea was applied as top dressing after 10 and 30 days of transplanting. Before 25 August 2017 the height of water depth was almost 1.0m and from 25 August 2017 water depth rose to 152.4 cm and remained till 30 August2017. Data on plant height, number of primary and secondary tiller, panicle length and yield hill^{-1} were recorded from randomly selected five hills. The recorded data were finally subjected to proper statistical analysis and are presented in Table 10.

Table10. Grain yield and yield components of some deepwater rice mutants screened under natural field condition at Gopalganj

Mutant/parent	Days to maturity	Plant height (cm)	Primary tiller plant^{-1} (no.)	Secondary tiller plant^{-1} (no.)	Effective tiller hill^{-1} (no.)	Panicle length (cm)	Grain yield plant^{-1} (g)
LD-200-1-3-2-1	145	172 ± 5.01	12 ± 3.16	24.2 ± 1.43	7.8 ±1.74	29 ± 1.87	16.8
LD-200-1-3-2-2	145	164 ± 6.81	11 ± 5.09	23.0 ± 1.41	12.2 ± 2.2	29 ± 1.87	13.9
LD-200-1-3-2-4	144	154 ± 8.45	9 ± 3.74	17.4 ± 0.75	9.6 ± 0.87	29 ± 1.99	10.7
LD-200-1-3-2-9	145	169 ± 5.91	12 ± 4.74	23.4 ± 1.54	10 ± 1.55	29 ± 1.87	13.7
LD-200-1-3-2-10	145	158 ±5.09	15 ± 6.6	25.6 ± 1.17	11.2 ± 2.24	31 ± 2.00	10.0
LD-200-1-3-2-13	144	165 ±12.40	9 ± 2.40	15.6 ± 0.97	7 ± 1.34	27 ± 2.00	10.6
LD-200-1-3-3-5	142	160 ± 9.87	11 ± 4.00	19.8 ± 0.66	9 ±0.71	29 ± 1.87	20.0
LD-200-1-3-3-8	143	152 ± 5.6	11 ± 4.34	20.6 ± 0.74	8.4 ± 0.51	28 ± 2.59	10.6
LD-200-1-3-3-9	144	174 ± 4.0	12 ± 4.00	22.6 ± 1.17	9.8 ± 1.62	27 ± 2.23	9.8
Laskmi digha (P)	196	230 ± 6.32	13 ± 2.5	13.4 ± 3.04	7.6 ± 1.21	25.6 ± 0.51	13.0

The progeny that matured later than the parent Laksmi digha were discarded but that matured earlier and produced 10g or more hill^{-1} were selected. Preliminary yield trial will be conducted with these nine mutants under natural deepwater conditions at Gopalganj and Barishal in the next Aman season.

Screening M_4 population of BR-11 for bacterial leaf blight tolerance

The seeds of two M_4 populations derived from irradiating the seeds of BR-11 with 300 Gy dose of gamma rays, BR11-300-1 and BR11-300-2, were sown on 13 July and seedlings were transplanted on 17 August 2017 along with the parent BR-11 at BINA HQ farm, Mymensingh. The experiment followed non replicated 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. The plants were severely infected by bacterial leaf blight and sheath blight. Five plants from BR11-300-2 were found with no or minimum symptoms of bacterial leaf blight and sheath blight and were selected for further screening in M_5 generation in the next T. aman season.

Screening and evaluation of M_4 population of Biroi rice in T. Aman season

To select lodging resistant plants/progenies with shorter duration and higher yield but keeping the quality same as the parent, seeds of two plant population, Biroi-200 and Biroi-250-2 derived from irradiating the seeds of Biroi with 200 and 250 Gy dose of gamma rays, respectively, were sown on 13 July 2017. The parent Biroi was also included in this experiment. Seedlings were transplanted on 17 August 2017 along with the parent Biroi at BINA HQ farm, Mymensingh following non replicated design at 15 cm distance within rows of 20 cm apart. 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. Based on shorter plant height, shorter maturity period and higher filled grains plant^{-1} than the parent, six plants were selected from Biroi-250-2.

Growing of recurrent gamma ray irradiated M_2R_1 populations of BR 11

The seeds of three recurrent irradiated population derived from 150 Gy +150Gy , 150 Gy+ 200 Gy and 150 Gy+250 Gy doses of gamma rays to BR11 were sown on 13 July 2017 and transplanted on 17 August 2017 at BINA HQ farm, Mymensingh. The parent BR-11 was also included in this experiment. The experiment followed non replicated design. Plants were spaced at 15 cm distances within rows of 20 cm apart. A unit plot size was 3.0m × 2.0 m. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied0 in the form of Urea, TSP, MoP, Gypsum and Zinc sulphate. Cultural and intercultural practices were followed as and when necessitated. The experiment was severely infected by bacterial leaf blight and sheath blight. Nine plants from 150Gy +250 Gy were found with no or minimum symptoms of bacterial leaf blight and sheath blight and were selected for further screening in $M_3 R_1$ generation in the next T. aman season.

Growing of recurrent gamma ray irradiated M_2R_1 populations of BRRI dhan49

The seeds of three recurrent irradiated population derived from 150 Gy +150Gy , 150 Gy+ 200 Gy and 150 Gy+250 Gy doses of gamma rays to BRRI dhan49 were sown on 13 July 2017 and transplanted on 17 August 2017 at BINA HQ farm, Mymensingh. The parent BRRI dhan49 was also included in this experiment. The experiment followed non replicated design. Plants were spaced at 15 cm distances within rows of 20 cm apart. A unit plot size was 3.0m × 2.0 m. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied0 in the form of Urea, TSP, MoP, Gypsum and Zinc sulphate. Cultural and intercultural practices were followed as and when necessitated. The experiment was severely infected by false smut. Two early maturing plants from 150Gy +200 Gy and another plant from 150 Gy +250 Gy were found with no or minimum symptoms of false smut disease were selected. These will be further screened in M_3 R_1 generation in the next T. aman season.

Growing of F_2 generation of Binadhan-7× Biroi cross

Seeds of two plants obtained from the cross Binadhan-7× Biroi were sown on 13 July 2017 and transplanted on 17 August 2017 at BINA HQ Farm, Mymensingh in two separate plots. The parent Binadahan-7 and Biroi were also included in this experiment. Distance between plants 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 necessitated. Based on grain color, lodging resistance and earliness 72 individual plants were selected.

Growing of M_1 generation of Nitrogen ion beam irradiated population of NERICA-1, NERICA-4 and NERICA-10

Dehusked seeds of NERICA-1, NERICA-4 and NERICA-10 were irradiated with three fluences (10^{14}ions/ cm^2, 10^{15}ions/ cm^2 and 10^{16}ions/cm^2) from a 30-kev nitrogen ion beam irradiator of Chiangmai University, Thailand. Foreach fluence, 300 seeds were used. After receiving the seeds, these were sprouted in petridishes separately variety and dose wise. The sprouted seeds were then sown in earthen pots on 13 July 2017 and transplanted on 21 August 2017 in the field in separate non replicated plots dose and variety wise. At harvest, the survived plants that produced seeds were harvested separately variety and dose wise for growing in M_2 population in the next Aus season.

BORO

On-farm and on-station trial with a short duration high yielding M_{10} mutant line

This trial was carried out with a short duration and high yielding mutant RM-40(C)-4-2-8 derived from irradiating the seeds of BRRI dhan29 with carbon ion beams to assess the yield potential over locations. The short duration Boro rice variety, BRRI dhan28 was used as a check variety. Seeds were sown during 23 November to 13 December 2017 and transplanted during 09 January to 21 January 2018 (Table 4). The experiments in the trial followed RCB designs with three replications. The size of the unit plots were 6.0 m × 5.0 m. Seedlings were transplanted at 15 cm distance within rows of 20 cm apart.

Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. Data on plant height, number of effective tiller, panicle length, and filled and unfilled grains panicle^{-1} were recorded after harvest from five 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 and are presented in Table 11.

Table 11. Date of sowing and transplanting of the short duration premium quality rice mutant and check variety at different locations of Bangladesh

Location	Date of sowing	Date of transplanting	Seedling age (days)
BINA HQ farm, Mymensingh	23 November 2017	14 January 2018	53
Farmer's field, Mymensingh	17 December 2017	23 January 2018	38
BINA sub-station farm, Sherpur	20 December 2017	21 January 2018	33
Farmer's field, Sherpur	20 December 2017	21 January 2018	33
BINA sub-station farm, Jamalpur	6 December 2017	15 January 2018	41
Farmer's field, Jamalpur	6 December 2017	21 January 2018	47
BINA sub-station farm, Gopalganj	13 December 2017	21 January 2018	40
BINA sub-station farm, Barishal	23 November 2017	2 January 2018	41
Farmer's field, Barishal	23 November 2017	9 January 2018	48
BINA sub-station farm, Magura	13 December 2017	20 January 2018	38
Farmer's field, Magura	13 December 2017	20 January 2018	38

It appears that the mutant RM- 40 (C)-4-2-8 took 5-8 days more to mature than the check variety in most of the locations (Table 5). But at Jamalpur, it took 11-15 days more which seems unusual, may be due to erroneous recording of maturity date. The plant height of the mutant was significantly taller than the check variety, BRRI dhan28 at all locations. Effective tiller number of the mutant did not differ significantly at seven out 11 locations. Panicle length was significantly longer in the mutant at all locations and number of filled grains panicle^{-1} was also significantly higher than the check variety which attributed to higher yield in the mutant at all.

Table 12. Yield and yield attributes of a short duration high yielding mutant line along with BRRI dhan28 in 2017-18

Variety/Line	Days to maturity	Plant height (cm)	Effective tillerplant^{-1} (no.)	Panicle length (cm)	Filled grain panicle^{-1} (no.)	Unfilled grain panicle^{-1} (no.)	Yield (tha^{-1})
BINA HQ farm, Mymensingh							
RM-40(C)-4-2-8	147	109.47	8.33	26.20	136.27	49.33	6.65
BRRI dhan 28	142	91.80	12.00	20.97	80.80	21.00	5.97
$LSD_{(0.05)}$	-	8.58	1.82	1.23	24.88	5.61	0.14
Farmer's field, Mymensingh							
RM-40(C)-4-2-8	152	113.33	9.07	24.80	138.20	48.27	6.78
BRRI dhan 28	142	95.80	11.07	20.67	103.33	41.00	6.52
$LSD_{(0.05)}$	-	4.86	NS	1.14	16.12	NS	NS
BINA sub-station farm, Magura							
RM-40(C)-4-2-8	146	123.67	9.67	28.07	123.67	18.53	8.03
BRRI dhan 28	139	105.67	13.73	24.13	146.67	28.00	7.67
$LSD_{(0.05)}$	-	6.01	NS	1.93	6.26	6.10	NS
Farmer's field, Magura							
RM-40(C)-4-2-8	145	100.07	7.07	20.60	85.13	29.93	5.73
BRRI dhan 28	137	96.27	13.73	21.13	146.67	28.00	5.50
$LSD_{(0.05)}$	-	9.44	1.13	NS	11.61	NS	NS
BINA sub-station farm, Barishal							
RM-40(C)-4-2-8	151	113.67	9.87	29.13	163.47	32.40	6.13
BRRI dhan 28	144	94.40	14.93	22.13	91.93	9.07	3.99
$LSD_{(0.05)}$	-	12.58	2.40	2.98	12.36	7.01	0.50
Farmer's field, Barishal							
RM-40(C)-4-2-8	151	126.93	13.80	30.17	198.93	56.27	5.00
BRRI dhan 28	142	104.40	16.33	24.50	122.87	32.40	4.85
$LSD_{(0.05)}$	-	6.77	NS	2.14	23.15	10.70	NS

Variety/Line	Days to maturity	Plant height (cm)	Effective tillerplant^{-1} (no.)	Panicle length (cm)	Filled grain panicle^{-1} (no.)	Unfilled grain panicle^{-1} (no.)	Yield (tha^{-1})
BINA Sub-station farm, Gopalganj							
RM-40©-4-2-8	148	125.00	15.20	26.23	154.33	33.67	6.78
BRRI dhan 28	142	100.20	13.73	23.13	123.07	14.33	6.52
$LSD_{(0.05)}$		10.66	NS	1.36	5.29	2.94	NS
BINA sub-station farm, Sherpur							
RM-40(C)-4-2-8	146	119.26	11.89	26.28	117.70	35.22	6.66
BRRI dhan 28	139	100.78	11.58	23.38	102.85	16.78	6.45
$LSD_{(0.05)}$	-	3.99	NS	0.96	2.25	5.99	0.10
Farmer’s field, Sherpur							
RM-40©-4-2-8	145	123.00	11.56	26.56	114.42	23.67	6.78
BRRI dhan 28	137	100.66	10.89	23.48	106.44	11.83	6.52
$LSD_{(0.05)}$	-	11.93	NS	0.55	NS	2.04	NS
BINA Sub-station farm, Jamalpur							
RM-40(C)-4-2-8	156	114.53	9.73	26.40	140.80	24.33	5.87
BRRI dhan 28	145	92.73	12.00	23.53	109.33	8.13	7.00
$LSD_{(0.05)}$	-	3.18	2.22	3.26	6.37	2.78	0.22
Farmer’s field, Jamalpur							
RM-40(C)-4-2-8	155	110.73	11.87	26.20	171.47	29.07	6.30
BRRI dhan 28	140	90.60	12.07	23.33	114.13	18.73	6.23
$LSD_{(0.05)}$	-	1.82	NS	0.93	18.01	5.88	NS
Combined over 11 locations							
RM-40(C)-4-2-8	149	116.33	10.73	26.42	140.14	34.61	6.43
BRRI dhan 28	141	97.57	12.92	22.76	113.46	20.84	6.04
$LSD_{(0.05)}$	-	1.91	0.49	1.74	5.45	2.21	0.08
$LSD_{(0.05)}$ for mutant × location interaction	-	6.34	1.63	1.54	18.08	7.35	0.27

Locations except BINA sub-station farm, Jamalpur (Table 5). Finally, considering yield premium quality grain (data not shown), this mutant will be put into Field Evaluation Trial in the next Boro season for release as a variety.

AUS

Screening of M_2 populations of NERICA-1, NERICA-4 and NERICA-10 irradiated with nitrogen ion beams

The seeds obtained from the nitrogen ion irradiated M_1 generation of NERICA-1, NERICA-4 and NERICA-10 grown during the Aman season 2016-17 were sown in Aus season 2018 on 11 April at BINA HQ Farm, Mymensingh and transplanted on 20 May. There were seven M_1 survived plants that produced seeds of NERICA-1 irradiated with 10^{14} ions/cm^2, five from 10^{15} ions/cm^2 and 12 from10^{16} ions/cm^2 of nitrogen ions. On the other hand, nine survived M_1 plants produced seeds of NERICA-4 irradiated with 10^{14} ions/ cm^2, 11 from 10^{15} ions/cm^2 and 23 from 10^{16} ions/ cm^2 of nitrogen ions. Similarly, four survived M_1 plants produced seeds of NERICA-10 irradiated with 10^{14} ions/ cm^2, 11 from 10^{15} ions/ cm^2 and 13 from 10^{16} ions/ cm^2 of nitrogen ions. The experiment was conducted following plant-progeny-row. A unit plot comprised a single row of 5.0 m length. Distance between plants and rows were 20 cm and 30 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 necessitated.

At maturity, based on earliness and stay green broader flag leaves, three and two progenies, respectively, were selected from NERICA-4 irradiated with 10^{16} ions/cm^2 nitrogen ion beams, seven tall, erect and lodging resistant individual plants from again NERICA-4 irradiated with 10^{15} ions/cm^2 nitrogen ion beam. Moreover, some seeds from a tall with very broad flag leaves and excessive effective tillers were collected from NERICA-1 irradiated with 10^{15} ions/cm^2 nitrogen ion beams.

Screening of some advanced mutant rice lines for salt tolerance using hydroponic system at the seedling stage

Twenty-seven advanced mutant lines of backcrossed population (Binadhan-7×FL-478) were used for salinity tolerance at different salt stresses (8, 10 and 12 dS/m) at seedling stage along with three check varieties i.e. Binadhan-10, FL-478 (salt tolerant) and Binadhan-7 (susceptible). Out of twenty-seven (27) lines, one tolerant, 17 moderately tolerant, six susceptible and three highly susceptible were found at 12 dS/m (Table 10) at the seedling stage.

Table 13. Performance of rice genotypes under salinized condition grown in hydroponic system at the seedling stage at the glasshouse of BINA HQs, Mymensingh in 2017

Sl. No.	Genotypes	Salinity tolerance score at different salt stresses			Salinity tolerance
		8 dS/m	10 dS/m	12 dS/m	
1.	SL-01	5	5	9	Highly susceptible
2.	SL-02	3	5	5	Moderately tolerant
3.	SL-03	5	5	5	Moderately tolerant
4.	SL-09	5	5	5	Moderately tolerant
5.	SL-10	5	5	5	Moderately tolerant
6.	SL-11	3	5	5	Moderately tolerant
7.	SL-15	3	3	5	Moderately tolerant
8.	SL-17	3	5	5	Moderately tolerant
9.	SL-18	3	5	5	Moderately tolerant
10.	SL-21	3	3	3	Tolerant
11.	SL-26	3	5	5	Moderately tolerant
12.	SL-32	3	5	5	Moderately tolerant
13.	SL-35	3	5	5	Moderately tolerant
14.	SL-36	5	5	5	Moderately tolerant
15.	SL-38	5	5	7	Susceptible
16.	SL-39	5	5	9	Highly susceptible
17.	SL-41	5	5	5	Moderately tolerant
18.	SL-45	5	7	7	Susceptible
19.	SL-51	3	5	5	Moderately tolerant
20.	SL-56	3	5	5	Moderately tolerant
21.	SL-57	5	5	7	Susceptible
22.	SL-58	3	5	5	Moderately tolerant
23.	SL-59	5	5	5	Moderately tolerant
24.	SL-63	5	5	7	Susceptible
25.	SL-68	5	5	7	Susceptible
26.	SL-70	5	5	9	Highly susceptible
27.	SL-77	5	5	7	Susceptible
28.	Binadhan-10 (check)	3	3	3	Tolerant
29.	Binadhan-7 (check)	5	7	9	Highly susceptible
30.	FL-478 (check)	3	3	3	Tolerant

SES Scoring 1-9:

1 = Highly tolerant, 3 = Tolerant, 5 = Moderately Tolerant, 7= Susceptible and 9 = Highly susceptible

Participatory varietal selection and Preference analysis of salt tolerant rice lines at Sadar, Satkhira

The nine (9) salt tolerant lines (moderately), two (susceptible) and one (highly susceptible) from previous experiment were used for PVS trial during Aman season 2017. The experiment was laid out in RCBD with two replications. Unit plot size was 2.0 m × 1.0 m and spacing between hills and rows were 15 cm × 20 cm. These twelve lines were selected for PVS trial based on early maturity, medium slender grain and higher seed yield. In the PVS rice lines yield ranges from 1.10 to 4.45 t/ha. Two entries, namely PVS-02 (SL-09) and PVS-12 (SL-51) were selected based on farmer's preference and the agronomic performances like early maturity, higher yield, more number of tillers/hill, attractive color of grain, medium slender grain. Preference score ranged from -1.00 to + 1.00. The participatory varietal selection result of trial is shown in Table 14. Selected two lines will be used for PVS in two locations in saline prone areas in next Boro season 2017-18.

Table 14. Preference analysis of some salinity tolerant rice lines in T. Aman 2017 at Satkhira Sadar

Preference analysis, BINA			
Country: Bangladesh	District: Satkhira	Date:	30/11/2017
Village: Satkhira Sadar	Station: Farmer's field	Stress: Salinity (4-5 dS/m)	

Entry		Male (n=15)		Female (n=15)		Researcher (n=6)		Total Farmers (n=30)		Preference score	Grain yield (t/ha)
Code	**Accession**	**Positive**	**Negative**	**Positive**	**Negative**	**Positive**	**Negative**	**Positive**	**Negative**		
PVS-1	SL-02	-	-	04	-	-	02	04	00	1.00	3.40
PVS-2	SL-09	14	-	13	-	03	-	27	00	1.00	**4.45**
PVS-3	SL-10	-	-	-	01	-	-	00	01	-1.00	3.10
PVS-4	SL-11	10	-	03	-	02	-	13	00	1.00	3.70
PVS-5	Binadhan-7 (Check)	-	-	-	-	-	-	00	00	0.00	2.80
PVS-6	SL-15	-	01	-	-	-	01	00	01	-1.00	1.10
PVS-7	SL-26	-	-	-	-	-	-	00	00	0.00	2.65
PVS-8	SL-32	-	03	-	-	-	-	00	03	-1.00	1.40
PVS-9	SL-35	-	13	-	04	-	03	00	17	-1.00	1.85
PVS-10	Binadhan-10 (Check)	-	-	01	-	-	-	01	00	1.00	4.40
PVS-11	SL-38	-	-	01	01	-	-	01	01	0.00	2.10
PVS-12	SL-51	06	01	08	01	-	-	14	02	0.75	**4.32**
PVS-13	SL-57	-	01	-	01	05	-	00	02	-1.00	2.00
PVS-14	FL-478 (Check)	-	09	-	11	-	03	00	20	-1.00	3.60
PVS-15	SL-70	-	02	-	11	-	02	00	13	-1.00	1.90
	TOTAL	**30**	**30**	**30**	**30**	**12**	**12**	**60**	**60**	**-**	**-**

Comments on the overall performance of the two (2) most preferred varieties

Variety 1: PVS-2 (SL-09)	Expected grain yield is obtained 4.45 t/ha flag leaf is erect, plant height, medium slender grain with attractive color. Short duration 115-118 (days).
Variety 2: PVS-12 (SL-51)	Grain yield is higher than other varieties and medium slender grain (4.32 t/ha).

Comments on the overall performance of the two (2) least preferred varieties

Variety 1: PVS-14 (FL-478)	Poor yield (3.60 t/ha) and bold grain.
Variety 2: PVS-9 (SL-35)	Very poor yield (1.85 t/ha), late maturity (135-140 days)

Observation yield trial of ten salt tolerant and two salt susceptible rice mutants under non-saline area (BINA Substation, Cumilla) during T. Aman season, 2017

An experiment was carried out in non-saline field at BINA sub-station, Cumilla during T. Aman season, 2017 and the experiment was laid out in RCBD with two replications. Unit plot size was 2.0 m × 1.0 m and spacing between hills and rows were 15 cm × 20 cm. Table 15.

Table 15. Selected rice lines grown in observational yield trial under non-saline area, BINA Sub-station, Comilla

SL. No.	Genotype	Days to maturity	Plant height (cm)	Effective tillers/hill (no.)	Panicle length (cm)	Gains/panicle (no.)	Grain yield (t/ha)
1.	SL-2	116	107.1	14	24.8	164	5.62
2.	SL-09	118	111.1	12	27.2	144	5.03
3.	SL-10	107	109.5	14	26.6	170	6.15
4.	SL-11	106	101.4	11	25.1	204	5.98
5.	SL-15	116	110.8	18	26.6	174	5.54
6.	SL-26	106	104.7	12	23.5	164	5.70
7.	SL-32	112	104.0	12	27.1	170	5.64
8.	SL-35	110	105.5	14	25.0	157	5.49
9.	SL-38	109	104.8	14	25.2	178	5.64
10.	SL-51	118	101.5	13	22.6	168	5.64
11.	SL-57	103	114.6	13	29.7	152	5.73
12.	SL-70	115	103.5	13	24.9	160	5.97
13.	Binadhan-7 (check)	115	97.1	14	25.2	199	5.12
14.	FL-478 (check)	118	104.7	11	25.2	145	4.77
15.	Binadhan-10 (Check)	122	106.0	13	22.6	138	5.56
	LSD $_{(0.05)}$	3.15	8.32	2.99	4.15	31.56	0.47
	CV%	1.36	3.88	11.52	8.00	9.10	4.12

Data were collected based on days to maturity, plant height (cm), effective tiller (no.), panicle length (cm), no. of grains/panicle and grain yield (t/ha). It was found that SL-11 and SL-26 matured earlier (106 days) than other entries and the check varieties. The highest plant height was obtained in SL-57 followed by SL-09. The highest grain yield was obtained from SL-10 (6.15 t/ha) followed by SL-11, other entries and check varieties. These selected lines will be further evaluated in preliminary yield trial (PYT) in next T. Aman 2018-19 in saline and non-saline areas.

Development of dual tolerant (salinity-submergence) rice lines

Crosses were made among IRRI dual tolerant rice lines (RC-251, RC-222, RC-191, RC-249, RC-192 and RC-193) with popular rice varieties for development of dual tolerant (salinity and submerge) rice varieties. For this attempt, dual tolerant IRRI rice lines were crossed with a salt tolerant high yielding boro rice variety Binadhan-10 and the submergence tolerant aman rice variety Binadhan-11. Cross combinations and seeds produced in different generations are presented in Table 16.

Table 16. Total number of seeds developed in different, cross combinations during 2015-2017

Cross Combinations	Total number of seeds developed at different generations		
	F_1	BC_1F_1	BC_2F_1
Binadhan-10 (Salt tolerant) X RC-251 (Dual tolerant)	479	1157	1526
Binadhan-10 (Salt tolerant) X RC-222 (Dual tolerant)	1030	102	201
Binadhan-10 (Salt tolerant) X RC-191 (Dual tolerant)	700	282	240
Binadhan-10 (Salt tolerant) X RC-249 (Dual tolerant)	439	268	109
Binadhan-11 (Submergence tolerant) X RC-193 (Dual tolerant)	607	179	921
Binadhan-11 (Submergence tolerant) X RC-192 (Dual tolerant)	448	146	616

Introgression of *saltol* and *sub1* genes through Marker Assisted Selection (MAS)

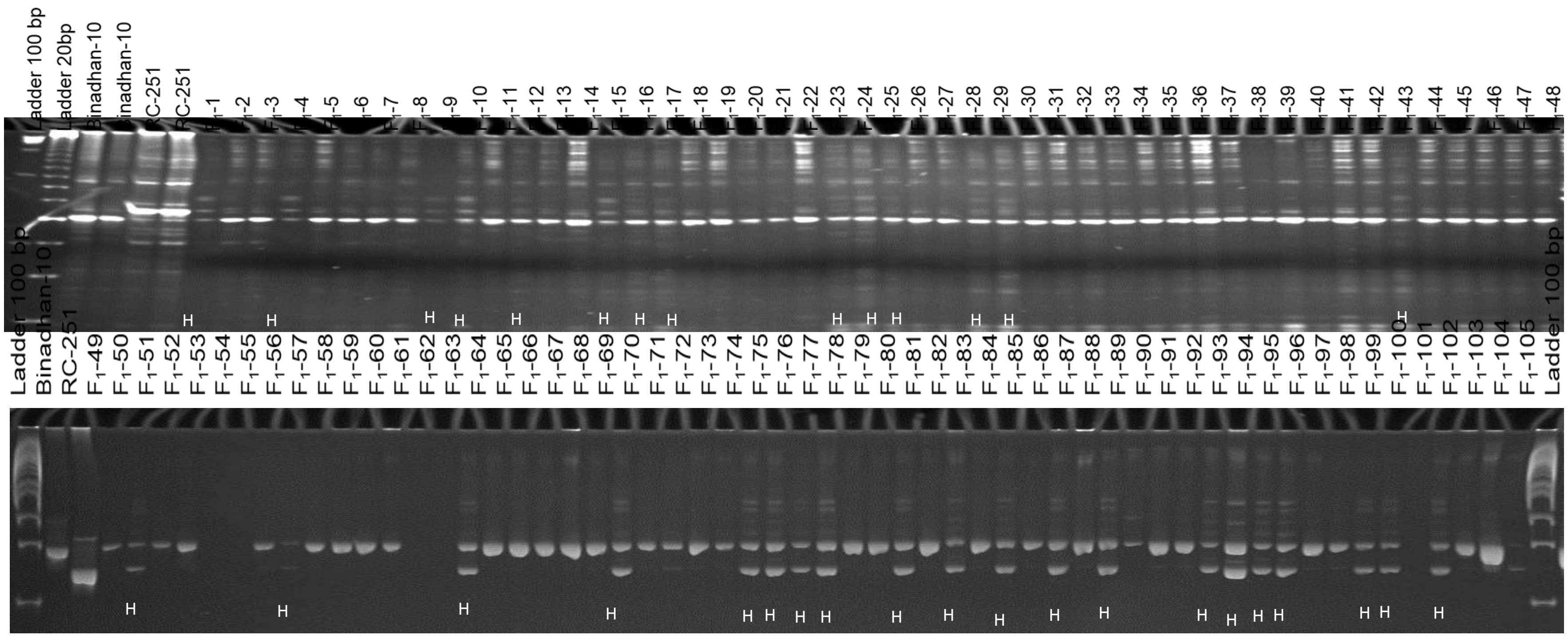
Marker assisted selection accelerated the selection to identify recombinants with *saltol* and *sub1*, introgressed into one genetic background. *Saltol*, a major quantitative trait locus (QTL) for salt tolerance on chromosome 1, found in IR29 × Pokkali. *Sub1*, a single QTL on chromosome 9 for submergence tolerance, characteristic of the landrace FR13A. Linked microsatellite markers used for *saltol* and *sub1* gene and detail information of some of the selected polymorphic markers are shown in Table 17 and 18, respectively.

Table 17. Linked polymorphic markers used for hybridization and foreground selection of Binadhan-10 × RC-251

Gene	Used Markers	Polymorphic Markers	Ratio of Polymorphic Markers on Parental Survey (%)
Saltol	25	11	44
sub1	15	7	46

Table 18. Some selected Polymorphic Markers used for *saltol* and *sub1* gene for Foreground Selection

Markers	Gene Marked	Chr. (Mb) Detected	PCR band size (bp)	Forward primer	Reverse primer
RM490	*Saltol*	1 (6.7)	100	ATCTGCACACTGCAAA CACC	AGCAAGCAGTGCTTT CAGAG
RM493	*Saltol*	1 (12.2)	230	TAGCTCCAACAGGATC GACC	TAGCTCCAACAGGAT CGACC
RM7075	*Saltol*	1 (15.1)	155	TATGGACTGGAGCAA ACCTC	GGCACAGCACCAAT GTCTC
RM23662	*sub1*	9 (0.4)	150	GAGAGGACGATGGCA CTATTGG	CGAGGAACTTGATTC GCATGG
RM5688	*sub1*	9 (1.7)	170	GCAGTGTCCAACCATC TGTG	ATCTGGTCACCCTTT GCTTG
SC3	*sub1*	9 (6.8)	200	GCTAGTGCAGGGTTGA CACA	CTCTGGCCGTTTCAT GGTAT



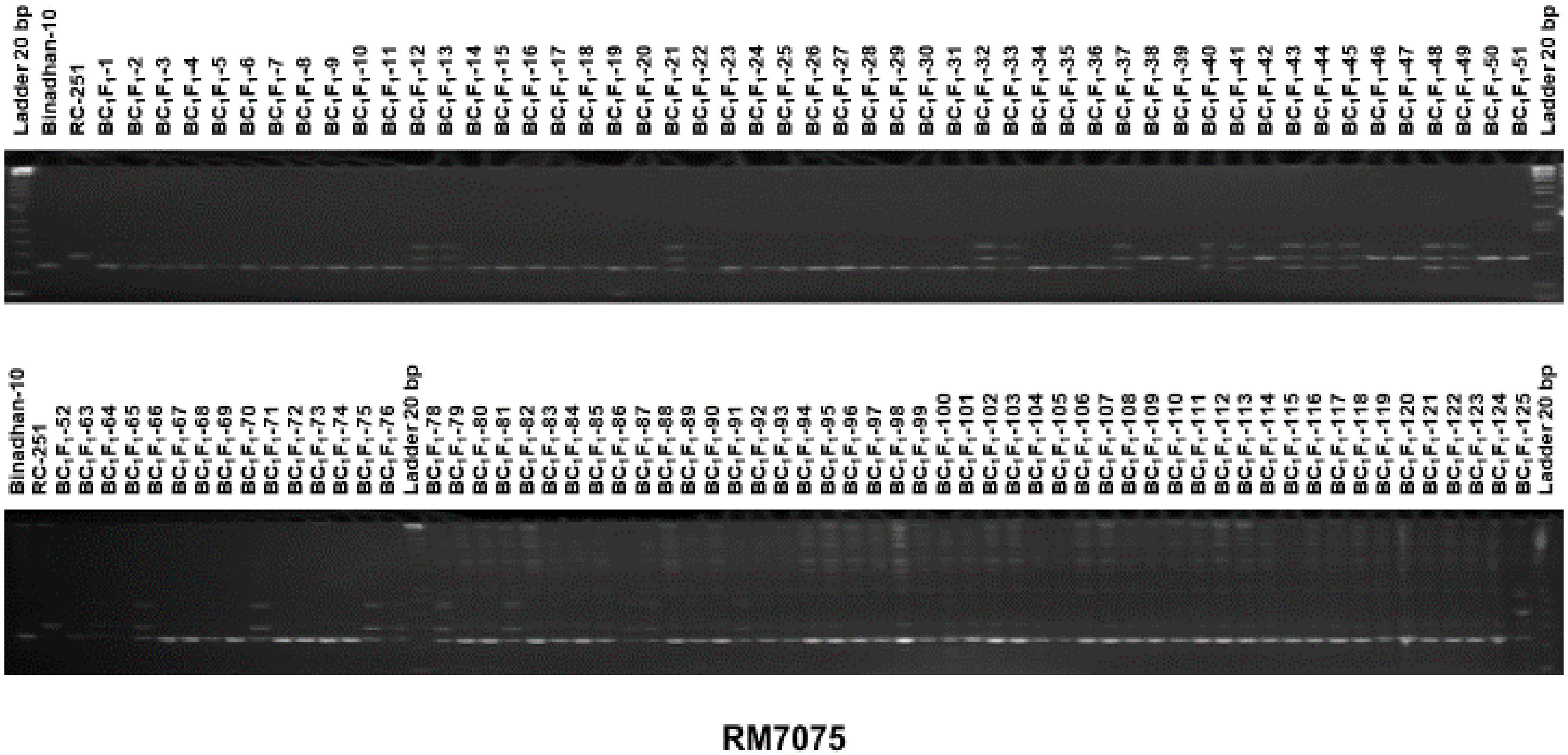


Fig. 3. DNA banding profiles of the BC_1F_1 of Binadhan-10×RC-251 to identify the candidate genes for salinity tolerance

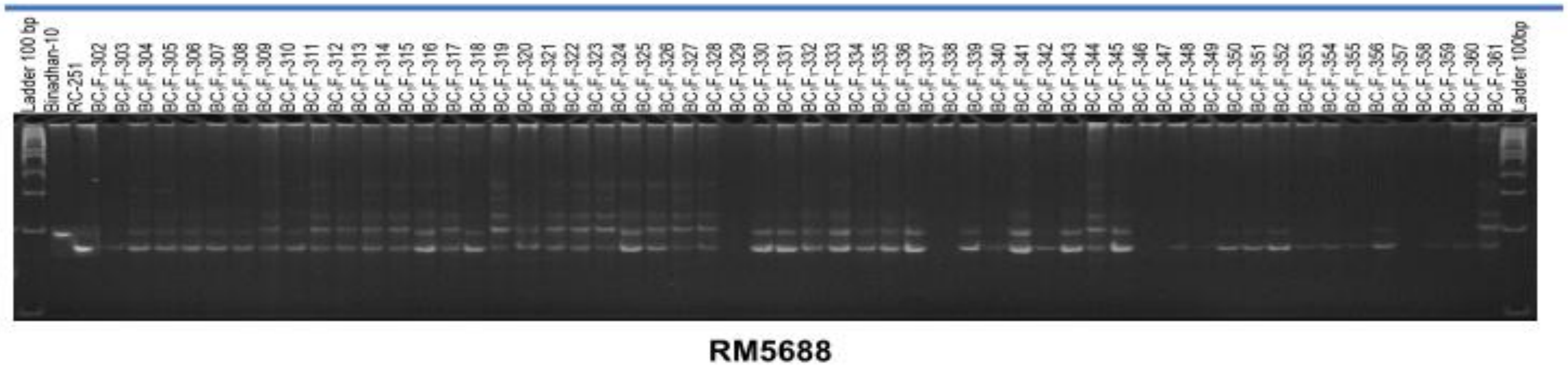


Fig. 4. DNA banding profiles of the genotypes (BC_1F_1) of cross combination of Binadhan-10 and RC-251 for submergence tolerant SSR markers

Table 19. Developed lines with two QTLs for salinity and submergence tolerance from Binadhan-10 × RC-251

Generations	Total No. of Seeds	Plants selected for *Saltol* (No.)			Plants selected for *sub1* (No.)			Plants with *saltol-sub1* (No.)
		RM490	RM493	RM7075	RM23662	RM5688	SC3	
F_1	479	-	-	113	-	97	-	80
BC_1F_1	1157	221	311	245	127	194	180	54

In RC-251 × Binadhan-10, 479 and 1157 lines were obtained from F_1 and BC_1F_1 respectively, where 80 and 54 lines having *saltol sub1* (dual) genes, respectively (Table 19).

Morphological characterization of the selected forty rice landraces

This study was conducted at BINA Headquarter farm, Mymensingh from July, 2017 to January, 2018. Forty landraces of rice were collected from different regions of Mymensingh and Sylhet Divisions of Bangladesh. The seeds were soaked into water for 24 hours and incubated in moist cloth sacks for 48 hours to facilitate quick germination. The pre-germinated seeds were sown in seedbed on 17th July, 2017. Randomized complete block design (RCBD) with three replications was followed to conduct field experiment. One seedling per hill was transplanted to the main plot on the 29th August, 2017. Row to row and plant to plant distance were 20cm and 15cm, respectively. Gap filling was done within seven days after transplanting to obtain uniform plant population. Irrigation, drainage and weeding were done as and when required. Different genotypes were matured at different times. Harvesting was done when 90% of the plant populations of each plot reached to maturity. Data were recorded on individual plant basis from 5 randomly selected plants on the following traits- days to flowering, days to maturity, flag leaf area, plant height, number of total tillers per hill, number of effective tillers per hill, panicle length, number of grains per panicle, number of filled grains per panicle, number of unfilled grains per panicle, 100-seed weight (g), grain yield per plant.

Days to 50% flowering among the genotypes ranged from 80.67 days to 120.33 days with a mean value of 105.19 days. Lal paijam took the lowest days to 50% flowering (80.67 days) followed by Porbotzira (89.33 days), Ajanabirun (92.67 days). Hashem irri took the highest days to 50% flowering (120.33 days). Days to maturity among the genotypes ranged from 130.3 days to 160.67 days with a mean value of 143.14 days. Lal paijam took the lowest days to maturity (130.3 days) which was followed by Kutimurabirun (135.7 days), Deshi 32 (135.7 days), (137.3 days), G15 (Soragoto birun). Hashem irri took the highest days to maturity (160.67 days) which was followed by G40 (Chanmoni) (153.3 days). Flag leaf area among the genotypes ranged from 45.41 cm2 to 157.7 cm2 with a mean value of 80.53 cm2. Kalojira had the lowest flag leaf area (45.41 cm2) and Hashem irri had the highest flag leaf area (157.70 cm2) which was followed by Boroabji (130.6 cm2), Govindo (122.6 cm2), Binni dhan (105.3 cm2).

The average range of plant height among the genotypes was 96 cm to 160.57cm with a mean value of 127.73 cm. Ajanabirun had the lowest plant height (96 cm) and Binni dhan had the highest plant height (160.57 cm).

In this study, the average number of total tillers per hill ranged from 9.6 to 22.4 with a mean value of 14.62. Hasa (sada) had maximum number of total tillers per hill (22.4) and Binni dhan had minimum number of total tillers per hill (9.6). The number of effective tillers per hill ranged from 7.87 to 20.23 with a mean value of 12.89. Hasa (sada) had maximum number of effective tillers per hill (20.23) which was followed by Boroabji (18.93), Vedabiron (18.43). Lal paijam had minimum number of effective tillers per hill (7.87) followed by Binni dhan (8.03), Ailaguta (8.5). In this study the average range of pollen fertility (%) among the genotypes was 37% to 96.67% with a mean value of 81.28%. G6 (Chinishail-1) had maximum Pollen fertility (96.67%) and Lal paijam had minimum Pollen fertility (37%). Panicle length among the genotypes ranged from 20.40 cm to 31.40 cm with a mean value of 24.6 cm. Binni dhan had the longest panicle (31.4 cm) followed by Kalo Biron (28.32 cm) and Ailaguta had the lowest panicle length (20.40 cm).In this study the number of grains per panicle ranged from 93.07 to 295.50 with a mean value of 170.85. Hashem irri had the highest number of grains per panicle (295.5) which was followed by Birui (288.5), Notiguarchara (287.7), Mukta (280.4). Guarchara had the lowest number of grains per panicle (93.07).

The number of filled grains per panicle ranged from 58.87 to 248.57 with a mean value of 134.88. Birui had the highest number of filled grains per panicle (248.57) which was followed by Notiguarchara (247.5), Hashem irri (231.2). Lal paijam had the lowest number of filled grains per panicle (58.87).The number of unfilled grains per panicle ranged from 12.07 to 80.93 with a mean value of 36.20. Mukta had the highest number of unfilled grains per panicle (80.93) and Chinishail-1 had the lowest number of unfilled grains per panicle (12.07). 100 seed weight ranged from 1.07 g to 3.45 g with a mean value of 1.88 g. The highest 100 seed weight was recorded in Lal paijam (3.45 g) and Chinishail-1 had minimum 100 seed weight (1.07 g).

Grain yield per plant (g) ranged from 8.00 g to 30.73 g with a mean value of 18.05 g. Lal Kumri had maximum yield per plant (30.73 g) which was followed by Hashem irri (29.77 g), (Vedabiron (27.8 g), Kalomotashail (26.7 g). Lal paijam had minimum yield per plant (8.0 g).

Table 20 : Mean performance of 40 rice genotypes on different morphological traits related to yield

Genotypes	DF (50 %)	DM	FLA (cm^2)	PH (cm)	TT	ET	PF (%)	PL (cm)	GPP	PG	UG	100 SW (g)	YPP (g)
Parbotjira	89.33	142.3	51.76	123.7	11.47	9.47	91.67	24.60	216.1	148.7	67.47	1.08	11.80
Ailaguta	106.7	139.7	71.33	137.2	10.27	8.50	48.67	20.40	129.1	90.27	38.87	2.25	11.13
Birui	99.33	142.0	96.77	124.9	12.80	11.07	93.00	23.07	288.5	248.57	39.93	1.83	17.90
Chinishail-3	106.7	142.0	89.30	127.6	15.27	13.07	96.00	25.08	155.2	130.6	24.60	1.10	18.33
Chinishail-2	104.7	144.0	126.8	121.2	17.40	15.40	91.00	24.33	123.55	110.33	13.13	1.31	22.73
Chinishail-1	109.0	141.0	65.89	116.9	17.07	15.53	96.67	23.93	128.00	116.00	12.07	1.07	18.03
Notiguarchara	107.3	145	64.65	144.3	15	13.93	88.67	28.04	287.7	247.5	40.13	1.14	23.77
Govindo	116.7	153.7	122.6	126.5	12.33	10.97	88.00	22.13	250.0	197.0	53.0	1.74	19.47
Paijam	104.7	150.3	71.38	122.2	14.80	13.07	94.33	22.27	169.9	117.7	52.23	2.40	22.10
Binnidhan	100	143.3	105.3	160.6	9.6	8.03	87.67	31.40	245.6	198.2	45.73	2.31	16.60
Paijam	106.3	142.7	101.3	118.9	11.73	10.67	87.33	23.20	221.1	173.3	47.67	1.73	22.23
Ajana birun	92.67	142.7	90.73	96.0	13.53	11.40	88.00	22.98	180.7	134.4	46.27	1.85	16.30
Lal paijam	80.67	130.3	84.84	107.4	10.0	7.87	37.00	23.71	111.7	58.87	52.80	3.45	8.00
Moynashail	105.	140.	80.1	128.	17.6	14.8	55.6	26.1	145.6	114.5	31.0	1.8	23.7

Genotypes	DF (50 %)	DM	FLA (cm 2)	PH (cm)	TT	ET	PF (%)	PL (cm)	GPP	PG	UG	100 SW (g)	YPP (g)
	3	3	8	1	7	0	7	3			0	6	7
Sorogoto birun	103	137.7	52.43	116.2	13.73	11.73	60.00	23.39	109.6	78.87	30.73	2.34	14.60
Kutimurarbirun	100.3	135.7	79.31	115.0	17.73	16.07	71.67	24.23	116.6	83.93	32.67	1.73	13.57
Kashiabinni	100.7	141	57.53	124.7	17.73	15.27	92.00	26.47	138.3	122.7	26.27	2.19	16.83
Chakloshi	103.3	138	74.03	116.7	15.80	13.93	93.33	24.77	133.5	104.5	29.07	1.93	16.13
Deshi-32	101.3	135.7	74.38	114.5	11.80	10.73	67.33	24.73	117.0	76.53	40.47	2.14	14.77
Chengermuri	107.3	147	74.45	129.6	11.77	10.13	92.00	25.71	152.1	117.5	34.47	1.48	17.17
Putibirun	106.3	141	57.50	138.5	12.60	10.77	95.00	26.47	158.7	143.9	14.87	2.45	15.63
Hashemirri	120.3	160.6	157.7	132.1	15.87	15.10	81.00	23.55	295.5	231.2	64.27	1.70	29.77
Guabari	106.7	139	58.88	133.9	18.20	16.50	90.33	25.86	149.9	122.1	27.80	1.99	24.67
Hasa (Kalo)	112	150.3	71.97	141.3	10.30	8.70	92.67	24.80	71.97	228.5	41.67	1.21	12.20
Kalomotashail	108.3	145.7	92.27	136.9	17.30	16.60	95.67	24.35	129.3	113.0	16.33	2.76	26.70
Mukta	110.3	143.7	91.48	121.5	12.60	11.00	56.67	23.31	280.4	199.5	80.93	2.03	18.80
Sada paijam	99.0	137.3	90.34	121.5	11.00	9.23	87.33	23.19	180.2	123.2	56.93	1.47	18.57
Hasa (sada)	106.3	138.3	92.93	125.2	22.4	20.23	92.33	22.53	153.1	117.9	35.20	1.61	17.67
Biroi dhan	106.3	138.3	92.93	125.2	22.40	20.23	92.33	22.53	113.5	85.30	28.20	1.93	13.10
Guarchara	103.7	136.7	51.63	124.0	14.27	12.33	67.00	21.83	93.07	68.87	24.20	2.03	9.00
Maloti	107.3	149.0	62.23	136.6	12.37	11.70	68.00	21.77	173.0	148.0	25.00	2.04	16.03
Lalcheng	107.3	143.7	68.86	127.4	15.07	12.70	90.67	24.30	165.7	149.5	16.13	1.85	19.37
Sonajuri	108.3	141.3	89.95	122.5	16.50	12.70	64.67	27.82	128.9	112.8	16.03	1.70	14.33
Lal kumri	105.7	143.7	73.20	135.3	17.47	15.93	92.00	25.13	161.8	128.8	32.93	1.92	30.73
Kalo Biron	106.7	143.3	82.59	136.4	11.73	10.33	53.33	28.32	169.4	136.6	32.77	2.06	17.43
Chinigura	104.7	148.0	49.08	138.5	15.97	14.77	65.33	27.10	157.9	104.1	53.80	1.76	17.47
Vedabiron	110.3	145.0	98.93	134.7	19.93	18.43	96.33	26.80	219.2	189.1	30.03	1.90	27.80
Kalojira	109.7	147.3	45.41	137.1	15.73	14.40	74.67	24.37	184.7	155.7	28.97	1.24	16.77
Boroabji	106.3	143.3	130.6	132.3	20.17	18.93	76.00	24.00	120.6	86.70	33.90	2.27	15.17
Chanmoni	113.3	153.3	45.77	134.3	11.73	10.57	96.33	23.57	109.5	80.30	29.43	2.32	15.43
LSD(0.05)	**5.43**	**7.92**	**6.36**	**6.34**	**3.15**	**1.5**	**6.86**	**1.91**	**40.47**	**31.93**	**6.03**	**0.10**	**3.51**
SE(±)	**1.08**	**.89**	**3.89**	**1.76**	**0.49**	**0.48**	**2.53**	**0.33**	**9.02**	**7.84**	**2.46**	**0.08**	**0.82**
SD	**6.82**	**5.61**	**24.60**	**11.16**	**3.10**	**3.05**	**16.00**	**2.10**	**57.07**	**49.57**	**15.55**	**0.49**	**5.22**
CV(%)	**3.18**	**3.41**	**4.86**	**3.06**	**13.28**	**7.16**	**5.19**	**4.80**	**14.57**	**14.56**	**10.25**	**3.32**	**11.96**

DF (50%)= Days to 50% flowering, DM= Days to maturity, FLA (cm2)= Flag leaf area (cm2), PH (cm)= Plant height (cm), TT= Number of total tillers per hill, ET= Number of effective tillers per hill, PF (%)= Pollen fertility (%), PL (cm)= Panicle length (cm), GPP= Number of grains per panicle, FG= Number of filled grains per panicle, UG= Number of unfilled grains per panicle, 100 SW (g)= 100 seed weight (g), YPP (g)= Yield per plant (g)

Grain quality characterization of the selected forty rice landraces

Grain size and grain shape: The genotypes were grouped into three classes of grain size: short, medium and long. Out of forty genotypes, nineteen genotypes were in each class of short and medium grain length (47%) and (48%), respectively and the rest two genotypes (5%) (Kutimurabirun and Kashiabinni) had long grain size. The grain length of the studied genotypes ranged from 3.41 mm (Chinishail-3) to 7.05 mm (Kutimurabirun) with an average value of 5.30 mm (Appendix VII). Similarly the genotypes were grouped into three classes of grain shape: bold, medium and slender. Out of forty genotypes, three genotypes (7%) were bold, twenty eight genotypes (70%) were medium and the rest nine genotypes (23%) were slender. The grain length/breadth ratio of the studied genotypes ranged from 1.66 (Sonajuri) to 3.82 (kutimurabirun) with the average value of 2.62.

Aroma: Among the studied genotypes, five genotypes had strong aroma (Porbotzira, Notiguarchara, Hasa (kalo), Chinigura, Kalojira), three had slight aroma (Chinishail-1, Chinishail-2, Chinishail-3) and the rest had no aroma.

Chalkiness and translucency: Most of the genotypes (twenty two genotypes) (55%) were observed to have no chalky texture in grains whereas ten genotypes (25%) had small chalky texture (<10% chalky area), five genotypes (12%) had medium chalky texture (10%-20% chalky area) and the rest three genotypes (8%) had large chalky texture (> 20% chalky area).

Gelatinization temperature (GT): GT was determined based on the alkali spreading value. The gelatinization temperature of rice may be classified as low (55 to 69°C), intermediate (70 to 74°C), and high (>74°C). In the present study, seventeen genotypes (43%) showed high GT, eighteen genotypes (45%) showed intermediate GT and the rest five genotypes (12%) showed low GT (Table).

Amylose content: From this study, amylose content of rice grains was seen to range from 10.58% (Hashem irri) to 34.39% (Govindo and Lalcheng) with an average of 24.62%. Hashem irrri had the lowest amylose content followed by Hasa (kalo) (11.47%) and Chanmoni (14.99%). Most of the genotypes had 16.76% to 34.39% amylose content (Appendix VII). Fifteen genotypes (37%) had high amylose content (>25% amylose content), seventeen genotypes (43%) had intermediate amylose content (20%-25% amylose content) and the rest eight genotypes (20%) had low amylose content (10%-19% amylose content) (Table).

Iron content (ppm) and zinc content (ppm): Iron content of rice grains of the studied genotypes was seen to range from 7.12 ppm (Chakloshi) to 172.23 ppm (Lal paijam). Chakloshi had the lowest iron content followed by Mukta (8.95 ppm), Guabari (10.16 ppm), Kalomotashail (12.71 ppm). Lal paijam had the highest iron content followed by Govindo (159.23 ppm), Paijom (104.36 ppm). Most of the genotypes had 16.06 ppm to 86.17 ppm iron content (Table 4.15). Zinc content of rice grains of the studied genotypes was seen to range from 13.04 ppm (Hashem irri) to 33.43 ppm (Lal paijam). Hashem irri had the lowest zinc content followed by Porbotzira (13.19 ppm), Biroi dhan (14.79 ppm), Sonajuri (15.87 ppm). Lal paijam had the highest zinc content followed by Kashiabinni (26.4 ppm), Kutimurabirun (26.21 ppm), Kalomotashail (25.18 ppm). Most of the genotypes had 17.12 ppm to 24.86 ppm zinc content (Table 21).

Table 21 : Different grain quality traits of the studied 40 rice landraces

Genotypes	aGrain size	bGrain shape	Aroma	CChalkiness (%)	Transluceny	dASV Score	eGelatinization temperature	fAmylose (%)	Iron content (ppm)	Zinc content (ppm)
Parbotjira	Short	Medium	Strong	None	100	1	High	Intermediate	32.01	13.19
Ailaguta	Short	Medium	No	Medium	85	1	High	High	55.38	24.86
Birui	Medium	Medium	No	None	100	1	High	High	31.4	19.9
Chinishail-3	Short	Bold	Slight	None	91	1	High	High	19.51	22.75
Chinishail-2	Short	Medium	Slight	Small	91	7	Low	Intermediate	13.32	19.65
Chinishail-1	Short	Medium	Slight	Small	100	4	Intermediate	Low	85.21	24.4
Notiguarchara	Short	Medium	Strong	None	100	1	High	High	51.01	17.37
Govindo	Short	Medium	No	None	100	5	Intermediate	High	159.23	22.41
Paijam	Short	Medium	No	Small	89	4	Intermediate	Intermediate	104.36	18.11
Binnidhan	Medium	Medium	No	None	100	7	Low	Low	14.74	22.12
Paijam	Medium	Slender	No	None	100	1	High	Low	37.4	18.49
Ajana birun	Short	Medium	No	None	100	1	High	High	38.41	23.79
Lal paijam	Medium	Medium	No	Large	70	2	High	Intermediate	172.23	33.43
Moynashail	Medium	Slender	No	None	100	1	High	Intermediate	46.75	22.29
Sorogoto birun	Medium	Medium	No	Small	91	4	Intermediate	Intermediate	37.6	24.14
Kashiabinni	Long	Slender	No	None	100	3	Intermediate	Intermediate	43.6	26.4
Chakloshi	Medium	Slender	No	Small	91	3	Intermediate	Intermediate	7.12	18.83
Deshi-32	Medium	Slender	No	None	100	4	Intermediate	High	33.64	8.97
Chengermuri	Medium	Medium	No	Medium	85	4	Intermediate	Intermediate	52.74	22.69
Putibirun	Medium	Slender	No	Medium	85	6	Low	High	23.98	23.49
Hashemirri	Short	Medium	No	Small	91	5	Intermediate	Low	82.31	13.04
Guabari	Short	Medium	No	Small	91	1	High	Low	10.06	16.1
Hasa (Kalo)	Short	Medium	No	Small	100	1	High	Low	83.53	19.56
Kalomotashail	Medium	Medium	Strong	None	100	1	High	Intermediate	12.71	25.18
Mukta	Short	Medium	No	Medium	80	4	Intermediate	High	8.95	17.94
Sada paijam	Short	Medium	No	Small	95	7	Low	Intermediate	45.83	17.12
Hasa (sada)	Short	Medium	No	Small	91	1	High	High	53.15	19.9
Biroi dhan	Medium	Medium	No	None	100	1	High	Intermediate	23.78	14.79
Guarchara	Short	Medium	No	None	100	5	Intermediate	Intermediate	22.05	23.05

Genotypes	[a]Grain size	[b]Grain shape	Aroma	[C]Chalkiness (%)	Translucency	[d]ASV Score	[e]Gelatinization temperature	[f]Amylose (%)	Iron content (ppm)	Zinc content (ppm)
Maloti	Medium	Slender	No	Medium	85	4	Intermediate	Intermediate	16.06	18.91
Lalcheng	Medium	Medium	No	None	100	4	Intermediate	High	36.89	20.22
Sonajuri	Short	Bold	No	None	100	1	High	Low	36.99	15.87
Lal kumri	Medium	Medium	No	None	100	4	Intermediate	High	57.82	20.09
Kalo Biron	Medium	Slender	No	None	100	4	Intermediate	High	14.13	19.58
Chinigura	Short	Medium	Strong	None	100	4	Intermediate	Intermediate	59.24	19.65
Vedabiron	Medium	Medium	No	None	100	5	Intermediate	Intermediate	48.07	19.67
Kalojira	Short	Medium	Strong	None	100	4	Intermediate	Intermediate	57.21	20.32
Boroabji	Medium	Medium	No	Large	60	1	High	High	86.17	22.22
Kutimurarbirun	Long	Slender	None	Small	91	4	Intermediate	High	71.74	26.21
Chanmoni	Medium	Medium	No	Large	70	2	High	Low	35.67	19.65

Legend,

a) Very long (> 7.5 mm), Long (6.61 to 7.50 mm), Medium (5.51 to 6.60 mm), Short (Less than or equal to 5.50 mm).
b) Slender (L/B ratio > 3.0), Medium (L/B ratio = 2.1- 3.0), Bold (L/B ratio 2.0 or < 2.0); * L/B ratio= Grain length/breadth ratio
c) None (0% chalkiness), Small (<10% chalky area), Medium (11%-20% chalky area), Large (>20% chalky area)
d) 1= Kernel not affected, 2= Kernel swollen, 3= Kernel swollen; collar complete or narrow, 4= Kernel swollen; collar complete and wide 5= Kernel split or segregated; collar complete and wide, 6= Kernel dispersed; merging with collar, 7= Kernel completely dispersed and intermingled
e) High (ASV score 1-2), High-intermediate (ASV score 3), Intermediate (ASV score 4-5), Low (ASV score 5-6) f) Waxy (0-2%), Very low (3-9%), Low (10- 19%), Intermediate (20- 25%), High (> 25%)
f) Waxy (0-2%), Very low (3-9%), Low (10- 19%), Intermediate (20- 25%), High (> 25%)

Maintenance of germplasm (Seed multiply of local and exotic collections)

320 local germplasm and 217 Africa rice and about 200 IRRI advance lines were grown at BINA Hqs. farm, Mymensingh. After harvest, seeds of all these germplasm were collected and preserved at BINA gene bank as breeding materials for future research programme.

RAPESEED-MUSTARD

On-station and on-farm yield trials with three F_6 rapeseed lines

Three F_6 rapeseed lines (Tori-7×Binasarisha-4) were put into the trial to assess their performance for earliness and seed yield through on-station and on-farm trials. The trial was conducted at the experimental farms of BINA Headquarter Mymensingh and BINA sub-stations Magura, Rangpur, Nalitabari and farmer’s field Mymensingh, Magura, Rangpur, Nalitabari, Manikganj and Tangail. The experiment was laid out in a randomized complete block design with three replications. Seeds were sown on mid November 2017 at BINA Headquarter and mid week of October 2017 at Ishurdi, Nalitabari and Magura. Unit plot size was 20m^2 (5m × 4m) with 25cm line to line spacing and 6-8cm from plant to plant within line. Recommended production packages i.e., application of fertilizers, weeding, thinning, irrigation, application of pesticide etc. were followed to ensure normal plant growth and development. Data on days to maturity, plant height, branches plant^{-1}, siliquae plant^{-1}, siliqua length and seeds siliqua^{-1} were taken from 10 randomly selected plants from each plot. Maturity period was counted when 90% siliquae were matured. Seed yield of each plot was recorded after harvest and converted into kg ha^{-1}. Appropriate statistical analyses were performed for comparison of means of each character.

Results of on-station trial showed significant variations among the lines and check for most of the characters obtained from the trail of individual location and combined over sex locations. Results obtained from on station and on farm trials for both of individual location and combination over location presented at Table 22 and 23. On an average, maturity period varied from 92 to 81days. Among the rapeseed lines and check variety RL-03 required the highest maturity period 92 days followed by RL-01. Tori-7 required the shortest maturity period of 72 days. RL-04 had the tallest plant height (101.3cm) having non-significant difference with RL-03. Tori-7 produced the shorter plant height (84.8cm). RL-01 produced higher number of (5.1) branches plant^{-1} where BARIsarisha-15 produced the lowest number of branches plant^{-1} (3.9) followed by Tori-7. On an average BARI Sarisha -15 produced the highest number of siliquae per plant (111.1) closely followed by RL-03 and RL-04. Seed per siliqua, the important yield component was highest in the Tori-7 (19.6) followed by RL-04.

Finally BARISarisha-15 produced the highest seed yield 1534.4 kg ha^{-1} followed by RL-04 (1192.9 kg ha^{-1}). The other lines RL-01 and RL-03 produced the seed yield of 1129.7 kg ha^{-1} and 1074.8 kg ha^{-1}.

Result of on-farm trials also showed significant variations among the rapeseed line and check varieties for most of the characters. On an average RL-04 produced the highest number of siliquae per plant (81.1) followed by RL-03 (86.6) and RL-01 (85.7). Number of seed per siliqueae was the highest in BARI sarisha-15 (20.8) followed by RL-01 (17.3). Like on-station trials BARI Sarisha-15 produced the highest seed yield of 1723.8 kg ha^{-1}. Among the lines RL-04 produced the highest seed yields of (1666.6) kg ha^{-1} followed by RL-03 (1558.0 kg ha^{-1}) and RL-01 (1521.4 kg ha^{-1}).

Table 22. Location-wise as well as combination means over four locations of different characters in on-station trial during rabi 2017-18

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 Headquarters	RL-01	82b	103.8a	4.2a	59.7ab	4.1a	15.1b	689.0a
	RL-03	84a	94.9a	4.6a	76.4a	4.0a	14.9b	592.6a
	RL-04	85a	94.6a	3.9a	71.7a	3.9a	15.9b	598.3a
	BARI Sarisha-15	82b	87.1ab	3.6a	68.8a	3.9a	14.9b	684.6a
	Tori-7	80c	73.2b	3.4a	41.1b	3.6a	21.4a	471.0a
On station Rangpur	RL-01	97a	100.2a	5.1a	145.7a	4.5a	14.0b	1813.3a
	RL-03	96a	100.1a	4.3a	106.6ab	4.5a	15.7ab	1866.7a
	RL-04	84b	103.9a	5.3a	118.5a	4.8a	16.3ab	1973.3a
	BARI Sarisha-15	83b	100.1a	4.1a	162.5a	4.2a	14.7ab	2030.0a
	Tori-7	78c	93.2a	4.0a	159.2a	4.3a	16.9a	1940.0a

On station Magura	RL-01	97a	112.1a	5.5a	135.4a	5.3a	18.1ab	1383.3b
	RL-03	94a	111.6a	4.3ab	105.4ab	4.6ab	16.5b	1200.0c
	RL-04	94a	108.5a	3.9ab	90.1ab	4.8ab	17.5ab	1566.7a
	BARI Sarisha-15	92a	108.4a	3.5b	96.0ab	3.9b	16.5b	1466.7ab
	Tori-7	82b	96.3b	4.2ab	44.8b	5.2a	19.4a	603.3a
On station Nalitabari	RL-01	90b	89.3ab	5.7a	103.6a	2.8a	13.06b	633.3a
	RL-03	94a	97.4a	5.5ab	103.3a	3.2a	13.0b	640.0a
	RL-04	87bc	89.5ab	5.0ab	108.4a	2.9a	15.6b	633.3a
	BARI Sarisha-15	87bc	96.0a	4.7b	119.5a	3.2a	16.2b	600.0a
	Tori-7	84c	76.7b	4.9ab	57.5b	3.2a	20.8a	663.3a
Combined means over locations	RL-01	91ab	101.3a	5.1a	111.1a	4.1a	15.0c	1129.7b
	RL-03	92a	101.0a	4.6b	97.9b	4.0a	15.0c	1074.8b
	RL-04	87b	99.1b	4.5b	97.1b	4.1a	16.3b	1192.9b
	BARI Sarisha-15	85c	98.2b	3.9d	94.5c	3.7b	15.4c	1534.4a
	Tori-7	81d	84.8c	4.1d	75.6d	4.0a	19.6a	919.4c
Location means	Mymensingh	82c	90.c	3.9e	63.54c	3.9ab	16.44b	607.1c
	Rangpur	72d	99.5ab	4.6b	118.5a	4.5a	15.5c	1924.0a
	Magura	91a	107.4a	4.3c	94.3b	4.6a	17.6a	1244.0b
	Nalitabari	88b	89.9c	5.2a	98.5b	3.1b	15.7c	638.5c

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

Table 23. Location-wise as well as combination means over four locations of different characters in on-farm trial during rabi 2017-18

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})
Rangpur	RL-01	84a	107.6a	3.9ab	77.8ab	4.1a	15.1ab	1400.0c
	RL-03	84a	110.0a	4.5a	117.2a	4.6a	15.6ab	1600.0b
	RL-04	84a	112.7a	4.1ab	76.5ab	4.5a	15.1ab	1800.0a
	BARI Sarisha-15	83a	101.5ab	3.9ab	93.8ab	3.9a	14.1b	1632.0d
	Tori-7	81a	90.3b	2.5b	54.1b	4.3a	16.2a	1200.0b
Magura	RL-01	97a	118.2a	5.5a	92.9a	4.7b	18.2b	1450.0a
	RL-03	96a	99.8a	5.1ab	63.5b	4.5bc	17.4b	1433.3a
	RL-04	91b	101.2a	4.9b	66.5b	4.2c	18.1b	1416.7a
	BARI Sarisha-15	89c	90.2a	4.9ab	66.1b	4.3bc	15.7b	1483.3a
	Tori-7	79d	94.7a	5.2ab	67.3b	5.4a	21.4a	1283.3c
Nalitabari	RL-01	92a	103.9a	4.8ab	94.7ab	3.5a	16.5b	1492.3a
	RL-03	94a	103.5a	4.9a	89.0ab	4.0a	15.5b	1428.3a
	RL-04	91a	102.3a	3.8abc	124.8a	3.7a	14.6b	1505.0a
	BARI Sarisha-15	85b	101.8a	3.3bc	92.6ab	3.5a	16.1b	1420.0a
	Tori-7	80c	85.5a	2.5c	55.1b	3.8a	24.6a	1361.7b
Mymenensingh	RL-01	87a	103.8ab	4.6ab	93.1a	3.5ab	16.80a	1000.0b
	RL-03	84a	106.3ab	3.8abc	85.1a	3.6ab	15.8ab	1166.6a

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})
								b
	RL-04	88a	111.8a	4.8a	93.8a	3.7a	16.8a	1200.0a
	BARI Sarisha-15	85a	111.5a	3.1bc	73.0ab	3.1b	13.8b	1093.3ab
	Tori-7	78b	92.1b	2.5c	48.7b	3.7ab	17.8a	1150.0ab
Manikganj	RL-01	92a	107.8a	4.1a	70.2ab	3.6b	15.9b	1445.0a
	RL-03	90a	106.6 a	3.1ab	47.9ab	3.5bc	15.9b	1428.6ab
	RL-04	92a	104.5a	3.8ab	76.2a	4.18a	16.2b	1288.3ab
	BARI Sarisha-15	91a	108.6a	3.3ab	69.6ab	3.3c	14.3b	1236.0b
	Tori-7	78b	96.5b	2.4b	49.3b	3.5bc	23.8a	1471.6a
Tangail	RL-01	86b	105.4a	4.7a	76.8bc	4.6a	21.3a	1141.6b
	RL-03	92a	108.6a	4.2b	117.4a	3.9bc	18.8b	1291.6ab
	RL-04	92a	101.0a	3.8c	97.3ab	3.6c	17.4b	1373.3a
	BARI Sarisha-15	79c	100.0a	4.6a	91.7ab	3.1d	14.0c	1141.6b
	Tori-7	87b	82.6b	3.2d	52.8c	4.1b	21.3a	1345.0a
Combined means over locations	RL-01	89a	107.7a	4.6a	85.7b	4.0a	17.3ab	1521.4d
	RL-03	90a	105.8b	4.2b	86.6ab	4.0a	16.5b	1558.0c
	RL-04	89a	105.5b	4.2b	89.1a	3.8b	16.3b	1666.6b
	BARI Sarisha-15	86b	102.7c	4.0bc	79.0c	4.1a	20.8a	1723.8a
	Tori-7	80c	90.2d	3.0c	54.5d	3.6b	14.8c	1526.0d
Location means	Rangpur	83d	104.4a	3.8c	83.8c	4.3a	15.2c	1526.0a
	Magura	96a	100.8a	5.1a	71.3e	4.3a	18.2a	1413.3b
	Nalitabari	91b	99.4b	3.9c	91.2a	3.7c	17.5ab	1491.5b
	Mymensingh	84d	105.1a	3.8c	78.8d	3.5d	16.2ab	1121.9e
	Manikganj	88c	104.8a	3.3d	58.6f	3.6d	17.2ab	1373.9c
	Tangail	87c	99.5b	4.1b	87.2b	3.9b	18.7a	1258.1d

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

Among the six locations, Rangpur performed better in seed yield (1526.0 kg ha^{-1}) followed by Nalitabari (1491 kg ha^{-1}) seed yield was lowest at Mymensingh (1121.9 kg ha^{-1}). Further evaluation is to be needed for releasing as a new variety.

Regional yield trial with M_6 rapeseed mutants (*B. napus* var yellow sarson*)*

Four M_6 rapeseed mutants along with mother variety BARI sarisha-15 were evaluated through the trial to assess overall performance of the mutant for earliness and other yield attributes. The trial was conducted at the experimental farms of BINA Headquarter farm Mymensingh and in the farms of BINA sub-stations Magura, Rangpur and farmer's field Magura, Rangpur and Nalitabari. The experiment was laid out in a randomized complete block design with three replications. Seeds were sown within mid week of October 2017. The unit plot size was 20 m^2 (5 m × 4 m) with 25 cm line to line spacing and 6-8 cm from plant to plant within lines. Recommended production packages i.e., application of fertilizers, weeding, thinning, irrigation, application of pesticide etc. were followed to ensure normal plant growth and development. Data on plant height, branches $plant^{-1}$, siliquae $plant^{-1}$, seeds $siliqua^{-1}$ and days to maturity were taken from 10 randomly selected plants from each plot. Maturity period was counted when 90% siliquae were matured. Seed yield of each plot was recorded after harvest and appropriate statistical analyses were performed for comparison of means of each character which are presented in Table 24.

The results obtained from the trials of individual location and combined over five locations for all the characters are presented in Table 2. Most of the characters showed significant differences among the mutants and check for both individual location and combined over locations. On average days to maturity varied from 86-90 days. The shortest maturity period was obtained from BARIsarisha-15 (86) followed by RM-03, RM-05, RM-07 and RM-10. The mutant RM-05 gave the highest plant height of 88.7 cm followed by mutant RM-07 and RM-10, and MR-03 had the shortest plant height of RM-03. The mutant RM-10 produced higher number of siliqua $plant^{-1}$ (78.4) as well as the highest seed yield 1707.8 kg ha^{-1}. The check variety BARI Sarisha-15 produced seed yield of 1673.9 kg ha^{-1}. Further evaluation will be done in the next year for releasing as a variety.

Table 24. Yield and yield attributes of M_8 rapeseed mutants and check variety of mustard

Locations	Mutants/ varieties	Days to maturity	Plant height (cm)	Branches $plant^{-1}$ (no.)	Siliquae $plant^{-1}$ (no.)	Siliquae length	Seeds $siliquae^{-1}$ (no.)	Seed yield (kg ha^{-1})
On station Rangpur	RM-03	88a	75.7cd	4.6ab	73.6ab	4.7a	23.6b	1590.0a
	RM-05	87a	75.2d	5.2a	62.3b	4.3bc	22.3b	1380.0ab
	RM-07	84a	83.73bc	5.2a	87.2a	4.4abc	27.2a	1320.0b
	RM-10	86a	85.46b	4.1b	76.9ab	4.1c	21.5b	1596.0a
	BARI Sarisha-15	86a	95.80a	4.3b	69.6ab	4.6ab	29.93a	1533.3a
On station Magura	RM-03	97b	98.4bc	6.0ab	76.5b	5.4a	22.2a	1466.6b
	RM-05	96b	94.0c	6.1a	80.9b	5.2a	21.7a	1550.0ab
	RM-07	104a	100.8b	5.2ab	119.4a	5.3a	22.4a	1533.3ab
	RM-10	103a	97.0bc	6.1a	85.2b	4.7b	21.3a	1650.00a
	BARI Sarisha-15	88c	124.2a	5.1b	66.9b	5.3a	23.4a	1500.0ab
Farmer’s field, Rangpur	RM-03	86a	70.3b	3.1a	41.7a	4.1a	21.3a	1866.6a
	RM-05	86a	76.2b	3.2a	45.4a	3.9a	21.4a	1566.6ab
	RM-07	84a	79.8b	3.8a	43.8a	4.2a	22.8a	1483.3b
	RM-10	84a	78.1b	3.4a	39.8a	4.2a	24.3a	1883.3a
	BARI Sarisha-15	83a	90.6a	3.1a	37.8a	4.2a	22.6a	1770.0ab
Farmer’s field, Magura	RM-03	85ab	96.8b	5.5a	76.5a	5.2a	26.1a	1500.0b
	RM-05	88ab	91.2b	5.6a	57.8c	5.1a	28.8a	1516.6ab
	RM-07	86ab	98.8b	5.8a	61.4b	5.0a	29.5a	1616.4ab
	RM-10	83b	98.0b	4.9a	54.3c	5.1a	28.2a	1666.8a
	BARI Sarisha-15	88a	116.8a	6.2a	77.1a	5.0a	26.2a	1566.6a
Farmer’s field, Nalitabari	RM-03	92bc	91.6b	4.3b	87.2a	3.4a	17.1b	1460.0a
	RM-05	97a	95.2b	5.2ab	80.1a	3.0b	17.1b	1423.3a
	RM-07	93b	99.4b	5.4a	97.6a	3.0b	17.1b	1405.0a

Locations	Mutants/ varieties	Days to maturity	Plant height (cm)	Branches plant^{-1} (no.)	Siliquae plant^{-1} (no.)	Siliquae length	Seeds siliquae^{-1} (no.)	Seed yield (kg ha^{-1})
	RM-10	97a	95.2b	5.2ab	91.1a	3.4a	19.0ab	1526.6a
	BARI Sarisha-15	90c	109.5a	4.8ab	73.1a	3.3a	21.5a	1396.6a
Combined means over locations	RM-03	90b	81.3d	4.2d	61.1c	4.1a	21.1c	1649.9c
	RM-05	90b	83.4c	4.5b	62.8c	4.1a	20.8c	1497.3d
	RM-07	90b	88.7a	4.6a	66.6b	4.2a	22.5b	1444.9e
	RM-10	90b	86.7b	4.4c	78.4a	4.3a	22.5b	1707.8a
	BARI Sarisha-15	86a	86.2b	4.5b	57.1d	4.3a	24.96a	1673.9b

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

On-station yield trial with advanced Mustard mutants

Three mustard mutants along with check variety Binasarisha-7 were evaluated to assess overall performance of the mutants for earliness, yield attributes and seed yield as compared to the check. The experiment was conducted at BINA sub-stations Magura, Ishurdi and Nalitabari. The trial was laid out in a randomized complete block design with three replications. The unit plot size was 12 m^2 (4 m × 3 m) keeping 25-30 cm spacing between two lines and 6-8 cm among the plants in a row. Seeds were sown on mid week of October 2017. Recommended production packages like application of recommended fertilizers, weeding, thinning, irrigation, application of pesticide etc. were followed to ensure normal plant growth and development. Data were taken for plant height, branches plant^{-1}, siliquae plant^{-1}, seeds siliqua^{-1}, maturity period, and seed yield. Maturity period was counted when 90% siliquae were matured and most of the plants turned into brownish in colour in each plot. Seed yield of each plot was recorded after harvest and appropriate statistical analyses were performed for comparison of means of each character which are presented in Table 25. Due to heavy rainfall during germination stage and hail-storm during flowering stage data was not recorded from Nalitabari.

Results showed significant variations among the mutants and check for most of the characters in individual locations and combined over locations. On an average, it was observed that plant height of MM-36 and MM-37 was found/recorded ranged from 137.1 to 131.1cm. Maturity period of Binasarisha-7 was 103 days which was statistically similar with the mutant MM-37. The mutant MM-35 produced the highest number of siliquae plant^{-1} (122.7) and Binasarisha-7 produced the lowest number of siliquae plant^{-1} (87.7). The mutant MM-37 produced higher seed yield 1696.6 kg ha^{-1} and Binasarisha-7 gave seed yield of 1503.8 kg ha^{-1}. Among the two locations yield performance was better at Magura (1770 kg ha^{-1}). Considering the yield performance of the mutant further trial will be needed for releasing as a variety.

Table 25. Yield and yield components of rapeseed mutants with check variety at different locations

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})
Rangpur	MM-35	97b	123.1a	2.6a	107.7a	3.6b	12.4b	1233.3a
	MM-36	96b	119.0a	2.6a	96.4a	3.6b	12.9b	1620.0a
	MM-37	104a	121.8a	2.8a	107.6a	3.6b	12.6b	1310.0a
	Binasarisha-7	103a	109.8b	2.4a	79.1a	6.6a	21.6a	1396.6a
Magura	MM-35	97b	150.6a	4.5a	117.8a	4.3a	10.6a	1666.6b
	MM-36	96b	156.0a	3.5bc	104.9a	4.4a	11.9a	1722.2ab
	MM-37	104a	140.9b	4.1ab	97.8a	4.2a	12.0a	2083.3a
	Binasarisha-7	103a	156.6a	3.2c	96.4a	4.3a	12.4a	1611.1b
Combined means over locations	MM-35	97b	136.8a	3.5a	112.7a	3.9c	11.5b	1449.9d
	MM-36	96b	137.1a	3.1a	100.7b	4.4b	12.4b	1671.1a
	MM-37	104a	131.3b	3.5a	102.7b	3.9c	12.3b	1696.6b
	Binasarisha-7	103a	133.2b	2.8b	87.7c	5.4a	17.0a	1503.8c
Location means	Rangpur	100a	118.4b	2.6b	97.7b	4.3a	14.8a	1389.9b
	Magura	100a	151.1a	3.8a	104.2a	4.3a	11.7b	1770.8a

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

Growing and screening of M_5 mutants

A large number of M_5 variants developed from Tori-7 and MRH were grown for selecting desirable mutant at BINA Head Quarter farm, Mymensingh. From them a total of 9 lines have been selected primarily for future generation of M_6 population.

Growing and screening of M_4 population

A large number of M_4 variants developed from Binasarisha-9 and Binasarisha-10 were grown in plant progeny rows for selecting desirable mutant at BINA Head Quarter farm, Mymensingh. From them a total of 71 lines have been selected primarily for future generation of M_5 population.

Growing and screening of M_3 population

A large number of M_3 variants developed from BARI Sharisha-15 were grown for selecting desirable mutant at BINA Head Quarter farm, Mymensingh. From them a total of 5 lines have been selected primarily for future generation of M_4 generations.

Growing of F_5 population

F_4 population developed from the cross between BARI Sarisha- 14 X Tori-7 and BARI Sarisha- 15 X Tori-7 were grown at BINA Headquarters farm, Mymensingh. From them, 78 lines were selected primarily for further generation of F_6 populations.

Growing of F_4 population

F_3 population developed from the cross between BARI Sarisha- 14 X Binasarisha-4 and MRH X Tori-7 were grown at BINA Head quarter farm, Mymensingh. From them 15 lines were selected primarily for further generation of F_5 populations.

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

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

Maintenance of germplasm (mutants, local and exotic collection)

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

Sesame

Regional yield trial with promising M_6 sesame mutants

Three promising mutants along with two check varieties Binatil-2 and BARI Till-4 were evaluated through this trial to assess the performance of the selected mutant for improved yield component. The experiment was conducted at the experimental field of BINA sub-station farms at Magura, Ishurdi and Chapainowabgong and farmers' field at Modukhali of Faridpur and Jussore Sador, during March to June 2018. The experiment was laid out in a randomized complete block design with three replications. Unit plot size was $20m^2$ ($4m \times 5m$) keeping 25cm spacing between two rows and 6-8cm among the plants in rows. Seeds were sown within second week of 2018. Recommended production packages like application of recommended doses of fertilizers, weeding, thinning, irrigation, application of pesticide etc. were followed to ensure normal plant growth and development. Data were taken on plant height, number of branches plant^{-1}, number of capsules plant^{-1} and number seeds capsule^{-1} from 10 randomly selected plants from each plot. Maturity period was counted when 80% capsules were matured and most of the plants turned into straw or yellowish color in each plot. Seed yield of each plot was recorded after harvest and converted into kg ha^{-1}. Due to heavy rain and wind complete data were not obtain from farmers field trial conducted at Jashore and BINA sub-station Ishurdi and Chapainowabgonj. Appropriate statistical analyses were performed for comparison of means of each character.

Table 26. Mean performance of sesame lines and check varieties for different quantitative characters

Locations	Mutants/ varieties	Days to maturity	Plant height (cm)	Branches plant^{-1} (no.)	Capsules plant^{-1} (no.)	Capsule length	Seeds capsaules^{-1} (no.)	Seed yield (kg ha^{-1})
On Station Magura	SM-001	76a	92.76d	0	80.2d	2.4a	50.33ab	900c
	SM-002	76a	105.46a	0	90.13a	2.2a	52.66a	900c
	SM-006	78a	99.16c	0	87.80b	2.2a	47.66ab	1000b
	Binatill-2	74a	98.60c	3a	85.20c	2.3a	46.80b	1065a
	BARI Till-4	73a	100.66b	2b	85.69c	1.4b	51.33ab	900c
Farmer's Field Faridpur	SM-001	74a	133.33a	0	107.06a	2.5a	70.66ab	1200b
	SM-002	76a	125.20a	0	92.73b	2.4a	63.73cd	1250a
	SM-006	78a	125.33a	0	100.66c	2.4a	67.46bc	1200b
	Binatill-2	72a	132.66a	2.0b	83.56d	2.2a	61.13d	1200b
	BARI Till-4	74a	133.95a	2.6a	104.0b	2.5a	75.00a	1050c
Combined means over locations	SM-001	75a	113.00c	0	93.63b	2.45a	60.45b	900e
	SM-002	76a	115.33b	0	91.43c	2.3a	94.33a	1000c
	SM-006	78a	112.25c	0	94.23a	2.5a	57.56c	1100b
	Binatill-2	73a	115.63b	2.5	84.38d	2.25a	53.96c	1150a
	BARI Till-4	73a	117.28a	2.3	94.87a	1.9b	63.16b	950d
Location Mean	Magura	75a	99.32b	1a	85.80b	2.1a	49.75b	953b
	Faridpur	74a	130.09a	0.92a	97.61a	2.4a	67.59a	1180a

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

The results showed significant variations for most of the characters among the mutants and check varieties. On an average, days to maturity ranged from 78 to 73 days. At Magura, among the mutant SM-002 was the tallest (105.46 cm) which was significantly higher than both of the check varietys. Both of check produce branched although all of the mutants were uniculm type. Mutants SM-01 and SM-06 produced the significantly higher number of capsules plant^{-1} as compared to the check Binatil-2. The significantly higher number of capsules plant^{-1} in SM-002 at Magura (90.13) and SM-001 at Faridpur (107.6). The significantly higher numbers of capsules as well as higher number of seed yield obtain from this two-mutant line. On an average, Binatil-2 produced the highest yield of 1150kgha^{-1}. Considering branches plant^{-1} and lower seed yield performance of mutant, it might not be wish to furthering this mutant for releasing as a variety.

Crossing of Binatill-1 and Binatill-2 with BARI Till-4, China black and China White

Binatill-1 and Binatill-2 were cross with BARI Till-4, China black and China White and F_1 seeds were harvested to grow F_2 generations.

Soybean

On-station and On-farm yield trials with advance soybean mutants

Three promising mutants (SB-02, SB-05 and SB-07) along with check varieties BARI Soybean-5 were evaluated through this trial. The experiment was conducted at the experimental field of BINA Headquarter farm Mymensingh and BINA substation farm Magura, Rangpur and farmers' field at Noakhali and Chandpur during January to April 2018. 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 × 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 were analyzed following appropriate statistical design.

Location-wise means and means combined over four locations for different characters of the mutants and check varieties are presented in Table 13. Due to heavy rainfall during germination stage as well as flowering and maturity stage data was not recorded from Magure and Rangpur. Significant variations were observed for all the characters at all the locations and combined over location.

On an average, maturity period ranged from 95 days in BARI Soybean-5 to 93 days in SB-02 abd SB-05. Plant height and branches/plant ranged from 48.1 cm to 34.5 cm and 3.1 to 2.7. The check variety BARI Soybeab-5 and the mutant RM-05 gave the highest plant height of 48.1 cm followed by mutant SB-07. The mutant SB-05 had the shortest plant height of 34.5 cm. The mutant SB-05 produced the highest number of pods/plant (53.0) followed by the check variety BARI Soybean-5. The mutant SB-07 produced highest number of seeds/pod (2.7) followed by the mutant SB-02 and SB-05. Seed yield was obtained from the mutant SB-05 and SB-07 were statistically non significant from each other's but significantly different from the other mutant SB-02 and the check BARI Soybean-05. The mutant SB-05 produced the highest seed yield of 1612.9 kg ha^{-1} followed by SB-07 (1609.9 kg ha^{-1}) and BARI Soybean-05 produced the lowest seed yield (1533.0 kg ha^{-1}). Further evaluation will be done in the next season to assess their yield potential.

Table 27. Mean performance of soybean mutants and check varieties for different quantitative characters

Mutants/ varieties	Days to maturity	Plant height (cm)	Branches plant^{-1} (no.)	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	100-seed weight (g)	Seed yield (kg ha^{-1})
BINA Hqs. farm, Mymensingh							
SBM-18	114a	80a	2.34ab	52a	2.20b	13.41b	2163a
SBM-22	113b	75b	2.40a	50b	2.30a	13.89a	2158a
Binasoybean-1	110c	80a	2.07b	46bc	2.10c	12.23c	1798b
BARI Soybean-5	113b	74bc	2.31ab	46c	2.22ab	13.62ab	1789b
BINA sub-station farm, Magura							
SBM-18	113b	78a	2.5a	72a	2.45a	14.46a	2920a
SBM-22	117ab	74b	2.3b	69ab	2.30b	13.67b	2796b
Binasoybean-1	118a	78a	2.1c	65b	2.20c	12.61c	2323c
BARI Soybean-5	117ab	75ab	2.1c	67ab	2.25bc	14.38ab	2382bc
Farmer's field, Chandpur							
SBM-18	120b	78b	2.13a	52a	2.10a	13.91a	1850a
SBM-22	123a	79ab	1.8b	47b	1.9b	12.41b	1720b
Binasoybean-1	119bc	81a	1.6c	44c	1.83c	12.54ab	1625c
BARI Soybean-5	117c	75c	1.7bc	47b	1.87bc	13.87ab	1723bc
Farmer's field, Noakhali							
SBM-18	119a	81ab	1.9a	48a	2.10a	13.86ab	1856a
SBM-22	118ab	79b	1.7ab	43ab	1.85b	13.91a	1763b
Binasoybean-1	117b	83a	1.65b	40b	1.73c	12.39ab	1687bc
BARI Soybean-5	118ab	72c	1.68ab	42ab	1.79bc	12.34b	1625c
Combined means over four locations							
SBM-18	117ab	79ab	2.22a	56a	2.23a	13.9a	2197a
SBM-22	118a	77b	2.05b	52b	2.09b	13.5ab	2109b

Mutants/ varieties	Days to maturity	Plant height (cm)	Branches plant^{-1} (no.)	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	100-seed weight (g)	Seed yield (kg ha^{-1})
Binasoybean-1	116b	81a	1.86c	49c	1.97c	12.4c	1858c
BARI Soybean-5	116ab	74c	1.96bc	51bc	2.03bc	13.6b	1880bc

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

On-station and On-farm yield trials with advance soybean mutants

Five promising BINA released soybean varietys (Binasoybean-1, Binasoybean-2, Binasoybean-3, Binasoybean-1 and Binasoybean-5) with three exotic germplasm (Asset, Lokon and GC-840) were evaluated through this trial. The experiment was conducted at the farmer fields Satkhira and Noakhali. The experiment conducted at Satkhira was damaged due to heavy rainfall in germination stage. Sowing was done within first week of January. Spacing between rows was 30cm and 7-10cm between plants in a row akhali and Chandpur during January to April 2018. 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 × 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. Due to heavy rainfall during germination stage as well as flowering and maturity stage data was not recorder from Satkhira.

Table 28: 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)	Seed yield (kg ha^{-1})
Farmer's field Noakhali							
Binasoybean-1	97.0cd	31.2e	2.6c	40.5ab	1.8a	3.4d	996.6d
Binasoybean-3	93.6d	38.8c	2.3c	34.6ab	1.8a	3.4cd	956.6e
Binasoybean-4	95.6cd	36.3d	4.8ab	33.2b	1.8a	3.4cd	921.6f
Binasoybean-5	99.0bcd	33.2cd	3.8abc	46.3ab	2.0a	3.8ab	1171.6c
Asset	104.0ab	41.4b	5.6a	47.0ab	1.9a	3.7bc	1211.6b
Lokon	100.6bc	47.0a	3.4bc	50.0a	2.2a	4.0a	1275.0a
GC-480	107. 0a	46.4a	2.80c	42.1ab	2.1a	3.9ab	975.0e

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

On an average, maturity period ranged from 107days in GC-840 to 93 days in Binasoybean-3. Plant height and branches/plant ranged from 47.0 cm to 38.8 cm and 5.6 to 2.5. Lokon showed the longest plant height of 47.0 cm followed by Gc-480 and Binasoybean-1had the shortest plant height of 31.2 cm. Lokon produced the highest number of pods/plant (50.0) which is significantly different from others. Lokon produced the highest seed yield of 1275.0 kg ha^{-1} followed by Asset (1211.6 kg ha^{-1}) and Binasoybean-4 produced the lowest seed yield of 921.6 kg ha^{-1}. Further evaluation will be done in the next season to assess their yield potential.

Growing of M_3 and M_4 population

A large number of M_3 and M_4 population from BARI Soybean-5, Binasoybean-2 and Sohage were grown in plant progeny rows for selecting desirable mutants at BINA Hqs. farm, Mymensingh. From them primarily a total of 11 mutant variants have been selected for further selection in subsequent generations.

Growing of M_1 population

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

Maintenance of germplasm (mutants, local and exotic collections)

Nine 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.

Sunflower

Radio sensitivity test of Sunflower

The experiment was conducted to observe the radio sensitivity of sunflower at BINA Head quarter farm Mymensingh. The well dried seed of BARI Surjomukhi-2 was taken to observ the effect of gamma radiation 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 10 seed was germinated in petridishes. After that 50 seed were exposed to 6 doses of gamma rays (100, 150, 200, 250, 300 and 500 Gy) on sunflowers. Prior to mutagenic treatment seeds were kept in desiccators for moisture equilibration. The seeds were subjected to gamma rays ^{60}Co irradiator at BINA Mymensingh. The germinated seeds were observed daily from 1st day of germination. Germination date was recorded at the 14th day and other data was taken at the 21th day after sowing. The results indicated differences for germination percentages to different gamma ray treatments (Fig 5).

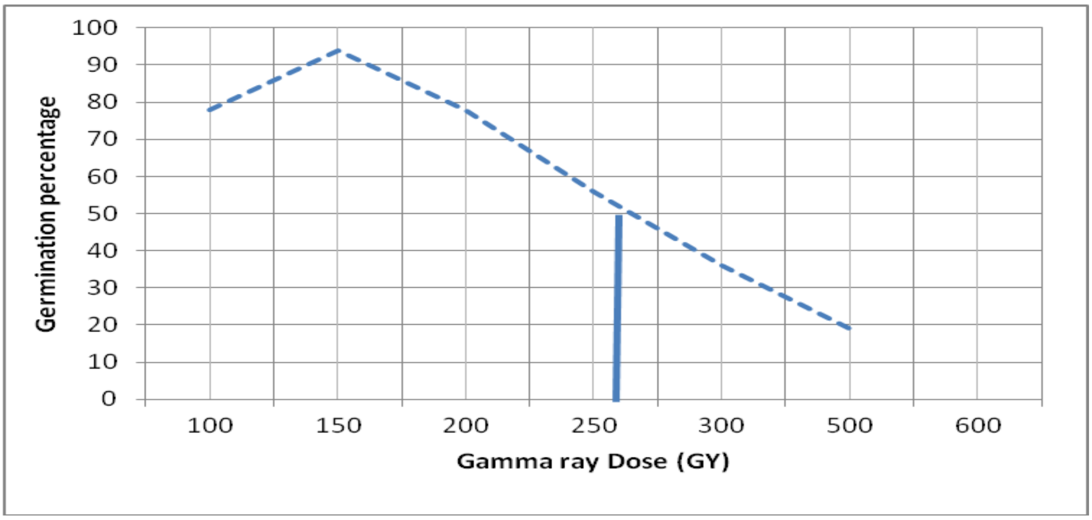


Fig. 5. Estimation of the lethal dose at 50% for sunflower (BARI Surjomukhi-2)

Table 29: Radio sensitivity of BARI Surjomokhi-2 using growth reduction percentage after 21 days of sowing

Gamma doses (Gy)	Seedling height	Seedling height (%) (Relative of control)	Reduction of seedling height over control (%)	Reduction of shoot weight over control (%)
0	37.8	100.00	0.00	0.00
100	31.4	83.06	16.93	3.21
150	33.5	88.62	11.37	7.25
200	27.7	73.28	26.71	11.23
250	25.8	68.25	31.74	48.27
300	13.2	35.5	65.07	59.77
500	**	**	**	**

**All seedling died

The seedling receiving no irradiation produced the highest seedling height 37.8 cm. Lowest seedling height was observed at 300 Gy (13.2) were no data was taken from 500 Gy. Seedling height reduction as well as shoot weight reduction percentage was higher at high doses. As from above discussion 260Gy determined as a LD_{50} for sunflower and future research will be done utilized this finding

Growing of M_1 population

To create genetic variability, seeds of popular sunflower variety BARI Surjomukhi-2 were irradiated with 250, 300, 350 and 400Gy of gamma rays. M_2 seeds from each plant were collected to grow M_2 population.

Groundnut

Evaluation of M_4 population of groundnut

An experiment was conducted at BINA Headquarter farm, Mymensingh with 14 M_4 mutant lines derived from irradiating the salt tolerant groundnut variety, Binachinabadam-6 to evaluate and select for short duration and high yielding lines. The parent Binachinabadam-6 was also included in this experiment as a check variety. The experiment followed non-replicated design.A unit plot comprised two rows of 2.0 m length. Seeds were sown on 6 December 2017 at 15 cm distances within rows of 30 cm apart. Recommended fertilizer dose, cultural and intercultural operations were also followed.

Table 30.Yield and yield contributing characters of mutants and the parent variety

Mutants/ Check	Plant height (cm)	Pod plant^{-1} (no.)	Pod weight plant^{-1} (g)	100 pod weight (g)	Shelling (%)
B6/282/11	27.17	13.33	7.6	57.23	56.00
B6/282/50	35.70	17.90	9.6	53.57	68.00
B6/282/53	26.70	17.20	9.0	52.00	56.00
B6/282/56	37.70	16.20	8.8	54.13	72.00
B6/282/62	35.70	15.30	9.6	62.50	78.70
B6/282/63	37.60	16.60	12.5	75.50	78.00
B6/282/64	42.60	14.10	20.9	62.00	77.00

B6/282/65	39.40	15.70	12.0	76.00	77.00
B6/282/66	39.80	15.00	7.5	50.00	73.40
B6/282/67	44.30	20.00	11.6	58.15	77.70
B6/282/68	36.30	17.90	12.3	68.50	74.40
B6/282/70	39.20	21.20	13.6	64.15	75.00
B6/282/77	34.90	12.80	9.6	75.00	74.00
B6/282/80	31.00	11.00	-	70.00	73.00
BCB-6 (c)	40.80	9.30	6.4	68.70	77.00
Mean± SE	36.59±1.31	15.57±0.82	10.79±0.96	63.16±2.29	72.48±1.87

There was continuous raining before the maturity of the experiment and thus the pods were not properly matured. However, the experiment was harvested on 6 May 2018. Data on plant height, pod number and pod weight plant^{-1}were gathered after harvest from randomly selected 10 competitive plants. Shelling percentage and 100 pod weight were calculated after proper sun drying. Finally, all the recorded data were subjected to proper statistical analyses and is presented in Table 30.

It appeared that all the mutants had significantly shorter plant height than the parent Binachinabadam-6 exceptB6/282/67, B6/282/66 and B6/282/64. These three mutants had significantly taller height than the parent variety. Interestingly, all the mutant lines had significantly higher number of pod than the check variety with B6/282/70 being the highest. Four mutants had significantly bigger pod sizes, expressed here as 100-pod weight, than the check variety. But the other mutants had either similar or smaller pod sizes. Yield is the most significant and desirable trait for selection of a better mutant which was significantly higher in almost all the mutants than the parent variety except B6/282/80.None of the mutants had significantly higher shelling percentage than the parent variety, Binachinabadam-6 but shelling percentages of four mutants like B6/262/62, B6/262/63, B6/262/64 and B6/262/65 appeared statistically indifferent with the parent variety (Table30). Finally, all these mutant will be put into preliminary yield trial in the next Rabi season.

On-station and on-farm trial with two M_7 and one bold seeded mutants of groundnut

This trial was conducted with two M_7 and one bold seeded previously developed mutants of groundnut along with the check variety, Binachinabadam-4 following RCB design with three replications. A unit plot size was 5.0 m × 4.0 m. recommended fertilizer dose, cultural and intercultural operations were followed. The seeds were sown at 15 cm distances within rows of 30 cm apart on 21 August, 2017at Bhaluka, Mymensingh, 23 August at Panchagarh, 24 August, 2017 at Jhenaidah and Lalmonirhat. The experiments were harvested on 26 November, 2017 at Bhaluka, 13 December, 2017 at Panchagar, 24 December, 2017 at Jhenaidah and 12 December 2017 at Lalmonirhat. Data on plant height, pod number and 100-pod weight were gathered after harvested from 10 randomly selected competitive plants. Pod yield was recorded from an area of 1 m^2 and later converted to tha^{-1}. Finally, all the recorded data were subjected to proper statistical analyses as per design used and are presented in the Table 31.

It appeared that the mutant D1/25/33 had significantly the tallest height of all (Table 2) at all locations followed by the check variety, Binachinabadam-4. The differences of plant height between D1/25/33 and the check variety were significant at all locations except Panchagar. At Panchagar, plant height of D1/25/33 and the check variety was not significant. In contrast, the mutant PK1/15/69 had the shortest height of all at all locations.

Table 31.Yield and yield contributing characters of groundnut mutants and the check variety in Kharif-II season, 2017

Mutants/Check variety	Plant height(cm)	Pod plant^{-1} (no.)	100-pod weight (g)	Shelling (%)	Yield (tha^{-1})
Bhaluka					
PK1/15/69	31.33	13.03	68.23	70.00	1.94
D1/25/33	48.00	13.37	59.10	81.32	1.72
M6/79-71	38.33	8.50	84.54	68.23	1.85
Binachinabadam-4	45.00	15.08	73.27	78.81	2.28
LSD(0.05)	**1.66**	**0.11**	**0.69**	**1.63**	**0.07**
Jhenaidah					
PK1/15/69	57.00	17.50	57.97	78.09	1.84
D1/25/33	71.00	16.00	49.65	79.76	1.62
M6/79-71	60.33	13.05	75.17	70.38	1.50
Binachinabadam-4	65.00	19.00	73.66	78.66	1.59
LSD(0.05)	**2.30**	**0.13**	**0.93**	**1.26**	**0.13**
Panchagar					
PK1/15/69	59.33	32.57	82.77	80.23	3.22
D1/25/33	67.67	32.80	71.52	81.23	2.82
M6/79-71	54.33	23.50	109.15	72.05	3.40
Binachinabadam-4	67.00	28.83	75.73	79.71	2.95
LSD(0.05)	**2.80**	**0.38**	**1.67**	**1.17**	**0.06**
Lalmonirhat					
PK1/15/69	73.33	33.50	69.98	78.75	2.27
D1/25/33	87.67	36.47	76.63	77.59	3.62
M6/79-71	64.67	34.20	91.47	70.48	3.46
Binachinabadam-4	83.33	25.87	78.69	80.07	2.34
LSD(0.05)	**2.33**	**0.44**	**0.67**	**0.69**	**0.11**
Combined over four locations					
PK1/15/69	75.29	31.63	87.20	99.41	2.87
D1/25/33	92.79	32.38	82.11	102.27	3.22
79-71	73.43	27.11	112.92	90.43	3.25
Binachinabadam-4	87.57	28.64	97.22	102.00	2.81
LSD(0.05)	**0.79**	**0.17**	**0.36**	**0.41**	**0.03**
LSD(0.05) for mutant × location interaction	**1.95**	**0.42**	**0.91**	**1.01**	**0.09**

All the three mutants had significantly higher number of pod at Panchagar and Lalmonirhat but lower at Bhaluka and Jhenaidah. The mutant M6/79-71 had significantly the largest pod size at all locations followed by the check variety, Binachinabadam-4 except Panchagar (Table 2). At Panchagar, the mutant PK1/15/69 had larger pod size than the check variety but smaller than the mutant M6/79-71 the reason behind is not clear.

Shelling is also a good indicator for selecting better genotype. It appeared that, the check variety had a good shelling of pods at all locations. But the mutant, D1/25/33 had the highest shelling (%) at Mymensing, Jhenaidah and Panchagarh. Among the other two mutants, the PK1/15/69 also had good shelling and very close to the check variety. But the mutant, 79-71 had significantly lowest shelling at all locations.

At Bhaluka, the check variety, Binachinabadam-4 produced significantly the highest pod yield through the highest number of pod, second largest pod size, expressed here as 100-pod weight, and shelling percentage (Table 2). The mutant PK1/15/69 produced the second highest yield although which was significantly lower than the check variety but higher than the other two mutants. In this location, the experiment was harvested before the pods matured properly which might attribute to the lower yield of the mutant PK1/15/69 than the check variety, Binachinabadam-4. Considering yield and other yield contributing characters at all locations, the mutants, PK1/15/69 and M6/79-71 have been selected for on station and on-farm trials in the next Rabi season.

On station and on-farm trials with one M_7 and one bold seeded mutants of groundnut in Rabi season

This trial was conducted with one M_7 and one bold seeded mutant developed earlier of groundnut along with the check variety, Binachinabadam-4 to assess yield performance over different locations. The trial followed RCB design with 3 replications. A unit plot size was 4.5 m × 3.3 m. Seeds were sown at 15 cm distances within rows of 30 cm apart on 4 February 2018 at Natore, on7 February at BINA Head Quarter's farm, Mymensingh, on 6 February, 2018 at Jhenaidah, on 10 February at Panchagar and Lalmonirhat and on 18 February at Rangpur. Recommended fertilizer dose, cultural and intercultural operations were followed. The experiment at Natore was partially damaged due to water logging by rain water before maturity. The experiments at different locations were harvested on 20 June, 2018 at Natore, on 11 June at Rangpur, 10 June at Panchagar, and 11 June 2018 at Lalmonirhat and at BINA Head Quarter's farm, Mymensingh, and on 11June, 2018 at Jhenaidah. Data on plant height, pod number and 100-pod weight were gathered after harvest from 10 randomly selected competitive plants. After proper sun drying, pod yield and shelling percentage were recorded. Pod yield was recorded from an area of 1 m^2 and later converted to tha^{-1}. Finally, all the recorded data were subjected to proper statistical analyses as per design used and are presented in the Table 32.

It appeared that the mutant PK1/15/69 had significantly the shortest plant height of all at all locations followed by the other mutant M6/79-71(Table3). Exceptionally, the plant height of the mutant M6/79-71 was the tallest of all at Panchagar.

Number of pod of the mutant PK1/15/69 was significantly the highest at Lalmonirhat and Mymensingh of all at Natore, Jhenaidah and Rangpur appeared indifferent statistically with the check variety. The other mutant, M6/79-71 had significantly the lowest number of pod at all locations.

The pod size, expressed as 100- pod weight was significantly highest in the mutant M6/79-71 at all locations except at Natore. Because, at Natore, the experiment was inundated by rain water before proper maturity of the pods and thus the pod size of the late maturing PK1/15/69 and M6/79-71 were smaller than expectation.

Shelling percentage of the mutant PK1/15/69 was at per the check variety at all locations (Table3) except Natore and Jhenaidah. At Natore, the lower shelling percentage of this mutant was due to improper maturity due to water logging. The cause of lower shelling percentage of this mutant at Jhenaidah is not clear. The other mutant M6/79-71 had significantly the lowest shelling percentages of all at all locations.

Yield is the ultimate goal of any breeding program, was significantly the highest in the mutant PK1/15/69 at Lalmonirhat, Rangpur and Mymensingh but yield of Jhinaidah did not differ significantly with the check variety. The other bold seeded mutant M6/79-71 had the lowest yield of all at all locations. Considering all, application will be made to the National Seed Board for registration of the mutant PK1/15/69 as Binachinabadam-10.

Table 32. Yield and yield contributing characters of groundnut mutants and the check variety in Rabi season, 2018

Mutants/Check variety	Plant height(cm)	Pod plant^{-1} (no.)	100-Pod weight (g)	Shelling (%)	Yield (t/ha)
Panchagarh					
PK1/15/69	64.67	25.33	82.00	76.67	3.38
M6/79-71	73.67	18.33	110.67	69.00	2.62
Binachinabadam-4	68.67	29.00	103.33	76.33	3.57
LSD(0.05)	**2.52**	**1.09**	**3.32**	**1.22**	**0.05**
Lalmonirhat					
PK1/15/69	79.33	29.67	85.33	80.33	4.47
M6/79-71	89.67	23.67	98.67	79.33	4.03
Binachinabadam-4	92.67	25.67	96.67	80.67	4.18
LSD(0.05)	**2.54**	**1.09**	**1.95**	**0.79**	**0.08**
Natore					
PK1/15/69	48.33	15.00	60.33	59.67	1.28
M6/79-71	51.67	13.33	59.33	54.67	1.27
Binachinabadam-4	54.33	14.33	68.67	71.00	1.46
LSD(0.05)	**2.20**	**1.19**	**3.02**	**2.72**	**0.07**
Jhenaidah					
PK1/15/69	83.33	27.67	70.67	73.00	3.12
M6/79-71	87.00	19.33	87.33	72.00	2.40
Binachinabadam-4	96.33	26.00	80.67	75.00	3.11
LSD(0.05)	**3.54**	**2.06**	**4.50**	**1.31**	**0.03**
Rangpur					
PK1/15/69	85.67	20.00	85.67	81.00	4.76
M6/79-71	91.00	16.67	107.00	71.00	4.35
Binachinabadam-4	91.00	18.33	88.00	80.33	4.10
LSD(0.05)	**3.02**	**1.85**	**2.56**	**3.16**	**0.17**
Mymensingh					
PK1/15/69	49.00	24.67	67.33	77.00	4.00
M6/79-71	52.00	18.33	88.33	65.00	3.05
Binachinabadam-4	52.67	22.67	72.00	75.33	3.64
LSD(0.05)	**1.51**	**1.51**	**1.77**	**1.99**	**0.09**
Combined analysis (mean values over locations)					
PK1/15/69	68.39	22.06	75.22	74.61	3.50
M6/79-71	74.17	18.28	91.89	68.50	2.95
Binachinabadam-4	75.94	22.67	84.89	76.44	3.34
LSD(0.05)	**-**	**-**	**-**	**-**	**-**
LSD(0.05) for mutant× location interaction	**3.09**	**1.28**	**2.82**	**1.57**	**0.09**

Jute

Preliminary yield trial with some M4 mutants derived from JRO-524

With a view to improve the Indian Tossa jute varietyJRO-524 keeping its early sowing potential and fiber quality intact, dry seeds of JRO-524 was irradiated with 700, 800, 900 and 1000 Gy doses of gamma rays. In M_3 generation, eight mutants were selected based on taller plat height and broader base diameter and put into preliminary yield trial following RCB design with three replications. The parent JRO-524 was also included in this experiment as a check variety. Seeds were sown on mid March 2018 at BINA HQ farm, Mymensingh, BINA sub-station farms at Magura and Rangpur at 5-7 cm distance within rows of 30 cm apart. A unit plot size was --- × ---.

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.

It appeared that plant height of the mutants and parent variety was the highest at BINA sub-station, Magura followed by Rangpur (Table 33). At Mymensingh, JRO-524-1000-5, JRO-524-1000-8, JRO-524-1000-9, JRO-524-1000-10 and JRO-524-700-3 had significantly taller height than the parent JRO-524. But the mutants JRO-524-1000-8 and JRO-524-1000-9 had significantly taller plant height at Magura and JRO-524-1000-1, JRO-524-1000-8, JRO-524-1000-9, JRO-524-1000-10, JRO-524-700-3 had significantly taller height at Rangpur.

Two mutants JRO-524-1000-8 and JRO-524-1000-9 had significantly broader base diameter than the parent variety only at Mymensingh (Table 1). In the other two locations, none of the mutant had significantly broader diameter than the parent variety. The mutants JRO-524-1000-5, JRO-524-1000-8, JRO-524-1000-9, JRO-524-1000-10, JRO-524-700-3 and JRO-524-800-7 had significantly higher fiber yield at Mymensingh; at Magura none of the mutants had significantly higher fiber yield and in contrast at Rangpur, all the

Table 33. Yield and yield contributing characters of groundnut mutants and the check variety in winter season, 2017

Mutants/Check variety	Plant height(cm)	Base diameter (cm)	Dry fiber weight of 10 plants (g)	Stick weight of 10 plants (g)
Mymensingh				
JRO-524-1000-1	274	1.30	124	257
JRO-524-1000-5	346	1.77	198	459
JRO-524-1000-8	350	1.70	202	443
JRO-524-1000-9	366	2.08	217	431
JRO-524-1000-10	349	1.98	173	337
JRO-524-700-3	355	1.01	208	460
JRO-524-800-3	313	1.48	121	213
JRO-524-800-7	321	1.71	166	284
JRO-524(P)	324	1.44	149	304
LSD(0.05)	**17**	**0.53**	**16**	**38**
Magura				
JRO-524-1000-1	367	1.54	300	503
JRO-524-1000-5	349	1.53	157	528
JRO-524-1000-8	385	1.61	293	770
JRO-524-1000-9	381	1.68	282	617
JRO-524-1000-10	370	1.60	276	653
JRO-524-700-3	368	1.42	213	513
JRO-524-800-3	360	1.49	313	790
JRO-524-800-7	367	1.58	257	543
JRO-524(P)	363	1.54	300	867
LSD(0.05)	**09**	**NS**	**24**	**54**
Rangpur				
JRO-524-1000-1	297	1.74	112	253
JRO-524-1000-5	278	1.23	92	208
JRO-524-1000-8	298	1.84	117	243
JRO-524-1000-9	288	1.29	112	263
JRO-524-1000-10	295	1.34	112	241
JRO-524-700-3	306	1.43	110	274

Mutants/Check variety	Plant height(cm)	Base diameter (cm)	Dry fiber weight of 10 plants (g)	Stick weight of 10 plants (g)
JRO-524-800-3	288	1.40	108	245
JRO-524-800-7	291	1.35	110	253
JRO-524(P)	280	1.72	99	240
LSD(0.05)	**11**	**0.16**	**07**	**08**
Combined over 4 locations				
JRO-524-1000-1	313	1.53	149	338
JRO-524-1000-5	324	1.51	149	398
JRO-524-1000-8	345	1.72	203	485
JRO-524-1000-9	345	1.68	205	437
JRO-524-1000-10	338	1.64	187	410
JRO-524-700-3	343	1.29	177	416
JRO-524-800-3	320	1.46	181	416
JRO-524-800-7	326	1.55	178	360
JRO-524(P)	322	1.56	183	470
LSD(0.05)	**6**	**0.17**	**10**	**22**
LSD(0.05) for mutant × location interaction	**10.53**	**0.30**	**16.77**	**38.13**

Mutants had significantly higher fiber yield than the parent variety except the mutant JRO-524-1000-5. Fiber yield of the mutant JRO-524-1000-5 was statistically indifferent with the parent variety.

The mutants JRO-524-1000-5, JRO-524-1000-8, JRO-524-1000-9 and JRO-524-700-3 produced significantly higher stick yield than the parent variety JRO-524 at Mymensingh but at Magura none of the mutants produced significantly higher stick yield (Table 1). In contrast, at Rangpur, JRO-524-1000-1, JRO-524-1000-9, JRO-524-700-3 and JRO-524-800-7 produced significantly higher stick yield than the parent.

When combined over three locations, the mutants JRO-524-1000-8, JRO-524-1000-9, JRO-524-1000-10 and JRO-524-700-3 had significantly taller plant height and JRO-524-1000-8 and JRO-524-1000-9 had significantly higher fiber yield than the parent, JRO-524. Finally, these five mutants after considering their seed yield potentials will be put into Advance Yield Trial in the next season.

Mungbean

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

On-farm trials were carried out with two mutants along with two check varieties (Binamoog-8 and BARI Mung-6) at BINA sub-station Ishurdi, Magura, farmer’s field Ishurdi, Magura and Natore during Kharif-1 season of 2018. But due to rainfall, the experiments were damaged at farmer’s field Ishurdi, Magura and Natore. Seeds were sown in RCB design with three replications. Unit plot size was 5 m × 4 m. Row to row and plant to plant distances were 40 and 10-15 cm, respectively. Due to heavy rain fall Ishurdi and Natore farmer’s field were damaged. Data on days to maturity, plant height, pods plant^{-1}, pod length, seeds pod^{-1} and seed yield plot^{-1} were recorded from five randomly selected plants of each plot. Plot seed yield was converted to kg ha^{-1}. Mean values are presented in Table 34.

It is observed from Table 34 that the check variety BARI Mung-6 had shorter plant height than other mutant and check variety (Binamoog-8) at all the locations. From mean over locations, both the mutants matured earlier than check varieties. The highest number of pods plant^{-1} (38) and pod length (9. 3cm) was found in MBM-427-87-3. In respect of seed yield, MBM-427-87-3 produced the highest seed yield of 1810 kg ha^{-1}followed by Binamoog-8 (1770 kg ha^{-1}). Application will be made to release this mutant (MBM-427-87-3) as a variety.

Table 34: Mean performance of mutants along with the check varieties grown at Ishurdi Magura and farmer's field Magura during 2018

Mutants/varieties	Days to maturity	Plant height (cm)	Pods plant^{-1} (no)	Pods length (cm)	Seeds pod^{-1} (no)	Seed yield (kg ha^{-1})
Ishurdi (Sub-station)						
MBM-656-51-2	67	63	38	8.3	11	1769b
MBM-427-87-3	64	60	39	9.1	12	1816a
Binamoog-8	64	56	35	8.7	12	1769b
BARI Mung-6	70	54	29	8.1	11	1679c
Magura (Sub-station)						
MBM-656-51-2	64	47	33	8.4	13	1803a
MBM-427-87-3	65	44	37	9.4	13	1827a
Binamoog-8	66	48	35	9.1	12	1776 b
BARI mung-6	69	44	31	8.9	10	1689c
Magura (Farmer's field)						
MBM-656-51-2	65	55	36	8.1	12	1685b
MBM-427-87-3	64	56	38	9.5	12	1789a
Binamoog-8	67	53	34	8.8	13	1765a
BARI Mung-6	71	50	30	8.3	11	1633c
Mean over locations						
MBM-656-51-2	65	55	35	8.3	12	1752a
MBM-427-87-3	64	53	38	9.3	12	1810a
Binamoog-8	65	52	34	8.9	12	1770a
BARI Mung-6	70	49	30	8.4	11	1667b

Regional yield trial of some promising mutants of mungbean

Two advanced mungbean mutant lines along with two check varieties were put into regional yield trial at BINA sub-station Magura, Ishurdi and farmer's field Ishurdi, Magura and Natore during Kharif-1 season of 2018. The design of experiment was RCB with three replications. Unit plot size was 4 m × 5 m. Row to row and plant to plant distance were 40 cm and 10-15 cm, respectively. Recommended cultural practices including fertilizer doses were applied as and when necessary. Due to heavy rain fall Ishurdi and Natore farmer's field were damaged. Data on various characters, such as plant height, number of pods plant^{-1}, pod length, number of seeds pod^{-1}, days to maturity and seed yield plot^{-1} were taken from five randomly selected plants of each plot. Plot seed yield was converted to kg ha^{-1}. Mean values are presented in Table 35.

From the result mean over locations, it is observed that the lowest days to maturity were observed in check variety Binamoog-8 whereas the highest was in MBM07-y-2. The highest plant height was found in MBM07-y-2 (54.5 cm) followed by check variety BARI Mung-6. In case of pods/plant, the mutant MBM-07(g)-2 had the highest number of pods/plant and pod length. The number of seeds pod^{-1} was almost similar for all the mutants and check varieties. Mutant MBM-07(g)-2 produced (1760 t/ha) almost similar seed yield as Binamoog-8 (1760 t/ha). One promising mutant MBM-07(g)-2 will be further evaluated in the next growing season.

Table 35: Mean performance of two mutants along with two check varieties grown at BINA sub-station Ishurdi, Magura and farmer's field Magura during 2018

Name of variety	Days to maturity	Plant height (cm)	pods plant^{-1} (no.)	Pod length (cm)	seeds pod^{-1} (no.)	Seed yield (kg ha^{-1})
Magura						
MBM-07(g)-2	68	43.67b	42	8.43	12	1736
MBM07-y-2	71	57.13a	36	7.62	10	1675
Binamoog-8 (check)	67	45.40b	39	8.35	12	1725
BARI Mung-6 (check)	70	52.13a	35	8.12	11	1684
Ishurdi						
MBM-07(g)-2	69	50.26a	35	8.25	11	1783a
MBM07-y-2	70	53.27a	30	7.55	10	1660b
Binamoog-8 (check)	65	44.69ab	35	8.39	12	1790a
BARI Mung-6 (check)	69	50.76a	29	8.14	10	1723ab
Magura (Farmer's field)						
MBM-07(g)-2	68	49.1a	34	8.75	12	1773
MBM07-y-2	68	53.3a	29	7.88	10	1720
Binamoog-8 (check)	66	43.2ab	33	8.09	12	1765
BARI Mung-6 (check)	69	50.6a	29	8.14	11	1698
Mean over locations						
MBM-07(g)-2	68	47.6	37	8.48	12	1764a
MBM07-y-2	70	54.5	32	7.68	10	1685b
Binamoog-8 (check)	66	44.4	35	8.28	12	1760a
BARI Mung-6 (check)	69	51.1	31	8.13	11	1702ab

Growing of M_2 generation of mungbean lines

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

Growing of M_1 generation of mungbean lines for Kharif-1

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

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

Growing of M_1 generation of yellow seeded germplasm

Seeds of sonamoog (collected from two places) and one advanced yellow seeded mungbean line (MBM-07-Y-1) were irradiated with $Cobalt^{60}$ gamma rays to develop high yielding variety maifor its palatability test. Irradiation doses were 300, 400 and 500 Gy. Two hundred and fifty seeds per dose were grown at BINA Hqs during Rabi season 2018. Plants were damaged due to rainfall.

Maintenance of AVRDC germplasm of mungbean

Thirteen AVRDC germplasm were grown at BINA Hqs farm, Ishurdi during Kharif-1, 2018. Cultural practices were done as and when necessary. At harvest, seeds of all these germplasm were collected and have been preserved as breeding materials for future research programme.

Chickpea

Regional yield trial of some selected chickpea mutants

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

It is observed from the result mean over locations that CPM-8-200 matured the earliest then other mutants and check varieties. Binasola-8 had the highest plant height (74.3 cm) whereas BARI Sola-7 produced the lowest among the test entries. The mutant CPM-8-200 produced the highest number of pods $plant^{-1}$ followed by Binasola-8. The 100-seed weight of CPM-8-200 was the highest, 24.1 (g) followed by CPM-8-300, 23.4 (g) and Binasola-8, 22.0 (g). Mutant CPM-8-200 produced the highest seed yield (1.83 t/ ha) among the mutants and check varieties. These two mutants will be further evaluated in next growing season.

Table 36: Regional yield trial of two promising mutants of chickpea during 2017-2018

Variety/mutants	Days to maturity	Plant height (cm)	Primary branches $plant^{-1}$ (no)	Pods $plant^{-1}$ (no)	Seeds $pods^{-1}$ (no)	100-seed weight (g)	Seed yield (t ha^{-1})
Magura							
CPM-8-200	125	65.6ab	3.4	124a	1.9	24.1a	1860a
CPM-8-300	128	69.8ab	3.1	112ab	1.7	23.6a	1810a
BARI Sola-7 (Check)	127	58.0b	2.9	106ab	1.5	15.7b	1688bc
Binasola-8 (Check)	129	72.2a	3.0	121a	1.6	22.1a	1770b
Magura (Farmers field)							
CPM-8-200	126	72.0a	3.3	133a	1.8	24.2a	1815a
CPM-8-300	130	65.0b	3.6	101ab	1.5	23.3a	1769ab
BARI Sola-7 (Check)	131	54.0b	2.9	94b	1.7	15.8b	1659bc
Binasola-8 (Check)	130	76.4a	3.1	129a	1.6	22.3a	1738b
Mean over location							
CPM-8-200	125	68.8	3.3	128	1.8	24.1	1837a
CPM-8-300	129	66.4	3.3	106	1.6	23.4	1789b
BARI Sola-7 (Check)	129	56.0	2.9	100	1.6	15.7	1673c
Binasola-8 (Check)	130	74.3	3.0	125	1.6	22.0	1754b

Growing of M_2 generation of chickpea

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

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

On-stations trials were conducted with three mutant lines along with two check varieties at BINA sub-stations at Ishurdi, Magura and Chapainowabganj during 2017-18. The experiment was laid out in a randomized complete block design with three replications. Unit plot size was 20 m^2 (5 m × 4 m) with 30 cm line to line distance. Recommended production packages i.e., application of fertilizers, weeding, thinning, irrigation, application of pesticide etc. were followed to ensure normal plant growth and development. Data on days to maturity, plant height, number of primary branches $plant^{-1}$ and pods $plant^{-1}$ were recorded from 10 randomly selected plants from each plot. Plot seed yield was converted into $kgha^{-1}$. Statistical analysis of different characters of the mutants and the check are presented in the Table 37.

Results revealed that significant variations were observed among the mutants and the check variety for pods per plant and seed yield in both of individual location and combined over locations. On an average, maturity period varied from 103 days to 108 days. LM-118-9 produced the highest number of pods $plant^{-1}$ as well as the highest seed yield 1796 kg ha^{-1} followed by LM-138-3 with 1750 kg ha^{-1}. LM-118-9 produced the highest seed yield followed by LM-138-3 at Chapainowabgonj and Ishurdi. The mutant line LM-138-3 performed better than the other two mutants and the checks at Magura. Evaluation will be continued in the next season.

Table 37. On-station trial with three lentil mutants/line along with two check varieties, Binamasur-6 and BARI Masur-5 at three locations, Magura, Ishurdi and Chapainowabgonj during 2017-18

Variety/ mutant	Days to maturity	Plant height (cm)	Primary Branches/ plant (no.)	Pods/plant (no.)	Yield/plot (kg/ha)
Magura					
LM-138-3	107bc	39.1	4.0	98.3a	2010a
LM-118-9	110a	38.2	3.6	69.2ab	1930b
LM-206-5	108b	38.6	3.3	66.3ab	1960b
Binamasur-6	111a	40.0	3.1	68.0b	1812c
BARI Masur-5	110a	39.5	3.2	51.0ab	1785cd
CV%	1.32	4.96	22.94	12.94	1.41
Chapainowabgonj					
LM-138-3	99c	29.2	1.2	29.6c	1490c
LM-118-9	102b	28.1	1.4	55.6a	1620a
LM-206-5	102b	29.3	1.3	35.6ab	1550b
Binamasur-6	104a	31.5	1.5	20.6c	1400d
BARI Masur-5	102b	26.8	1.4	62.6bc	1570b
CV%	1.25	3.80	12.27	12.29	0.61
Ishurdi					
LM-138-3	104	31.0	2.5	50.1ab	1750b
LM-118-9	109	30.4	2.6	67.1a	1810a
LM-206-5	108	28.1	2.3	40.5b	1735b
Binamasur-6	109	30.8	2.2	34.8bc	1745b
BARI Masur-5	108	27.7	2.2	30.3bc	1690c

CV%	1.29	4.47	4.47	12.77	1.14
			Combined		
LM-138-3	103c	33.1	2.5	59.3a	1750a
LM-118-9	107b	32.2	2.5	63.9a	1796a
LM-206-5	106b	32.0	2.3	47.4b	1738ab
Binamasur-6	108a	32.4	2.2	41.1b	1652b
BARI Masur-5	106b	31.0	2.2	47.9b	1681b
CV%					

Advanced yield trial with some selected mutants of lentil

The advanced yield trials were conducted with four mutants along with a check variety, Binamasur-8 at Magura and Ishurdi during 2017-18. Seeds were sown in randomized complete block design with three replications. Unit plot size was 5m x 4m and rows were 30cm apart. Normal cultural practices were done. Data on days to maturity, plant height, number of primary branches, pods per plant were recorded from 10 randomly selected plants from each plot. Plot seed yield was converted into kgha^{-1}. Statistical analysis of different characters of the accessions and the check are presented in the Table 38.

Results revealed that 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 varied from 98 in LM-24-3 to 102 days in LM-185-2. The highest number of pods plant^{-1}(107) and seed yield (kgha^{-1}) were found in LM-185-2 at Magura. This mutant also produced highest seed yield at Chapain and combined over two locations the same mutant gave the highest seed yield followed by Binamasur-8. This mutant will be evaluated in the next season at different locations.

Table 38. Yield and yield contributing characters of four promising mutants along with a check variety, Binamasur-8 at Magura and Chapain during 2016-17

Variety/ mutant	Days to maturity	Plant height (cm)	Primary Branches/ plant (no.)	Pods/plant (no.)	Yield (kg/ha)
			Magura		
LM-185-2	108a	39.0	2.3	107a	1910a
LM-99-4	105b	38.1	2.4	81b	1864ab
LM-24-3	103d	37.2	2.8	52c	1710c
LM-21-6	106b	41.0	2.5	58c	1725c
Binamasur-8	104c	42.0	3.5	92a	1900a
			Chapainowabgonj		
LM-185-2	96b	34.0	1.3	68.4ab	1482a
LM-99-4	95c	33.2	1.4	59.8b	1428ab
LM-24-3	93d	33.2	1.2	59.7b	1240d
LM-21-6	96b	31.1	1.3	63.4ab	1323c
Binamasur-8	99a	30.4	1.4	71.2a	1480a
			Combined		
LM-185-2	102a	36.5	1.8	87.7a	1696b
LM-99-4	100b	35.6	1.9	70.4a	1646b
LM-24-3	98c	35.2	2.0	55.8b	1475d
LM-21-6	101a	36.0	1.9	60.7a	1524cd
Binamasur-8	101a	36.2	2.4	81.5a	1795a

Preliminary yield trial with some selected lentil mutants

The preliminary yield trials were carried out with seven lentil mutants along with a check variety (Binamasur-8) at Magura during 2017-2018. The experiment was conducted in randomized complete block design with three replications. Unit plot size was 3 m × 2 m with 30 cm row to row distance. Normal cultural practices were done. Data on days to maturity, plant height, primary branches plant^{-1} and pods plant^{-1} were recorded from 10 randomly selected plants from each plot. Plot seed yield was converted into kgha^{-1}. Statistical analysis of different characters of the mutants and the check are presented in the Table 39.

From the result, significant variations were observed for all the characters. It was observed that mutant LM-216-3 and LM-195-3 was the earliest for maturity period and produced less seed yield. The exotic line ICF-6-2 produced highest yield followed by other two exotic line IFC-6-3 and IFC-6-1. The three lines were selected for further trial in the next growing season.

Table 39. Yield and yield contributing characters of seven promising mutants/exotic lines along with a check variety, Binamasur-8 at Magura 2017-18

Variety/ mutant	Days to maturity	Plant height (cm)	Primary branches/ plant (no.)	Pods/plant (no.)	Yield (kg/ha)
Magura					
LM-216-3	94c	40.0a	3.4a	74a	1600c
ICF-6-2	106a	42.0a	4.2a	106a	2050a
ICF-6-3	106a	40.3a	3.2a	99a	1900ab
ICF-6-4	106a	39.0a	4.0a	60b	1600c
ICF-6-1	106a	40.0a	4.1a	102a	1902a
LM-195-3	94c	40.1a	2.0b	50b	1400e
LM-175-1	96b	36.2b	2.2b	62b	1500d
Binamasur-8	97b	36.3b	5.2a	91a	2000a

Growing of M_3 generation of lentil

To create variability Binamasur-5, a popular variety was irradiated with 150 Gy, 200 Gy and 250 Gy of gamma rays. A total of 150 M_1 plants were harvested from three doses, 150 Gy, 200 Gy and 250 Gy. Seeds of these 150 M_2 plants were grown in plant-progeny-rows at Magura sub-station along with the mother lines. 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 and seed yield. A total of 19 lines were selected on the basis of higher yield, earliness and disease reactions. All this lines will be grown for further selection in the next generation.

Table 40. Yield contributing characters of promising mutants/exotic lines

Sl. no.	Plant height(cm.)	Primary branch(no.)	Pods/ plant (no.)	Characters
1	46	5	75	Tall plant
2	51	5	70	Tall plant
3	53	3	56	Tall plant
4	34	3	83	Short plant
5	34	3	47	Short plant
6	44	4	37	Early
7	37	4	91	Many pods
8	50	5	72	Early
9	52	3	84	Early, more pods
10	52	3	89	More pods, healthy plant
11	54	4	85	Early, more pods
12	47	3	86	More pods
13	58	3	93	More pods
14	41	3	123	More pods
15	38	5	102	More pods
16	47	6	156	More pods
17	97	9	119	Early
18	79	8	132	Early
19	45	5	113	More pods
Mean	50.47	4.42	90.15	
Range	34-97	3-9	37-156	

Growing of M_2 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 136 M_1 plants were harvested from four doses, 150 Gy, 200 Gy and 250 Gy. Seeds of these 136 M_2 plants were grown in plant-progeny-rows at Ishurdi sub-station and BINA Hqs. Mymensingh along with the mother lines. 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 and seed yield. A total of 79 lines were selected on the basis of higher yield, earliness and disease reactions. All this lines will be grown for further selection in the next generation.

Table 41. Characteristics of the 79 selected mutant lines

Sl. No.	Plant height(cm.)	Primary branch(no.)	Pods/ plant(no.)	Seeds/plant
Mutant of Binamasur-5, 200 Gy (Ishurdi)				
1	38 (check)	4	170	215
2	40	3	190	242
3	41	3	109	202
4	39	3	135	288
5	42	4	275	300
6	42	3	138	217
7	45	3	160	250
8	45	2	60	125
9	37	2	75	140
10	45	2	136	210
11	46	3	103	215
12	51	3	120	205
13	41	3	165	235
14	36	2	137	213

Sl. No.	Plant height(cm.)	Primary branch(no.)	Pods/ plant(no.)	Seeds/plant
15	40	2	203	330
16	43	2	296	440
17	41	2	212	390
18	43	2	87	150
19	46	2	115	213
20	51	2	110	213
21	39	3	93	160
22	49	2	66	105
23	38	2	83	127
24	45	2	143	217
25	40	2	126	337
26	37	2	137	220
27	37	3	43	61
28	40	2	115	213
29	42	2	175	211
30	45	2	52	93
31	42	2	55	97
32	42	2	65	125
34	45	3	82	147
35	33	2	177	234
36	36	4	109	196
37	37	3	171	250
38	36	3	101	170
39	35	3	103	170
40	45	4	161	253
41	46	4	143	244
42	38	4	253	417
Mutant of Binamasur-10, 150 Gy (Mymensingh)				
43	63	3	16	17
44	48	2	160	248
45	49	3	130	204
46	42	3	178	248
47	43	2	320	460
48	51	2	172	278
49	49	3	228	380
50	48	2	118	170
51	49	2	278	452
52	39	3	192	318
53	40	4	165	288
54	36	3	125	198
55	50	3	183	295
56	41	3	168	288
57	55	3	140	225
58	40	3	141	245
59	44	4	101	173
60	42	2	130	215
61	44	2	52	97
62	42	3	93	101
63	45	3	104	190
64	64	7	301	451
65	44	3	106	177
66	43	2	103	171
67	43	3	92	130
68	42	2	52	71
69	42	2	143	226

Sl. No.	Plant height(cm.)	Primary branch(no.)	Pods/ plant(no.)	Seeds/plant
70	47	3	133	220
71	60	4	74	105
72	56	3	88	110
73	44	3	63	94
74	44	3	210	375
75	43	1	54	71
76	42	2	52	85
77	36	2	30	55
78	39	2	53	88
79	39 (check)	3	77	105

Growing of M_1 generation of lentil

To create variability two varieties, Binamasur-8 and Binamasur-10 were irradiated with 150 Gy, 200 Gy and 250 Gy of gamma rays. A total of 120 M_1 plants were harvested from three doses, 150 Gy, 200 Gy and 250 Gy. Seeds of these plants will be grown in plant progeny-rows next generation.

Comparative effect of foliar application of diammonium phosphate and triple superphosphate on lentil at drought prone area of Bangladesh

Drought is a slow onset natural disaster which creates a threat to social and agro-ecological balance in the northern region of Bangladesh. In this regard, field experiment was conducted at the BINA substation, Chapainawabganj to test the effect of foliar fertilizer spray on yield and yield attributing characters of lentil during 2017-18. Treatment combinations were F_0= control (no foliar fertilizer spray), F_1= foliar fertilizer (DAP) spray and F_2= foliar fertilizer (TSP) spray. The experiment was laid out in a randomized block design with three replications. Binamasur-5 was used as the test crop. Two spray were applied of 3% DAP (diammonium phosphate) and 2% TSP (triple super phosphate) at flowering and pod formation stage of lentil. Results revealed that maximum fresh weight of plant, nodule number and dry weight of nodule were recorded in F_2 treatment at 50% flowering stage of lentil.

Table 42. Effect of foliar fertilizer spray on yield attributing characters of lentil

Treatment	50% flowering stage				Harvest stage			
	Plant height (cm)	Fresh wt./plant (gm)	Nodule no./plant	Dry wt. of nodule /plant	Plant height (cm)	Branch/ plant (no.)	Pod/plant (no.)	Effective pod/plant (no.)
F_0	27.73	6.47	2.33b	12.33	30.92a	2.62	102.93	86.73
F_1	28.87	7.73	2.00b	10.33	27.80b	2.66	106.47	96.27
F_2	27.73	7.80	4.50a	13.00	28.00b	2.63	103.13	98.73
CV(%)	6.42	21.07	17.90	30.65	1.73	6.68	6.60	6.61
Sig. level	***NS***	***NS***	*	***NS***	*	***NS***	***NS***	***NS***

Note: NS: non-significant, *: 1% level of significance

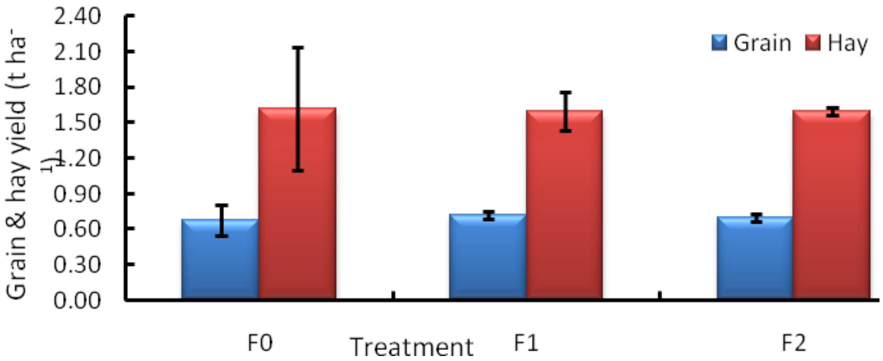


Fig. 6. Effect of foliar fertilizer spray on grain and hay yields of lentil

At harvest stage, the highest branch number per plant and pod per plant was observed in F_1 treatment. Maximum seed yield was found in F_1 treatment and the lowest grain yield was obtained from F_0 treatment. From these results it may be concluded that foliar application of DAP can increase seed yield of lentil at drought prone area of Bangladesh.

Screening of nutrient use efficient genotypes of lentil

Pot experiment was carried out at the Bangladesh Institute of Nuclear Agriculture headquarters to test the effect of different doses of molybdenum (Mo) on lentil genotypes/varieties in hydroponic condition. Four levels of Mo (0, 50, 75 & 100%) and seven lentil genotypes/varieties (Binamasur 6, Binamasur 7, Binamasur 8, Binamasur 10, Binamasur 138-3, Binamasur 206-5 & Binamasur 118-9) were used for this experiment. Factorial experiment was laid out in a CRD design with three replications. Liquid Mo fertilizer solutions were changed after 7 days interval during growth period of lentil.

Table 43. Effect of different dose of Mo and lines/variety on yield attributing characters of lentil in hydroponics condition

Fertilizer/variety	Plant height (cm)	Branch/plant (no.)	Pod/plant (no.)	Seed/plant (no.)
Mo dose (%)				
0	37.04	4.23b	20.61a	27.86b
50	38.37	5.26a	21.84a	32.33a
75	36.82	3.46c	15.15b	18.65c
100	37.38	3.19c	14.92b	21.17c
Sig. level	**NS**	**	**	**
Lines/variety				
Binamasur 6	36.50	4.42a	17.74	26.93
Binamasur 7	37.46	4.34a	20.35	24.19
Binamasur 8	34.67	3.94abc	19.91	25.81
Binamasur 10	37.62	4.64a	18.21	24.37
LM-138-3	39.52	3.28c	16.59	23.04
LM-206-5	37.62	4.28ab	17.20	24.58
LM-118-9	38.43	3.343bc	16.91	19.37
Sig. level	**NS**	*	**NS**	**NS**
CV(%)	**9.70**	**14.59**	**15.33**	**12.99**

Notes-**-significant at 1% level, *-significant at 5% level, NS: non-significant

Effect of different doses of Mo on plant height, branch plant^{-1}, pod plant^{-1} and seed plant^{-1} results are present (Table 22). The highest plant height (38.37cm), branch number plant^{-}1(5.26) and seed number plant^{-1} (28.50) were found in 50% Mo from the recommended dose of molybdenum. Maximum pod per plant was obtained from 50% Mo treatment. The minimum plant height (37.04cm), branch number per plant (3.19), pod number per plant (14.92) and seed number per plant (18.65) were observed in control, 100% Mo, 100% Mo and 75% Mo, respectively. It may be concluded that 50% Mo is the suitable dose for lentil production. Yield contributing characters of lentil were significantly different among the lentil genotypes/varieties (Table 44). Binamasur-10 produced the maximum branch number per plant (4.64) which was followed by Binamasur 6 and 7. Lowest branch number per plant (3.34) was found in LM-118-9. The highest pod number per plant was obtained from Binamasur-7 and the lowest pod number per plant was found in Binamasur-118-9. Binamasur-7 produced the highest seed per plant. It may be concluded that Binamasur-6, Binamasur-7, Binamasur-8, Binamasur-10 &LM- 206-5 performed better results than other genotypes/varieties of lentil.

Table 44. Interaction effect between Mo and lines/variety on yield attributing characters of lentil in hydroponic condition

Fertilizer/variety	Plant height (cm)	Branch/plant (no.)	Pod/plant (no.)	Seed/plant (no.)
Mo_0 × Binamasur 6	38.28	4.27	20.27	26.47b-g
Mo_{50} × Binamasur 6	36.80	6.38	20.30	44.00a
Mo_{75} × Binamasur 6	35.75	3.73	10.50	13.17j
Mo_{100} × Binamasur 6	35.16	3.31	19.89	24.10c-h
Mo_0 × Binamasur 7	38.77	4.17	25.10	33.46b
Mo_{50} × Binamasur 7	40.08	6.00	24.40	25.30b-g
Mo_{75} × Binamasur 7	36.36	3.40	15.75	18.30e-j
Mo_{100} × Binamasur 7	34.63	3.80	16.13	19.68e-j
Mo_0 × Binamasur 8	33.33	4.43	19.53	27.10b-e
Mo_{50} × Binamasur 8	32.69	4.57	26.30	30.44bcd
Mo_{75} × Binamasur 8	35.61	3.15	15.85	22.13d-j
Mo_{100} × Binamasur 8	37.08	3.60	17.97	23.57c-h
Mo_0 × Binamasur 10	38.24	5.03	20.20	29.73bcd
Mo_{50} × Binamasur 10	39.82	5.37	20.31	32.23f-j
Mo_{75} × Binamasur 10	35.46	4.33	18.45	17.86g-j
Mo_{100} × Binamasur 10	36.98	3.85	13.90	17.63d-i
Mo_0 × LM-138-3	40.52	4.17	18.90	23.00b
Mo_{50} × LM -138-3	40.54	3.70	19.65	33.35d-j
Mo_{75} × LM-138-3	35.78	3.17	18.73	21.50i-j
Mo_{100} × LM-138-3	41.23	2.10	9.07	14.29bcd
Mo_0 × LM-206-5	35.36	4.26	21.73	29.37b
Mo_{50} × LM-206-5	38.65	7.20	21.75	34.10hij
Mo_{75} × LM-206-5	38.29	3.10	12.70	16.05ej
Mo_{100} × LM-206-5	38.17	2.55	12.60	18.79bg
Mo_0 × LM-118-9	34.81	3.30	18.55	25.87bf
Mo_{50} × LM-118-9	40.01	3.60	20.18	26.87b-g
Mo_{75} × LM-118-9	40.47	3.35	14.05	21.50i-j
Mo_{100} × LM-118-9	38.43	3.12	14.85	30.10bcd
Sig. level	**NS**	**NS**	**NS**	
CV(%)	**9.70**	**14.59**	**15.33**	**12.99**

Notes-**-significant at 1% level, *-significant at 5% level, NS:non-significant

The combined use of different levels of Mo and lentil varieties showed significant response on yield attributing characters of lentil. Mo_{50} × Binamasur-6 produced the highest branch number per plant of lentil. Mo_{100} × LM-138-3 produced the lowest branch number per plant (2.10) of lentil. On the other hand, the highest pod number per plant was obtained from Mo_{50} × Binamasur- 8 treatment. Maximum seed per plant was found in Mo_{50} × Binamasur-6 treatment. It may be concluded that combined use of Mo_{50} and all the genotypes/varieties produced significant seed plant $^{-1}$ of lentil.

Participatory varietal selection (PVS) with three advanced mutants along with seven popular varieties

Participatory varietal selection was carried out with three lentil mutants along with seven popular varieties developed by BINA and BARI at Magura and Ishurdi during 2017-2018. The experiment was conducted in randomized complete block design with three replications. Unit plot size was 3 m × 2 m with 30 cm row to row distance. Normal cultural practices were done. Data on days to maturity and yield data were recorded from 10 randomly selected plants from each plot. Plot seed yield was converted into kgha^{-1}. Statistical analysis of different characters of the mutants and the check are presented in the Table 45. From the result it was observed that variety, BARI Masur-8, Binamasur-8, LM-118-9 and BARI Masur-6 produced the highest seed yield followed by Binamasur-5 and Binamasur-7. The newly registered variety, developed by BARI, BARI Masur-8, Binamasur-8 developed by BINA, was the earliest for maturity period at Magura. These same two varieties also performed better regarding seed yield and they took six days less for maturity at Ishurdi. Most of the farmers liked these two varieties very much.

Table 45. Maturity period and yield of three advanced mutants along with seven varieties, at farmers' field at Magura and Ishurdi during 2017-18

Variety/ mutant	Days to maturity	Yield (kg/ha)
Magura		
Binamasur-5	105bc	2050ab
Binamasur-6	107ab	1800d
Binamasur-7	107ab	2025ab
Binamasur-8	102e	2150a
BARI Masur-5	106b	2000bc
BARI Masur-6	108a	2100a
BARI Masur-8	102e	2150a
LM-118-9	106b	2100a
LM-138-3	104d	2000bc
LM-206-5	106b	1850d
Ishurdi		
Binamasur-5	107bc	2150b
Binamasur-6	110b	2000c
Binamasur-7	112a	2100b
Binamasur-8	104d	2200ab
BARI Masur-5	106c	2100bc
BARI Masur-6	112a	2100b
BARI Masur-8	104d	2250a
LM-118-9	110b	2150b
LM-138-3	106c	1900d
LM-206-5	108c	2100bc

Varietal improvement of blackgram through induced mutation

Advanced Yield Trial with three promising blackgram mutants

The trials were conducted with three promising blackgram mutants along with a check variety. BARI Mash-3 at Magura and Chapainowabganj. The experiment was laid out in a randomized complete block design with three replications. Plant to plant distance was 3 - 4 cm in a row while line to line distance was 30 cm. Unit plot size was 20 m^2 (5 m × 4 m). Intercultural operations; like weeding, thinning, application of pesticides, etc. were done for proper growth and development of plants in each plot. Harvesting was done depending on maturity of the lines. Data on various characters as plant height, number of primary branches $plant^{-1}$, number of seeds pod^{-1}, 100-seed weight were taken from 10 randomly selected plants of each plot. Seed yield per plot was recorded and converted into Kg ha^{-1}. Appropriate statistical analyses were performed by Duncan`s Multiple Range Test (Gomez and Gomez, 1984).

Table 46. Mean of yield and yield contributing characters of three promising mutants of blackgram grown at two locations, Magura and Chapainowabganj during 2017

Variety	Plant height (cm)	Primary branches/ plant (no.)	Pods/plant (no.)	Seeds/pod (no.)	100-seed weight (g)	Yield (kg/ha)
			Magura			
BM-404	56.0 ab	3.8 a	30.2 a	6.6	4.37 a	750a
BM-108	48.2 c	2.7a	35.0 a	6.7	3.80b	670b
BARI Mash-3	51.9 ab	1.2 b	22.1b	6.6	4.52a	700b
			Chapainoabganj			
BM-404	35.0	1.8	27.0 a	6.1	4.49a	706 a
BM-108	32.7	1.2	29.5 a	6.3	3.60b	660 b
BARI Mash-3	32.1	1.2	19.2 b	6.3	4.56a	650 b
			Combined			
BM-404	45.5	2.8	28.6	6.35	4.43	728a
BM-108	40.4	1.9	32.2	6.50	3.70	665b
BARI Mash-3	42.0	1.2	20.6	6.45	4.54	675b

Results revealed that there was significant difference for most of the characters except seeds per pod at Magura. It was also significant for pods per plant, 100-seed weight and seed yield at Chapainowabganj. BM-404 was the tallest among the mutants and check at Magura. In case of primary branches per plant BM-404 had the highest number of branches and 100-seed weight was higher than the other mutant and the check variety, BARI Mash-3. Seed yield was the highest for BM-404 because of its bigger seed size and higher number of pods per plant. BM-404 possessed higher plant height, primary branches per plant, 100-seed weight and also seed yield at both the locations. Combining mean of two locations, it was observed that BM-404 produced the highest seed yield followed by BM-108 and BARI Mash-3. These two mutants will be evaluated in the next season.

Growing of M_2 generation of blackgram

To create variability BARI Mash-3 was irradiated with 600 Gy, 700Gy and 800Gy of gamma rays and was grown at Magura. A total of 350 M_1 plants were harvested from three doses, 600 Gy, 700 Gy and 800 Gy. Seeds of these 350 M_1 plants were grown in plant-progeny-rows at Magura during 2017 and a total of 23 plants were selected based on higher number of pods, earliness, plant type, synchronus in pod maturity and disease and insect pest reactions. These lines will be grown in plant progeny rows in the next season.

Table 47. Mean of yield and yield contributing characters of mutants

Sl. No.	Plant height(cm)	Primary branch (no.)	Pods/ plant(no.)	Seed/ plant (no.)	Characters
1.Barimash-3, 600 Gy	29	2	237	7	Healthy plant
2.Barimash-3, 700gy	51	3	66	6.8	Large pod, tall and healthy plant
3.Barimash-3, 600 Gy	38	8	3	66	Early, tall and healthy plant
4.BARImash-3, 600 Gy	35	2	36	6.2	Green plant, synchronous
5.BARImash-3, 600 Gy	31	3	32	6	Many pods, short synchronous
6.BARIMash-3, 600 Gy	35	2	35	6.2	Short, more pod, early
7.BARIMash-3, 600 Gy	34	2	46	6.2	More pod, early, short and synchronous
8.BARIMash-3, 600 Gy	38	2	19	6.8	Early, short, seeds are bold
9.BARIMash-3, 600 Gy	28	2	24	6.6	Very short, early maturity
10.BARI Mash-3, 600 Gy	41	3	32	6.2	More pod, plant healthy
11.BARI Mash-3, 600 Gy	57	2	16	6.4	Tall plant, bold seed
12.BARI Mash-3, 700 Gy	62	3	69	7.2	Tall plant, more pods
13. BARI Mash-3, 700 Gy	42	3	47	5.8	Large seed and more pods
14.BARI Mash-3, 700 Gy	48	3	27	7.2	Early and medium plant
15.BARI Mash-3, 700 Gy	48	2	26	5	early and fresh plants
16.BARI Mash-3, 900 Gy	24	2	29	6.4	Short plant and fresh
17.BARI Mash-3, 700 gy	36	1.8	22.4	6.8	Short
18.BARIMash-3, 600 Gy	21	2	23	6	Short and early
19.BARI Mash-3, 800Gy	36	4	30	6.5	Early Mature
20.BARI Mash-3, 800Gy	38	3	41	7	Short plant, early
21. BARIMash-3, 800Gy	33	3	52	7	Short plant, early Mature
22. BARI Mash-3,800Gy	45	3	62	6.8	Many pods
23. BARI Mash-3,800Gy	43	2	49	6.4	Fresh, early mature
23. BARI Mash-3	42	3	40	6.2	Moderate

Growing of M_3 generation of blackgram

To create variability BARI Mash-3 was irradiated with 600 Gy, 700Gy and 800 Gy of gamma rays and were grown at Magura in 2015. A total of 350 M_1 plants were harvested from three doses, 600 Gy, 700 Gy and 800 Gy. Seeds of these 350 M_1 plants were grown in plant progeny rows. A total of 125 plants were selected from M_2 generation and In M3 generation a total of 22 lines were selected on the basis of higher pod number, earliness and synchronous in pod maturity and disease reaction. These lines will be grown in in plant-progeny-rows in the next season.

Table 48. Mean of yield and yield contributing characters of mutants

Serial No	Plant height (cm)	Primary branch (no.)	Pods/ plant (no.))	Seeds/plant (no.)	Characters
1.BARI Mash-2	43	2	22	7.4	
2	41	3	54	5.8	Plant grassy, many pods, early mature
3	53	3	57	6.67	Many pods, early mature
4	49	2	59	6	More pods
5	39	3	57	5.8	Many pods, short plant.
6	51	2	27	5.4	Medium plant, very early
7	42	2	45	6.8	Early mature
8	50	29	40	7.2	Same size plant, many pods
9	48	4	58	6.2	Many pods

10	45	2	51.5	6.4	many pod, early
11	42	2	39	5.2	Medium, many pods, early
12	41	2.2	38	6.4	Same size, many pods,
13	51	3	64	35	Many pods, early
14	47	4	72	6.7	Many pods, early
15	54	3	69	7.2	More pods, early
16	45	3.5	40	6.7	Many pods, early
17	41	3	76	6.8	Many pods, early, mature pod
18	51	4	56	7.2	Many pods, early
19	39	2	79	6	Bushy type, many pods, healthy
20	44	3	56	6.7	Fresh and early
21	48	3	49	7	Early
22	39	3	42	6.2	Short plant, early

Growing of M_1 generation of blackgram

To create variability BARI Mash-3 was irradiated with 600 Gy, 700 Gy and 800 Gy of gamma rays and was grown at Magura. A total of 350 M_1 plants were harvested from three doses, 600 Gy, 700 Gy and 800 Gy. Seeds of these 350 M_1 plants will be grown in plant-progeny-rows in the next season.

Varietal improvement of grasspea through induced mutation

Preliminary yield trial with six selected mutants of grasspea

The preliminary yield trials were carried out with six selected mutants along with a check variety (Binakheshari-1) at Magura and Barishal during 2017-2018. The experiment was conducted in randomized complete block design with three replications. Unit plot size was 3 m × 2 m with 40 cm row to row distance. Normal cultural practices were done. Data on days to maturity, plant height, primary branches plant^{-1}, pods plant^{-1} and 100-seed weight were recorded from 10 randomly selected plants from each plot. Plot seed yield was converted into kgha^{-1}. Statistical analysis of different characters of the mutants and the check are presented in the Table 49.

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

Table 49. Mean of yield and yield contributing characters of six promising mutants of grasspea grown at two locations, Magura and Barisal during 2017

Variety/ mutants	Days to maturity	Plant height (cm)	No of primary branch	No of pods /plant	100-seed weight (gm)	Seed yield/plot (kg)
			Magura			
GM (BN)-102	99c	86 a	3.4 a	80.4 a	6.4 a	1113 a
GM (BR)-250	101 b	71 b	3.6 a	54.8 ab	5.6 bc	696 b
GM (BN)-105	101 b	72 b	3.6 a	35.8 b	5.2 e	720 b
GM (BR)-300	101 b	65 c	3.4 a	40.9 b	5.6 bc	686 b
GM (BN)-108	101 b	73 b	3.6 a	66.6 ab	5.2 e	1013 ab

GM (BR)-350	101 b	76ab	3.4 a	50.8 ab	5.3 de	690 b
Binakhasari-1	105 a	67 ab	3.8 a	56.0 ab	5.7 b	873 b
BARI Khasari-2	106 a	67 ab	3.6 a	49.6 ab	5.5 cd	1006 ab
CV	**0.03**	**9.3**	**10.7**	**21.9**	**2.47**	**12.9**
LSD	**0.05**	**11.4**	**0.67**	**20.58**	**0.25**	**110**
			Barisal			
GM (BN)-102	110 d	106 a	3.8 a	72.0 ab	4.5ab	1205 a
GM (BR)-250	111 c	86 bc	3.6 a	49.6 ab	5 ab	1008 b
GM (BN)-105	111 c	91 abc	3.4 a	48.4 ab	5.3 a	1004 b
GM (BR)-300	111 c	92 ab	3.6 a	51.8 ab	5 ab	1013b
GM (BN)-108	111 c	91 abc	3.6 a	75.8 a	4.3b	1223 a
GM (BR)-350	113 b	95 ab	3.4 a	50.9 ab	5.1ab	1007b
Binakhasari-1	114 a	101 ab	3.6 a	66.6 a	4.6ab	1111ab
BARI Khasari-2	114 a	77 c	3.4 a	30.8 b	5.1ab	906c
CV	**0.03**	**9.4**	**10.7**	**21.9**	**10.48**	**19.9**
LSD (0.05)	**0.05**	**15.2**	**0.68**	**20.5**	**0.9**	**80**

Growing of M_3 generation of grasspea

To create variability Binakheshari-1 and BARI Kheshari-2 were irradiated with 250 Gy, 300 Gy and 350 Gy of gamma rays. A total of 300 M_1 plants were harvested from three doses, 250 Gy, 300 Gy and 350 Gy. Seeds of these 300 M_2 plants were grown in plant-progeny-rows at BINA Headquarters with the mother varieties. A total of 39 M_2 mutants were selected and these mutants were grown in plant- progeny-rows at Magura. Each row was 2 m long with 30 cm row to row distance. Normal cultural practices were done. A total of 20 mutants were selected on the basis of earliness, more number of pod and disease reactions. Selection will be done in the next season.

Table 50. Mean values of different characters of the selected M_3 mutants of grasspea during 2017

SL No	Plot	Plant height (cm)	Branch/ plant (no.)	Pods/ plant(no.)	Characteristics
1	BinaKhesari-1, P-4, 250 Gy	77	7	158	Many pods
2	P-7, 250 Gy	85	6	98	Many pods
3	P-6, 300 GY	55	4	52	Short plant
4	250 Gy	90	5	109	More pods
5	P-13, 350 Gy	85	6	80	More pods
6	P-5, 300 Gy	45	6	80	Short stature
7	P-1, 300 G y	79	5	120	More pods
8	P-1, 300 Gy	83	5	115	Many pods
9	P-6, 250 G y	79	7	75	Early
10	P-12, 250 G y	82	5	98	Many pods
11	P-7, 250 G y	94	6	111	Long plant and fresh
12	P-13, 350 Gy	85	7	105	Many pods
13	P-4, 250 Gy	79	6	142	Many pods
14	P-3, 300 Gy	72	6	110	Many pods
15	P-11, 250 Gy	70	4	51	Early
16	P-7, 250 Gy	87	5	72	Early
17	P-11, 250 Gy	100	4	51	Tall plant
18	p-12, 250 Gy	43	4	35	Early, short

19	P1, 250Gy	58	5	42	Early
20	P-5, 250 Gy	94	5	105	More pods
21	Binakhesari-1 (check)	74	3	50	

Growing of M_2 generation of grasspea

To create variability Binaheshari-1 was irradiated with 250 Gy, 300 Gy and 350 Gy of gamma rays and were grown at Ishurdi with their parents. A total of 101 M_2 plants were harvested separately from three doses, 250 Gy, 300 Gy and 350 Gy. Seeds of these 101 M_2 plants will be grown in plant-progeny-rows in the coming seasons.

Growing of M_1 **generation of grasspea**

To create variability Binaheshari-1 was irradiated with 250 Gy, 300 Gy and 350 Gy of gamma rays and was grown at BINA Headquarters with their parent. A total of 145 plants were harvested separately from three doses, 250 Gy, 300 Gy and 350 Gy. Seeds of these plants will be grown in plant-progeny-rows in the coming seasons.

Germplasm collection and growing of M_1 generation of garden pea

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

Germplasm collection and evaluation of pigeon pea

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

Onion

Up scaling of the registered varieties in farmers field using M_{10} seed

During the Kharif-I season 2018; demonstration trials of Binapiaz-1 and Binapiaz-2 were set at five locations viz. Pabna (Santhia), Jessore, Bogura, Rajshahi (Godagari) and Lalmonirhat following RCB design with three replications. BARI Piaz-3 and BARI Piaz-5 were used as check varieties. But the germination was very poor of both the check varieties thus could not be accommodated in the trial. A unit plot size was 3.0 m × 1.0 m. Seeds were sown on 24 January 2018 at BINA Head Quarter’s farm Mymensingh. The seedlings were transplanted on 13 March at Lalmonirhat, Rajshahi and Bogura, on 9 March at Santhia, Pabna, and on 24 April 2018 at Jashore. Fertilizers were applied at the rate of Urea 200 kg, Triple Super Phosphate (TSP) 175 kg, Muriate of Potash (MoP) 150 kg and Gypsum 110 kg/ha apart from recommended cultural and intercultural operations. Data on leaves plant^{-1} at vegetative stage, bulb diameter and individual bulb weight were recorded. Bulb yield were recorded from the whole plot and later converted to t ha^{-1}. Finally, appropriate statistical analyses were made as per the design used and presented in Table 51. The experiments at Lalmonirhat and Bogura were damaged due to heavy rainfall at the seedling stage.

Up scaling of Binapiaz-1 and Binapiaz-2 in farmer's field using M_{10} seed in Kharif-I season

Leaves plant^{-1} of Binapiaz-1 and Binapiaz-2 ranged from 4.27 to 7.50 with being the highest in Binapiaz-2 (Table 51). Among the locations, Santhia, Pabna ranked first for leaf number. Individual bulb weight of of Binapiaz-1 and Binapiaz-2 ranged from 13.07 to 34.0 grams with Binapiaz-1 being the largest at Santhia, Pabna. The other variety also had similar bulb size (expressed here as individual bulb weight) at Santhia, Pabna. Bulb diameter of the mutants ranged from 5.20 to 7.40 cm over different locations and showed similar result as individual bulb weight.

Table 51. Bulb yield and related traits of two mutant lines and the check varieties of summer onion at five locations in Kharif-I, 2018

Mutant/ variety	Leaves plant^{-1} (no.)	Individual bulb weight (g)	Bulb diameter (cm)	Yield ha^{-1} (t)
Rajshahi				
BP_2/75/2	4.27	13.07	5.20	6.75
BP_2/100/2	6.03	23.87	6.20	12.33
LSD(0.05)	**NS**	**1.98**	**0.15**	**0.22**
Jashore				
BP_2/75/2	5.87	26.85	6.20	13.87
BP_2/100/2	5.03	27.43	6.40	14.17
LSD(0.05)	**0.38**	**2.25**	**NS**	**0.40**
Pabna				
BP_2/75/2	7.50	34.00	7.40	17.57
BP_2/100/2	7.00	33.67	7.20	17.39
LSD(0.05)	**0.24**	**0.93**	**NS**	**0.67**

Bulb yield of the varieties ranged from 6.75 to 17.57 t/ha (Table 1). The highest yield was found in the mutant Binapiaz-1 at Santhia, Pabna. The other variety Binapiaz-2 also produced similar yield at Santhia, Pabna. The comparatively low yield of the varieties at Rajshahi and Jashore was attributed to saturated soil moisture at the bulb formation stage due to heavy rainfall. This indicates growing of summer onion in Kharif-I season requires raised bed to drain out the excess moisture.

Pure Seed Production

Seeds of two M_{10} mutant lines: BP2/75/2 and BP2/100/2 of summer onion (Later registered as Binapiaz-1 and Binapiaz-2, respectively) were sown on 30 October at BINA Head Quarter's farm, Mymensingh. Seedlings of the mutant BP2/75/2 was transplanted at BINA sub-station farm, Ishurdi in an area of 180 m^2 and at BINA sub-station farm Chapainowabganj in an area of 200 m^2 on 17 and 18 December, 2017, respectively. The seedlings of BP2/100/2 were transplanted at BINA sub-station farm, Rangpur in an area of 240 m^2 on 12 December 2017 at 15 cm distance within rows of 20 cm apart. Fertilizers were applied at the rate of Urea 320 kg, TSP 415 kg, MoP 170 kg and Gypsum 100 kg/ha apart from recommended cultural and intercultural operations. Finally, seeds were collected from the whole plot at harvest and the amount of pure seed is presented in Table 52.

Table 52. Pure seed yield of Binapiaz-1 and Binapiaz-2 at three separate locations during winter season, 2017-18

Mutants/ varieties	Location	Seed yield (g)
BP_2/75/2	Chapainowabganj	500
BP_2/100/2	Rangpur	150
BP_2/75/2	Ishurdi	1000

The seed plot of BP_2/100/2 at Rangpur produced limited amount of seeds because of plant damage by severe rain before maturity (Table 2). The other mutant BP_2/75/2 produced plenty of seeds at Chapainawabganj and Ishurdi. The maturity period of the mutants ranged from 148 to 152 days.

Production of sets from the M_9 seeds

Seed of two varieties, Binapiaz-1 (BP_2/75/2) and Binapiaz-2 (BP_2/100/2) along with the check variety BARI Piaz-3 were sown on 1 March, 2018 at BINA Head Quarter’s farm, Mymensingh. Unit plot size was 10.0 m × 1.5 m. 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. Sets were harvested when at maturity (25 May, 2018). The harvested sets were kept in storage after optimum drying under sunlight. Sufficient quantity of sets has been produced of the varieties, Binapiaz-1 and Binapiaz-2. But due to germination failure, few sets could be harvested from the check variety, BARI Piaz-3 (Table 53).

Table 53. Production of sets of Binapiaz-1 and Binapiaz-2 and BARI Piaz-3 at BINA HQ Farm, Mymensingh during Kharif-I season, 2018

Sl. No.	Name of mutant/check variety	Quantity of sets (no.)
1	Binapiaz-1	1000
2	Binapiaz-2	1900
3	BARI Piaz-3	500

Crop Physiology Division

Research Highlights

Five lentil varieties (Binamasur-2, Binamasur-4, Binamasur-5, Binamasur-10 and BARImasur-5) were evaluated under four soil moisture regimes (Control, 60, 45 and 30% FC) for photosynthesis, yield attributes and yield. Binamasur-5 was found comparatively tolerant under water stress condition than the others. In another experiment, four mungbean varieties (Binamoog-5, Binamoog-7, Binamoog-8 and Binamoog-9) were evaluated under three soil moisture levels (Control, 60 and 40% FC) on growth and yield, and Binamoog-7 was found comparatively more tolerant under water stress condition than the others.

Ten lentil varieties (Binamasur-2, Binamasur-3, Binamasur-4, Binamasur-5, Binamasur-6, Binamasur-7, Binamasur-8, Binamasur-9, Binamasur-10 and BARI Masur-5) were evaluated under high temperature regime (34 ^{0}C) for photosynthesis, yield attributes and yield, and no variety was found temperature tolerant. Four mungbean varieties (Binamoog-5, Binamoog-7, Binamoog-8 and Binamoog-9) were evaluated under high temperature (36 ^{0}C) and Binamoog-7 was found comparatively tolerant than the others.

Eleven local land races of sesame were evaluated under different water logging periods (Control, 24, 48 and 72 hours) for photosynthesis, growth and yield. Two genotypes, Rajshahi Khoeri and Kalotil Gopal showed more tolerance to water logging.

Two mungbean varieties, Binamoog-7 and Binamoog-8 were defoliated at flowering stage with different degrees of defoliation (Control, 100% defoliation, 50% defoliation from top, 50% defoliation from bottom). All the defoliation treatments significantly decreased seed yield over control. Two sesame varieties *viz*. Binatil-2 and Binatil-3 were evaluated under different debranching levels *viz*., i) control, ii) mainstem (MS) only, iii) MS with 1 branch, iv) MS with 2 branches, v) MS with 3 branches and vi) MS with 4 branches. The increase pod yield was recorded in mainstem with 3 branches. In another tomato experiment, imposed 5 debranching levels *viz*., i) control, ii) mainstem (MS) only, iii) MS with 1 branch, iv) MS with 2 branches, v) MS with 3 branches and vi) MS with 4 branches and found the highest fruit yield plant^{-1} in MS with 4 branches.

Nine lentil mutants were evaluated based on morphological and seed yield attributes and two lentil mutants (LMM-4 and LMM-7) were found promising. Thirteen mungbean mutants were evaluated based on morphological and seed yield attributes, and two mutants, MM-8 and MM-12 showed the highest seed yield. Ten lentil cultivars were evaluated based on flowering pattern and found that high yielding genotypes have higher rate of flowers production.

Three tomato mutants (TM-4, TM-5 and TM-8) were evaluated based on morphological parameters and fruit yield, and the mutant TM-5 showed the highest fruit yield. Among the three cherry type tomato genotype, Trumling Red showed the highest fruit yield.

Silicon was applied at the rate of 5, 10 and 15 kg ha^{-1} on Aman rice and application of silicon at the rate of 10 kg ha^{-1} significantly increased grain yield. In Boro season, under saline condition, application of silicon at the rate of 10 kg ha^{-1} also increased grain yield.

Effect of water stress on photosynthesis, dry matter production and yield of lentil varieties

A pot experiment was carried out with five lentil varieties to assess the effects of water stress on photosynthesis, dry mass production and chlorophyll content in leaves and seed yield. Control (100% FC), 60, 45 and 30% FC water stress were imposed on Binamasur-2, Binamasur-4, Binamasur-5, Binamasur-10 and BARI masur-5 at flowering starting stage and continued until flowering ceased. The experiment was laid out in a Complete Randomized Design with three replications. Chlorophyll content (SPAD reading) and photosynthetic rate were measured at 10 days after water stress imposed. Data on yield and yield attributes were also recorded at maturity. The collected data were analyzed statistically.

Results showed that photosynthesis and yield attributes decreased with increasing water stress (Tables 1 and 2). The highest grain weight and photosynthetic rate were found in control plants and the lowest was recorded in 30% water stress condition. Under stress condition, the highest grain yield was recorded in Binamasur-5 and the lowest was observed in Binamasur-2. The lowest yield reduction under water stress was also recorded in Binamasur-5 and the highest yield reduction was recorded in Binamasur-10 (Table 3). In conclusion, among the varieties, Binamasur5 was found comparatively tolerant under water stress condition than the others.

Table 1. Effect of water stress on photosynthesis and total dry matter at flowering stage of lentil varieties

Variety	Photosynthesis at flowering stage (µmolCO_2m^{-2}s^{-1})				Total dry matter plant^{-1} (g)			
	Moisture levels							
	Control	60% FC	45% FC	30% FC	Control	60% FC	45% FC	30% FC
Binamasur-2	51.93 a	49.88 ab	48.00 b	39.93 c	3.98 a	3.45 b	2.65 c	1.37 d
Binamasur-4	50.90 a	50.77 a	49.77 a	44.67 b	5.93 a	3.94 b	2.48 c	0.86 d
Binamasur-5	54.17 a	51.33 b	49.73 bc	47.27 c	5.27 a	4.87 b	3.23 c	2.42 d
Binamasur-10	54.47 a	54.03 a	51.65 b	46.73 c	6.14 a	4.82 b	3.71 c	2.59 d
BARI masur-5	56.60 a	53.30 b	52.73 b	48.10 c	5.78 a	4.39 b	3.59 c	2.76 d

Figure (s) with same letter, in a row, within variety indicates do not differ significantly at $P \leq 0.05$

Table 2. Effect of water stress on morphological and yield contributing characters of lentil varieties

Treatment	Plant height (cm)	Main branches plant^{-1} (no.)	Secondary branches plant^{-1} (no.)	Tertiary branches plant^{-1} (no.)	Filled pods plant^{-1} (no.)	unfilled pods plant^{-1} (no.)	Grain yield plant^{-1} (g)
Moisture levels							
Control (T_0)	29.87 a	3.27 a	11.87 a	7.67 a	72.33 a	18.73 a	2.59 a
60% FC (T_1)	26.25 b	3.07 ab	10.60 ab	5.80 b	52.20 b	13.87 b	1.84 b
45% FC (T_2)	24.85 b	2.87 b	9.27 b	4.73 c	44.80 c	11.40 c	1.57 b
30% FC (T_3)	21.90 c	2.27 c	7.93 c	3.40 d	34.73 d	12.27 bc	1.15 c
Genotypes							

Binamasur-2	27.18 ab	2.92 b	8.58 b	4.42 c	36.75 d	14.67 ab	1.12 c
Binamasur-4	28.79 a	2.58 c	8.08 b	3.83 d	42.92 c	12.33 c	1.18 c
Binamasur-5	26.25 b	3.58 a	12.3 a	4.67 c	66.33 a	13.17 c	2.48 a
Binamasur-10	24.69 c	2.92 b	8.50 b	7.75 a	56.75 b	16.08 a	2.11 b
BARI masur-5	25.42 bc	3.08 b	12.1 a	6.33 b	63.58 a	14.08 ab	2.55 a

In a column, figure (s) with same letter, within treatment, indicates do not differ significantly at P≤0.05

Table 3. Grain yield reduction % of lentil varieties under different soil moisture stress conditions

Treatments	Varieties									
	Binamasur-2		Binamasur-4		Binamasur-5		Binamasur-10		BARI masur-5	
	Grain yield (g plant^{-1})	Yield reduction over control (%)	Grain yield (g plant^{-1})	Yield reduction over control (%)	Grain yield (g plant^{-1})	Yield reduction over control (%)	Grain yield (g plant^{-1})	Yield reduction over control (%)	Grain yield (g plant^{-1})	Yield reduction over control (%)
Control	1.39 a	--	1.68 a	--	2.93 a	--	3.48 a	--	3.48 a	
60%FC	1.37 a	1.20	1.30 b	22.82	2.60 ab	11.16	2.79 b	18.56	2.76 b	20.52
45%FC	0.87 b	37.17	0.89 c	47.02	2.42 b	17.43	1.69 c	51.53	1.99 c	42.86
30%FC	0.74 b	41.33	0.76 c	51.01	1.96 c	32.92	1.48 c	57.57	1.77 c	48.24

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

Screening of four mungbean varieties for water stress based on seed yield

A pot experiment was carried out with four mungbean varieties to assess the effects of water stress on dry mass production and seed yield. Control (100% FC), 60 and 40% FC water stress were imposed on Binamoog-5, Binamoog-7, Binamoog-8 and Binamoog-9 at 25 days after sowing and continued until flowering ceased. The experiment was laid out in a Complete Randomized Design with three replications. Five seeds were sown in a plastic pots containing 10 kg soils pot^{-1} on 12 March 2018 and at 15 days after sowing kept 2 plants pot^{-1}. At harvest, seed yield and yield related traits were recorded and collected data were analyzed statistically.

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

Table 4. Effect of water stress on morphological and yield contributing characters of mungbean varieties

Treatment	Plant height (cm)	Branches plant^{-1} (no.)	Pods plant^{-1} (no.)	Pod length (cm)	Seeds pod^{-1} (no.)	100-seed weight (g)	Seed weight plant^{-1} (g)	Total dry matter plant^{-1} (g)	Harvest index (%)
Moisture levels									
Control (T_0)	25.7 a	1.75 a	15.0 a	7.84 a	11.15 a	2.92 a	4.17 a	7.66 a	36.10 a
60% FC (T_1)	22.5 b	1.41 b	10.9 b	7.29 b	10.17 b	2.85 ab	2.65 b	5.46 b	32.02 b
40% FC (T_2)	20.2 c	1.05 c	7.75 c	6.86 c	9.32 c	2.75 b	1.78 c	3.85 c	29.03 c
F-test	**	**	**	**	**	*	**	**	**
Varieties									
Binamoog-5	24.1 b	1.11 b	10.5 b	8.11 a	11.40 a	3.17 ab	2.56 c	3.66 d	31.16c
Binamoog-7	26.8 a	3.00 a	16.3 a	6.77 c	10.55 b	1.93 c	3.46 a	6.33 a	32.96 b
Binamoog-8	20.5 c	1.11 b	9.77 bc	7.77 b	9.81 c	3.27 a	3.03 b	5.58 b	34.21 a
Binamoog-9	19.9 c	0.41 c	8.11 c	6.79 c	9.10 d	3.09 b	2.35 c	4.94 c	31.17 c
F-test	**	**	**	**	**	**	**	**	**

In a column, within treatment, figure (s) with same letter do not differ significantly at $P \leq 0.05$ by DMRT; ** indicates significant at 1 % level of probability

Table 5. Interaction between variety and water stress on seed yield and yield related traits of mungbean

Interaction		Plant height (cm)	Branches plant^{-1} (no.)	Pods plant^{-1} (no)	Seeds pod^{-1} (no)	100-seed weight (g)	Seed weight plant^{-1} (g)	Total dry weight plant^{-1} (g)	Harvest index (%)
Variety	**Water stress (FC %)**								
Binamoog-5	Control	26.4 b	1.66 c	13.66 c	12.23 a	3.30	3.60 b	7.86 b	34.99
	60% FC	24.2 c	1.00 d	10.66 ef	11.16 b	3.18	2.24 d	5.11 d	30.17
	40% FC	21.7 d	0.66 e	7.02 g	10.8 c	3.03	1.85 e	4.00 ef	28.33
Binamoog-7									
	Control	29.4 a	3.33 a	22.66 a	11.00 b	1.92	4.77 a	8.53 a	35.86
	60% FC	26.7 b	3.00 a	17.67 b	10.62 c	1.86	3.42 b	6.67 c	32.16
	40% FC	24.1 c	2.66 b	12.65 cd	10.03de	1.78	2.37 d	4.34 e	30.86
Binamoog-8									
	Control	24.5 c	1.33 cd	14.00 c	11.11 b	3.32	4.74 a	7.99 b	37.33
	60% FC	19.4 e	1.29 d	9.32 f	9.96 e	3.28	2.74 c	5.16 d	34.68
	40% FC	17.7 f	0.67 e	6.10 h	8.36 g	3.18	1.59 f	3.60 f	30.63
Binamoog-9									
	Control	22.6 d	0.66 e	11.11 de	10.25 d	3.14	3.55 b	6.26 c	36.18
	60% FC	19.8 e	0.33 f	8.00 gh	8.95 f	3.07	2.20 d	4.88 d	31.07
	40% FC	17.4 f	o.26 f	5.34 h	8.10 h	3.04	1.31 f	3.68 f	26.25
F-test		*	*	**	*	**NS**	**	*	**NS**

In a column, figure (s) with same letter do not differ significantly at $P \leq 0.05$ by DMRT; NS, not significant; *, ** indicates significant at 5 % and 1 % level of probability, respectively.

Evaluation of mungbean varieties for temperature tolerance

An experiment was conducted with four mungbean varieties *viz*. Binamoog-5, Binamoog-7, Binamoog-8 and Binamoog-9 at pot yard and in plant growth chamber of Bangladesh Institute of Nuclear Agriculture (BINA) during March to May, 2018 to assess the effect of high temperature (36 ^{0}C) at two growth stages like flower initiation stage and pod growth stage on morpho-physiological parameters and seed 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. Chlorophyll content and photosynthesis rate of leaves were determined during temperature imposed. At harvest, seed yield and yield related parameters were recorded. The collected data were analyzed statistically.

Results indicated that high temperature imposed both at flowering stage and pod growth stage had significant negative influence on plant parameters (Table 6). But temperature imposed at flowering stage had greater significant negative influence on morpho-physiological parameters as well as seed yield than temperature imposed at pod growth stage. Amongst the varieties, only Binamoog-7 had no significant negative influence on seed yield when temperature imposed at pod growth stage. Considering the effect of high temperature imposed at flowering stage, Binamoog-9 was affected more than other varieties on morpho-physiological parameters as well seed yield and yield related traits. On the other hand, Binamoog-7 was less affected than other varieties.

Table 6. Temperature effect at different growth stages on morpho-physiological characters, seed yield and yield attributes in mungbean

Treatment	Plant height (cm)	Branches plant^{-1} (no.)	Photo-synthesis rate (μmol CO_2 $m^{-2}S^{-1}$)	Chloro-phyll content (mgg^{-1} fw)	Straw weight plant^{-1} (g)	Pod length (cm)	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	Seed weight plant^{-1} (g)
36 ^{0}C temperature imposed at									
Control	23.41 ab	1.84 a	26.44 a	1.97 a	5.77 a	8.91 b	10.6 a	10.87 a	3.41 a
Flowering stage	19.67 b	1.08 b	34.80 b	1.42 b	3.98 b	8.72 a	4.84 b	7.00 b	0.68 c
Pod formation stage	24.25 a	2.16 a	27.53 a	1.87 a	5.15 a	8.91 b	8.80 a	10.54 a	2.61 b
F-test	*	**	**	**	*	NS	**	**	**
Variety									
Binamoog-5	18.00 c	1.08 c	28.08	2.01 a	3.89 b	8.61 b	5.00 c	10.3 a	1.55 c
Binamoog-7	26.88 a	3.35 a	27.76	1.72 b	6.81 a	6.88 c	13.8 a	10.6 ab	3.46 a
Binamoog-8	22.77 b	2.14 b	31.13	1.59 b	5.88 a	10.0 a	8.44 b	9.65 b	2.02 bc
Binamoog-9	20.77 bc	1.00 bc	30.73	1.71 b	3.74 b	9.53 b	5.00 c	9.54 b	1.67c
F-test	**	**	**NS**	*	**	**	**	*	**

Figure(s) in a column within treatment, figure (s) with same letter indicates do not differ significantly at P ≤0.05

Table 7. Interaction effect between variety and growth stage on morph-physiological parameters, seed yield and yield attributes of mungbean

Interaction	Plant height (cm)	Branches plant^{-1} (no.)	Photo-synthesis rate (µmol CO_2 m^{-2}S^{-1})	Chloro-phyll content (mgg^{-1}fw)	Straw weight plant^{-1} (g)	Pods plant^{-1} (no.)	Pod length (cm)	Seeds pod^{-1} (no.)	Seed weight plant^{-1} (g)
V_1T_1	18.0 cd	1.0 d	25.86	2.11 ab	4.83 cde	6.00 c-f	9.36 bc	10.67 a	2.42 c
V_1T_2	15.7 d	1.0 d	30.53	1.84 abc	3.08 de	4.00 ef	9.75 b	10.14 a	1.19 e
V_1T3	20.3bcd	1.1 d	27.86	2.08 ab	3.77 de	5.00 def	9.73 b	10.2 a	2.18 d
V_2T_1	25.3 ab	3.3 ab	26.91	1.76 abc	6.94 abc	15.67ab	6.92 d	10.80 a	3.83 a
V2T_2	24.3 bc	3.3 ab	29.96	1.60cd	6.29 bc	10.00 c	6.86 d	10.20 ab	2.74 b
V_2T3	26.0 a	3.4 a	26.41	1.81abc	7.16 a	15.67 a	6.86 d	10.80 a	3.83 a
V_3T_1	25.0 ab	2.0 cd	25.86	2.19 a	7.39 ab	12.67 b	9.69 bc	11.13 a	2.48 bc
V_3T_2	18.3 cd	2.0 e	37.83	1.08 e	4.36 cde	4.00 ef	10.73 a	6.67 b	1.19 e
V_3T_3	25.0 ab	2.3 bc	29.71	1.72 bc	5.86 cde	8.67 cd	9.60 bc	11.14 a	2.38 c
V_4T_1	21.0bcd	1.0 d	27.13	1.80 abc	4.75 cde	8.00 c	9.66 bc	10.8 a	2.69 a
V_4T_2	15.7 d	1.0 d	38.91	1.20 de	1.79 e	1.34 f	9.53 bc	7.00 ab	0.52 f
V_4T_3	21.3bcd	1.0 d	26.16	2.10 ab	4.70 bcd	5.86 cde	9.41 bc	10.80 a	2.33 cd
F-test	**	**	**NS**	**	**	***	**	**	**

V_1 = Binamoog-5, V_2 = Binamoog-7, V_3= Binamoog-8 and V_4= Binamoog-9; T_1 = Control, T_2 = 36 ^{0}C temperature imposed at flowering stage, T_3 = 36 ^{0}C temperature imposed at pod development stage, NS, not significant, ** significant at 1% level of probability

Evaluation of lentil varieties for temperature tolerance

An experiment was conducted with ten lentil varieties *viz*. Binamasur-2, Binamasur-3, Binamasur-4, Binamasur-5, Binamasur6, Binamasur-7, Binamasur-8, Binamasur-9, Binamasur-10 and BARImasur-5 at pot yard and in plant growth chamber of Bangladesh Institute of Nuclear Agriculture (BINA) during November 2017 to March 2018 to assess the effect of high temperature (34 ^{0}C) at two growth stages like flower initiation stage and pod growth stage on morpho-physiological parameters and seed yield. The 34 ^{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. The nitrate reductase activity, chlorophyll content and photosynthesis rate of leaves were determined during temperature imposed. At harvest, seed yield and yield related parameters were recorded. The collected data were analyzed statistically.

Results indicated that high temperature imposed either at flowering stage or pod growth stage had high significant negative influence on plant parameters (Table 8). But temperature imposed at pod development stage had greater negative influence on morpho-physiological parameters as well as seed yield than temperature imposed at flowering stage. Seed yield drastically reduced under high temperature in all varieties at any growth stages. But the yield loss under high temperature was less in two varieties *viz*., Binamasur-6 and Binamasur-8 (Fig. 1). On the other hand, the higher yield reduction was recorded in Binamasur-2 and Binamasur-3. However, no variety was found tolerant to high temperature.

Table 8. Effect of high temperature at two growth stages on morpho-physiological parameters, seed yield and yield related traits of lentils

34 ^{0}C imposed at	Plant height (cm)	Photo-synthesis rate (µmol CO_2 m^{-2} S^{-1})	Chloro-phyll content (mgg^{-1} fw)	Nitrate reductase (µ mol NO_2/gfw /h)	Total dry mass $plant^{-1}$ (g)	Pods $plant^{-1}$ (no.)	Seeds $plant^{-1}$ (no.)	Seed weight $plant^{-1}$ (g)	Harvest index (%)
Control	29.5a	32.36 a	2.85 a	2.84a	8.53 a	230 a	249.1 a	6.49 a	40.33 a
Flowering stage	27.0c	27.66 b	2.29 b	0.78b	3.16 c	197 b	84.21 b	1.81 b	36.41 b
Pod growth stage	28.2 b	25.05 b	2.14 b	1.52c	3.13 b	181 c	15.91 c	0.74 c	19.12 c
F-test	**	**	**	**	**	**	**	**	**

In a column, figure(s) with same letter do not differ significantly at $P \leq 0.05$ by DMRT;
** indicates significant at 1 % level of probability

Table 9. Variation in morpho-physiological parameters, seed yield and yield attributes of 10 lentil varieties

Variety	Plant height (cm)	Photo-synthesis rate (µmol CO_2 m^{-2} S^{-1})	Chloro-phyll content (mgg^{-1} fw)	Nitrate reductase (µ mol NO_2/gfw/h)	Total dry mass $plant^{-1}$ (g)	Pods $plant^{-1}$ (no.)	Seeds $plant^{-1}$ (no.)	Seed weight $plant^{-1}$ (g)	Harvest index (%)
Binamasur-2	27.6 b	32.66 bc	2.42bcd	1.62 cd	3.75 cd	88.2 b	133.8 b	3.18 bc	38.12 bc
Binamasur-3	28.1 b	26.94 f	1.96e	1.96 a	3.84 bc	75.9 e	116.7 c	3.21 bc	37.05 c
Binamasur-4	25.0 c	30.07 d	2.26cde	1.61 cd	3.45 e	71.0 f	111.1 d	3.04 bc	38.72 b
Binamasur-5	27.4 b	28.56 e	2.81ab	1.87 ab	4.00 ab	78.9 d	119.8 c	3.21 bc	37.21 c
Binamasur-6	30.7 a	32.06 c	2.53bc	1.44 d	3.59 de	69.7 g	103.1 e	2.28 de	33.88 d
Binamasur-7	26.5 bc	36.65 a	2.39cd	1.79abc	3.64 d	75.1 e	110.5 d	2.87 c	37.24 c
Binamasur-8	30.8 a	30.16 d	2.50bc	1.42 d	3.66 d	53.9 h	76.44 f	1.89 e	26.21 f
Binamasur-9	27.6 b	29.61 de	2.07de	1.76abc	4.05 ab	85.8 c	132.4 b	3.59 ab	39.19 ab
Binamasur-10	32.3 a	33.35 b	3.00a	1.71 bc	4.15 a	71.4 f	109.4 d	2.57 cd	31.18 e
BARImasur-5	26.3 bc	26.81 f	2.34cde	1.98 a	4.17 a	98.2 a	150.9 a	3.94 a	41.92 a
F-test	**	**	**	**	**	**	**	**	**

In a column, figure (s) with same letter do not differ significantly at $P \leq 0.05$ by DMRT; ** indicates significant at 1 % level of probability

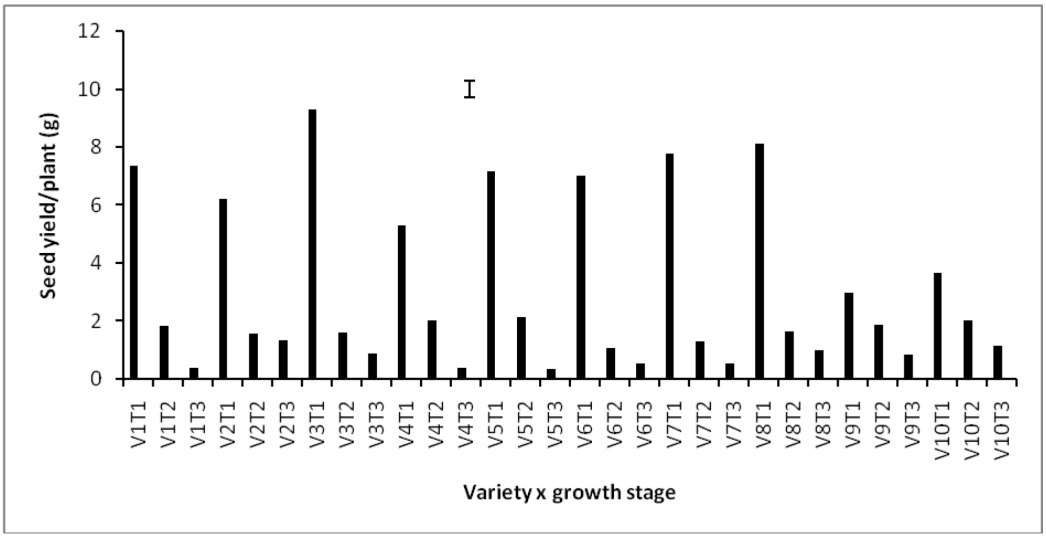


Fig. 1. Interaction effect of high temperature between variety and growth stage on seed yield in lentil. Vertical bar represents LSD (0.05). V1 = Binamasur-2, V2= Binamasur-4, V3= BARImasur-5, V4= Binamasur-10, V5= Binamasur-5, V6= Binamasur-7, V7= Binamasur-3, V8= Binamasur-9, V9= Binamasur-8, V10= Binamasur-6; T1= Control, T2= 34 ^{0}C temperature imposed at flowering stage, T3= 34 ^{0}C temperature imposed at pod growth stage

Identification of sesame genotypes for water logged tolerance

A pot experiment was conducted at BINA pot yard, Mymensingh during February to May 2018 to assess the effect of different duration of water logging on dry matter production and seed yield of ten sesame genotypes. The water logging period was imposed at flowering starting stage and water logging period was: i) control (No water logging), ii) water logged for 48 hours and iii) water logged for 72 hours. Recommended fertilizers and cultural practices were followed. At harvest, seed yield and yield related traits were recorded. The collected data were analyzed statistically.
Results revealed that plant height, number of branches, capsules plant^{-1}, number of seeds capsule^{-1}, total dry matter plant^{-1}, 1000-seed weight, seed yield plant^{-1} were significantly decreased with increasing water logging periods (Table 10). Rajshahi Khoyeri, Kalotil Gopal and Sherpur Black produced higher seed yield under water logging condition and showed more tolerance to water logging (Table 10.)

Table 10. Effect of water logged period on some morph-physiological attributes of 11 sesame genotypes during 2018

Treatments	Plant height (cm)	Branches plant^{-1} (no.)	Total dry weight plant^{-1} (g)	Capsules plant^{-1} (no.)	Seeds capsule^{-1} (no.)	1000-seed weight(g)	Seed weight plant^{-1} (g)
Water logging period							
Control	54.3 a	4.33 a	6.61 a	15.26 a	67.80 a	2.61 a	3.51 a
48 hours	49.5 b	3.90 c	3.71 b	8.70 b	35.37 b	2.09 b	1.72 b
72 hours	47.8 b	3.74 b	2.32 c	6.97 c	20.60 c	1.58 c	0.50 c
F-test	**	**	**	**	**	**	**
Genotype							
Kistotil Chapai	34.7 e	3.67 e	4.40 c	10.30 c	49.44 a	2.20 ab	1.94 bc
Kathtil Chapai	56.9 ab	4.33 c	4.48 bc	10.00 cd	43.67 c	2.16 ab	1.59 de
Rajshahi Khoyeri	55.2 b	4.67 b	4.14 bc	11.33 a	48.67 a	2.39 a	2.70 a
Laltil Gopal	50.7 cd	5.00 a	4.04 c	9.78 cd	34.45 e	2.13 b	1.75 cd

Kalotil Gopal	53.3 bc	4.55 b	4.32 abc	6.78 e	35.56 e	2.39 a	2.60 a
Gopal MV-40	53.4 bc	3.89 d	4.04 bc	9.33 d	37.67 d	2.09 b	1.69 d
Atsia Magura	59.6 a	3.78de	4.57 a	10.11 cd	35.44 e	2.18 ab	1.55 de
Khagra White	37.7 e	1.70 g	3.83 bc	7.44 e	38.22 d	1.55 c	1.41 e
Sherpur Black	56.2 ab	3.22 f	3.94 bc	8.00 de	43.89 c	1.66 c	2.08 b
Binatil-2	47.4 d	5.11 a	4.40 ab	10.00 cd	45.55b	2.20 ab	1.75 cd
F-test	**	**	**	**	**	**	**
CV (%)	**7.47**	**3.19**	**13.40**	**7.52**	**3.83**	**1.47**	**12.67**

In a column, within treatment, figure (s) with same letter do not differ significantly at $P \leq 0.05$ by DMRT; ** indicates significant at 1 % level of probability

Effect of defoliation at reproductive stage on yield in mungbean

A field experiment was conducted at BINA farm, Ishurdi and Magura during March to May 2018 to assess the effect of different levels of defoliation on grain yield of two mungbean varieties *viz*., Binamoog-7 and Binamoog-8. The defoliation levels were: i) control, ii) 50% leaves defoliation from bottom, iii) 50% leaves defoliation from top and iv) 100% defoliation. The defoliation treatments were imposed at flowering starting stage. Recommended fertilizers and cultural practices were followed. At harvest, seed yield and yield related data were recorded. The collected data were analyzed statistically.

Results showed in Ishurdi that all the studied parameters were statistically significant due to different levels of defoliation (Table 11). Results indicated that total dry matter, seed yield and yield related treats were greater in control plants than the defoliated plants. However, 50% leaf defoliation from bottom was less affected than 50% leaf defoliation from top. Seed yield and yield attributes were drastically reduced in 100% defoliation. Considering interaction between variety and defoliation on seed yield and yield related treats, Binamoog-8 was comparatively less affected than Binamoog-7 due to defoliation (Table 12).

Table 11. Effect of different levels of defoliation on seed yield and yield attributes of mungbean varieties at Ishurdi

Defoliation levels	**Total dry weight plant^{-1} (g)**	**Pods plant^{-1} (no)**	**Seeds pod^{-1} (no)**	**100-seed weight (g)**	**Seed weight plant^{-1} (g)**	**Harvest index (%)**	**Shellin g %**	**Seed yield (kg ha^{-1})**
Control (T_0)	13.33 a	19.55 a	11.9 a	3.34 a	4.49 a	33.53 a	65.85 a	1346 a
50% leaf defoliation from bottom (TB_{50})	11.61 b	19.10 a	9.87 b	3.30 a	3.72 b	31.82 b	64.70 a	1072 b (20.25)
50% leaf defoliation from top (TP_{50})	8.96 c	12.45 b	7.54 c	3.17 b	2.80 c	30.20 b	61.40 b	854 c (37.0)
100% leaf defoliation (D_{100})	4.64 d	6.30 c	4.86 d	2.97 c	1.30 d	27.48 c	54.55 c	387 d (71.6)
F-test	**	**	**	**	**	**	**	**
Variety								
Binamoog-7	8.44 b	16.28 a	6.58 b	2.73 b	2.65 b	29.76 b	61.10	773 b
Binamoog-8	10.8 a	12.42 b	8.73 a	3.66 a	4.50 a	31.76 a	62.15	1057 a
F-test	**	**	**	**	**	*	NS	**

In a column, within treatment, figure (s) same letter do not differ significantly at $P \leq 0.05$ by DMRT; *, ** indicates significant at 5 % and 1 % level of probability, respectively; figures in parenthesis indicate percent decreased over control

Table 12. Interaction between variety and defoliation level on seed yield and yield related treats of mungbean at Ishurdi

Interaction		Total dry weight plant^{-1} (g)	Pods plant^{-1} (no)	Seeds pod^{-1} (no)	100-seed weight (g)	Seed weight plant^{-1} (g)	Harvest index (%)	Shelling %	Seed yield (kg ha^{-1})
Variety	**Defoliation level**								
Binamoog-7	To	12.19 bc	23.4 a	11.7 a	2.90 c	3.88 b	31.83 b	66.4 a	1163
	TB_{50}	10.43 c	22.9 a	9.92 b	2.83 c	3.41 c	32.12 b	66.3 a	934 (19.7)
	TP_{50}	7.19 d	12.4 c	7.02 d	2.67 d	2.31 e	29.83 d	60.3 c	694 (40.3)
	T_{100}	3.96 f	6.40 d	4.68 e	2.50 e	1.01 g	25.25 e	51.4 e	299 (74.3)
Binamoog-8	To	14.47 a	15.7 b	12.0 a	3.78 a	5.10 a	35.24 a	65.3 a	1528
	TB_{50}	12.79 ab	15.3 b	9.82 b	3.77 a	4.03 b	31.51bc	63.1 b	1210 (20.8)
	TP_{50}	10.73 c	12.5 c	8.05 c	3.67 a	3.28 d	30.57cd	62.5 b	1013 (33.7)
	T_{100}	5.32 e	6.19 d	5.04 e	3.43 b	1.58 f	29.70 d	57.7 d	475 (68.9)
F-test		*	*	*	*	**	**	*	**

In a column, figure (s) with same letter do not differ significantly at $P \leq 0.05$ by DMRT; *, ** indicates significant at 5 % and 1 % level of probability, respectively; figures in parenthesis indicate decreased in percentage over control.

Study of flowering pattern in ten lentil varieties

A pot experiment was carried out at BINA pot yard, Mymensingh during November 2017 to February 2018 to assess the flowering pattern and its relationship with seed yield of lentil released varieties. The experiment was laid out in a Completely Randomized Design with three replications. Flowers counts were recorded from each plant of each replication just from the date of first flowering and there after every day up to flowering ceased. At harvest, seed yield and yield attributes were recorded. 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. The collected data were analyzed statistically.

Daily flowering converted to 5-day interval had shown differential peak period (Table 13). The flowering duration range from 25 to 40 days after flowering started. The shortest flowering duration was recorded in Binamasur-3 (25 DAF) and the longest was recorded in Binamasur-9 (40 DAF). Binamasur-7 and Binamasur-8 showed greater number of flowers at early flowering period than the others. In contrast, Binamasur-6 produced the lowest flowers at all growth stages. Binamasur-6 showed its earliest flowering peak of 10 days after flowering start (DAF), while BARI masur-5 showed flowering peak at 25 DAF. Other six varieties, Binamasur-2, Binamasur-3, Binamasur-7, Binamasur-8, Binamasur-9 and Binamasur-10 showed its flowering peak at 15 DAF. Binamasur-8 produced the highest number of flowers (686 plant^{-1}) followed by Binamasur-4 (515 plant^{-1}). In contrast, Binamasur-6 produced the lowest number of flowers (254 plant^{-1}). Results indicated that the genotypes which had shorter flowering duration, also showed higher reproductive efficiency (Table 14). The highest seed yield was recorded in Binamasur-8 followed by Binamasur-7 might be due to higher pod production with good dry matter partitioning to economic yield. On the other hand, the lowest seed yield was recorded in Binamasur-10 might be due to poor dry matter portioning to economic yield and smaller size seeds. Binamasur-7 and Binamasur-8 matured earliest (96 days after sowing) and Binamasur-3 and Binamasur-4 took the longest days to maturity (109-110 days after sowing). It may be concluded that high yielding genotypes have higher rate of flowers production with medium to bolder seed size whilst reverse trends hold for the low yielders.

Table 13. Flowering pattern at five-day interval of ten lentil varieties

Varieties	Days to flow-ering	Number of opened flowers at 5 days interval								Total flowers plant^{-1} (no)
		Days after flowering start								
		0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	
Binamasur-2	58 a	24 d	59 d	110 d	49 e	65 cd	59 c	51 b	11 b	428 d
Binamasur-4	60 a	39 b	49 f	81 e	160 a	138 a	48 d	0	0	515 b
BARI masur-5	50 b	29 c	52 f	62 f	64 d	82 b	89 a	67 a	17 a	462 c
Binamasur-10	50 b	26 cd	57 e	69 ef	46 ef	50 e	70 b	45 b	17 a	382 e
Binamasur-5	50 b	23 d	68 c	58 fg	86 c	70 c	44 de	21 c	0	370 e
Binamasur-7	51 b	28 c	110 a	118 c	60 d	59 d	43 e	0	0	418 d
Binamasur-3	60 a	59 a	67 c	140 b	105 b	14 g	0	0	0	385 e
Binamasur-9	51 b	10 e	39 g	66 f	63 d	85 b	73 b	69 a	21 a	426 d
Binamasur-6	51 b	29 c	60 d	54 g	45 f	44 f	22 f	0	0	254 f
Binamasur-8	51 b	36 b	98 b	169 a	106 b	142 a	95 a	40	0	686 a
CV (%)	**1.51**	**9.08**	**8.88**	**13.98**	**10.45**	**14.43**	**17.06**	**21.54**	**25.12**	**13.55**

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

Table 14. Variation in reproductive efficiency, days to maturity, biological yield, yield attributes and seed yield of 10 lentil varieties

Varieties	Repro-ductive efficiency (%)	Days to maturity	Biolo-gical yield (g plant^{-1})	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	100-seed weight (g)	Seed weight plant^{-1} (g)	Harvest index (%)
Binamasur-2	44.4 ab	106 b	15.81 bc	190.4 b	1.65 ab	1.91 c	5.99 c	35.88 bc
Binamasur-4	40.4 b	110 a	16.44 ab	206.0 ab	1.69 a	1.60 e	5.57 cd	31.88 f
BARImasur-5	32.7 d	106 b	14.76 cd	151.0 c	1.63 b	2.15 a	5.55 d	35.60 bcd
Binamasur-10	40.3 bc	99 de	12.47 e	154.7 c	1.58 c	1.67 de	4.07 g	31.64 f
Binamasur-5	36.8 cd	103 c	13.10 de	136.9 d	1.63 b	2.17 a	5.02 ef	36.32 b
Binamasur-7	45.9 a	96 e	16.65 ab	192.8 b	1.65 ab	2.09 ab	6.93 b	39.62 ab
Binamasur-3	41.6 b	109 a	13.25 de	160.5 c	1.59 c	1.80 d	4.57 f	32.49 de
Binamasur-9	45.5 a	101cd	13.64 d	194.2 b	1.61 bc	1.91 c	5.74 cd	40.08 a
Binamasur-6	45.3 a	103 c	12.92 e	115.9 e	1.72 a	2.18 a	4.53 f	33.06 d
Binamasur-8	31.3 d	96 e	17.13 a	215.0 a	1.69 a	1.99 b	7.51 a	42.42 a
CV (%)	**13.24**	**1.88**	**10.11**	**14.42**	**3.25**	**1.98 b**	**8.90**	**8.41**

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

Debranching effect on morpho-physiological attributes and seed yield of sesame

A pot experiment was conducted at BINA pot yard, Mymensingh during February to May 2018 to assess the effect of different levels of debranching on yield of two sesame varieties viz. Binatil-2 and Binatil-3. The debranching levels were: i) control, ii) mainstem (MS) only, iii) MS with 1 branch, iv) MS with 2 branches, v) MS with 3 branches and vi) MS with 4 branches. Control plants had 5-6 branches/plant. Recommended fertilizers and cultural practices were followed. The treatments were imposed after branch initiation and maintained up to harvest. The collected data were analyzed statistically.

Results showed that debranching had no significant effect on plant height, photosynthesis, chlorophyll content and seed size (Table 15). The higher pod yield was recorded in mainstem with 2 and 3 branches with being the highest in mainstem with 3 branches. The pod yield was higher in mainstem with 2 branches and mainstem with 3 branches due to increase number of pods plant^{-1}. The third highest pod yield was recorded in mainstem with 4 branches. The lowest pod yield was recorded in uniculm plant due to fewer pod plant^{-1}.

Table 15. Effect of debranching on physiological parameters and yield contributing characters of sesame variety

Treatments	Chlorophyll content (SPAD reading)	Photosyn-thesis at flowering stage (μmolCO$_2$m^{-2} s^{-1})	Plant height (cm)	Pods plant^{-1} (no)	Dry weight plant^{-1} (g)	Pod yield plant^{-1} (g)	1000-seed weight (g)
Debranching levels							
Control (T_0)	48.08	57.80	72.00	42.33 c	10.32 c	9.58 b	3.30
Mainstem only(T_1)	49.83	57.97	71.08	18.00 e	8.59 d	4.52 c	3.18
Mainstem with one branch(T_2)	48.55	57.58	73.25	31.00 d	10.58 c	8.45 b	3.20
Mainstem with two branches(T_3)	50.02	57.47	74.67	58.67 a	11.47 a	14.25 a	3.22
Mainstem with three ranches(T_4)	48.97	57.55	71.50	59.67 a	10.45 c	14.34 a	3.23
Mainstem with four branches(T_5)	49.77	57.67	72.08	50.00 b	11.09 b	13.75 a	3.20
F-test	**NS**	**NS**	**NS**	**	**	**	**NS**
Varieties							
Binatil-2 (v_1)	47.19	57.19	69.86	44.89 a	10.69	11.03	3.20
Binatil-3 (v_2)	49.21	58.15	70.33	40.67 b	10.15	10.60	3.21
F-test	**NS**	**NS**	**NS**	**	**NS**	**NS**	**NS**

In a column, figure (s) with same letter indicates do not differ significantly at P≤0.05; **, significant at 1% level of probability; NS, not significant

Debranching effect on reproductive characters and fruit yield in tomato

A field experiment was conducted at BINA pot yard, Mymensingh during the winter season of 2017-18 to assess the effect of different levels of debranching on reproductive efficiency and yield of tomato *cv*. TM-4. The debranching levels were: i) control, ii) mainstem (MS) only, iii) MS with 1 branch, iv) MS with 2 branches, v) MS with 3 branches and vi) MS with 4 branches. Control plants had 5-6 branches/plant. Recommended fertilizers and cultural practices were followed. The treatments were imposed after branch initiation and maintained up to harvest.

Results showed that all the studied parameters were statistically significant due to different levels of debranching (Table 16). The highest number of effective flower clusters, flowers and fruits/plant were recorded in the treatment of MS with 4 branches followed by the treatment MS with 3 branches (62.4). The highest contribution by branches was also recorded by the treatment

MS with 4 branches followed by MS with 3 branches with same statistical rank. In contrast, the lowest number of effective flower clusters, flowers and fruits plant^{-1} were recorded in the treatment of MS only. The plants of MS only produced largest fruits than the others and the control plants produced the smallest traits. Results further indicated that fruit size and reproductive efficiency decreased with increasing branch number. The highest fruit yield plant^{-1} was recorded in the treatment of MS with 4 branches due to increase number of fruits. On the other hand, the lowest fruit yield was recorded in control plant due to smaller size fruits. The plants of MS with 2 or 3 branches produced the second highest fruit yield.

Table 16. Effect of debranching on morphological, yield and yield attributes of tomato cv. TM-4

Treatments	**Effective flower clusters Plant^{-1} (no.)**	**Flowers plant^{-1} (no)**	**Fruits Plant^{-1} (no.)**	**Single fruit weight (g)**	**Fruit weight plant^{-1} (kg)**	**Repro-ductive effi-ciency (%)**	**Branch contri-bution to fruit yield (%)**
Control	8.50 ab	67.5 b	23.0 bc	64.1 d	1.47 c	34.1 b	23.5 b
Main stem (MS) only	6.00 d	53.0 d	20.0 c	80.1 a	1.60 bc	37.7 ab	---
MS + 1 branch	7.67 c	58.6 c	23.7 b	75.5 b	1.79 ab	40.4 a	16.7 c
MS + 2 branches	8.17 b	66.3 b	25.0 b	72.9 c	1.82 ab	37.7 ab	18.7 c
MS + 3 branches	8.67 ab	66.7 b	24.8 b	74.0 b	1.83 ab	37.2 ab	30.3 a
MS + 4 branches	10.0 a	84.9 a	29.0 a	71.5 c	2.10 a	34.2 b	31.3 a
CV (%)	**7.60**	**11.24**	**9.37**	**4.02**	**7.55**	**10.14**	**8.34**

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

Morpho-physiological evaluation of three promising mutants of tomato

The experiments were carried out with three advanced tomato genotypes *viz*. TM-4, TM-5, TM-8 along with two check varieties, Binatomato-7 and Binatomato-11 at different locations during November 2017-March 2018. The locations were BINA farm, Mymensingh, Rangpur, Magura and Ishurdi and farmers' field at Sutiakhali, Mymensingh, Rangpur and Magura. The experiments were laid out following a randomized complete block design with three replicates having a unit plot size of 4 m × 5 m. Row to row and plant to plant distances were 50 cm. Recommended doses of fertilizers were used and proper cultural practices were done as and when necessary. Data on morphological, yield and yield attributes were recorded at harvest from 10 randomly selected plants in each plot and fruit yield was taken from the whole plot and converted into kg/ha. The collected data were analyzed statistically.

Results revealed that all the studied parameters were significantly different among the genotypes (Tables 17-24). The variety, Binatomato-11 was the shortest one. On the other hand, the mutant TM-8 was the tallest. TM-5 produced the highest number of branches whilst Binatomato-11 the lowest. The mutant TM-5 produced the highest number of fruits/plant with larger fruit size than the two varieties and gave the highest fruit yield at most of locations (Table 24). The second and third highest fruit yield was recorded in TM-8 and TM-4, respectively. Considering yield performance over locations (Table 24), TM-5 showed the highest fruit yield at 5 locations out of 7 locations. TM-8 showed the highest fruit yield at 2 locations out of 7 locations followed by TM-4. The two varieties, Binatomato-7 and Binatomato-11 showed poor yield performance as compared to other 3 mutants at all locations. The mutant TM-5 performed the best followed by TM-8 and TM-4.

Table 17. Mean performance of five tomato genotypes on morphological, yield attributes and yield at Mymensingh during 2017-18

Genotypes	Plant height (cm)	Branches plant^{-1} (no.)	Fruits plant^{-1} (no.)	Single fruit weight (g)	Fruit weight plant^{-1} (kg)	Fruit yield (t ha^{-1})
TM-4	128.1 a	4.77 a	51.55 b	60.57 b	2.03 b	81.33 c
TM-5	130.2 a	4.77 a	64.33 a	69.86 a	2.56 a	102.4 a
TM-8	126.3 ab	4.00 bc	49.89 bc	61.50 b	2.37 a	94.80 b
Binatomato-7	121.8 b	4.30 ab	38.44 d	57.57 c	1.48 c	59.20 e
Binatomato-11	109.0 c	3.78 c	47.22 c	55.44 c	1.73 b	69.20 d
CV (%)	**5.23**	**11.19**	**9.34**	**4.80**	**10.39**	**12.22**

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

Table 18. Mean performance of five tomato genotypes on morphological, yield attributes and yield at farmer's field, Sutiakhali, Mymensingh during 2017-18

Genotypes	Plant height (cm)	Branches plant^{-1} (no.)	Fruits plant^{-1} (no.)	Single fruit weight (g)	Fruit weight plant^{-1} (kg)	Fruit yield (t ha^{-1})
TM-4	126.3 a	6.26 a	37.78 b	59.70 b	1.80 b	72.0 bc
TM-5	124.2 a	5.41 b	42.89 a	65.89 a	2.26 a	90.4 a
TM-8	122.8 a	4.67 c	31.44 c	67.31 a	1.69 b	67.6 c
Binatomato-7	125.7 a	6.00 a	35.89 bc	61.90 ab	1.78 b	71.2 bc
Binatomato-11	101.5 b	5.02 bc	44.77 a	53.05 c	1.90 ab	76.1 b
CV (%)	**5.00**	**8.56**	**14.05**	**3.99**	**9.54**	**8.73**

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

Table 19. Mean performance of five tomato genotypes on morphological, yield attributes and yield at Magura farm during 2017-18

Genotypes	Plant height (cm)	Branches plant^{-1} (no.)	Fruits plant^{-1} (no.)	Single fruit weight (g)	Fruit weight plant^{-1} (kg)	Fruit yield (t ha^{-1})
TM-4	104.9 ab	3.40 b	26.32 a	58.89 b	1.55 ab	65.33 ab
TM-5	106.5 a	4.13 a	23.90 ab	71.55 a	1.71 a	73.43 a
TM-8	107.0 a	4.00 a	21.08 bc	73.31 a	1.44 bc	59.91 c
Binatomato-7	102.2 b	3.37 b	22.00 b	70.00 a	1.54 ab	64.87 bc
Binatomato-11	90.87 c	3.27 b	19.60 c	53.78 c	1.25 c	50.41 d
CV (%)	**3.94**	**6.91**	**13.54**	**3.87**	**8.11**	**6.70**

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

Table 20. Mean performance of five tomato genotypes on morphological, yield attributes and yield at farmer's field, Magura during 2017-18

Genotypes	Plant height (cm)	Branches plant^{-1} (no.)	Fruits plant^{-1} (no.)	Single fruit weight (g)	Fruit weight plant^{-1} (kg)	Fruit yield (t ha^{-1})
TM-4	119.7 c	3.77 b	27.68 a	62.14 b	1.72 a	84.33 ab
TM-5	124.7 b	4.16 a	25.48 ab	68.29 ab	1.74 a	86.44 a
TM-8	129.5 a	3.88 b	23.17 b	74.31 a	1.59 a	82.88 b
Binatomato-7	122.6 bc	4.22 a	26.10 a	63.98 b	1.67 a	80.66 b
Binatomato-11	109.1 d	4.09 ab	23.25 b	56.08 c	1.36 b	65.37 c

CV (%)	4.02	12.16	11.63	5.32	7.50	8.48

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

Table 21. Mean performance of five tomato genotypes on morphological, yield attributes and yield at Ishurdi farm during 2017-18

Genotypes	Plant height (cm)	Branches plant^{-1} (no.)	Fruits plant^{-1} (no.)	Single fruit weight (g)	Fruit weight plant^{-1} (kg)	Fruit yield (t ha^{-1})
TM-4	112.3 b	3.59 b	26.00 cd	59.61 bc	1.55 ns	62.0 b
TM-5	115.6 ab	4.15 a	28.67 bc	61.00 b	1.69	69.9 a
TM-8	118.2 a	3.94 a	24.53 d	70.23 a	1.72	68.4 a
Binatomato-7	112.4 b	3.80 ab	29.67 b	55.84 c	1.59	68.4 a
Binatomato-11	100.0 c	3.68 b	38.33 a	41.65 d	1.60	63.9 b
CV (%)	**6.67**	**9.98**	**7.79**	**4.51**	**8.94**	**7.88**

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

Table 22. Mean performance of five tomato genotypes on morphological, yield attributes and yield at Rangpur farm during 2017-18

Genotypes	Plant height (cm)	Branches plant^{-1} (no.)	Fruits plant^{-1} (no.)	Single fruit weight (g)	Fruit weight plant^{-1} (kg)	Fruit yield (t ha^{-1})
TM-4	126.3 a	6.27 a	53.87 a	58.82 ab	2.62 a	95.30 b
TM-5	124.2 a	5.40 b	55.07 a	61.93 a	2.86 a	104.4 a
TM-8	125.7 a	4.67 d	42.93 b	67.08 a	2.88 a	105.2 a
Binatomato-7	121.8 a	5.89 ab	27.40 c	62.04 a	1.70 b	68.00 c
Binatomato-11	101.8 b	5.00 c	21.33 d	50.66 b	1.12 c	53.22 d
CV (%)	**5.16**	**10.43**	**16.06**	**3.66**	**9.81**	**12.42**

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

Table 23. Mean performance of five tomato genotypes on morphological, yield attributes and yield at Rangpur farmer's field during 2017-18

Genotypes	Plant height (cm)	Branches plant^{-1} (no.)	Fruits plant^{-1} (no.)	Single fruit weight (g)	Fruit weight plant^{-1} (kg)	Fruit yield (t ha^{-1})
TM-4	108.5 a	4.67 b	44.30 a	60.57 b	1.99 a	79.6 b
TM-5	105.4 a	5.30 a	41.03 ab	62.81 a	2.03 a	81.2 b
TM-8	106.8 a	5.00 a	42.67 a	64.96 a	2.24 a	89.6 a
Binatomato-7	103.2 b	4.23 bc	38.67 b	55.56 c	1.58 b	63.2 c
Binatomato-11	96.61 c	4.01 c	32.87 c	46.11 d	1.16 c	51.4 d
CV (%)	**4.66**	**13.12**	**11.58**	**2.77**	**9.99**	**7.49**

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

Table 24. Mean performance of tomato genotypes over locations on fruit yield

Genotypes	Fruit yield (t ha^{-1})							
	Locations							
	Mymen-singh farm	Mymen-singh farmer's field	Magura farm	Magura farmer's field	Rangpur farm	Rangpur farmer's field	Ishurdi farm	Mean

TM-4	81.33 c	72.0 bc	65.33 ab	84.33 ab	95.30 b	79.6 b	62.0 b	77.13 b
TM-5	102.4 a	90.4 a	73.43 a	86.44 a	104.4 a	81.2 b	69.9 a	87.03 a
TM-8	94.80 b	67.6 c	59.91 c	82.88 b	105.2 a	89.6 a	68.4 a	81.20 b
Binatomato-7	59.20 e	71.2 bc	64.87 bc	80.66 b	68.00 c	63.2 c	68.4 a	67.93 c
Binatomato-11	69.20 d	76.1 b	50.41 d	65.37 c	53.22 d	51.4 d	63.9 b	61.37 d

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

Evaluation of two cherry type tomato genotypes based on fruit yield potential

The experiment was carried out with two advanced cherry type tomato genotypes *viz.* Cherolla and TB Red along with one check variety Binatomato-10 at 5 locations during November 2017-March 2018. The locations were BINA farm, Mymensingh, Jamalpur, Rangpur, Magura and Ishurdi. The experiment was laid out following a randomized complete block design with three replicates having a unit plot size of 4 m × 5 m. Row to row and plant to plant distances were 50 cm. Recommended doses of fertilizers were used and proper cultural practices were done as and when necessary. Data on morphological, yield and yield attributes were recorded at harvest from 10 randomly selected plants in each plot and fruit yield was taken from the whole plot and converted into kg ha^{-1}.

Results revealed that all the studied parameters were significantly different among the genotypes except fruit weight plant^{-1} at Rangpur (Tables 25-30). The genotype, TB Red was the shortest one. The shortest genotype also produced greater number of branches plant^{-1} than the other two genotypes and Cherolla produced the lowest number of branches plant^{-1}. Among three genotypes, Cherolla performed the poorest in case of yield attributes and fruit yield at all five locations. The variety, Binatomato-10 produced the highest fruit yield at only one location out of five locations whilst TB Red performed the best at four locations out of five. The fruit yield was higher in TB Red due to increase number of fruits plant^{-1}. Considering the mean yield performance over locations, the genotype TB Red performed the best followed Binatomato-10 (Table 26). Cherolla performed the lowest.

Table 25. Mean performance of three tomato genotypes on morphological, yield attributes and yield conducted at Mymensingh during 2017-18

Genotypes	Plant height (cm)	Branches plant^{-1} (no.)	Fruits plant^{-1} (no.)	Single fruit weight (g)	Fruit weight plant^{-1} (kg)	Fruit yield (t ha^{-1})
Cherolla	139.0 a	8.07 b	189.3 c	10.3 a	1.94 ns	77.60 b
TB Red	31.24 c	10.3 a	222.6 b	9.37 b	2.08	83.21 a
Binatomato-10	125.1 b	10.6 a	258.5 a	8.82 c	2.12	81.80 ab

In a column, figure (s) with same letter do not differ significantly at P≤ 0.05 by DMRT; ns, not significance

Table 26. Mean performance of three tomato genotypes on morphological, yield attributes and yield conducted at Jamalpur during 2017-18

Genotypes	Plant height (cm)	Branches plant^{-1} (no.)	Fruits plant^{-1} (no.)	Single fruit weight (g)	Fruit weight plant^{-1} (kg)	Fruit yield (t ha^{-1})
Cherolla	161.0 a	7.00 b	129.4 b	8.22 b	1.06 c	42.40 c
TB Red	44.30 b	9.67 ab	268.1 a	8.92 a	2.39 a	85.65 a
Binatomato-10	157.3 a	11.3 a	268.4 a	7.68 c	2.06 b	72.41 b

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

Table 27. Mean performance of three tomato genotypes on morphological, yield attributes and yield conducted at Magura farm during 2017-18

Genotypes	Plant height (cm)	Branches plant^{-1} (no.)	Fruits plant^{-1} (no.)	Single fruit weight (g)	Fruit weight plant^{-1} (kg)	Fruit yield (t ha^{-1})
Cherolla	168.6 a	7.87 c	79.97 c	8.51 a	0.78 c	37.08 c
TB Red	44.10 c	8.67 b	149.4 b	8.42 a	1.26 b	54.40 b
Binatomato-10	155.2 b	10.1 a	220.0 a	7.65 b	1.68 a	66.20 a

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

Table 28. Mean performance of three tomato genotypes on morphological, yield attributes and yield conducted at Ishurdi farm during 2017-18

Genotypes	Plant height (cm)	Branches plant^{-1} (no.)	Fruits plant^{-1} (no.)	Single fruit weight (g)	Fruit weight plant^{-1} (kg)	Fruit yield (t ha^{-1})
Cherolla	164.5 a	7.44 b	128.9 c	8.76 a	1.12 c	46.8 c
TB Red	45.10 c	11.3 a	231.0 a	8.68 a	2.01 a	80.2 a
Binatomato-10	149.5 b	10.7 a	171.8 b	7.72 b	1.32 b	57.8 b

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

Table 29. Mean performance of five tomato genotypes on morphological, yield attributes and yield conducted at Rangpur farm during 2017-18

Genotypes	Plant height (cm)	Branches plant^{-1} (no.)	Fruits plant^{-1} (no.)	Single fruit weight (g)	Fruit weight plant^{-1} (kg)	Fruit yield (t ha^{-1})
Cherolla	172.6 a	9.07 c	180.7 c	8.72 a	1.57 c	62.80 c
TB Red	48.80 c	18.7 a	492.1 a	8.03 b	3.95 a	118.0 a
Binatomato-10	164.1 b	14.2 b	368.0 b	7.66 c	2.82 b	83.82 b

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

Table 30. Mean performance of five tomato genotypes over five locations on fruit yield

Genotypes	Days to maturity	Fruit yield (t/ha)					
		Locations					
		Mymensingh	Jamalpur	Magura	Ishurdi	Rangpur	Mean
Cherolla		77.60 b	42.40 c	37.08 c	46.8 c	62.80 c	53.34 c
TB Red		83.21 a	85.65 a	54.40 b	80.2 a	118.0 a	84.29 a
Binatomato-10		81.80 ab	72.41 b	66.20 a	57.8 b	83.82 b	72.41 b

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

Morpho-physiological evaluation of lentil mutants

Twelve lentil mutants were selected in M3 generation derived from Binamasur-8 through gamma mutagenesis. Performance of twelve promising mutants viz., LMI-1, LMI-2, LMI-3, LMM-1, LMM-2, LMM-3, LMM-4, LMM-5 LMM-6, LMM-7, LMM-8, LMM-9 and a check variety of Binamasur-8 were evaluated at BINA farm Magura and Ishurdi during the winter season of 2017-18. The experiment was laid out in a randomized complete block design with three replications. Recommended fertilizers and intercultural practices were followed for proper growth and development of the plants. The yield contributing characters were recorded at harvest from ten competitive plants of each plot. The collected data were analyzed statistically.

Results revealed that all studied mutants were out yielded than the check variety, Binamasur-8. Mutant LMM-7 produced higher seed yield per plant in both the locations due to the production of higher number of pods plant^{-1} (Table 31). Mutants LMI-3 and LMM-7 produced higher seed yield per plant in Ishurdi and Magura due to the production of higher number of pods plant^{-1}.The harvest index was also superior in these two mutants. In contrast, the lower seed yield was recorded in LMM-5, LMM-6, LMM-7 (767 kg/ha), LM-9 and LM -3 (853 kg/ha) and LM-6 and LM -1 (962 kg/ha) due to inferiority in yield attributes and also poor dry matter partitioning to economic yield. Based on the superior yield attributes and yield, two mutants, LMM-4 and LMM-7 may be selected for further field trial at different agro-ecological zones of Bangladesh for confirmation the results.

Table 31. Variation in seed yield and yield components of lentil mutants conducted at Magura and Ishurdi farm during 2017-18

	Magura					Ishurdi				
Variety/ Mutant	**Plant height (cm)**	**Branches plant^{-1} (no.)**	**Pods plant^{-1} (no.)**	**Seed pod^{-1} (no.)**	**Seed weight plant^{-1} (g)**	**Plant height (cm)**	**Branches plant^{-1} (no.)**	**Pods plant^{-1} (no.)**	**Seed pod^{-1} (no.)**	**Seed weight plant^{-1} (g)**
LMI-1	30.60	12.47	176	1.73	4.52	33.93	17.07	341	1.63	6.30
LMI-2	30.73	11.93	98	1.80	2.43	33.47	17.40	395	1.90	7.44
LMI-3	30.20	12.27	105	1.70	3.53	30.93	17.80	494	1.67	8.67
LMM-1	30.40	12.60	131	1.50	4.46	31.27	12.93	341	1.57	4.96
LMM-2	28.27	12.27	127	1.60	4.27	33.33	13.73	462	1.67	6.85
LMM-3	31.73	12.47	108	1.57	3.46	30.13	13.67	405	1.73	7.99
LMM-4	33.53	12.80	159	1.47	5.15	33.67	14.13	376	1.67	6.58
LMM-5	32.47	12.27	133	1.80	4.30	31.33	13.53	262	1.83	6.30
LMM-6	34.33	12.67	136	1.93	4.44	31.07	15.20	429	1.73	8.19
LMM-7	32.47	12.53	156	1.83	4.88	32.00	14.53	462	1.83	8.71
LMM-8	32.00	12.53	120	1.70	3.90	31.07	14.67	290	1.57	6.44
LMM-9	32.27	12.33	130	1.60	4.20	37.07	13.80	389	1.70	8.00
Binamasur-8	33.27	12.13	87	1.87	2.86	35.07	14.27	272	1.73	5.30
$LSD_{0.05}$	**2.06**	**0.44**	**12.79**	**0.28**	**0.81**	**2.14**	**1.97**	**51.34**	**0.11**	**1.46**

Morpho-physiological evaluation of some selected mungbean mutants

The experiments were conducted during Kharif-I season of 2018 at two locations *viz.*, BINA farm, Magura and Ishurdi with thirteen mungbean mutants along with one check variety (Binamoog-8). The experiments were laid out in a randomized complete block design with three replications having a unit plot size of 2 m × 1.5 m. Row to row and plant to plant distances were 30 cm and 10 cm, respectively. Urea, triple superphosphate and muriate of potash were applied at the rate of 40, 120 and 80 kg/ha, respectively at the time of final land preparation. Proper cultural practices were followed as and when necessary. Data on morphological and yield attributes were recorded at harvest from 10 randomly selected plants in each plot and seed yield was taken from the whole plot and converted into kg/ha.

Results showed that MM-5 was the shortest one with the highest number of branches (Tables 32 and 33). However, high yielding genotypes, in general, had greater number of branches plant^{-1} than the low yielding ones. Eight mutants/genotypes matured synchronous in nature. Six mutants out of thirteen showed out yielded than check variety, Binamoog-8. The higher seed yield at both locations was observed in two mutants, MM-8 and MM-12 with being the highest in MM-8 due to the production of higher number of pods plant^{-1}. These two mutants also showed synchrony in maturity. The lowest seed yield at both locations was observed in MM-4. Considering location effect, results showed that all the mutants performed better at Magura than Ishurdi. Two mutants, MM-8 and MM-12 were found promising in seed yield.

Table 32. Variation in seed yield and yield components of mungbean mutants conducted at BINA farm, Ishurdi during March-May 2018

Variety/ Mutants	Plant height (cm)	Branches plant^{-1} (no.)	Pod length (cm)	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	Seed weight plant^{-1} (g)	Seed yield (kg ha^{-1})	% maturity at 1st harvest
MM-1	56.20	1.40	11.27	21.13	11.27	5.93	1779	88.56
MM-2	50.53	0.77	9.50	24.80	9.50	5.18	1554	85.52
MM-3	49.67	1.57	11.53	25.93	11.53	3.49	1047	57.44
MM-4	42.47	1.33	10.90	17.60	10.90	3.07	921	81.16
MM-5	37.20	1.40	11.33	22.13	11.33	5.88	1764	85.40
MM-6	45.00	1.50	9.47	19.07	9.47	4.88	1464	80.67
MM-7	48.80	0.80	11.13	26.47	11.13	4.42	1326	61.45
MM-8	42.13	0.97	9.97	20.40	9.97	6.06	1818	83.00
MM-9	45.47	0.97	10.67	17.80	10.67	4.75	1425	76.82
MM-10	46.33	1.07	10.17	18.70	10.17	4.12	1236	85.75
MM-11	47.40	1.00	10.93	18.38	10.93	5.21	1563	80.52
MM-12	54.60	0.77	11.10	18.07	11.10	5.93	1779	79.81
MM-13	57.90	1.07	11.63	17.13	11.63	4.75	1425	93.48
Binamoog-8	55.20	1.40	11.33	16.63	11.33	5.07	1521	82.05
$LSD_{0.05}$	**3.03**	**0.3**	**0.72**	**1.29**	**ns**	**0.72**	**216**	**2.41**

Table 33. Yield and yield components of mungbean mutants conducted at BINA farm, Magura in Kharif-I season of 2018

Variety/ Mutants	Plant height (cm)	Branches plant^{-1} (no.)	Pod length (cm)	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	Seed weight plant^{-1} (g)	Seed yield (kg ha^{-1})	% maturity at 1st harvest
MM-1	54.0	1.27	8.62	45.23	12.40	4.71	1413	65.32
MM-2	54.7	2.37	7.61	47.63	11.63	6.12	1836	87.19
MM-3	47.5	2.42	8.21	39.95	11.70	6.25	1875	81.38
MM-4	44.1	2.33	8.27	26.47	12.00	7.62	1286	91.82
MM-5	40.9	2.20	8.85	42.07	11.90	5.94	1782	71.50
MM-6	47.7	2.00	8.19	39.37	12.31	5.49	1647	77.60
MM-7	51.7	2.00	7.62	42.00	12.20	5.84	1752	80.44
MM-8	38.4	1.87	8.87	40.13	11.50	7.64	2292	85.71
MM-9	46.5	2.13	9.16	38.07	11.59	6.41	1923	80.10
MM-10	48.2	1.40	7.62	39.20	11.77	4.37	1311	90.69
MM-11	49.7	2.20	9.15	41.53	11.80	7.03	2109	84.08
MM-12	65.7	2.67	8.66	58.33	11.53	6.75	2025	79.01
MM-13	58.0	1.93	8.71	50.20	12.57	6.64	1992	79.42
Binamoog-8	69.0	1.33	7.71	40.33	11.80	5.50	1650	50.73
$LSD_{0.05}$	**2.52**	**0.32**	**1.01**	**2.75**	**ns**	**0.79**	**237**	**2.64**

Effect of silicon on yield of Aman rice

During July-December 2017, a pot experiment was set to determine the effective does of silicon, on yield components of Aman rice. Three silicon doses *viz*., 5, 10 and 15 kg ha^{-1} were applied on four rice mutants (N_4/350/P-4(5), N_{10}/350/P-5-4, B10 and B11) and two varieties (Binadhan-17 and BRRI dhan71). The experiment was conducted at BINA farm Mymensingh following Complete Randomized Design with three replications. Thirty day old seedlings were transplanted in plastic pots containing 11 kg soils pot^{-1} on July 2017. Recommended doses of fertilizers were applied and cultural practices were done whenever required. Na-silicate was added as a source of silicon at the time of transplanting. At harvest, yield and yield related parameters were recorded from each pot. The collected data were analyzed statistically.

Results showed that application of silica had no significant effect on plant height, tillers production, panicle length and grain size. Effective tiller hill^{-1}, filled grain panicle^{-1} and grain weight hill^{-1} were significantly influenced by silicon application (Table 34). Among four doses, silicon @ 10 kg ha^{-1} showed better performance on yield attributes thereby grain yield. The dry matter partitioning to economic yield was also better in 10 kg Si ha^{-1}. BRRIdhan71 performed the best due to higher grains panicle^{-1}. Interaction effect between silicon dose and genotype, result indicated that all genotypes increased the highest grain yield when applied silicon @ 10 kg ha^{-1}(Table 35).

Table 34. Yield and yield attributes of rice genotypes under different water stress levels in 2016-17

Treatment	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-grain weight (g)	Grain weight hill^{-1} (g)	Straw weight hill^{-1} (g)	Harvest index (%)
Silicon @ kg/ha										
Control	91.59	21.83	17.22 b	23.88	118.9 b	34.72 b	22.77	23.22 b	37.29 a	38.37 b
15	89.56	20.33	17.06 b	23.78	124.1 ab	26.90 c	22.66	24.22 b	33.07 ab	42.28 b
10	91.81	21.67	20.61 a	23.98	133.1 a	40.02 a	22.58	28.25 a	30.74 b	52.11 a
5	90.13	21.61	17.90 b	23.16	119.4 b	29.58 c	22.67	23.10 b	32.01 b	42.00 b
F-test	**NS**	**NS**	**	**NS**	**	**	**NS**	**	**	**
Genotype										
Binadhan-17	78.65 d	21.83 a	17.66 b	19.39 d	128.7 b	29.61 c	21.21 b	29.29 a	36.03 b	44.84 b
N_4/350/P-4(5)	84.74 c	20.58 a	18.50 b	22.03 cd	97.68 c	38.10 b	21.14 b	26.63 ab	26.87 e	49.78 a
N_{10}/350/P-5-4	79.08 d	22.92 a	19.42 ab	23.01 bc	122.3 bc	32.53 bc	21.06 b	21.32 c	28.80 de	42.54 b
BRRI dhan71	103.3 a	16.00 b	14.16 b	25.04 ab	160.6 a	53.43 a	24.33 a	24.84 b	41.64 a	44.00 b
B-10	94.91 b	24.50 a	20.92 a	27.28 a	127.4 b	23.07 cd	24.49 a	24.29 bc	33.36 bc	42.13 b
B -11	103.9 a	22.33 a	18.50 b	25.41 ab	106.6 c	20.08 d	23.78	27.10 b	32.93 c	38.70 c

F-test	**	**	**	**	**	**	*	**	**	**

In a column, values having common letter(s) within treatment do not differ significantly at P≤0.05

Table 35. Interaction effect of silicon dose on yield and yield components of aman rice genotypes

Interaction	Effective tillers hill^{-1} (no.)	Filled grains panicle^{-1} (no.)	Grain weight hill^{-1} (g)
T_1V_1	19.33 a-d	103.5 e-h	20.10 ef
T_1V_2	22.67 ab	100.9 f-h	29.22 a-e
T_1V_3	21.33 a-c	121.9 c-g	22.61 b-f
T_1V_4	17.00 b-e	146.6 a-d	23.92 b-f
T_1V_5	19.33 a-d	135.9 b-f	30.73 a-c
T_1V_6	20.33 a-c	104.3 e-h	30.72 a-c
T_2V_1	17.33 b-e	139.0 a-e	31.58 ab
T_2V_2	17.00 b-e	90.87 gh	28.42 a-e
T_2V_3	18.00 a-d	119.5 d-g	21.68 c-f
T_2V_4	11.67 e	155.7 a-c	20.95 d-f
T_2V_5	19.67 a-d	126.4 c-g	23.33 b-f
T_2V_6	18.67 a-d	113.1 d-h	22.76 b-f
T_3V_1	15.67 c-e	144.4 a-d	30.22 a-d
T_3V_2	18.00 a-d	116.7 d-h	27.29 a-e
T_3V_3	23.67 a	121.3 c-g	25.32 b-f
T_3V_4	14.00 de	170.5 a	21.38 c-f
T_3V_5	22.67 ab	121.0 c-g	21.26 c-f
T_3V_6	19.00 a-d	124.8 c-g	32.03 ab
T_4V_1	18.33 a-d	128.0 c-f	35.29 a
T_4V_2	16.33 c-e	82.20 h	21.61 c-f
T_4V_3	17.67 a-e	126.5 c-g	15.68 f
T_4V_4	14.00 de	169.7 ab	21.13 c-f
T_4V_5	21.00 a-c	126.4 c-g	21.86 c-f
T_4V_6	16.00 c-e	84.1 h	22.89 b-f

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT; V_1= Binadhan-17, V_2 =N_4/350/P-4(5), V_3= N_{10}/350/P-5-4, V_4= BRRI dhan71, V_5= B10 & V_6-B11, T_1=Control, T_2= Si @ 15 kg/ha, T_3=Si @ 10 kg/ha &T_4= Si @ 5 kg/ha.

Effect of silicon on yield of Boro rice under salinity

A pot experiment was carried out at BINA farm, Mymensingh to assess the effects of silicon (Si) on salinity stress of Boro rice on the basis of morphology and yield attributes. Two varieties (Binadhan-8 and Binadhan-10) were used as planting material. Four treatments were applied i) Control, ii) 6 dSm^{-1} salinity, iii) 10 kg ha^{-1} silicon and iv) 6 dSm^{-1} salinity+10 kg ha^{-1} silicon in this experiment. The experiment was laid out in a Complete Randomized Design with three replications. Thirty-day-old seedlings were transplanted in plastic pots containing 11 kg soils pot^{-1} on 28 December 2017. Recommended doses of fertilizers were applied and cultural practices were done whenever required. Salt and silicon were applied at the time of transplanting. Salinity level was checked each week by EC meter. Data on yield and yield attributes were also recorded at maturity. The collected data were analyzed statistically.

Result revealed that all morphological and yield contributing characters were significantly responded to silicon treatment except plant height (Table 36). Total tillers hill^{-1} and effective tillers hill^{-1} were found the highest in Si @10 kg ha^{-1} under salinity. The highest grain yield was also recorded in Si @10 kg ha^{-1} under salinity. From the interaction between variety and treatment Binadhan-10 with 10 kg Si ha^{-1} under salinity performed the best for increased effective tillers hill^{-1} (Table 37).

Table 36: Effect of silicon on morphological characters and yield components of Boro rice under saline condition

Treatment	Plant height (cm)	Total tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000-grain weight (g)	Grain weight hill^{-1} (g)	Straw weight hill^{-1} (g)
Control	89.33	24.17 a	22.17 ab	159.4 a	17.07 a	24.97 a	31.74 a	41.97 a
6 dSm^{-1}	87.17	19.83 b	17.50 b	101.3 b	17.53 a	23.65 b	19.34 c	37.04 b
Si	88.17	24.34 a	23.83 a	113.4 b	13.30 b	23.73 b	28.41 b	36.59 b
Si + 6 dSm^{-1}	87.17	26.00 a	26.17 a	102.4 b	13.17 b	23.15 c	34.68 a	32.74 c
F-test	**NS**	*	*	*	**	**	**	**

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

Table 37. Interaction effect on some yield contributing characters of boro rice varieties

Variety x Treatment	Total tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000- grain weight (g)	Grain weight hill^{-1} (g)
$V_1 T_1$	24.67 ab	22.67 ab	116.9 b	15.33 ab	25.90 a	29.51 ab
$V_1 T_2$	20.00 b	17.33 b	101.4 b	17.60 ab	24.93 c	15.52 d
V_1T_3	23.00 ab	20.33 ab	103.5 b	15.93 ab	25.30 b	17.79 cd
$V_1 T_4$	25.33 ab	25.33 a	93.53 b	14.73 ab	24.37 d	33.61 a
$V_2 T_1$	23.67 ab	21.67 ab	201.9 a	18.80 a	24.03 e	33.98 a
$V_2 T_2$	19.67 b	17.67 b	101.3 b	17.47 ab	22.37 f	23.17 bc
$V_2 T_3$	25.00 ab	25.33 a	123.3 b	10.67 c	22.17 fg	27.02 b
$V_2 T_4$	26.67 a	27.00 a	111.3 b	13.60 bc	21.93 g	35.75 a

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT.
V_1-=Binadhan-8; V_2-=Binadhan-10; T_1=Control, T_2=6 dS/m, T_3=Si @ 10 kg/ha, T_4=Si + salt.

Soil Science Division

Research Highlights

The study on soil characterization and assessment of land degradation situation revealed the variations in soil properties and location-specific increase or decrease in the particle size distribution (sand, silt and clay), soil pH, total carbon, total N and exchangeable cation (Ca, K and Na) contents in the soils of Old Brahmaputra Floodplains and Northern and Eastern Piedmont Plain areas during the period between 1960s and 2017.

The treatments were identical except control (no organic matter added) which ensured that organic matter could play an important role and attributed to increase soil fertility and crop productivity. The combinations of organic materials were very useful to produce higher yield in T.aman and mungbean crops.

The physico-chemical properties of the soil of Charlatif are loamy to clay loam in texture, alkaline in nature. Organic matter content is low to medium, total nitrogen is very low to low, available phosphorus is low to very low, available sulphur is low to very high, exchangeable potassium is low to optimum and exchangeable calcium and sodium is very high. At Char Monpura, the texture of the soil is loamy to clay loam, neutral to slightly saline and alkaline in nature. Organic matter content is low to medium, total nitrogen is very low to low, available phosphorus is very low, available sulphur is low to very high, exchangeable potassium is medium to optimum, exchangeable calcium is in optimun level and exchangeable sodium is very high. Profitable crops and crop cultivation measures are recommended for both of the charland areas.

The study of Chapainawabganj substation farm showed variations in soil characters might be due to the local differences in micro-topographic variations and soil characteristics, changes in cropping systems (e.g. crop types, fertilization, irrigation, etc.) and other management practices in the farm areas.

Suitable management practices are the key for higher crop production and combination of organic manure and chemical fertilizers was found to be better for higher crop production. Based on the most profitable treatment, the doses of fertilizers recommended for Mustard-Boro-T.aman cropping pattern are $N_{120}P_{36}K_{72}S_{36}Zn_2B_1$-$N_{100}P_{20}K_{50}S_{16}$-$N_{90}P_{15}K_{45}S_{12}$ at BINA substation, Nalitabari, Sherpur (AEZ 8). Among the organic manure sources used, the performance was better with vermicompost compared to others.

Economic doses of nutrients for mutant lines of Boro rice were determined and $N_{100}P_{16}K_{60}S_{12}Zn_2B_1$ nutrient dose was found suitable for higher production of mutants lines at Mymensingh. Economic nutrients doses for Binapias were determined and $N_{120}P_{60}K_{120}S_{36}Zn_2B_1$ nutrient was found suitable for higher production of Binapias at Mymensingh.

NPK @ 70, 100 & 130 kg ha^{-1} increase 144, 185 & 187% respectively grain yield of maize. In respect of organic residue sources, only root and 1/3 shoot + root of previous rice crop increase 11 and 27% respectively grain yield of maize over no use of organic residue.

Foliar spray of di-ammonium phosphate and TSP (flowering and pod formation stages) fertilizers increased grain yield of lentil 6 and 3% respectively at drought prone areas of Bangladesh.

Urea 11.5 and 25.3 kg N ha^{-1} grain yield of lentil increased 13% and decreased -18% respectively over no use of urea fertilizer.

Red wigglers isolated from vermicompost pits and other earthworms were isolated from different areas. Maximum earthworm was found in loam soil at BINA substation farm, Jamalpur (AEZ-9).

Positive correlation was observed between the abundance of earthworms and soil properties org C, N and P; whereas negative correlation was observed with soil bulk density, soil pH and exchangeable K.

Greater CO_2 was evolved with rice straw aided treatments with red wiggler earthworms. Red wigglers can decompose faster of the different organic materials and made the vermicompost greater stable than the mixtures of local earth worms.

Maximum total N content (1.16%) was observed with the treatment T_4 (Soil+ CD+RS+PM+GMR+Ew_1).

Mixture of cowdung (CD), rice straw (RS), poultry manure (PM), giant mimosa residue (GMR) at the ratio of 2:1.33:1.33:1.33 with red wiglers earthworms was more suitable for the production of quality and nutrient rich vermicompost among the treatments.

The results indicated that 75% chemical fertilizer (CF) with 4 t ha^{-1} vermicompost or 85% CF with 2 t ha^{-1} vermicompost almost equally effective to produce seed yield of mustard (Binasharisha 10) which was also comparable with the full dose from only chemical fertilizer (100% CF). Therefore 15-25% chemical fertilizer (NPKS) could be saved either with the application of 75% CF with 4 t ha^{-1} vermicompost or 85% CF with 2 t ha^{-1} vermicompost for mustard cultivation in Bangladesh.

Zinc 3.0 kg ha^{-1} was the best rate for grain yield of wheat. Zinc 4.5 kg ha^{-1} demonstrated the highest Zn concentration (39.7 µg g^{-1}) in wheat grain, which was 17.1% increase over control. Zinc 4.5 kg ha^{-1} appeared the optimum rate to obtain higher Zn fortification in wheat grain.

Sedimentation in the basin is contributed by different land use as forest, wheat, banana, mustard, rice and onion by 11.2%, 16.9%, 17.9%, 18.0%, 17.5% and 18.4%, respectively, which shows that forest contributed the lowest and onion the highest.

The study of Chapainawabganj substation farm showed variations in soil characters which might be due to the local differences in micro-topographic variations and soil characteristics, changes in cropping systems (e.g. crop types, fertilization, irrigation, etc.) and other management practices in the farm areas.

Bench line survey on micronutrient status of soils across the Northern and Eastern Piedmont Plains (AEZ 22) showed that the Zn status of soil was found 29 % as ‘low’, 17% ‘optimum’, 29% ‘medium’, 6% ‘high’ and 19% as ‘very high’. Similarly, 55% soils had ‘low’, 8% ‘very low’, 7% ‘optimum’, and 30% as ‘medium’ soil B status.

From experiments of Mymensingh and Magura it was observed that felon rhizobial inoculants increased grain yield of felon by 15-25% and Green pod by 14-24%.

A total of 504.5 biofertilizer were produced and distributed to the farmers, extension workers, students and other users of the country.

A total number of 139 farmers and extension workers were trained up on benefits and application of biofertilizer in pulse and oilseed production at Barisal and Rangpur.

From a pot experiment using sterilized sand, 6 blackgram rhizobial strains (Strain-3, 4, 6, 9, 11 and 12) were found effective on the basis of nodule number and dry weight.

Soil characterization and land degradation assessment for sustaining fertility and productivity

Evaluation of changes in soil characters for assessment of land degradation situation in Old Brahmaputra Floodplain and Northern & Eastern Piedmont Plain areas

This study was initiated to collect existing information on land, soil, hydrology, major crops/cropping patterns, fertilization, etc. and to develop land/crop management system for sustaining soil fertility and crop productivity in the study area. The study was based on those soils of the selected sampling sites of RSS (1963-75). Based on those previous sites, soil samples from the same sites/series were collected during November-December, 2017. The sampled soils covered part of the Old Brahmaputra Floodplains (AEZ 9) and Northern & Eastern Piedmont Plains (AEZ 22) and a brief description of the soils are presented in Table 1.

Table 1. Description of soils from Mymensingh in terms of morphology and land uses

Soil series/location	AEZ	Land type	Present land use
Dhamrai, Gobindapur, Kotwali, Mymensingh	Old Brahmaputra Floodplain (AEZ 9)	Medium highland	Mustard/vegetables-Boro/aus-T.aman
Sandy Brahmaputra alluvium, Gobindapur, Kotwali, Mymensingh	,,	Medium highland	Groundnut/vegetables-Boro-F
Susang, Purba Narail, Haluaghat, Mymensingh	Northern & Eastern Piedmont Plains (AEZ 22)	Lowland	Boro-T.aman
Marisi, Sangara, Haluaghat, Mymensingh	,,	Highland	vegetables--Boro/aus-T.aman

The soil samples were collected from different depths from each of the locations and taken to the laboratory for physical and chemical analysis. The soil samples were analyzed following standard methods, viz.: particle size distribution by hydrometer method, soil pH by glass electrode pH meter, organic carbon by wet oxidation and total nitrogen by micro-Kjeldahl method. Exchangeable calcium, potassium and sodium were determined by ammonium acetate extraction method.

Results and Discussion

On the basis of local landscape characteristics and hydrological condition, the soils of the study areas fall under highland to lowland condition (Table 1). The ranges of the soil characters were presented in Table 2. From the particle size distribution (Table 2), the surface soils were loam to loam sandy loam in texture and the pH values of the soils were moderately acidic to slightly alkaline in reaction. The organic carbon and total nitrogen contents were low to medium. Available phosphorus and available sulfur contents were low and medium to optimum, respectively. The exchangeable calcium, potassium and sodium contents were location-specific very low to low in the study soils. The variations in the soil characters within the studied soils might be due to the local differences in soil characteristics, changes in cropping systems (e.g. crop types, fertilization, irrigation, etc.) and other management practices in the farming communities.

Table 2. Mean and ranges of some selected characters of the surface soils under study during the period 2017

Soil characters	Range
Sand (%)	8.5-58.6
Silt (%)	14.0-80.1
Clay (%)	4.1-34.1
Texture	Loam to sandy loam soils
pH	5.90-7.80
Organic C (%)	0.08-1.57
Total N (%)	0.03-0.192
Avail-P (ppm)	2.94-7.89
Avail-S (ppm)	10.2-23.2
Exch. Ca (me%)	4.34-6.60
Exch. K (me%)	0.04-0.24
Exch. Na (me%)	0.23-0.38

Changes in particle size distribution

Table 3 showed the particle size distribution (sand, silt and clay contents) of the studied soils during the period 1960s and 2017. The data of sand, silt and clay contents showed location specific changes during the period between 1960s and 2017.

Table 3. Changes in sand, silt and clay content in different soils during the period between 1960s and 2017

Soil series/location	Depth (cm)	Sand		Silt		Clay	
		1960s	2017	1960s	2017	1960s	2017
Dhamrai, Char	0-15	58.0	14.3	33.0	77.5	9.0	8.2
Dolabari, Kotwali,	15-30	56.0	19.2	32.0	75.6	12.0	5.2
Mymensingh	30-45	55.0	14.3	31.0	80.1	14.0	5.6
	45-60	58.0	29.3	27.0	69.2	15.0	4.5
	60-75	67.0	21.1	17.0	73.5	16.0	5.4
Sandy Brahmaputra	0-15	49.0	8.5	26.0	76.2	25.0	15.3
alluvium, Char	15-30	75.0	13.7	15.0	72.5	10.0	13.8
Gobindapur,	30-45	92.0	20.6	6.0	71.8	2.0	7.6
Kotwali,	45-60	48.0	32.1	42.0	63.8	10.0	4.1
Mymensingh	60-75	88.0	33.8	6.0	61.7	6.0	4.5
Susang, Purba	0-15	6.0	58.6	38.0	22.0	56.0	19.4
Narail, Haluaghat,	15-30	6.0	58.6	34.0	14.0	60.0	27.4
Mymensingh	30-45	13.0	51.9	19.0	19.0	68.0	29.1
	45-60	12.0	35.9	11.0	30.0	77.0	34.1
Marisi, Sangara,	0-15	58.0	44.6	31.0	28.0	11.0	27.4
Haluaghat,	15-30	55.0	45.6	33.0	25.0	12.0	29.4
Mymensingh	30-45	57.0	38.9	28.0	28.0	15.0	33.1
	45-60	61.0	57.9	25.0	16.0	14.0	26.1

Changes in soil pH, organic carbon and total N contents

Table 4 showed the pH values of selected soils during the period 1960s and 2017. The data of pH values showed an increase in all the soils under study. The organic carbon contents showed location specific increase or decrease during the period between 1960s and 2017.

The data of total N contents showed an increase in all the soils except an increase in the Susang series during the period between 1960s and 2017 (Table 4). The differential changes in soil pH, organic C and total N of different soils were mainly due to the local differences in cropping system and farm management practices in the study areas.

Table 4. Changes in soil pH, organic C and total N in different soils during the period between 1960s and 2017

Soil series & location	Depth (cm)	pH		Organic C (%)		Total N (%)	
		1960s	2017	1960s	2017	1960s	2017
Dhamrai,	0-15	6.0	6.40	0.80	1.04	0.06	0.140
Char	15-30	6.0	6.28	-	0.24	-	0.087
Dolabari,	30-45	6.2	6.63	0.32	0.32	0.05	0.073
Kotwali,	45-60	6.3	6.20	0.28	0.28	0.04	0.060
Mymensingh	60-75	6.3	6.20	-	0.20	-	0.074
Sandy	0-15	5.6	6.18	1.07	0.92	0.11	0.192
Brahmaputra	15-30	6.0	6.48	0.35	0.34	0.07	0.080
alluvium,	30-45	5.2	6.27	0.11	0.08	0.02	0.059
Char Gobindapur,	45-60	6.5	7.06	-	0.24	-	0.063
Kotwali, Mymensingh	60-75	6.7	7.15	-	0.28	-	0.052
Susang, Purba	0-15	4.6	5.97	1.32	1.57	0.13	0.080
Narail,	15-30	5.6	6.43	1.25	1.14	0.13	0.039
Haluaghat,	30-45	4.6	6.71	0.94	1.04	0.12	0.030
Mymensingh	45-60	4.6	6.82		1.42		
Marisi,	0-15	4.6	5.90	0.51	1.52	0.06	0.090
Sangara,	15-30	4.8	6.63	0.46	1.23	0.06	0.059
Haluaghat,	30-45	4.8	6.45	0.38	1.28	0.04	0.046
Mymensingh	45-60	4.8	6.69	0.34	1.19	0.04	

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

Table 5 showed the exchangeable cation (Ca, K and Na) contents of the soils under study during the period 1960s and 2017. The data of exchangeable Ca and K contents showed an indication of increase in the soils of Dhamrai and Marisi series under study except a decline in the Susang series during the period between 1960s and 2017.

Conclusion

The study on soil characterization and assessment of land degradation situation revealed the variations in soil characters and location-specific increase or decrease in the particle size distribution (sand, silt and clay), soil pH, organic carbon, total N and exchangeable cation (Ca, K and Na) contents in the Old Brahmaputra Floodplain and Northern & Eastern Piedmont Plain soils during the period between 1960s and 2017. The study suggested for an improvement in land management practices for controlling the land degradation processes and maintenance of soil fertility for sustaining crop productivity.

Table 5. Changes in exchangeable Ca, K and Na content in different soils during the period between 1960s and 2017

Soil series & location	Depth (cm)	Exch. Ca (me%)		Exch. K (me%)		Exch. Na (me%)	
		1960s	2017	1960s	2017	1960s	2017
Dhamrai, Char Dolabari, Kotwali, Mymensingh	0-15	-	2.82	-	0.070	-	0.28
	15-30	-	3.05	-	0.072	-	0.30
	30-45	3.2	5.42	0.05	0.065	0.18	0.26
	45-60	-	3.09	-	0.086	-	0.22
	60-75	-	2.25	-	0.057	-	0.20
Sandy Brahmaputra alluvium, Char Gobindapur, Kotwali, Mymensingh	0-15	-	3.04	-	0.070	-	0.21
	15-30	-	2.86	-	0.048	-	0.19
	30-45	-	2.08	-	0.043	-	0.28
	45-60	-	2.26	-	0.041	-	0.22
	60-75	-	1.18	-	0.046	-	0.22
Susang, Purba Narail, Haluaghat, Mymensingh	0-12	10.8	4.34	0.29	0.10	0.79	0.23
	12-29	9.8	5.70	0.17	0.10	0.36	0.23
	29-47	5.3	4.84	0.20	0.15	0.52	0.31
	-	-	6.02	-	0.24	-	0.31
Marisi, Sangara, Haluaghat, Mymensingh	0-15	-	4.70	-	0.11	-	0.23
	15-30	-	4.92	-	0.13	-	0.31
	30-45	1.1	4.78	0.07	0.13	0.06	0.31
	45-75	-	6.60	-	0.12	-	0.38

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

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

A field experiment was initiated at BINA sub-station farm at Rangpur from Rabi season of 2014 using different organic matter treatments (T_1 = control, T_2 =10 tha^{-1} CD, T_3 =5 tha^{-1} PM, T_4 =3 tha^{-1} RS + 3 tha^{-1} PM, T_5 =3 tha^{-1} SD + 3 tha^{-1} PM and T_6 =5 tha^{-1} LF + 5 tha^{-1} CD for the first crop) along with chemical fertilizer. Initial data have been collected from the experimental soil. During harvesting of T.aman rice (2017), the post harvest soil samples have been collected. The data of T.aman rice (Binadhan-7) and mungbean (Binamoog-7) are presented in Table 6 and selected bio-chemical properties of initial and post harvest soils are presented in Table 7.

(a) T.aman rice (Binadhan-7)

The yield of T.aman rice (Binadhan-7) was significantly influenced by the different treatment combinations (Table 6). The grain yield ranged from 3.74 to 5.47 t ha^{-1}. The highest yield (5.47 t ha^{-1}) was found in treatment T_4 (3 tha^{-1} rice straw + 3 tha^{-1} poultry manure) and the lowest yield (3.74 t ha^{-1}) observed in control treatment T_1. The straw yield ranged from 4.97 to 5.97 t ha^{-1}. The highest straw yield (to 5.97 t ha^{-1}) was recorded in treatment T_5 (3 tha^{-1} SD + 3 tha^{-1} PM) and the lowest straw yield (to 4.97 t ha^{-1}) was obtained from control treatment T_1. The result indicated that the combination of organic matters is very useful to produce higher yield of T.aman rice.

(b) Mungbean

After havesting of cabbage, mungbean was planted in the same experimental plots. The yield of mungbean grain was significantly influenced by the different combinations of fertilizer materials used in the previous cabbage crop (Table 7). The highest grain yield of mungbean was found in treatment T_4 (1.35 t ha^{-1}) and the lowest grain yield (1.15 tha^{-1}) was observed in the control treatment (T_1). The highest stover yield of mungbean was found in treatment T_4 (7.56 t ha^{-1}) and the lowest stover yield (6.36 tha^{-1}) was observed in treatment (T_5). All the stover of mungbean was incorporated into the plots.

Table 6. Effect of organic fertilizers on the yields of Binadhan-7 and mungbean (tha^{-1}) at Rangpur

Treatment	Binadhan-7		Mungbean	
	Grain	Straw	Grain	Stover
T_1	3.74 e	4.97 c	1.15	6.42 b
T_2	4.01 de	5.47 abc	1.22	7.42 a
T_3	4.37 cd	5.55 ab	1.33	7.47 a
T_4	5.47 a	5.78 ab	1.35	7.56 a
T_5	5.04 ab	5.97 a	1.29	6.36 b
T_6	4.71 bc	5.38 bc	1.33	6.64 b
CV (%)	**4.13**	**3.28**	**12.62**	**3.89**

Same letter (s) in the column are not statistically significant at 5% level, CV = Coefficient of variation

Post harvest soil nutrient status

The post harvest soil pH, organic carbon, total N, available P, available S and exchangeable K due to the use of chemical fertilizers and organic residues in different crops/cropping pattern for three years are given in Table 3. In comparison with initial soil status, it appeared an increasing tendency in soil nutrient contents. In general, control treatment had decreasing tendency of nutrient status compare with initial values.

Table 7. Effect of organic fertilizers on the post harvest soil of the BINA substation farm at Rangpur

Soil character	pH	OC (%)	TN (%)	Avail. P (ppm)	Avail. S (ppm	Exch. K (me%)
Initial soil	**5.6**	**0.620**	**0.058**	**17.63**	**11.24**	**0.11**
Post harvest Soil						
T_1	5.4	0.593	0.054	15.73	10.46	0.097
T_2	5.6	0.690	0.074	20.48	16.26	0.140
T_3	5.7	0.632	0.073	19.79	15.55	0.135
T_4	5.6	0.632	0.070	19.57	16.20	0.113
T_5	5.7	0.653	0.072	20.21	15.13	0.139
T_6	5.7	0.711	0.078	23.12	18.89	0.144

Conclusion

All the treatments were identical except control which ensured that application of organic matter along with chemical fertilizer could play an important role and attributed to increase soil fertility and crop productivity. The combinations of organic fertilizers were very useful to produce higher yield of crops.

Physico-chemical characterization and soil management in Charlatif and Char Monpura of Bhola district for increasing cropping intensity and productivity

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

Soil sample collection and soil analyses:

Based on the objectives, soil survey and suitable crops across seasons have been done. The soil samples were collected from different depths from each of the sites and taken to the laboratory for physic-chemical analyses. The soils were then dried at room temperature, processed and passed through a 10 mm sieve and stored for analysis. The soil samples were analyzed following standard methods, viz.: particle size distribution by hydrometer method, soil pH and EC by glass electrode, organic carbon by wet oxidation and total nitrogen by micro-Kjeldahl method. Exchangeable calcium, potassium and sodium were determined by ammonium acetate extraction method.

(A) Charlatif Borhanuddin Upazila

General survey and crop cultivation suitability across the areas

Charlatif of Borhanuddin upazila is an isolated charland in the Tetulia river in the North-West part of Borhanuddin upazila. This char is surrounded by Bauphal upazila of Patuakhali district on the South and West, Bhola Sadar on the North and Borhanuddin upazila sadar area on the East, It is located in between 22°23´ and 22°29´ North latitudes and in between 90°36´ and 90°38´ East longitudes. The total area of this char is 2,274 hectare. Charlatif is almost flat which is formed by the Meghna floodplains. The nature of soil is medium high. Most of the area is short temporarily flooded by tidal water during the moon soon. There are innumerable small canals in this char, which have fresh water flow throughout the year. There is no settlement and ownership as the land is isolated from the mainland. The farmers come from the mainland to cultivate. There is problem of crop cultivation due to proper management, rat and grazing. Crop yield and market value is very low.

Soil properties:

The physic-chemical properties of the soil of charlatif are described in Table 8. The texture of soil is loamy to clay loam. Soil pH is slightly alkaline. The organic matter content is low to medium (1.23-2.53%), the total nitrogen is very low to low (0.081-0.221%), available phosphorus is low to very low (4.67-14.14ppm), available sulphur is low to very high (4.02-156.8ppm), exchangeable potassium is low to optimum (0.138-0.311%) and exchangeable calcium and sodium is very high.

Table 8. Texture, pH, EC and organic matter (OM) of soils in Charlatif

Sl. No.	GPS	Depth (cm)	Texture	pH	EC(dSm^{-1})	OM (%)
1	N: 22°31.288	0-13	Loam	8.0	0.22	1.89
2	E: 090°37.212	13+	Loam	7.9	0.17	1.26
3	N: 22°31.218	0-11	Loam	7.8	0.31	1.82
4	E: 090°37.312	11+	Loam	8.0	0.18	1.68
5	N: 22°30.987	0-10	Loam	7.7	0.43	1.33
6	E: 090°37.371	10+	Loam	7.8	0.17	1.96
7	N: 22°30.904	0-10	Loam	7.7	0.20	2.25
8	E: 090°37.583	10+	Loam	7.8	0.20	1.33
9	N: 22°31.745	0-10	Loam	7.5	0.50	2.11
10	E: 090°37.00	10+	Loam	7.6	0.25	1.47
11	N: 22°32.005	0-11	Loam	7.5	0.25	2.53
12	E: 090°36.803	11+	Loam	7.7	0.16	1.68
13	N: 22°32.229	0-12	Loam	7.4	0.40	1.52
14	E: 090°36.750	12+	Loam	7.5	0.18	1.33
15	N: 22°32.361	0-12	Loam	7.4	0.33	2.04
16	E: 090°36.665	12+	Silty Loam	7.6	0.15	1.40
17	N: 22°32.588	0-11	Loam	7.4	0.25	1.82
18	E: 090°36.653	11+	Loam	7.5	0.22	1.23
19	N: 22°32.588	0-11	Silty Loam	7.5	0.30	2.18
20	E: 090°36.653	11+	Loam	7.5	0.16	1.82

Table 9. Total N (TN), avail. P, avail. S, exch. K, exch. Ca and exch. Na of soils in Charlatif

Sl. No.	Depth (cm)	TN (%)	Avail. P (ppm)	Avail. S (ppm)	Exch. K (me%)	Exch. Ca (me%)	Exch. K (me%)
1	0-13	0.140	14.14	42.2	0.235	10.21	0.639
2	13+	0.094	13.43	12.1	0.154	13.76	0.588
3	0-11	0.136	8.91	84.5	0.204	13.835	0.729
4	11+	0.081	8.06	10.1	0.143	16.256	0.740
5	0-10	0.095	8.06	156.8	0.249	15.20	0.690
6	10+	0.160	6.93	12.1	0.237	19.73	0.757
7	0-10	0.119	10.04	22.1	0.166	9.22	0.565
8	10+	0.091	4.67	4.02	0.138	9.90	0.690
9	0-10	0.221	8.06	154.8	0.309	15.95	0.876
10	10+	0.095	7.64	78.4	0.245	11.72	0.656
11	0-11	0.157	5.09	100.5	0.311	11.49	0.627
12	11+	0.133	4.81	6.03	0.181	14.59	0.622
13	0-12	0.181	6.08	155.1	0.204	10.74	0.622
14	12+	0.098	4.81	22.1	0.157	10.96	0.690
15	0-12	0.143	6.65	100.5	0.240	11.42	0.639
16	12+	0.165	6.65	8.04	0.180	13.84	0.622
17	0-11	0.172	5.23	84.5	0.292	15.88	0.661
18	11+	0.153	4.67	62.3	0.214	12.63	0.593
19	0-11	0.217	6.08	100.5	0.304	10.66	0.554
20	11+	0.126	5.37	20.11	0.186	10.81	0.605

Suggestions/Recommendations:

- Crops of T.aman (HYV & local), Deep water rice, Boro (HYV & local), T.aus (Local), Mustard, Mungbean, Groundnut, Soybean, Potato, Jute, Maize, Chilli, Cauliflower, Cabbage, Onion, Garlic, Tomato, Water melon, Cucumber, Melom, etc. could be grown. Farmers could be benefited by improved management and HYV of crops, irrigation, fertilizer, etc. at this area.

- Bio-fertilizer should be used for pulse and oilseed crop cultivation.
- Profitable crops and cropping pattern can be recommended through research.
- Measures should be taken to reduce rats and buffalo intrusion for minimizing crop loss.
- Comprehensive agricultural development programs should be taken by different GO/NGO and other organizations.

(B). Manpura Upazila

General survey and crop cultivation suitability across the areas

The Monpura upazila, a separate island of Shahbazpur river is situated at the east of Bhola district. It is bounded by Tazumuddin upazila on the North, Hatiya upazila of Noakhali on the East, Bay of Bengal on the South, Lalmohan and Charfasson upazila on the West. It is located in between 21° 50´ and 22° 24´ North latitudes and in between 90° 52´ and 91° 02´ East longitudes.

From ten years (2004-2013) weather data, the warmest and coldest temperatures are observed in May and December which averaged approximately 33.3 and 18.7 degree Celsius. Average rainfall in the dry winter is 387mm and remains during the period of 4-5 months. Again there is excessive rainfall in the rainy season of the pre-kharif and kharif season (June-October) which averaged 3.657 mm.

Land of Manpura Upazila is almost flat, which is formed by the Meghna floodplain. Major part of this area is short temporary flooded in rainy season and some area is medium to deeply flooded by locally. All the sediments of the plains transported from the river Meghna and its channels.

The waters of the river channels are saline in dry season. There is no is no irrigation system developed but some deep tubewells have been installed for household purposes. Water of bound canals surrounded by the dams is congenial to irrigation throughout the year.

Soil salinity is a major problem in this area. Due to salinity, whole crop is damaged sometimes. Yield of crops is low due to improper crop and fertilizer management.

Farmers cultivate local varieties of crops rice such as aman rice, mungbean, khesari, groundnut, sweet potato, chilli, garlic and different kinds of vegetables which is low yielding (BRRI dhan23: 4-4.5, local variety: 3-3.5, Mungbean: 0.8-0.9, Groundnut: 2.5-3, Potato: 18-20 and Chilli: 15-19 t/ha).

Soil properties:

The physicochemical characteristics of the soil of Manpura upazila is described in Table 8. The texture of the soil is loamy to clay loam. The soil pH is neutral to slightly alkaline and the upper layer of the soil is slightly saline (1.2-4.13 dsm^{-1}). The organic matter content of the soil is low to medium (0.21-2.60%), the total nitrogen is very low to low (0.032-0.181%), the available phosphorus is very low (2.40-6.65 ppm), available sulphur is low to very high (4.02-156.8ppm), exchangeable potash is medium to optimum (0.199-0.478 me%), exchangeable calcium is in desired level (4.54-9.07me%) and exchangeable sodium is very high (1.64-5.14me%).

Table 10. Texture, pH, EC and OM of soils in Charmonpura of Monpura Upzilla of Bhola district

Sl. No.	GPS	Depth (cm)	Texture	pH	EC (dSm^{-1})	OM (%)
1	N: 22°07.591´ E: 090°56.317´	0-10	Silty Loam	7.0	1.2	2.04
2		10-72	Silty Clay Loam	7.6	0.61	1.05
3		72+	Silty Clay Loam	8.0	0.959	0.56
4	N: 22°07.592´ E: 090°56.280´	0-7	Silty Loam	6.2	2.32	2.11
5		7-70	Silty Clay Loam	7.4	0.571	0.70
6		70+	Silty Clay Loam	8.0	0.826	0.49
7	N: 22°11.344´ E: 090°56.193´	0-10	Silty Loam	6.3	2.99	2.04
8		10-45	Silty Loam	7.3	0.908	0.84
9		45+	Silty Loam	7.5	0.951	0.77
10	N: 22°12.580´ E: 090°56.778´	0-09	Silty Loam	6.3	2.46	2.11
11		9-60	Silty C Silty Clay Loam	7.4	0.837	0.63
12		60+	Silty Loam	7.5	0.488	0.91
13	N: 22°13.949´ E: 090°57.418´	0-8	Silty Loam	6.9	4.13	2.53
14		8-70	Silty Clay Loam	7.7	1.34	0.42
15		70+	Silty Clay Loam	7.8	1.77	0.77
16	N: 22°16.681´ E: 090°58.705´	0-9	Silty Loam	6.3	3.46	0.98
17		9-42	Silty Clay Loam	7.5	1.01	0.21
18		42+	Silty Clay Loam	7.8	1.06	0.49
19	N: 22°18.222´ E: 090°59.144´	0-8	Silty Loam	6.8	1.99	2.18
20		8-55	Silty Clay Loam	8.2	0.448	0.49
21		55+	Silty Clay Loam	8.4	0.622	0.63
22	N: 22°18.795´ E: 090°58.810´	0-9	Silty Loam	7	0.619	2.60
23		9-45	Silty Clay Loam	7.9	0.0833	0.70
24		45+	Silty Clay Loam	8.0	0.207	0.70

Table 11. TN, avail. P, avail. S, exch. K, exch. Ca and exch. Na of soils in Charmonpura of Monpura Upzilla of Bhola district

Sl. No.	Depth (cm)	TN (%)	Avail. P (ppm)	Avail. S (ppm)	Exch. K (me%)	Exch. Ca (me%)	Exch. (me%)
1	0-10	0.181	5.51	313.66	0.311	6.048	3.759
2	10-72	0.062	3.25	88.47	0.300	6.199	2.911
3	72+	0.053	4.10	48.26	0.333	7.636	2.883
4	0-7	0.091	5.37	321.70	0.364	6.124	3.730
5	7-70	0.06	3.96	44.23	0.269	6.275	2.430
6	70+	0.032	3.54	112.60	0.281	5.670	2.374
7	0-10	0.109	6.50	261.38	0.423	5.594	4.267
8	10-45	0.064	6.22	20.11	0.306	4.763	3.024
9	45+	0.067	5.37	36.19	0.235	4.536	3.843
10	0-09	0.116	6.65	321.70	0.369	5.368	4.324
11	9-60	0.071	6.22	76.40	0.226	5.443	2.713
12	60+	0.111	3.11	80.43	0.214	5.141	2.770
13	0-8	0.099	5.09	369.96	0.478	9.072	7.970
14	8-70	0.025	4.81	140.75	0.325	6.426	3.278
15	70+	0.045	4.67	156.83	0.357	6.880	4.267
16	0-9	0.13	5.23	345.83	0.345	9.072	5.143
17	9-42	0.071	4.81	88.47	0.262	5.368	2.346
18	42+	0.09	4.24	84.45	0.261	4.914	2.713
19	0-8	0.078	5.09	305.62	0.380	9.072	3.024
20	8-55	0.074	2.97	28.15	0.264	6.124	2.346
21	55+	0.038	4.81	68.36	0.199	5.292	3.080
22	0-9	0.165	4.52	72.38	0.299	6.426	1.837
23	9-45	0.079	2.40	16.09	0.223	6.577	1.639
24	45+	0.041	3.54	16.09	0.216	6.350	1.667

Suggestions/Recommendations:

- Crops of T.aman (HYV & local), Deep water rice, Boro (HYV & local), T.aus (Local), Mustard, Mungbean, Groundnut, Soybean, Potato, Jute, Maize, Chilli, Cauliflower, Cabbage, Onion, Garlic, Tomato, Water melon, Cucumber, Melom, etc. could be grown. Farmers could be benefited by improved management and HYV of crops, irrigation, fertilizer, etc. at this area.
- Use bio-fertilizer in pulse and oilseed crop cultivation.
- Profitable crops and cropping pattern can be recommended through research.
- Measures should be taken to reduce rats and buffalo intrusion for minimizing crop loss.
- Establish of new embankments, sluice gates and new water reservoirs for the development of irrigation system.
- Expand cultivation of salt tolerant crop varieties (e.g. Binadhan-8 and Binadhan-10).
- Farmers training should be arranged for extension of different modern technologies to the farmers' and other comprehensive agricultural development programs should be taken by different GO/NGO and other organizations.

Physicochemical characterization of the BINA substation farm soils at Chapainawabganj

A study was undertaken for the characterization of Chapainawabganj substation farm soils. The objective was to evaluate the physico-chemical characteristics of the soil in the different blocks of the farm area. The soil sample had been collected from each individual block during February, 2018. The soil samples were collected from different depths (0-15 cm, 15-30 cm, 30-45 cm and 45-60 cm). Each sample is a composite of randomly selected spots of different blocks. The soil samples were analysed for physico-chemical characteristics e.g particle size distribution (sand, silt and clay contents), soil pH, organic carbon, total N, available P and S, exchangeable K contents. The collected soil samples were dried at room temperature, grinded and sieved with a 10 mm sieve. The soil samples have been analyzed following standard method, *viz.* particle size distribution by particle size analyzer (Microtec) and soil pH by glass electrode pH meter, organic carbon by wet oxidation and total nitrogen by kjeldal method, available P by Bray and Kurtz method, available S by turbidimetric method of titration, exchangeable potassium was determined by ammonium acetate extraction method. The results of soil physico-chemical characteristics are presented in table Tables 12 and 13.

Particle size distribution

Table 12 showed the particle size distribution (sand, silt and clay) and the texture of the soils. The sand, silt and clay distribution among the blocks more or less same within the depths of the profiles. The soils were silty loam in texture.

Table 12. Soil texture in the different depth of the BINA substation farm at Chapainawabganj

Location	Depth (cm)	% Sand	% Silt	% Clay	Soil Texture
Block-1	0-15	12.4	72.59	15.01	Silty loam
	15-30	3.54	75.93	20.53	Silty loam
	30-45	9.13	72.17	18.70	Silty loam
	45-60	12.74	71.76	15.50	Silty loam
Block -2	0-15	8.47	78.14	13.38	Silty loam
	15-30	8.22	75.42	16.36	Silty loam
	30-45	6.04	77.34	16.63	Silty loam
	45-60	6.84	73.89	19.27	Silty loam

Soil pH, organic C, total N, available P, available S and exchangeable potassium contents

Table 13 showed the Soil pH, total C, total N, available P available S and exchangeable potassium contents of the soils collected from different depths of each block. The pH values of the soils were neutral to slightly alkaline, the pH values range from 7.20 to 8.25 among the block with different, organic carbon contents varied from 0.12 to 1.20% with a surface soil mean value of 1.12 and and total nitrogen contents varied from 0.075 to 0.134% with a surface soil mean value of 0.112, available phosphorus contents varied from 1.86 to 4.33 ppm with a surface soil mean value of 3.10 ppm and available sulfur contents varied from 20.17 to 40.33 ppm with a surface soil mean value of 30.25 ppm, the exchangeable potassium contents in the soils ranged from 0.077-0.139 me% with a surface soil mean values of 0.108 me% of the different blocks.

Table 13. Soil pH, Org. C, total N, available P, available S and exchangeable contents in different depth of soils at selected sites of the BINA substation farm at Chapainawabganj

Location	Depth (cm)	pH	%OC	%N	Avail. P (ppm)	Avail. S (ppm)	Exch. K (%meq)
Block-1	0-15	7.76	1.04	0.134	4.33	40.33	0.110
	15-30	8.06	0.36	0.096	4.18	34.57	0.126
	30-45	8.25	0.36	0.086	1.86	25.93	0.097
	45-60	8.15	0.12	0.075	2.17	28.81	0.096
Block-1	0-15	7.20	1.20	0.105	2.49	30.25	0.119
	15-30	7.60	0.44	0.086	3.70	20.17	0.105
	30-45	7.61	0.44	0.092	2.79	34.57	0.139
	45-60	7.68	0.34	0.094	2.48	21.61	0.077

Conclusion

The variations in the soil characters within the studied soils might be due to the local differences in micro-topographic variations and soil characteristics, changes in cropping systems (e.g. crop types, fertilization, irrigation, etc.) and other management practices in the farm.

Organic and inorganic fertilizer management practices for increased crop production in Mustard-Boro-T. aman rice cropping pattern

An attempt was made to find out suitable fertilizer dose for the cropping pattern of Mustard-Boro-T.Aman rice at Nalitabari, Sherpur for sustaining soil fertility and crop yields.

Methodology

The experiment was initiated during 2014-2015 at BINA substation farm, Nalitabari, Sherpur. There were seven treatments and the experiment was laid out in a randomized complete block design (RCBD) with three replications. Organic manures were used in the mustard crop of the cropping pattern. Nutrient sources and contents of the organic manures are presented in Table 14. The recommended doses of fertilizer treatments were used in the experiment. Full dose of P, K, S, Zn, B fertilizers and 1/3rd of N fertilizer were applied at the time of final land preparation. The rest of N fertilizer was applied in two equal split. The soil sample was collected for soil texture, pH, organic matter, total N, exchangeable K, available P, and S determination.

Results

The yields (mean of three years) of the cropping pattern are presented in Fig. 1. In case of mustard (Binasharisha-10), the highest seed yield (1009 $kgha^{-1}$) was obtained from fertilizer combination of $N_{120}P_{36}K_{72}$ $S_{36}Zn_2B_1$ kg ha^{-1} along with vermicompost $3tha^{-1}$. The highest yield of boro rice (Binadhan-14) was obtained in treatment T_5 and T_6 (6.18 t ha^{-1}) followed by with treatment T_4 (6.09 t ha^{-1}) and the lowest was obtained from treatment T_7 (2.41 t ha^{-1}). Regarding T.aman rice, the highest yield (Binadhan-7) was obtained in treatment T_6 (5.09 t ha^{-1}) and the lowest was obtained from treatment T_7 (2.25 t ha^{-1}). Among the organic manure sources used, the performance was better with vermicompost compared to others.

Table 14. Nutrient content (%) of the organic materials used in the experimental field

Name of the manure	N	P	K	S
Mustard residue	0.60	0.23	1.15	0.25
Rice straw	0.50	0.20	1.52	0.22
Cow dung	1.01	0.26	1.16	0.14
Poultry manure	1.75	0.53	0.75	0.45
Vermicompost	1.05	0.33	0.65	0.32
Range	0.50-1.75	0.20-0.53	0.65-1.52	0.14-0.45

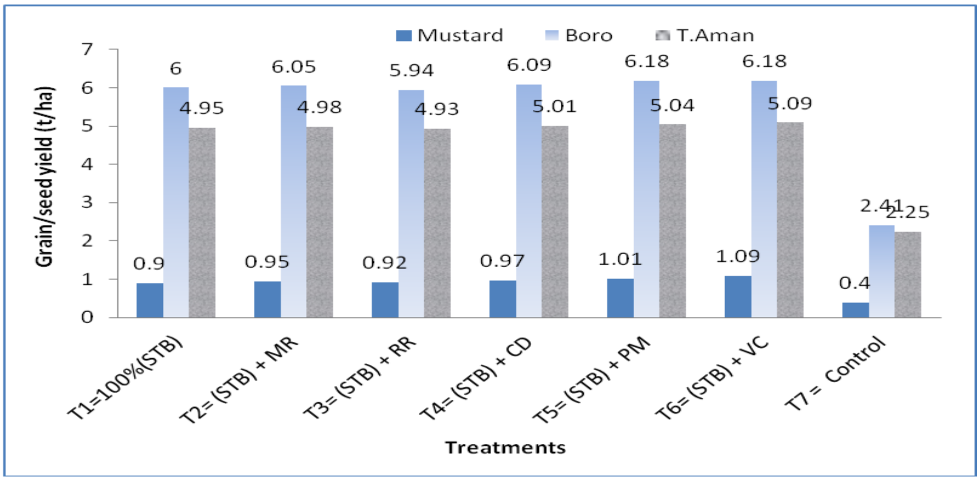


Fig 1. Effects of fertilizers on the yield (t ha^{-1}) of Mustard-Boro-T.aman pattern at Nalitabari, Sherpur

Cost and return analysis

Regarding cost and return analysis, the highest net benefit of Tk ha^{-1} 1,47,876 was obtained in T_6 followed by Tk ha^{-1} 1,44,726 and Tk ha^{-1} 1,41,226 in T_5 and T_4 treatments at Nalitabari, Sherpur (Table 15). The lowest net benefit of Tk ha^{-1} 81,900 was observed in control treatment (T_7). Though the fertilizer cost was higher in T_6, MBCR was also observed highest in treatment T_6 (4.75). The highest MBCR was found higher in T_6 (1.70) treatment which was followed by T_5 (1.62) and T_1 (1.59) treatments, respectively due to higher gross return compared to all other treatment.

Changes in soil Status

The changes in soil pH, organic matter and different nutrients are due to the use of different doses of fertilizers in Mustard-Boro-T. Aman cropping pattern for three years of cropping are shown in Table 16. There is a little change in soil pH. It appeared the increasing tendency of soil organic matter content to some extent. The changes in soil N, P, K and S content do not follow any definite trend. In general, control treatment had tendency to decrease nutrient status of soil compared with initial value.

Table 15. Effects of fertilizers on fertilizer use economy in Mustard-Boro-T. aman rice cropping pattern at Nalitabari, Sherpur

Treatments	Gross return	Fert. cost	Net return	Marginal return	MBCR
			Tk ha^{-1}		
T_1	1,76,250	36,874	1,39,376	57,476	1.59
T_2	1,78,950	39,374	1,39,576	57,676	1.46
T_3	1,75,650	39,874	1,35,776	53,876	1.35
T_4	1,80,600	39,374	1,41,226	59,326	1.51
T_5	1,83,600	38,874	1,44,726	62,826	1.62
T_6	1,86,750	38,874	1,47,876	65,976	1.70
T_7	81,900	-	81,900	-	-

T_1=100%(STB), T_2= (STB) + MR, T_3= (STB) + RR, T_4= (STB) + CD, T_5= (STB) + PM, T_6= (STB) + VC and T_7 = Control

(Grain = 15 Tk. kg^{-1}; Mustard=30 Tk. kg^{-1}; N = 45 Tk. kg^{-1}; P = 150 Tk. kg^{-1}; K = 50 Tk. kg^{-1}; S = 55 Tk. kg^{-1}, Zn = 102 Tk. kg^{-1} and B = 200 Tk. kg^{-1} MBCR = Marginal benefit cost ratio).

Table 16. Changes in soil status after three years of cropping at Nalitabari, Sherpur

Treatments	pH	OM (%)	N (%)	P (mg kg^{-1})	K (cmolkg^{-1})	S (mg kg^{-1})
T_1	5.9	1.16	0.066	14.26	0.176	19.07
T_2	5.7	1.32	0.088	15.51	0.338	25.5
T_3	5.8	1.30	0.088	16.22	0.422	23.0
T_4	6.0	1.30	0.084	15.78	0.335	25.0
T_5	6.0	1.41	0.097	17.84	0.363	20.6
T_6	5.8	1.43	0.086	17.21	0.399	28.9
T_7	6.0	1.02	0.058	9.70	0.228	20.6
Initial soil	5.4	1.20	0.060	16.60	0.190	21.90

Conclusion

Based on the most profitable treatment, the doses of fertilizers recommended for Mustard-Boro-T.aman cropping pattern are $N_{120}P_{36}K_{72}S_{36}Zn_2B_1$-$N_{100}P_{20}K_{50}S_{16}$-$N_{90}P_{15}K_{45}S_{12}$ at Nalitabari, Sherpur (AEZ 1). Among the organic manure sources used, the performance was better with vermicompost compared to others.

Determination of optimum and economic doses of nutrients for major crops developed by BINA under different environment

Soil fertility is a dynamic property which varies with crops, cropping intensity and input uses. Environment is a global concern at present day. Soil fertility management practice of modern intensive high yielding systems are harmful to the environment and as a consequence modern agricultural production is not sustainable. Therefore, the challenge is to develop an environment friendly, agronomically and economically suitable combination of inorganic and organic fertilizers for sustaining soil fertility with higher crop productivity. Initial soil characteristics of the experimental sites shown in Table 17.

Table 17: Initial soil characteristics of the experimental sites

Locations	pH	OM (%)	Total N (%)	Available nutrients (ppm)				Exchangeable K (meq%)
				P	S	Zn	B	
BINA farm, Mymensingh	6.8	1.40	0.068	8.5	10.4	1.3	0.25	0.089
Critical limit			0.12	8	10	0.6	0.20	0.12

(a) Yields of Boro rice mutant lines at BINA farm, Mymensingh

Field trial of mutant lines of boro rice were conducted at BINA farm, Mymensingh during 2018 to determine the amount of fertilizer require for higher crop production. There were five treatments viz; T_1 = Control, $T_2 = N_{80}P_{12}K_{45}S_8Zn_2B_1$, $T_3 = N_{100}P_{16}K_{60}S_{12}Zn_2B_1$, $T_4 = N_{120}P_{20}K_{75}S_{16}Zn_2B_1$ and $T_5 = N_{140}P_{24}K_{90}S_{20}Zn_2B_1$ (kg ha^{-1}). The trails were laid out in a Randomized Complete Block Design (RCBD) with three replications. Results indicated that application of different levels of fertilizers increased yield significantly over absolute control treatment (Table 18). In mutant line RM (2)-40(c)-1-1-10, the highest grain (6.93 t ha^{-1}) was obtained from treatment T_3 followed by treatment T_5 (6.32 t ha^{-1}) and treatment T_4 (6.24 t ha^{-1}). On the other hand, the highest straw (7.93 t ha^{-1}) yields were obtained from treatment T_5 followed by treatment T_4 (7.55 t ha^{-1}) and treatment T_3 (7.52 t ha^{-1}). The lowest yield was found in control treatment.

Table 18. Effect of different levels of inorganic fertilizer on yield and yield contributing characters of Binadhan-19 (kharif I) during 2018

Treatments	Plant height (cm)	Tiller/ hill (no.)	Panicle length (cm)	Filled grain/ panicle (no.)	1000 seed weight (g)	Grain yield (t/ha)	Straw yield (t/ha)
T_1: Control	89	5.0	23.0	104	18.09	2.89	3.60
T_2: $N_{80}P_{12}K_{45}S_8$	102	9.6	27.3	111	17.90	5.58	6.27
T_3: $N_{100}P_{16}K_{60}S_{12}$	110	10.4	28.0	125	18.22	6.93	7.55
T_4: $N_{120}P_{20}K_{75}S_{16}$	112	11.3	28.2	139	19.18	6.24	7.52
T_5: $N_{140}P_{24}K_{90}S_{20}$	115	9.8	25.5	131	19.25	6.32	7.93

Date of seeding: 29.11.2017, Date of transplanting: 22.01.2018, Date of harvesting: 16.05.2017

(a) Yield and yield attributes of summer onion at BINA farm, Mymensingh

Field trial of mutant lines of summer onion were conducted at BINA farm, Mymensingh during 2018 to determine the amount of fertilizer require for higher crop production. There were five treatments viz; T_1 = Control, $T_2 = N_{80}P_{30}K_{80}S_{24}Zn_2B_1$, $T_3 = N_{100}P_{45}K_{100}S_{30}Zn_2B_1$, $T_4 = N_{120}P_{60}K_{120}S_{36}Zn_2B_1$ and $T_5 = N_{140}P_{75}K_{140}S_{42}Zn_2B_1$ (kg ha^{-1}). The trails were laid out in a Randomized Complete Block Design (RCBD) with three replications. Results indicated that application of different levels of fertilizers increased yield significantly over absolute control treatment (Table 18). In Binapias-1, the highest bulb yield (8.34 t ha^{-1}) was obtained from treatment T_4. In Binapias-2, the highest bulb yield (7.82 t ha^{-1}) was obtained from treatment T_3. In both the cases, the lowest yield was found in control treatment.

(a) Yield and yield attributes of summer onion at BINA farm, Mymensingh

Treatments	Leafs/plant (no.)		Bulb diameter (cm)		Bulb yield (t/ha)	
	Binapiaj-1	Binapiaj-2	Binapiaj-1	Binapiaj-2	Binapiaj-1	Binapiaj-2
T_1: Control	3.87	3.06	8.35	8.56	6.76	6.56
T_2: $N_{80}P_{30}K_{80}S_{24}$	4.87	4.67	9.10	8.52	7.38	7.02
T_3: $N_{100}P_{45}K_{100}S_{30}$	5.30	4.87	9.00	9.13	8.26	7.82
T_4: $N_{120}P_{60}K_{120}S_{36}$	5.13	4.40	9.60	8.77	8.34	7.62
T_5: $N_{140}P_{75}K_{140}S_{42}$	5.00	4.47	8.90	9.66	7.72	7.24

Date of seeding: 24.01.2018, Date of transplanting: 14.03.2018, Date of harvesting: 15.05.2018

(b) Optimum fertilizer doses for summer onion at BINA farm, Mymensingh

Locations	Fertilizer dose (kg/ha)						
	N	P	K	S	Zn	B	*Organic manure (t/ha)
BINA farm, Mymensingh	80-100	30-45	80-100	24-30	02	01	05

Note: All of organic manure, phosphorus, sulphur, zinc and boron; and half of nitrogen and potassium should be applied as basal during final land preparation. Remaining nitrogen and potassium should be applied in two equal splits at 25 and 45 days after planting under moist soil condition and mixed thoroughly with the soil as soon as possible for better utilization. Organic manure will be applied based on IPNS.

Influence of organic residue sources and chemical fertilizer doses on grain and straw yield of maize

Field experiment was conducted at the BINA head quarter farm, Mymensingh to evaluate the combined effect of organic residue and chemical fertilizers on grain and straw yield of maize. Three sources of organic residue viz. OR_0=no root and shoot of rice, OR_1=only root of rice and OR_2= 1/3 shoot and root of rice and four levels of chemical fertilizers (CF_0=no chemical fertilizers, CF_1=70% NPK chemical fertilizers, CF_2=100% NPK chemical fertilizers and CF_3=130% of NPK chemical fertilizers) were used for this experiment. Factorial experiment was laid out in randomized completer block design with three replications. Influence of organic residue sources grain and straw yield of maize are shown (Fig. 2). Highest grain and straw yields were found in OR_2 (1/3 rice shoot and root) treatment. Second highest grain and straw yield was observed in OR_1 (only rice root) treatment. OR_0 treatment produced the lowest grain and yield of maize.

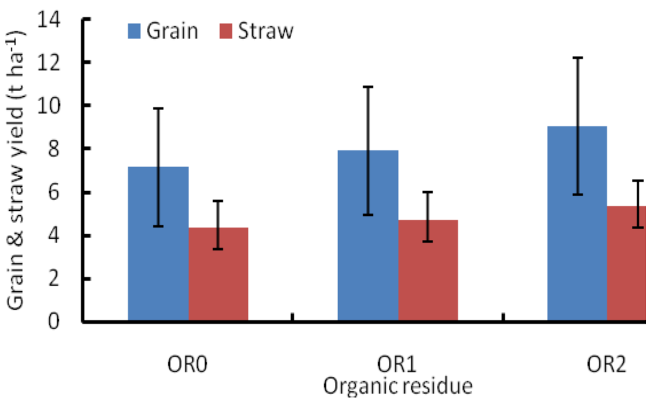


Fig. 2. Effect of organic residue sources on grain and straw yield of maize

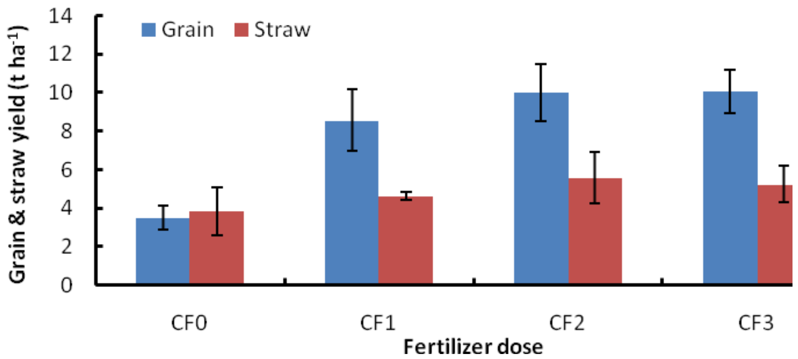


Fig. 3. Effect of different doses of chemical fertilizer on grain and straw yield of maize

Effect of chemical fertilizer on grain and straw yields are depicted in Fig. 3. Maximum grain and straw yields were found in CF_3 treatment. The second highest grain and straw yields were observed in CF_2 treatment. Control (CF_0) treatment produced the lowest grain and yields of maize. From these results it may be concluded that increase in chemical fertilizers increases the grain yield of maize.

Table 19. Interaction effect of organic residue source and dose of chemical fertilizer on grain and straw yield of maize

Treatment	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
$OR_0 \times CF_0$	3.19	4.09
$OR_0 \times CF_1$	7.17	4.19
$OR_0 \times CF_2$	9.02	4.67
$OR_0 \times CF_3$	9.22	4.52
$OR_1 \times CF_0$	3.33	3.43
$OR_1 \times CF_1$	8.53	4.29
$OR_1 \times CF_2$	9.34	5.43
OR1 $\times CF_3$	10.47	5.71
$OR_2 \times CF_0$	4.01	4.00
$OR_2 \times CF_1$	10.02	5.43
$OR_2 \times CF_2$	11.64	6.57
$OR_2 \times CF_3$	10.56	5.52
Significance level	**NS**	**NS**
CV(%)	**12.17**	**20.77**

NS= Not significant at 5% level by DMRT.

Effect of interaction between organic residue source and chemical fertilizers on grain and straw yield of lentil are /presented (Table 19). Maximum grain yield was found in $OR_2 \times CF_2$ treatment. The lowest grain yield was observed in $OR_0 \times CF_0$ treatment. Organic residue source such as root and 1/3 shoot + root increased 4.39 and 25.71% grain yield over control (OR_0) treatment. Treatment $OR_1 \times CF_3$ produced good yield of maize. It may be concluded that combined use of $OR_2 \times CF_2$ and $OR_1 \times CF_3$ is the optimum dose for increasing grain yield of maize.

Effect of foliar application of different fertilizers on grain yield increase of lentil at drought prone area of Bangladesh

Field experiment was conducted at the sub-station of Bangladesh Institute of Nuclear Agriculture, Chapai Nawabganj to evaluate the performance of foliar fertilizer spray on grain yield of lentil. Treatment combination were F_0= no foliar spray (control), F_1= foliar fertilizer (DAP) spray and F_2= foliar fertilizer (TSP) spray. Experiment was laid out in a randomized block design with three replications. Two spray were applied of 3% DAP (diammonium phosphate) and 2% TSP (triple super phosphate) at flowering and pod formation stage of lentil. Maximum grain yield was found in F_1 treatment and the lowest grain yield was obtained from F_0 treatment.

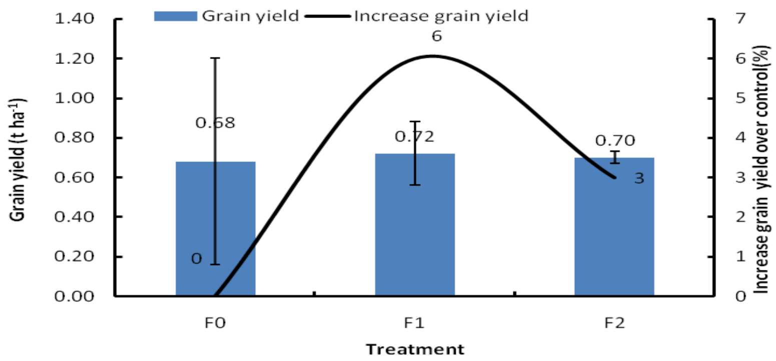


Fig. 4. Effect of foliar fertilizer spray on grain yield lentil and its increase over control

Foliar application of DAP and TSP increased 6 and 3% higher yield over control, respectively. From these results it may be concluded that foliar application of DAP can increase grain yield of lentil at drought prone area of Bangladesh.

Effect of different doses of urea fertilizer on grain yield of lentil using tracer techniques

Field experiment was conducted at the sub-station of Bangladesh Institute of Nuclear Agriculture, Ishwardi to test the effect of different doses of urea fertilizer on grain yield of lentil. Treatment combinations were N_0= control, $N_{11.5}$= 11.5 kg N ha^{-1} and $N_{25.3}$= 25.3 kg N ha^{-1}. Experiment was laid out in a randomized block design with three replications. Binamasur 5 was the test crop.

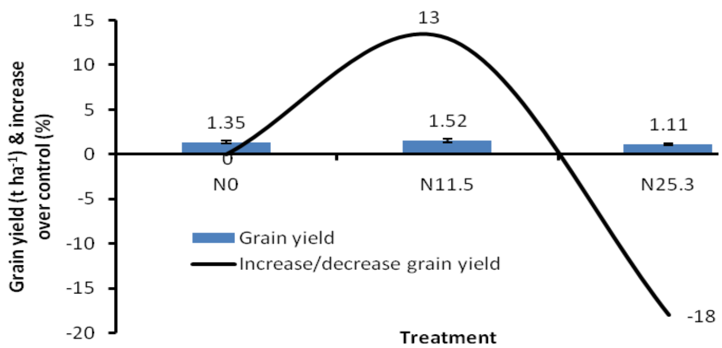


Fig. 5. Effect of different doses of urea fertilizer on grain yield of lentil and its increase/decrease over control

Application urea of fertilizer (25.3 kg N ha^{-1}) produced the lowest grain yield of lentil over control treatment. Urea (N11.5 kg ha^{-1}) produced the highest grain yield of lentil. The second highest grain yield was observed in control treatment. Urea (N 25.3 kg ha^{-1}) decreased grain yield of lentil against control treatment. It may be concluded that higher amount of nitrogen (25.3 N kg ha^{-1}) decrease the nitrogenous activity during crop production.

Studies on the performance of vermicompost and organic materials for improving soil fertility and crop productivity (PIU-BARC-NATP-2-CRG ID: 802)

Background survey and isolation of earthworms from three agro-ecological zones (AEZs)

Various earthworms were isolated from different places from six areas (Ishurdi, Satkhira sadar, Mymensingh sadar, Jamalpur sadar, Rangpur sadar and Dinajpur sadar) of three AEZs (AEZ 9, AEZ 11and AEZ 3) which have been presented in the Table 20. Different physico-chemical properties of corresponding soils were related to the abundance of earthworms have been presented in the Table 21 and fig. 6a-f. The properties of collected soils varied in their texture, pH, bulk density EC, organic C, total N, available P and exchangeable K. The abundance of earthworms also related with the properties of different soils. Gray coloured and large sized earthworms were isolated from maximum sites. Maximum earthworms (127 earthworms m^{-2} area) were found in mahogani plantation at BINA substation farm, Jamalpur (AEZ 9) where the soil was loam and minimum earthworms were recorded from mixed plantation of RARS farm Ishurdi, Pabna (AEZ 11) and mixed garden of ATI, Ishurdi, Pabna (Table 21). As regard to AEZ highest number of earthworms were observed in the AEZ 9 (Fig.6) followed by the AEZ 3. The results showed the positive correlation of soil properties org C, N and P with the earthworm's abundance and a negative correlation was observed with soil bulk density, soil pH and exchangeable K. The present results indicated that abundance of earthworms (no. m^{-2} area) was varied with the changes of land use, land type, soil properties and other anthropogenic practices. Changes in vegetation can affect the distribution and abundance of earthworms through changes in litter quality and indirectly through changes in soil properties.

Table 20. Abundance of earth worms in soils of different AEZs

SL No.	GPS	AEZ, Area and Location	Land use	Abundance of earth worm m^{-2} (No.)	Type of earthworm	Code No.
		AEZ 11: Isurdi, Pabna:				
1.	N:24^0 07.386' E: 89^0 04.867'	BINA, Substation Farm	Fallow	15	Black, Large	ISD-1
2.	N:24^0 07.129' E: 89^0 05.460'	Aronkula	fallow	10	Black, Large	ISD-2
3.	N:24^0 07.394' E: 89^0 04.787'	ATI	Mixed garden	8	Grey, Large	ISD-3
4.	N:24^0 07.362' E: 89^0 04.709'	RARS	Mixed garden	8	Red, thin, narrow	ISD-4
5.	N:24^0 06.651' E: 89^0 06.077'	Charmirkamari	Mixed garden	20	Black, large	ISD-5
		Satkhira sadar:				
6.	N:22^{0}45.071' E: 89^{0}06.411'	BINA substation	Coconut garden	17	Grey, Large	SAT-1
7.	N: 22^0 44.728' E: 89^0 0.1593'	Nebakhali	Mango orchard	25	Grey, Large,	SAT-2
8.	N: 22^0 45.052' E: 89^0 01.361'	Godaghata Kormkarpara	Fallow (Jute)	34	Reddish Large	SAT-3
9.	N: 22^0 45.750' E: 89^0 06.900'	Ramitia, Nagarghata	Banana garden	10	Reddish large	SAT-4
10	N: 22^0 45.794' E: 89^0 06.877'	Motbari, Nagarghata	Mango orchard	15	Black, Large	SAT-5
		AEZ 9: Mymensingh sadar:				
11.	N:24^0 42.715' E: 90^0 26.847'	Boira	Fallow	41	Grey, Large	My-1

12.	N:24^0 40.165' E: 90^0 26.994'	Bhabokhali	Banana garden	10	Black, Large	My-2
13.	N:24^0 40.321' E: 90^0 25.149'	churkhai	Chili field	34	Black, Large	My-3
14.	N:24^0 46.150' E: 90^0 26.869'	Shombugonj	Mixed garden	70	Grey, large	My-4
15.	N:24^0 43.553' E: 90^0 25.764'	BINA Farm, Mymensingh	Giant mimosa field	95	Black, Large Grey, Large Reddish medium large	My-5
			Jamalpur:			
16.	N:24^0 56.318' E:89^{0}55.523'	BINA substation farm	Mahogani plantation	127	Grey, Large Reddish, large	JP-1
17.	N:24^0 56.287' E:89^{0}55.896'	RARS	Brinjal-fallow	55	Grey, Large,	JP-2
18.	N:24^0 56.228' E:89^{0}55.806'	Chandra	Mixed garden	33	Grey, Large	JP-3
19.	N:24^0 57.560' E:89^{0}54.856'	Goabaria	Mixed garden	60	Grey, Large	JP-4
20.	N:24^0 55.331' E:89^{0}54.581'	Rashidpur	Dhaincha-fallow	15	Grey, Large	JP-5
			AEZ 3: Tista Meander Floodplain, Rangpur			
21.	N:25^0 43.402' E: 89^0 16.720'	BINA sub station farm	Summer mungbean - Fallow	54	Redish, Grey, Lare	RP-1
22.	N:25^0 42.511' E: 89^0 14.769'	Ghagot para, Akkelpur	Sugarcane	11	Black, medium	RP-2
23.	N:25^0 42.281' E: 89^0 14.146'	Dangarpara, Akkelpur	Mango orchard	22	Black Large	RP-3
24.	N:24^0 47.936' E: 89^0 14.129'	Chabbish Hazari, Burirhar	Ginger field	30	Black Large	RP-4
25.	N:25^0 49.201' E: 89^0 14.471'	Uttar Kubaro	Amaranthus	30	Black, large, Redish, medium	RP-5
			Dinajpur			
26.	N:25^0 44.983' E:88^0.40.365'	Gornurpur	Summer mungbean - Fallow	30	Grey, Large	DP-1
27.	N:25^0 44.509' E:88^{0}40.430'	Wheat Research Center, Nashipur	Sugarcane	35	Large, Grey	DP-2
28.	N:25^0 42.932' E:88^{0}39.710'	Nashipur	Mango orchard	21	Grey, Large	DP-3
29.	N:25^0 36.502' E:88^{0}40.779'	Chuniapara	Ginger field	38	Grey Large	DP-4
30.	N:25^0 35.472' E:88^{0}42.429'	Jaliapara	Amaranthus	11	Large, Grey	DP-5

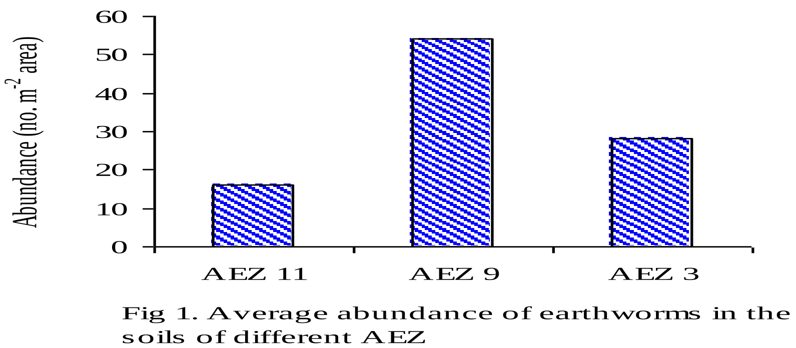
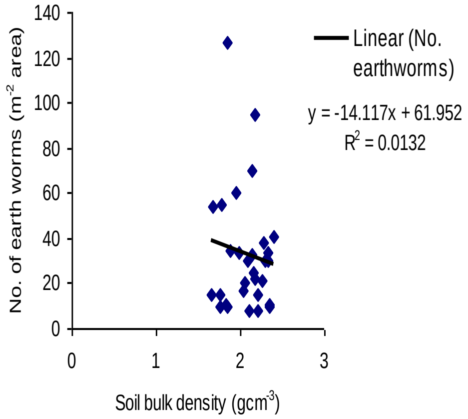


Fig. 6. Average abundance of earthworms in the soils of different AEZ

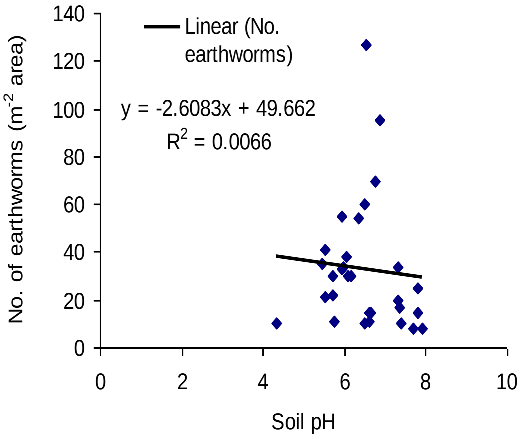
Table 21. Physico-chemical charateristics of corresponding soils where from earthworms isolated

Sample code and AEZ	Soil pH	Texture	Bulk density (g cm^{-3})	Org.C (%)	EC(dsm^{-1})	Total N (%)	Availabe P ($mgkg^{-1}$)	Exchangeable K (meq%)
				AEZ- 11:				
ISD-1	7.78	Silt loam	1.65	0.70	0.55	0.14	13.6	0.171
ISD-2	7.4	Silt loam	1.76	0.93	0.32	0.13	16.3	0.192
ISD-3	7.7	Silt Loam	2.1	0.86	0.65	0.15	10.8	0.156
ISD-4	7.92	Silt loam	2.20	0.74	0.32	0.12	9.6	0.143
ISD-5	7.3	Sill loam	2.05	0.78	0.74	0.07	13.7	0.167
SAT-1	7.36	Silt loam	2.04	1.05	1.6	0.10	12.0	0.182
SAT-2	7.79	Silt loam	2.16	1.08	1.2	0.13	11.5	0.211
SAT-3	7.31	Sill loam	1.98	0.74	1.3	0.11	14.8	0.198
SAT-4	6.51	Silt loam	1.85	1.01	1.5	0.14	18.3	0.225
SAT-5	6.59	Silt loam	1.75	1.68	1.8	0.16	16.5	0.234
				AEZ-9:				
My-1	5.52	Silt loam	2.39	0.85	0.09	0.10	14.0	0.125
My-2	4.34	Silt loam	2.35	0.59	0.15	0.10	9.2	0.136
My-3	5.96	Sill loam	2.33	0.702	0.25	0.09	12.2	0.127
My-4	6.75	Silt loam	2.13	1.17	0.34	0.11	8.4	0.128
My-5	6.85	Silt loam	2.18	0.702	0.18	0.08	14.9	0.132
JP-1	6.52	Silt loam	1.84	1.092	0.13	0.16	15.8	0.082
JP-2	5.94	Silt loam	1.78	0.98	0.08	0.12	9.3	0.095
JP-3	5.94	Sill loam	2.13	0.74	0.06	0.08	10.6	0.121
JP-4	6.49	Silt loam	1.95	1.05	0.21	0.09	11.2	0.078
JP-5	6.65	Silt loam	2.2	0.62	0.15	0.09	10.9	0.092
				AEZ-3:				
RP-1	6.33	Silt loam	1.68	0.66	0.17	0.09	13.4	0.157
RP-2	5.73	Silt loam	1.83	0.62	0.26	0.11	12.0	0.134
RP-3	5.72	Sill loam	2.17	0.86	0.08	0.10	11.9	0.108
RP-4	6.08	Silt loam	2.29	0.51	0.29	0.11	12.8	0.132
RP-5	6.15	Silt loam	2.09	0.85	0.14	0.12	9.7	0.125
DP-1	5.72	Silt loam	2.32	0.55	0.25	0.07	10.7	0.093
DP-2	5.44	Silt loam	1.88	0.59	0.36	0.08	14.8	0.117
DP-3	5.52	Sill loam	2.25	0.51	0.31	0.09	11.0	0.108
DP-4	6.04	Silt loam	2.27	0.74	0.19	0.09	9.5	0.132
DP-5	6.59	Silt loam	2.35	0.54	0.20	0.11	8.2	0.128

Range	4.34-7.92	1.65-2.39	0.51-1.71	0.06-1.8	0.07-0.17	8.2-18.5	0.078-0.234

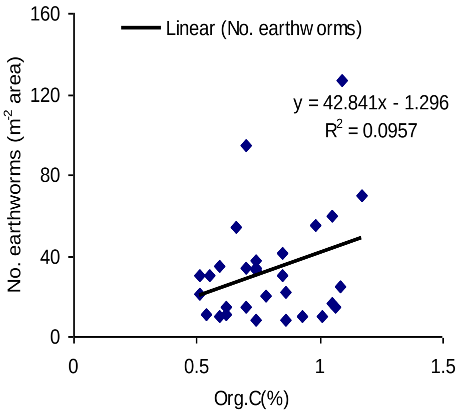


6a.

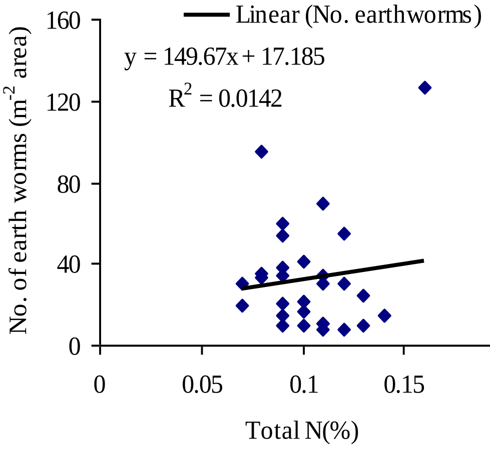


6

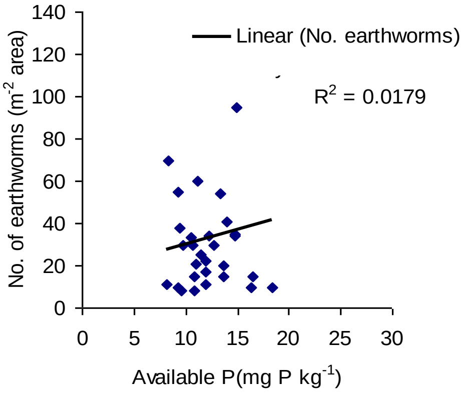
b.



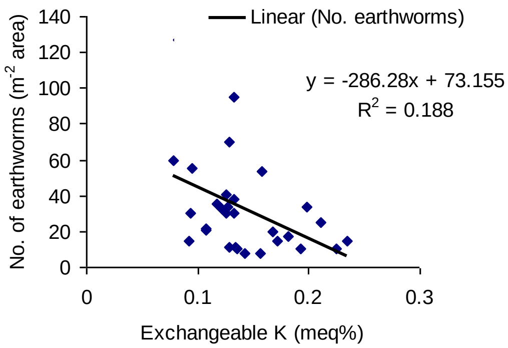
6c



6d



6e



6f

Fig 6 (a-f). Correlation (n=30) between different soil parameters and abundance of earthworms

Evaluation of different earthworms on the basis of decomposition and nutrient release using various organic residues

The glasshouse experiment conducted for selection of efficient earthworms and suitable organic materials for producing quality vermicompost. Soil was collected from farmer's field, Mymensingh. Rice straw and cowdung was collected from farmer's house, Boyra, Mymensingh. Partial decomposed poultry manure was collected from poultry farm, Kewatkhali, Mymensingh. Earthworms-1 (EW_1) was collected from farmer's vermicompost farm, Nebakhali, Satkhira sadar. Earthworms-2 (EW2) is mixed culture which has been collected from giant mimosa field, BINA farm, Mymensingh. Fifteen treatment combinations were used for the experiment. These were as follow:

T_1: Soil + cowdung (CD)+Rice straw (RS)+ Earthworms -1(Ew_1)
T_2: Soil+ CD+poultry manure (PM)+Ew_1
T_3: Soil+ CD+Giant mimosa residue (GMR)+Ew_1
T_4: Soil+ CD+RS+PM+GMR+Ew_1
T_5: Soil+RS+PM+GMR+Ew_1(Without CD)
T_6: Soil + CD+RS + Mixed earthworms -2(Ew_2)
T_7: Soil+ CD+PM +Ew_2
T_8: Soil+ CD+GMR +Ew_2
T_9: Soil+ CD+RS+PM+GMR+Ew_2
T_{10}: Soil+ RS+PM+GMR+Ew_2 (Without CD)
T_{11}: Soil+ CD +RS
T_{12}: Soil+ CD+PM
T_{13}: Soil+ CD+GMR
T_{14}: Soil+ CD+RS+PM+GMR
T_{15}: Soil+ RS+PM+GMR (Without CD)

The experiment conducted in completely randomized design (CRD) with four replication at the glass house, Soil Science Division, BINA, Mymensingh. Treatment wise organic materials have been filled up into the plastic buckets (50L size). About eight kilogram of organic materials was taken in each bucket but their ratios were varied from treatment to treatment. Initial nutrients status and rate of different residues have given in the table 3 and 4. Filled up organic residues were mixed up properly and sufficient water was added for wet the residue. All the treatments are being pre-incubated about 5 weeks for overcoming of thermal phase and softening the organic materials, so that released earthworms can survive and multiply into organic residues. The total incubation of period was 15 weeks (pre-incubation for 5 weeks +after inoculation with earth forms for 10weeks). Evolution of CO_2 and changes of pH have been recorded in 7 days interval after inoculation of earth worms as treatment plan up to 10 weeks. Evolution of CO2 was measured by alkali (NaOH) trapping and titrating with hydrochloric acid. The trap was prepared taking 40 ml of 2 M NaOH in a plastic bottle of 100 ml in size. Such traps were placed on the surface of decomposing organic materials in the pots for each treatment and empty glass jar were inverted on the trap so that trap can stand in central position and inserted the glass jar about 2cm into the decomposing organic materials for airtighting the system. Empty pot with alkali alone was used as control. After 7 days, traps were collected at 11.00 a.m. covering with screw cap and replaced with new traps. Timing was maintained in such a way that CO_2 absorption takes place for 7 days. Data were collected at 7 days interval up to 10 weeks. The evolution of CO_2 expressed in mg CO_2 cm^{-2} $week^{-1}$. Organic carbon and total N have been determined from the decomposed organic materials or vermicompost. Determination of other nutrient contents (P, K, S, etc) are being progress.

Table 22. Nutrient contents in different organic materials used in the experiment

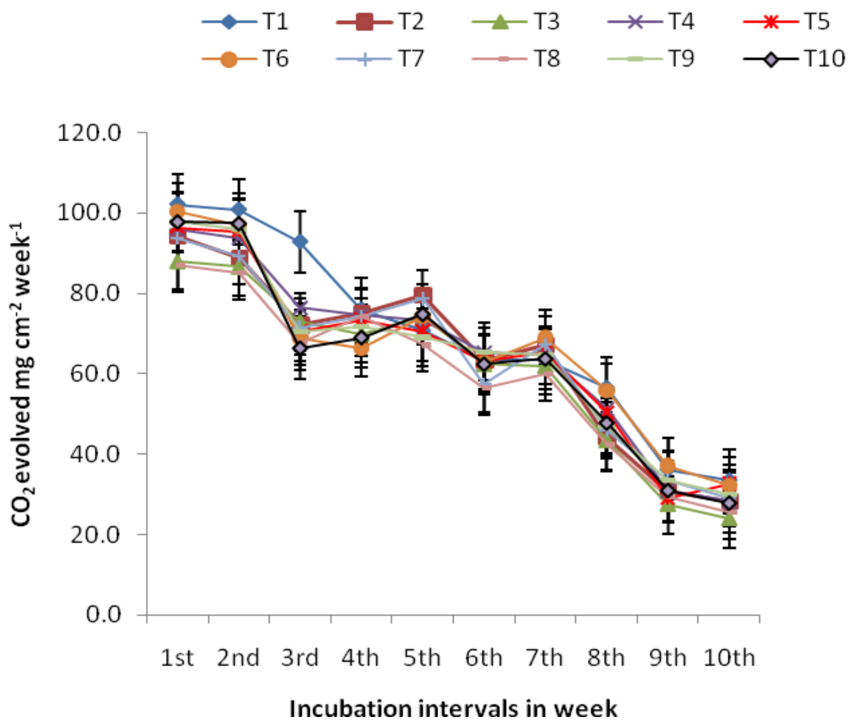
Organic materials	Org C(%)	%N	%P	%K	%S
Poultry manure	29.15	1.34	0.45	1.1	0.85
Cowdung	35.3	0.78	0.38	0.46	0.28
Rice straw	37.5	0.67	0.12	1.4	0.09
Giant mimosa residue	31.0	1.76	0.25	0.56	0.34
Soil	0.94	0.13	15 (mg kg^{-1})	0.13 (meq%)	14 (mg kg^{-1})

Table 23. Rates of different organic materials used for each treatment on the basis of oven dry

Treatment Code	kg $bucket^{-1}$					Earthworms
	Soil	Cowdung (CD)	Rice straw (RS)	Poultry manure (PM)	Giant mimosa residue (GMR)	
T_1	2	2	4	0	0	EW1
T_2	2	2	0	4	0	EW1
T_3	2	2	0	0	4.0	EW1
T_4	2	2	1.33	1.33	1.33	EW1
T_5	2	0	2	2	2	EW1
T_6	2	2	4	0	0	EW2
T_7	2	2	0	4	0	EW2
T_8	2	2	0	0	4.0	EW2
T_9	2	2	1.33	1.33	1.33	EW2
T_{10}	2	0	2	2	2	EW2
T_{11}	2	2	4	0	0	-
T_{12}	2	2	0	4	0	-
T_{13}	2	2	0	0	4	-
T_{14}	2	2	1.33	1.33	1.33	-
T_{15}	2	0	2	2	2	-

Evolution of CO_2 during decomposition after inoculated with earthworms:

Measurement of CO_2 evolution is an important indice for understanding the compost maturation or stabilization over the decomposition periods. Therefore, after pre-incubation of the treatments, CO_2 was measured for every week up to 10 weeks i.e. until the termination period. The data on evolution of CO_2 have been shown in the figure 7a and 7b. At first week, all the treatments showed highest peaks of CO_2 both in with earthworms (fig.7a) or without earthworms (Fig.7b) aided treatments. After second week, evolution was gradually decreased up to termination time (at 10 th week) but some variation was observed regarding with earthworms types and organic materials. As regard to earthworms, the earthworm-1(EW1) aided treatments evolved greater CO_2 than the earthworm-2 aided treatments with all the organic materials at early incubation period. Without earthworms treated organic materials evolved lesser amount of CO_2 than with earth worms treated organic materials at early of incubation and peaks were also higher in later incubation period than the with earthworm treatments. The result indicated that earthworm-1 faster decomposed the organic materials or stabilized the compost than the earthworm-2 (Ew_2). As regard to organic materials treatment T_1 gave maximum peaks of CO_2 all most throughout the incubation period might be due to high carbon content in rice straw than other combination of organic materials. The treatment T_3 and T_8 evolved less carbon dioxide in throughout the incubation period might be due to low C:N ratio in the giant mimosa residue and this organic materials goes faster stabilization than all other treatments. The result indicated that the characteristic of organic materials were also vital factor during the vermicomposting for faster decomposition or stabilization of the vermicompost. The treatments T_3 and T_4 converted more stable vermicompost than other treatments might be both the treatment received giantmimosa residue owing low C:N ratio.



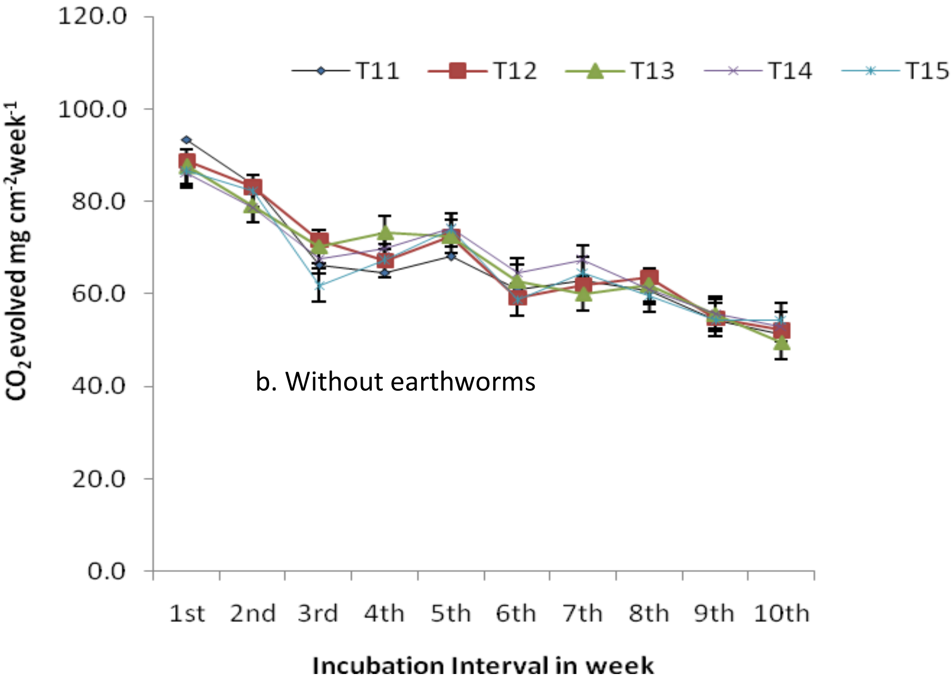


Fig.7. (a-b). Effect of earthworms or without earthworms on evolution of carbon dioxide during decomposition of organic materials in different incubation intervals

Number of earthworms at the end of incubation:

Earthworms were counted at the end of the incubation and number earthworms have been shown in the fig.4. The highest number of redwigglers earthworms were recorded in the treatment T_3 (Soil+ CD+GMR+Ew_1) followed by the treatment T_4 (Soil+ CD+RS+PM+GMR+Ew_1) at the end of the incubation. These two treatment combination might be produced more stable vermicompost compost among the treatments.

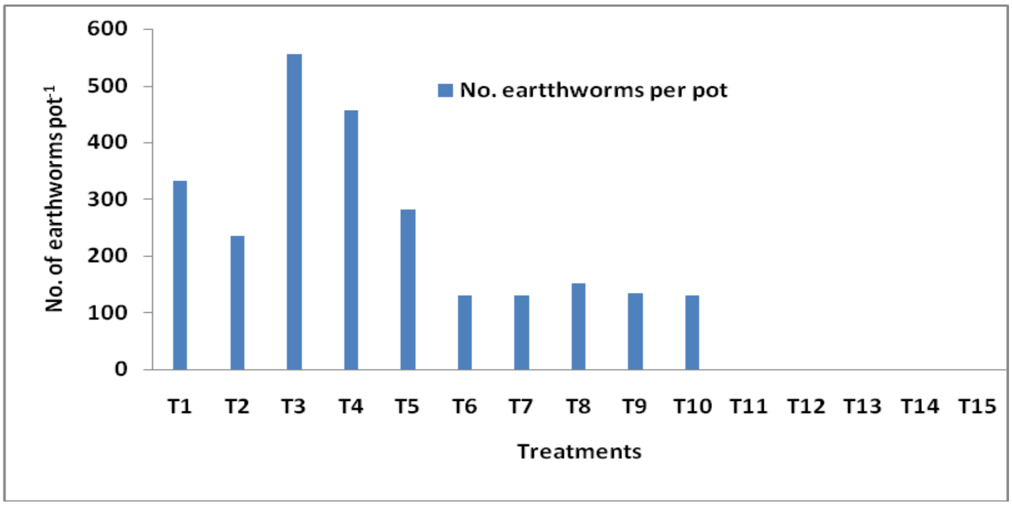


Fig. 8. Number of earthworms as affected by different treatments at the end of the incubation

Nutrient content in decomposed organic materials:

Organic carbon and total N content and C:N ratio were affected with earthworms or without earthworms treated organic materials during the end of the incubation and the results have been presented in the table 24. The lowest organic carbon and C:N ratio were recorded in the treatment T_2 followed by the treatment T_3 and the highest organic carbon C:N ratio were observed in the treatment T_{15}. The results indicated that the Earthworm-1 treated organic materials which one contained low organic C made more stable vermicompost than other treatment combination. The third lowest organic carbon content and C:N ratio were observed in the treatment T_4 which received poultry manure+ giantmimosa residue+rice straw + cow dung+ earthworm-1(Ew_1) which is also comparable with T_2 and T_3. Maximum total N content (1.16%) was observed with the treatment T_4 (Soil+ CD+RS+PM+GMR+Ew_1) followed by the treatment T_2 (Soil+ CD+poultry manure +Ew_1) and the lowest N content (0.65%) was recorded in the treatment T_{11}(Soil+ CD +RS). The results showed that the mixture of low and high C:N ratio containing different organic materials treated with earthworms could be an effective approach for producing vermicompost. The results revealed that the treatment T_4 (Soil+ CD+RS+PM+GMR+Ew_1) could be used for production of vermicompost followed by the treatment T_2 (Soil+ CD+poultry manure (PM)+Ew_1 and T_3 (Soil+ CD+Giant mimosa residue (GMR)+Ew_1) in terms of nutrient contents in the vermicompost. However final conclusion will be made after the determination other some nutrients (P, K and S) which analysis is in progress.

Table 24. Organic carbon and total N content and C: N ratio in decomposed organic materials with or without earthworms at the end of the incubation

Treatments	% organic carbon	% total N	C:N ratio
T_1: Soil + cowdung (CD)+Rice straw (RS)+ Earthworms -1(Ew_1)	14.3±0.88	0.78±0.02	18.3
T_2: Soil+ CD+poultry manure (PM)+Ew_1	9.5±0.18	1.09±0.04	8.7
T_3: Soil+ CD+Giant mimosa residue (GMR)+Ew_1	10.9±0.05	1.05±0.06	10.4
T_4: Soil+ CD+RS+PM+GMR+Ew_1	13.3±0.80	1.16±0.02	11.5
T_5: Soil+RS+PM+GMR+Ew_1(Without CD)	16.9±0.81	0.87±0.05	19.4
T_6: Soil + CD+RS + Mixed earthworms -2(Ew_2)	15.1±0.16	0.74±0.01	20.5
T_7: Soil+ CD+PM +Ew_2	12.1±0.73	0.94±0.03	13.0
T_8: Soil+ CD+GMR +Ew_2	12.9±0.58	0.96±0.02	13.5
T_9: Soil+ CD+RS+PM+GMR+Ew_2	13.3±0.75	0.96±0.02	13.9
T_{10}: Soil+ RS+PM+GMR+Ew_2 (Without CD)	17.9±0.72	0.82±0.03	21.9
T_{11}: Soil+ CD +RS	17.3±0.42	0.65±0.02	26.6
T_{12}: Soil+ CD+PM	13.6±0.75	0.88±0.04	15.5
T_{13}: Soil+ CD+GMR	14.5±0.72	0.87±0.02	16.7
T_{14}: Soil+ CD+RS+PM+GMR	15.8±0.72	0.90±0.01	17.5
T_{15}: Soil+ RS+PM+GMR (Without CD)	18.0±0.54	0.75±0.05	24.1

± indicated standard errors

Integrated effects of vermicompost with inorganic fertilizer on soil fertility and crop productivity

Field experiments were conducted to investigate the effect of vermicompost on soil fertility and crop productivity in mustard -boro rice cropping sequence. The experiments were carried out with eight treatments and three replication in randomized complete block design (RCBD). The treatments for both the crops used in the experiments were as follows:

T_1: Native soil fertility
T_2:100% chemical fertilizer (CF)
T_3: 75% CF
T_4: 75% CF + Vermicompost (VC) @ 4 tha^{-1}
T_5:85%CF
T_6: 85% CF + VC @ 4 tha^{-1}
T_7: 75%CF +VC @ 2 tha^{-1}
T_8: 85%CF+VC @ 2 tha^{-1}

The unit plot size was 3m× 4m in all the location. The experiments conducted at three location viz. i) BINA farm Mymensingh (AEZ-9) ii) Farmer's field Khoddo Tampat, Rangpur sadar (AEZ-3) and iii) Farmer's field, Ista, Ishurdi, Pabna (AEZ-11).

Initial soil was collected from all the location to determine the physico-chemcal properties. The properties of initial soil have been given in the Table 25. Fertilizer applied on the basis of soil test (STB) in both the crops (Table 26). Nutrient content of applied vermicompost was determined and have been given in table 27. Amount of nutrients added from vermicompost (VC) in mustard or boro rice were determined (Table 28). After harvest of mustard (Binasharisha-10), boro rice was transplanted using same layout. The sowing and harvesting date of both the crops have been given in the Table 29 . Yield and yield contributing characters of mustard and boro rice were recorded at the harvest. Post harvest soil was collected after harvesting of boro rice for determination of pH and Org.C and different nutrients (N, P, and K).

Table 25. Properties of initial soil of experimental field

Soil properties	BINA farm Mymensingh	Khoddo Tampat, Rangpur sadar (Farmer's field)	Ista, Ishurdi, Pabna (Farmer's field)
Soil texture	**Silt loam**	**Silt loam**	**Silty clay loam**
pH	6.85	5.9	7.1
Organic carbon(%)	0.93	0.91	0.84
Total N(%)	0.1	0.09	0.1
Available P (mg kg^{-1} soil)	15.0	13.0	14.0
Exchangeable K (meq%)	0.151	0.141	0.171
Available S (mg kg^{-1} soil)	15.0	14.0	13.0

Table 26. Full (100%) fertilizer rates (kg ha^{-1}) on the basis of soil test for mustard and boro rice at different location.

Location	Mustard				Boro rice			
	N	P	K	S	N	P	K	S
i) BINA farm Mymensingh	87	18	47	10	131	9.8	60.4	10.2
ii) Khoddo Tampat, Rangpur sadar (Farmer's field)	120	20	49	11	136	11.9	64	11.2
iii) Ista, Ishurdi, Pabna (Farmer's field)	87	19	49	12	131	11	63.6	11.5

Table 27. Nutrient contents in applied vermicompost

N (%)	P (%)	K (%)	S(%)
1.3	0.6	1.4	0.38

Table 28. Amount of nutrients added from vermicompost (VC) in mustard or boro rice

Rate of vermicompost (t ha^{-1})	Amount of Nutrients (kgha^{-1})			
	N	P	K	S
2	26	12	28	7.6
4	52	24	56	15.2

Table 29. Sowing and harvesting time of mustard (Binasharisha 10) and boro rice (Binadhan-14)

Location	Mustard (Binasharisha-10)		Boro rice (Binadhan-14)	
	Date of sowing	Date of harvest	Date of sowing	Date of harvest
i) BINA farm Mymensingh	23-11-2017	08-02-2018	01-03-2018	21-05-208
ii) KhoddoTampat, Rangpur sadar	20-11-2017	11-02-2018	08-03-2018	29-05-2018

(Farmer's field)				
ii) Ista Ishurdi, Pabna (Farmer's field)	27-11-217	21-02-2018	27-03-2018	07-05-2018

Mustard:

Seed yield of mustard (Binasharisha 10) was significantly influenced with the different treatments at Rangpur, Ishurdi and Mymensingh (Table 30). Maximum seed yield was observed with the treatment T_6 (1.82, 1.26 and 1.49 t ha^{-1} at Rangpur, Ishurdi and Mymensingh, respectively) in all the location followed by the treatment T_8 (1.80, 1.23 and 1.46 t ha^{-1} at Rangpur, Ishurdi and Mymensingh, respectively but they were identical with the treatments T_4 and T_2 for producing of seed yield of mustard. The treatment T_6 gave identical seed yield with treatment T_2, T_4 and T_8 at Rangpur and Mymensingh while at Ishurdi, the treatment T_6 gave statistically similar seed yield with all the treatments except the treatments T_1 and $T_{2.}$ The treatments T_4, T_6 and T_8 did not differ significantly in case of seed yield of mustard which were also comparable to the treatment T_2 (100% chemical fertilizer). The lowest seed yield of mustard was observed with the treatment T_1 at all the location. Similar trends were also observed in case of straw yield of mustard at all the location. The results indicated that 75% chemical fertilizer (CF) with 4 t ha^{-1} vermicompost or 85% CF with 2 t ha^{-1} vermicompost almost equally effective to produce seed yield of mustard (Binasharisha 10) which was also comparable with the full dose from only chemical fertilizer (100% CF). Therefore 15-25% chemical fertilizer (NPKS) could be saved either with the application of 75% CF with 4 t ha^{-1} vermicompost or 85% CF with 2 t ha^{-1} vermicompost for mustard cultivation in Bangladesh.

Some yield contributing characters viz. plant height, siliqua plant^{-1}, seed siliqua^{-1} and plant population m^{-2} of mustard also recorded and presented in the table 31. The treatments T_4, T_6 and T_8 showed also better performance in the growth and development of yield contributing characteristics which was very comparable with the treatment T_2 (100% CF).

Chemical analysis of plant and soil samples are being progress. Boro rice (Binadhan 14) has been harvested. Data analysis is in progress.

Table 30. Effect of vermicompost with inorganic fertilizer on seed and straw yield (t ha^{-1}) of mustard (Binasharisha 10) in different location during 2017-18

Treatments	Rangpur		Ishurdi		Mymensingh	
	Seed yield	Straw yield	Grain yield	Straw yield	Grain yield	Straw yield
T1	0.58c	2.22b	0.29c	0.83b	0.26d	1.41b
T2	1.72a	4.47a	1.22a	3.78a	1.43ab	3.23a
T3	1.42b	4.36a	0.81b	3.27a	0.88c	3.03a
T4	1.76a	4.51a	1.20a	3.73a	1.44ab	3.37a
T5	1.53b	4.44a	1.07a	3.43a	1.03c	3.10a
T6	1.82a	4.55a	1.26a	3.91a	1.49a	3.40a
T7	1.54b	4.45a	1.13a	3.63a	1.34b	3.33a
T8	1.80a	4.71a	1.23a	3.85a	1.46ab	3.32a
CV(%)	**6.25**	**5.50**	**12.26**	**10.50**	**7.09**	**8.00**

In a column, the values having same letter do not differ significantly at 5% level by DMRT.

Note:T_1: Native soil fertility, T_2:100% chemical fertilizer (CF), T_3: 75% CF, T_4: 75% CF + Vermicompost (VC) @ 4 tha^{-1}, T_5:85%CF, T_6: 85% CF + VC @ 4 tha^{-1}, T_7: 75%CF +VC @ 2 tha^{-1}, T_8: 85%CF+VC @ 2 tha^{-1}

Table 31. Effect of vermicompost with inorganic fertilizer on yield contributing characters of mustard at different location during 2017-18

Treatment	Rangpur				Ishurdi				Mymensingh			
	Plant height (cm)	Siliqua plant^{-1} (no.)	Seeds siliqua^{-1} (no.)	Plants m^{-2} (no.)	Plant height (cm)	Siliqua plant^{-1} (no.)	Seeds siliqua^{-1} (no.)	Plants m^{-2} (no.)	Plant height (cm)	Siliqua plant^{-1} (no.)	Seeds siliqua^{-1} (no.)	Plants m^{-2} (no.)
T1	65.5b	31.9d	11.97c	135.8b	52.6b	18.3b	11.2b	83.0b	29.8b	11.5c	9.3c	125.0b
T2	97.4a	102.4ab	15.6a	170.7a	83.8a	62.4a	15.4a	181.3a	91.2a	76.7ab	15.9a	173.0a
T3	93.0a	72.7bc	13.0bc	160.5a	81.2a	56.3a	14.5a	162.7a	80.1a	66.8b	12.1b	155.0ab
T4	98.5a	101.3ab	15.3a	166.9a	83.5a	63.0a	15.4a	179.0a	80.7a	80.2ab	15.8a	168.7a
T5	93.6a	82.2abc	14.5ab	164.2a	83.3a	59.0a	15.0a	173.3a	80.0a	74.8ab	14.8a	166.3a
T6	98.7a	106.3a	16.1a	168.3a	86.1a	64.0a	15.8a	183.3a	86.3a	86.7a	16.0a	172.0a
T7	98.3a	88.2c	14.5ab	171.0a	83.1a	60.0a	15.2a	180.0a	80.3a	75.0ab	15.5a	167.0a
T8	99.3a	105.2a	15.8a	164.0a	83.1a	64.6a	15.6a	187.7a	81.6a	83.0a	15.9a	170.0a
CV (%)	**4.68**	**19.92**	**5.86**	**8.89**	**6.00**	**9.67**	**9.05**	**11.17**	**8.62**	**12.28**	**7.71**	**9.25**

In a column, the values having same letter do not differ significantly at 5% level by DMRT.

Reduction of chemical fertilizer in crop production using organic manures

Effects of different organic manures on rice –rice cropping sequence (Long term experiment)

Field experiment was conducted to reduce the chemical fertilizer with the integrated use of organic manures in T. Aman-Boro rice cropping sequence at BINA Headquarter farm, Mymensingh during 2017-18. The experiments have been conducted with two cropping cycle 2016-17 and 2017-18. The reported data is only for 2017-18. Six treatments were used for both the crops in 2017-18. The treatments of T. aman rice were as follows: T_1: Absolute control (native fertilizers), T_2: 100% N from Chemical Fertilizer (CF), T_3:70% N from CF, T_4: 30% N from Sesbania green manure + 70% N from CF , T_5:30% N from Giant mimosa green manure + 70% N from CF. T_6: 100% PKS. The treatments of Boro rice (var. Binadhan 10) were: T_1: Absolute control (native soil fertility), T_2: 100% N from chemical fertilizer (CF), T_3:75% N from CF, T_4: 25% N from Giant mimosa brown manure + 75% N from CF, T_5: 25% N from Vermicompost-1+ 75% N from CF and T_6: 100% PKS. The experiments were conducted in a Randomized Complete Block Design with three replications for each treatment. The experimental soil was silt loam having 6.8 pH, 1.1% organic carbon, 0.12% total N, 14 µgg^{-1} available P, 0.145 meq% exchangeable K and 15 µgg^{-1} available S. T. Aman rice (var. Binadhan-17) was transplanted on August 2017 and harvested on Nov. 2017 where as Boro rice (Binadhan-10) was transplanted on Feb 2018 and harvested on May 2018. Fertilizer rates were applied in both the crops on the basis of soil analysis. In case of manure treatments, IPNS was followed. Nutrient contents of different organic manures have been given in Table 1. All manures were applied at 15 days before of transplanting of both the rice crops except vermicompost. Vermicompost and all inorganic fertilizers (TSP, MOP and gypsum) were applied during final land preparation except urea. Urea was applied in three equal splits. Fertilizer and manures rates have been given in Table 33.

All the yields and yield contributing characters of T. Aman rice were significantly affected with the different treatments (Table 32). The treatment T_5 gave maximum grain yield (4.8 t ha^{-1}) followed by the treatment T_4 (4.75 t ha^{-1}). But the treatment T_5, T_4, and T_2 gave identical grain yields of T. Aman rice. The treatment T_1 (Absolute control) gave significantly minimum grain yield of T. Aman rice. Similar results were observed in case of straw yields of T. Aman rice. The result indicated that 70% N from chemical fertilizer with 30% N from either giant mimosa or sesbania green manures gave comparable yield to the sole application of 100% N from chemical fertilizer alone.

The different treatments significantly influenced yields and yield contributing characters of Boro rice (Binadhan-10) and the results have been presented in the Table 33. The treatment T_2 (100% CF) gave the highest grain yield (6.03 t ha^{-1}) of Boro rice followed by the treatment T_4 and$T_{5,}$. Both the manure treatments with chemical fertilizer produced statistically similar grain yield to the full dose of chemical fertilizer (100%CF). The native soil fertility treatment T_1 gave the lowest yield of boro rice. Similar trends were also observed in case of straw yields. The results revealed that 25% N could be saved with the integrated use of giant mimosa brown residue or vermicompost-1.

Table 32. Nutrient contents in different manures

Name of manures	%N	%P	%K	%S
Sesbania green manure	1.75	0.3	0.45	0.25
Giant mimosa green manure	3.5	0.4	1.3	0.30
Giant mimosa brown manures	3.2	0.4	1.5	0.3
Vermicompost-1	1.1	0.5	1.0	0.4

Table 33. Full rates (100%) of nutrients and 30% (for T. Aman) or 25% (for Boro rice) N equivalent manures for T. Aman rice and Boro rice.

	Nutrients (kg ha^{-1})				Manures (t ha^{-1})*			
Crops	N	P	K	S	30% N equivalent Sesbania green manure	30% N equivalent giant mimosa green manure	25% N equivalent giant mimosa brown manure	25% N equivalent vermicompost-1
T. Aman rice	77	9	24	9	1.320	1.283	-	-
Boro rice	134	14	68	13	-	-	2.015	3.022

* Oven dry weight basis

Table 34. Yield and yield contributing characters of T. Aman rice (Binadhan-17) as affected by different treatments

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	2.66c	3.37b	80.53b	22.27b	5.67c	172.73b	32.47b
T_2	4.57ab	5.54a	109.55a	24.20ab	9.90a	222.48a	48.40ab
T_3	3.89b	4.93b	101.81a	23.60ab	7.53b	209.40ab	49.33ab
T_4	4.75a	5.41a	109.98a	23.93ab	10.08a	225.60a	41.47ab
T_5	4.80a	5.55a	111.02a	25.07a	11.57a	230.20a	50.67a
T_6	2.76c	4.01b	83.87b	23.07ab	5.80c	181.33b	39.07
%CV	**11.08**	**10.37**	**6.55**	**6.42**	**11.30**	**10.92**	**22.83**

In a column, figures having common letter(s) do not differ significantly at 5% level of probability.

Table 35. Yield and yield contributing characters of Boro rice (Binadhan-10) as affected by different treatments

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	2.17c	3.06c	79.13b	21.33c	5.47c	107.96b	3.20c
T_2	6.03a	6.6a	95.53a	23.13ab	10.47a	157.79a	14.93ab
T_3	5.1b	6.59a	93.87a	23.27ab	9.13ab	151.73a	11.27abc
T_4	5.67a	6.76a	94.87a	24.00a	9.80a	159.69a	17.60a
T_5	5.76a	6.34b	95.27a	23.87a	9.67ab	156.36a	10.00abc
T_6	2.24c	3.10c	79.53b	22.60b	7.13c	115.29b	7.27bc
CV(%)	**12.5**	**16.8**	**5.31**	**4.5**	**16.84**	**5.53**	**18.9**

In a column, figures having common letter(s) do not differ significantly at 5% level of probability.

Improvement of soil fertility and crop productivity using soil conservation practices and organic amendments:

Effect of giant mimosa residue and tillage practices on yield of mustard yield

Field experiment was conducted at the BINA farm, Mymensingh to the see effect of giantmimosa residue and tillage practies on yield of mustard during 2017-18. Six treatments were used in the experiment with three replication in a RCB design. The treatments were T_1: Minimum tillage only (native soil fertililty), T_2: Minimum tillage (MT)+ 75% chemical fertilizer (CF)+Giant mimosa residue (GMR) mulch (@ 3 tha^{-1}, T_3: Minimum tillage (MT) + 100%CF, T_4: Conventional tillage (CT) + 75% CF+ GMR (@ 3 tha^{-1} incorporation, T_5: Conventional tillage (CT) + 100% CF and T_6: Conventional tillage only (native soil fertility. The experimental soil was silt loam having 6.8 pH, 0.83% organic carbon, 0.1% total N, 10 μgg^{-1} available P, 0.13 meq% exchangeable K and 12 μgg^{-1} available S. Mustard (var. Binasharisha 10) was sown on 14 Nov. 2017 and harvested first week of February 2018. Full dose of N, P, K, and S were applied @ 90, 20, 48, and 15 kg ha^{-1} from urea, TSP, MoP and gypsum. Zinc and boron was applied as basal @ 2 kg ha-1 from zinc sulphate and boric acid. Giant mimosa residue was incorporated or spread as treatment plan @ 3 t ha^{-1} before two weeks of sowing of mustard. Mustard was sown in furrow under minimum tillage as treatment plan. All the fertilizers were applied at the final land preparation except urea. Urea was applied in two split. First split was applied at 21 days of sowing and 2nd split was applied at 35 days of sowing. Minimum tillage plots were severely invested with weeds. So, weeding was done in regular interval for removing the weeds. Other intercultural operation was done as and when necessary.

Yield and yield contributing characters of mustard were significantly influenced with the tillage practices and manure or fertilizer treatments. The treatment T_5 (CT + 100% CF) produced significantly highest seed yield of mustard followed by the treatment T_4 (CT + 75% CF + GMR @ 3 tha^{-1} incorporation). The treatment T_2 (MT+ 75% CF+GMR mulch (@ 3 t ha^{-1}) also produced statistically similar seed yield to the treatment T_5 and T_4.The result indicated that minimum tillage + GMR mulch with 75% CF gave almost equal yield to the conventional tillage with 100%CF or conventional tillage +75% CF with GMR. The similar trends were also observed in case of straw yield of mustard. Different recorded yield contributing characters of mustard such as plant height, number of siliquae $plant^{-1}$ and seeds $siliquae^{-1}$ also influenced with the minimum tillage treatments which was comparable with the conventional treatments. Weed infestation is one of worst barrier for successful cultivation of mustard under conservation practices like minimum tillage. In this study we controlled the weed through hand weeding or manually. But minimum tillage coupled with chemical controlling of weed might be an effective approach for successful cultivation of mustard under conservation practices. However, the experiment will be repeated for getting effective result with the modification of some management practices.

Table 36. Yield and yield contributing characters of mustard (Binasharisha-10) as affected by different conservation practices

Treatments	Seed yield (tha^{-1})	Straw yield (tha^{-1})	Plant height (cm)	Siliquae $plant^{-1}$ (no.)	Seeds $siliquae^{-1}$ (no.)
T_1	0.21c	1.02c	59.20	13.78c	11.80
T_2	1.22ab	3.52ab	89.07	46.53a	13.00
T_3	1.04b	3.28b	77.27	28.73b	12.40
T_4	1.29ab	3.83a	87.60	54.40a	16.40
T_5	1.33a	3.60ab	86.87	54.73a	12.20
T_6	0.30c	1.05c	54.17	20.10bc	12.13
CV(%)	**15.83**	**9.59**	**6.73**	**14.9**	**7..01**

In a column, figures having common letter(s) do not differ significantly at 5% level of probability.

Micronutrient and Heavy metal group

Biofortification of zinc in grains of wheat varieties by fertilizer management.

An experiment was conducted at the Soil Science Field Laboratory of Bangladesh Agricultural University (BAU) farm, Mymensingh during November 2016 to March 2017. The experimental field was located at 24.75°N latitude and 90.50°E longitude at a height of 18 m above the mean sea level. The soil was medium high land with Sonatala silt loam. General characteristics of the soil are presented in Table 37.

Table 37: Morphological, physical and chemical characteristics of the soil

A. Morphological characteristics

AEZ	:	Old Brahmaputra Floodplain (AEZ 9)
General Soil type	:	Non-calcareous Dark Grey Floodplain Soils
Parent material	:	Brahmaputra river borne deposits
Drainage	:	Moderate
Topography	:	Medium high land
Flood level	:	Above flood level

B. Physical characteristics

% Sand	:	20
% Silt	:	64
% Clay	:	16
Textural class	:	Silt loam

C. Initial soil analytical results and fertility class of experimental site

pH	OM (%)	Total N (%)	Exch. K (meq%)	Available status (mg kg^{-1})				
				P	S	Zn	Fe	B
6.73	3.23	0.179	0.196	7.35	11.7	0.780	55.4	0.240
N	M	L	M	VL	L	L	VH	L

OM- Organic Matter, N-Neutral, M-Medium, L- Low, VL- Very Low, VH – Very High

The crop under study was wheat. Two varieties were used in this study. The varieties were BARI Gom-25 and BARI Gom-26.

The land was prepared in the last week of November 2016. The land was prepared by repeated ploughing by power tiller and country plough. Weeds and stubbles of the previous crop were collected and removed from the field. After leveling, the experimental plots were laid out as per treatments and design.

The experiment was laid out in a split plot design. There were five Zn treatments and two wheat varieties, each replicated three times. The zinc treatments were distributed to the sub-plots and wheat varieties to the main plots. Thus, the number of plots was $5\times2\times3 = 30$. The unit plot size was 5m × 2.5m. The plots were separated from each other by 0.5 m bunds, the block-to-block distance being 1m.

The experiment consisted of two wheat varieties and five zinc rates as follows:

(A) Wheat variety

V_1 : BARI Gom-25

V_2 : BARI Gom-26

(B) Zinc rates

T_1: Zn_0 (Zinc control)

T_2: $Zn_{1.5}$ (Zinc @ 1.5 kg ha^{-1})

T_3: $Zn_{3.0}$ (Zinc @ 3.0 kg ha^{-1})

T_4: $Zn_{4.5}$ (Zinc @ 4.5 kg ha^{-1})

T_5: $Zn_{6.0}$ (Zinc @ 6.0 kg ha^{-1})

Fertilizers were applied to each plot as per treatments. Fertilizers such as urea, TSP, MoP, gypsum, zinc sulphate ($ZnSO_4.7H_2O$) and boric acid were used as sources for N, P, K, S, Zn and B, respectively. Nitrogen was applied @ 120 kg ha^{-1} from urea (46% N), P @ 30 kg ha^{-1} from TSP (20% P), K @ 60 kg ha^{-1} from MoP (50% K), S @ 10 kg ha^{-1} from gypsum (18% S) and B @ 1.5 kg ha^{-1} from boric acid (17% B). The one-third dose of urea and the full dose of all other fertilizers were applied as basal to the individual plots during final land preparation. The second split of urea was applied after 25 days of sowing (crown root stage) and the third split was after 55 days (booting stage/spike initiation stage). Zinc sulphate (23% Zn) as a source of zinc was applied to the respective plots and mixed with soil prior to sowing. The fertilizers were incorporated into soil by hand.

Wheat seeds were sown in the field on 03 December 2016 at the rate of 125 kg ha^{-1}. Seeds were sown continuously in 20 cm apart lines. After sowing, the seeds were covered by soil.

Top dressing of urea was done as per schedule and the normal cultural practices including weeding and insecticide spray were done as and when required. The plots were irrigated twice, the first irrigation done after 25 DAS and the second irrigation done after 55 DAS. Weeding was done two times during the growth period, the first weeding after 21 DAS and the second weeding after 50 DAS. The field was attacked by rodent at later stage of crop growth which was successfully controlled by using Fostoxin tablet (zinc phosphate bait).

The crop was harvested at maturity on 17 March 2017. The harvested crop from each plot was bundled separately and brought to the threshing floor. The crops were threshed, cleaned and processed. Then, air dry weight of both grain and straw was recorded for every plot and the weight in g plot^{-1} was converted to kg ha^{-1}.

The yield data included grain and straw yields and the growth and yield components included plant height, number of tillers m^{-2}, spike length, number of spikelets spike^{-1}, number of grains spike^{-1}, and 1000-grain weight. The yield component information was noted on 10 plants of each plot. These data were taken when the crop attained maturity. The grain and straw yields were recorded for each plot.

Soil samples at 0-15 cm depth from five spots of the experimental field were collected and were mixed to make a composite soil sample. The composite sample was air dried, ground and sieved. Then the soil sample became ready for analysis.

Mechanical analysis was done by hydrometer method. The textural class was determined following Marshall's triangular coordinate using USDA system. Soil pH was measured with the help of a glass electrode pH meter, the soil-water ratio was 1:2.5.Organic carbon content of soil was determined following wet oxidation method. The amount of organic matter was calculated by multiplying the percent organic carbon with the van Bemmelen factor, 1.73.Total N content in soil was determined by Kjeldahl method. The soil was digested with 30% H_2O_2, conc. H_2SO_4 and catalyst mixture (K_2SO_4: $CuSO_4.5H_2O$: Se = 10:1:0.1). Nitrogen in the digest was determined by distillation with 40% NaOH followed by titration of the distillate trapped in H_3BO_3 with 0.01 N H_2SO_4. Available P content was extracted from soil with 0.5M $NaHCO_3$ solution at a pH 8.5. The P in the extract was then determined by developing blue color with $SnCl_2$ reduction of phosphomolybdate complex and measuring the color by spectrophotometer at 660 nm wavelength.Exchangeable K content of soil was determined by extraction with 1M NH_4OAc, pH 7.0 solution followed by measurement of extractable K by flame photometer. Available S content of soil was determined by extracting soil sample with $CaCl_2$ (0.15%) solution. The S content in the extract was determined turbidimeterically and the turbid was measured by spectrophotometer at 420 nm wavelength. Available Zn and Fe contents in soil were determined by DPTA extraction method. The concentrations of Zn and Fe in the extract were estimated by atomic absorption spectrophotometer (AAS). Available B content of soil was extracted by hot water and extractable B was determined by azomethine-H method.

The grain samples were dried in an oven at 65°C for about 48 hours and then ground by mottle pestle. The ground plant materials (grain) were stored in paper bags in a desiccator. The grain samples were analyzed for determination of N, Zn and Fe concentrations. A sub-sample weighing 0.5 g was transferred into a dry clean 100 ml long narrow tube. A 10 ml of diacid mixture (HNO_3: $HClO_4$ in the ratio of 2:1) was added. After leaving for while, the flask was heated at a temperature slowly raised to 180°C. Heating was momentarily stopped when the dense white fumes of $HClO_4$ occurred. The contents of the flask were boiled until they became clean and colorless. Elements such as Zn & Fe concentrations were determined from this single digest. The N concentration in the digest was determined by distillation with 40% NaOH followed by titration of the distillate trapped in H_3BO_3 with 0.01 N H_2SO_4. The concentrations of Zn and Fe in the extract were estimated by atomic absorption spectrophotometer (AAS).

The analysis of variance (ANOVA) for various crop characters and also for nutrient concentrations was done using statistical programme package STAR version 2.0.1. Mean comparisons of the treatments were adjudged by the Duncan's Multiple Range Test. Correlation statistics was performed to examine the relationship between nutrient (N, Zn & Fe) concentrations and zinc rates under study.

Results and discussion

There was no significant effect of zinc treatments on the plant height of wheat (Table 38). The crop varieties (BARI Gom-25 and BARI Gom-26) did not differ significantly based on this parameter (Table 39). Interaction effect of zinc treatments and wheat varieties on plant height was not significant as well (Table 40). However, the highest plant height (95.6 cm) was recorded for Zn @ 3.0 kg ha^{-1} and the lowest plant height (92.5 cm) for Zn @ 4.5 kg ha^{-1}. Between the varieties tested, BARI Gom-25 produced taller plant (96.0 cm).

The number of tillers $plant^{-1}$ was significantly influenced by the Zn treatments. It was observed that the treatment having Zn at 3.0 kg ha^{-1} ($Zn_{3.0}$) recorded the maximum number of tillers $plant^{-1}$ (2.37) that was statistically similar with $Zn_{4.5}$ (4.5 kg Zn ha^{-1}) treatment. The lowest number of tillers $plant^{-1}$ (1.65) was found in control treatment (Table 38). There was no significant variation tillers $plant^{-1}$ between two varieties (Table 39). Furthermore, interaction effect of wheat varieties and zinc treatments on tillering was not significant (Table 40).

Zinc application had a significant positive effect on the number of spikes m^{-2} of wheat. Application of Zn at 3.0 kg ha^{-1} resulted in 403 spikes m^{-2} against 292 spikes m^{-2} in Zn control. The number of spikes m^{-2} was not affected by variety and its interaction with Zn (Table 38-40).
Spike length of wheat responded significantly to zinc application. Spike length ranged from 9.10 to 9.89 cm over the Zn treatments. The crop varieties did not vary significantly on this plant parameter, although BARI Gom-26 had longer spikes compared to BARI Gom-25. Again, interaction effect of wheat variety and Zn treatment on spike length was not significant (Table 33-35).

The number of spikelets $spike^{-1}$ varied significantly with different Zn treatments. The maximum number of spikelets $spike^{-1}$ (18.0) was observed in $Zn_{3.0}$ treatment (3.0 kg Zn ha^{-1}) and the minimum result (16.6) in control treatment (Zn_0). Concerning varieties, spikelet's $spike^{-1}$ were significantly higher in BARI Gom-26 (19.1) than that in BARI Gom-25 (16.4). Interaction effect of wheat varieties and Zn treatments with respect to this plant character was not significant (Table 38-40).

The Zn treatments resulted in a significant improvement in the number of grains $spike^{-1}$. Among the treatments, $Zn_{3.0}$ (3.0 kg Zn ha^{-1}) demonstrated the highest number of grains $spike^{-1}$ and similar performances were observed in $Zn_{4.5}$ (4.5 kg Zn ha^{-1}). The Zn treated plots produced significantly higher number of grains $spike^{-1}$ compared to control. In case of varieties, the number of grains $spike^{-1}$ were significantly higher in V_2 (BARI Gom-26) and lower in V_1 (BARI Gom-25). There was no significant interaction between wheat variety and zinc rate on the number of grains $spike^{-1}$ (Table 38-40).

There was no significant effect of Zn application on 1000-grain weight of wheat. The 1000-grain weight varied within a narrow range (39.1-41.2 g) over the treatments. Thousand grain weight of

BARI Gom-25 was 45.1 g and that of BARI Gom-26 was 34.4 g. The interaction of zinc with variety on this yield component was not significant (Table 38-40).

Table 38 Growth and yield contributing characters of wheat as influenced by Zn rates

Zinc rate	Plant height (cm)	Tillers plant^{-1} (no.)	Spikes m^{-2} (no.)	Spike length (cm)	Spikelets spike^{-1} (no.)	Grains spike^{-1} (no.)	1000-grain weight (g)
Zn_0	93.8	1.65c	292b	9.10c	16.6c	42.5c	39.1
$Zn_{1.5}$	93.6	2.02b	346ab	9.27bc	17.7b	48.7b	39.0
$Zn_{3.0}$	95.6	2.37a	403a	9.89a	18.5a	52.1a	39.3
$Zn_{4.5}$	92.5	2.10ab	350ab	9.62ab	18.0ab	50.0ab	40.7
$Zn_{6.0}$	95.3	2.02bc	349ab	9.56ab	17.9ab	49.0b	41.2
CV (%)	**2.95**	**13.1**	**14.4**	**3.43**	**3.76**	**4.60**	**8.26**
Level of significance	**NS**	**	*	**	**	**	**NS**

In a column, the values having same letter do not differ significantly at 5% level by DMRT.

Zn_0 = Control
$Zn_{1.5}$ = Zinc @ 1.5 kg ha^{-1}
$Zn_{3.0}$ = Zinc @ 3.0 kg ha^{-1}
$Zn_{4.5}$ = Zinc @ 4.5 kg ha^{-1}
$Zn_{6.0}$ = Zinc @ 6.0 kg ha^{-1}

** = 1% level of significance
* = 5% level of significance
NS = Not significant
CV = Co-efficient of variation

Table 39 Growth and yield contributing characters of wheat as influenced by varieties

Variety	Plant height (cm)	Tillers plant^{-1} (no.)	Spikes m^{-2} (no.)	Spike length (cm)	Spikelets spike^{-1} (no.)	Grains spike^{-1} (no.)	1000-grain wt. (g)
V_1	96.0	2.00	342	9.60	16.4b	43.8b	45.1a
V_2	92.3	2.06	354	9.38	19.1a	53.1a	34.4b
CV (%)	**5.52**	**2.70**	**4.98**	**3.17**	**2.80**	**0.90**	**6.41**
Level of significance	**NS**	**NS**	**NS**	**NS**	*	**	**

In a column, the values having same letter do not differ significantly at 5% level by DMRT.

V_1 = BARI Gom-25
V_2 = BARI Gom-26

** = 1% level of significance
* = 5% level of significance
NS = Not significant
CV = Co-efficient of variation

Table 40: Growth and yield contributing characters of wheat as influenced by variety × Zn interaction

Zinc rate	Plant height (cm)		Tillers plant^{-1} (no.)		Spike length (cm)		Spikes m^{-2} (no.)		Spikelets spike^{-1} (no.)		Grains spike^{-1} (no.)		1000-grain weight (g)	
	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2
Zn_0	96.2	91.5	1.63	1.67	9.22	8.98	284	300	15.3	18.0	37.5	47.6	46.3	32.0
$Zn_{1.5}$	95.6	91.6	1.97	2.07	9.47	9.07	340	353	16.4	18.9	44.0	53.5	43.8	33.8
$Zn_{3.0}$	96.	94.	2.2	2.4	9.9	9.8	39	41	17.	20.	47.	57.	44.	34.

	7	5	7	7	2	7	7	0	0	1	1	1	5	0
$Zn_{4.5}$	94.5	90.5	2.13	2.07	9.70	9.55	346	354	16.4	19.5	44.7	54.8	45.0	36.3
$Zn_{6.0}$	97.0	93.5	2.00	2.03	9.68	9.43	344	355	16.7	19.2	45.6	52.4	46.7	35.7
CV (%)	**2.95**		**13.1**		**3.43**		**14.4**		**3.76**		**9.91**		**8.28**	
Level of significance	**NS**		**NS**		**NS**		**NS**		**NS**		**NS**		**NS**	

The grain yield of wheat was significantly influenced by Zn application (Table 41). The highest grain yield (3.90 t ha^{-1}) was obtained from treatment $Zn_{3.0}$ (3.0 kg Zn ha^{-1}) which was significant over all other treatments except $Zn_{4.5}$ and $Zn_{6.0}$ (Fig. 9). The Zn control treatment (Zn_0) produced the lowest grain yield that was statistically similar with $Zn_{1.5}$ treatment (1.5 kg Znha^{-1}).

The grain yield varied from 2.99 to 3.90 t ha^{-1} due to different rates of Zn application. Concerning varietal effect, the crop varieties did not vary significantly based on this parameter (Table 42). However, numerically the higher grain yield was obtained from V_2 variety (BARI Gom-26) and lower from V_1 variety (BARI Gom-25). There was no significant interaction between variety and zinc on the grain yield of wheat (Table 43).

The straw yield of wheat did not increase significantly due to Zn application to soil (Table 41). The straw yield across the treatments ranged from 4.80 t ha^{-1} to 5.35 t ha^{-1}. Obviously, unlike other parameters, the $Zn_{6.0}$ (6.0 kg Zn ha^{-1}) treatment produced the highest straw yield. The yield of straw did not vary significantly with varieties, apparently BARI Gom-25 demonstrated higher straw yield (5.22 t ha^{-1}) over BARI Gom-26 producing 4.74 t ha^{-1} straw yield (Table 42). Interaction effect of variety and zinc on the straw yield was not significant showing that the influence of zinc on the straw yield was same over the varieties (Table 43).

Harvest index of wheat was also influenced by Zn application (Table 41). It is noted that treatment $Zn_{3.0}$ (3.0 kg Zn ha^{-1}) gave the highest harvest index (45.3%) and Zn control treatment (Zn_0) had the lowest harvest index (38.4%). In respect of varietal effect, the crop varieties did not vary significantly in terms of this parameter (Table 41). In value, the higher harvest index (42.8%) was obtained from V_2 (BARI Gom-26) and lower (40.0 %) from V_1 (BARI Gom-25). There was no significant interaction between variety and zinc on the harvest index of wheat (Table 43).

Table 41 Grain and straw yields of wheat as influenced by Zn rates

Zinc rate	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
Zn_0	2.99c	4.80	38.4b
$Zn_{1.5}$	3.36bc	5.08	40.1b
$Zn_{3.0}$	3.90a	4.76	45.3a
$Zn_{4.5}$	3.56ab	4.93	42.2ab
$Zn_{6.0}$	3.69ab	5.35	41.1b
CV (%)	**8.99**	**15.7**	**7.81**
Level of significance	**	NS	*

Table 42 Grain and straw yields of wheat as influenced by wheat varieties

Variety	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
V_1	3.48	5.22	40.0
V_2	3.52	4.74	42.8
CV (%)	**5.30**	**16.82**	**8.2**
Level of Significance	**NS**	**NS**	**NS**

Table 43 Grain and Straw yields of wheat as influenced by variety × Zn interaction

Zinc rate	Grain yield (t ha^{-1})		Straw yield (t ha^{-1})		Harvest index (%)	
	V_1	**V_2**	**V_1**	**V_2**	**V_1**	**V_2**
Zn_0	2.96	3.02	5.11	4.48	36.6	40.3
$Zn_{1.5}$	3.26	3.47	4.81	5.35	40.6	39.6
$Zn_{3.0}$	3.83	3.96	4.98	4.53	43.6	47.0
$Zn_{4.5}$	3.63	3.49	5.42	4.44	40.2	44.2
$Zn_{6.0}$	3.71	3.68	5.80	4.89	39.1	43.1
CV (%)	**8.99**		**15.7**		**7.81**	
Level of significance	**NS**		**NS**		**NS**	

Effects of zinc fertilization on nutrient concentrations of wheat grain

Wheat grain was analyzed for determination of Zn concentrations. The results are presented in Tables 44-46.

The grain Zn concentration was markedly influenced by the Zn fertilization (Table 44). Comparing the five rates of Zn application, $Zn_{4.5}$ (4.5 kg Zn ha^{-1}) demonstrated the highest Zn concentration (39.7 µg g^{-1}) that was statistically different with all other treatments. Obviously, the Zn control treatment had the lowest Zn concentration (33.9 µg g^{-1}). The grain Zn concentration varied from 33.9 to 39.7 µg g^{-1} across the Zn rates. The Zn concentrations of wheat grain due to $Zn_{4.5}$ (4.5 kg Zn ha^{-1}) and $Zn_{6.0}$ (6.0 kg Zn ha^{-1}) treatments were 17.1% and 10.9% increase over control, respectively (Table 44). The highest Zn fortification of wheat grain was obtained from treatment $Zn_{4.5}$ (4.5 kg Zn ha^{-1}). The Zn concentration of wheat grain was not affected by varieties (Table 45). However, the grain Zn content in BARI Gom-26 was 37.1 µg g^{-1} and that in BARI Gom-25 was 36.1 µg g^{-1}. The interaction effect of variety and zinc on Zn concentration was not significant showing that the influence of zinc application on grain-Zn concentration was unaffected by the varieties (Table 46).

Table 44: Zn concentrations of wheat grain as influenced by zinc rates

Zinc rate	Zn (µg g^{-1})	% Zn increase over control
Zn_0	33.9d	-
$Zn_{1.5}$	35.5cd	4.7
$Zn_{3.0}$	36.3bc	7.1
$Zn_{4.5}$	39.7a	17.1
$Zn_{6.0}$	37.6b	10.9
CV (%)	**4.22**	**-**
Level of significance	**	**-**

Table 45: Zn concentrations of wheat grain as influenced by varieties

Variety	Zn ($\mu g\ g^{-1}$)
V_1	36.1
V_2	37.1
CV (%)	**5.88**
Level of significance	**NS**

Table 46: Zn concentrations of wheat grain as influenced by variety × Zn interaction

Zinc rates	Zn ($\mu g\ g^{-1}$)	
	V_1	V_2
Zn_0	33.2	34.5
$Zn_{1.5}$	34.8	36.2
$Zn_{3.0}$	35.5	37.1
$Zn_{4.5}$	39.9	39.5
$Zn_{6.0}$	37.1	38.1
CV (%)	**4.22**	
Level of Significance	**NS**	

Conclusion

The study indicates that the experimental field was deficient in Zn and the performance of zinc @ 3.0 kg ha^{-1} was the best in respect of grain yield of wheat. In case of Zn concentration, zinc @ 4.5 kg ha^{-1} demonstrated the highest Zn concentration (39.7 $\mu g\ g^{-1}$) in wheat grain which was 17.1% increase over Zn control. Although not significant, BARI Gom-26 showed better response in terms of yield and nutrient concentration. The response curve shows 4.62 kg ha^{-1} for BARI Gom-25 and 3.94 kg ha^{-1} for BARI Gom-26 as the optimum Zn rate for achieving higher grain yield of wheat. However, 5.5 kg ha^{-1} appeared as the optimum Zn rate for obtaining higher Zn fortification in wheat grain.

Determination of sediment source in a small watershed by Compound-specific stable isotope (CSSI) technique.

Soil erosion and subsequent sedimentation are natural processes caused by water and wind. Several of man's activities such as deforestation, overgrazing, changes in land use, non-sustainable farming practices and global climate change tend to accelerate soil erosion. The result is degradation of the landscape with impacts on soil fertility, crop productivity, water pollution, potential effects on global climate, and sedimentation in lakes, reservoirs and floodplains. Accordingly, determining the main sediment sources in a watershed and thus identifying the sites with critical soil erosion, is of growing importance to improve soil management and sustainable food supply.

Compound-specific stable isotope (CSSI) is to develop, identify and apportion soil sources from land use. This technique, linked with fallout radio nuclide (FRN) techniques, will enable quantitative assessment of source–specific rates of soil erosion and sediment mass transport within the watershed. The CSSI technique was developed to positively identify the linkages between sources of soil erosion from different land-uses within a single watershed depositing in an estuary, to allow mitigation of the sediment loads by managing the sources. While the CSSI technique can identify and apportion soil sources by land-use, the technique is not totally quantitative and requires additional mass transport information. This additional information can be in the form of measured flow-weighted sediment loads in rivers and streams, modeled sediment loads using geographical information system (GIS) and climate data, and sediment budgets or estimations of sediment erosion or accumulation rates obtained from FRN measurements.

An experiment was undertaken in a small watershed at Sutiakhali to determine the source proportions of erosion contributed to the total deposition. The watershed situated at 24°40'55.25" E and 90°27'42.22" N. The watershed is a concave basin (Fig. 10 & 11) where the lowest elevation was 2.14 m from sea level as sediment and the highest elevation was 4.94 m from mean sea level as source (fig. 10). Annual maximum temperature is 22.2°C and minimum is 10.8°C, annual mean rainfall is 2153 mm and the annual mean humidity is 79.3%.

Fig. 10: Experimental watershed for CSSI study

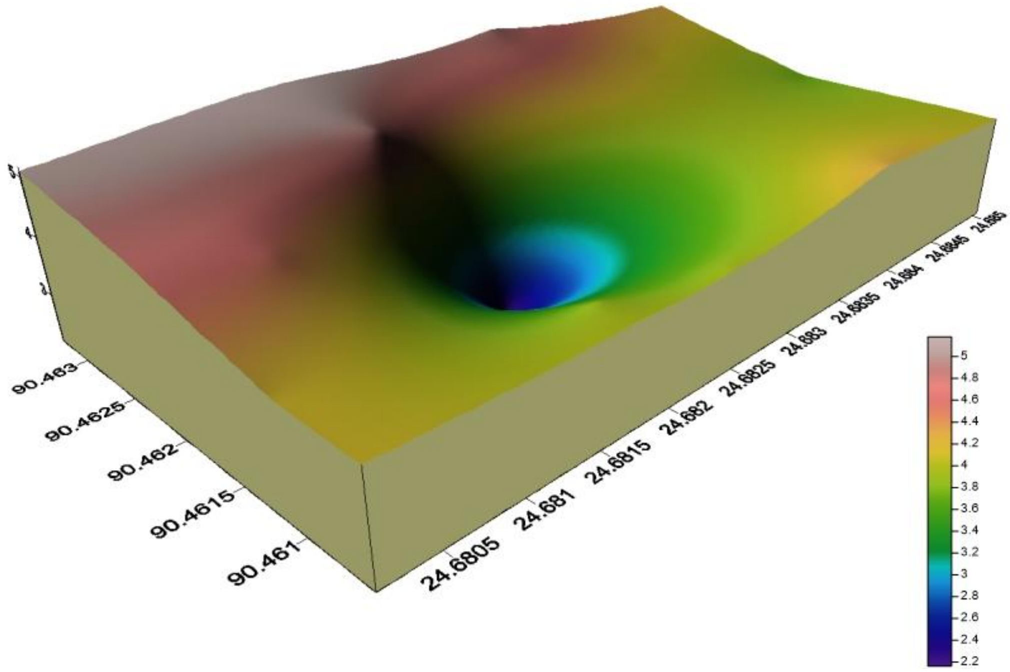


Fig.11: Elevation map of the studied watershed

The basin in the watershed is surrounded by cultivable land with silt loam soil. Several crops are grown as rice, wheat, onion and mustard, also forest and banana in the upper elevation. Due to rainfall soils from this different land use eroded and deposited in to the basin as sediment. So, 6 (six) composite soil samples from rice, wheat, onion, mustard, forest and banana as source and 1 (one) composite sample from basin as deposition (Fig.12) was taken.

Fig. 12: Showing soil sampling points of source and sediments

Soil Sampling:

Soil sample has taken from each site in the catchment (including both sediment and land use sites). For every source and sediment 1 composite soil sample was taken from 5 samples 2-cm deep surface and uniform-size, spaced across the site. Roots, leaves stones, insects, sticks etc., was removed to avoid contamination. Soil samples were mixed well as it is critical that the sample is well mixed to be representative of the site. A handful of mixed sample (400 g) was placed in a zip-lock bag. Rolled up the bag around the sample, expelled the air before sealing it. These sample bags were placed inside a second bag. Label containing: site name, date of collection, location, and sample code was written on card or water-proof paper with water proof ink or pencil. Soil samples air dried and sieve whole sample through 2 mm mesh sieve. Soil samples prepared for bulk $\delta^{13}C$ and $\delta^{13}C$ of fatty acids by isotope ratio mass spectrometry-gas chromatography-mass spectrometer (IRMS-GC-MS). Bulk $\delta^{13}C$ and $\delta^{13}C$ of fatty acids value in ‰ (permil) was recorded from IRMS. These bulk $\delta^{13}C$ and $\delta^{13}C$ of fatty acids data have used in the mixing model (Iso-source) for deconstructing the mixture into soil source proportions. The outputs from the mixing model was isotopic proportions not soil proportions. As the isotopic biomarkers are a small fraction of the total organic carbon in the soil and the total organic carbon is typically less than 10% of the whole soil, the isotopic proportions must be converted to soil proportions. That is, if the source soils were mixed together in the corrected soil proportions, the resultant mixture would have the same isotopic signatures as found in the sediment mixture.

Results and discussion:

Traditional geological techniques for determining the origin of soil rely on the elemental composition and the crystal structure to characterize the soil particles. This technique works well on a regional scale but cannot be used on a watershed scale where the soil geological characteristics may be uniform. Consequently, an alternative method of characterizing the soil was required that would allow its source to be identified when working at the watershed scale.

Flora and fauna (including microbiological) in a particular habitat produce substantial amounts of organic compounds that can be stabilized to some extend in soil. Consequently some of these organic compounds can be used as biomarkers to check for the presence of particular flora and fauna in a habitat (e.g., Liang et al. 2008). One group of organic compounds often used as biomarkers are the straight-chain fatty acids (FA), especially those with a carbon chain-length from 14 to 24. Fatty acid methyl ester (FAME) analysis of a soil can provide a "fingerprint" characteristic of that soil based on a concentration profile of the FA present. That soil profile can then be compared with a library of similar profiles of soils from known geographical locations, to identify the source of that soil (Kennedy 1998; Ibekweand Kennedy 1999). This approach has limited ability to separate soil sources in mixtures and, when used to estimate the origin of sediments in surface waters (Banowetz et al. 2006), it was found that the FA biomarkers rapidly degrade (Muri et al. 2004).Stable isotopes are one of nature's ecological recorders (West et al. 2006) and an advance on the FAME profile technique was to look at the stable isotopic signature of the carbon atoms in each compound i.e., the compound-specific stable isotope (CSSI) value of each FA. Moreover, it was demonstrated that once formed, the CSSI value of the individual organic compound didn't change significantly (Boyd et al. 2006)

The concepts associated with CSSI analysis of soil FAME compounds were applied to the task of identifying the source of soil erosion. The key factors making this possible were:

1) The CSSI values were stable when bound to soil particles and could survive hundreds of years unchanged
2) The CSSI values were characteristic of specific flora and fauna growing on the soil; and
3) Land-use is typically defined by the flora and fauna on the land. Conceptually, the CSSI values from the eroded soil represent the isotopic signatures of the soils contributing to the eroded soil mixture. By having a set of reference soils or "library" of CSSI values from known land-use soils from the same watershed, the proportion of each source soil contributing to the eroded soil mixture could be estimated using a mixing model.

Because C14:0 to C24:0 FA are produced by all plants and each plant species produces each FA with a $\delta^{13}C$ value characteristic of that plant, different plants can be distinguished by the FA-specific $\delta^{13}C$ value (i.e., the compound-specific isotopic value). When leached from the plants, FA enters the soil where they become bound to various clay particulate phases, preserving the isotopic value of the plant FA in the soil. Accordingly, the unique isotopic values of the plant FA biomarkers can be used to identify the origin/land-use of the soil. Because land-use is defined by the plant communities growing on it, e.g., pasture, crops, forestry, the land-use contributing to sediment from erosion can be identified by the FA biomarker isotopic signatures (i.e., their CSSI values). Consequently, the blend of FA in the soil for any land use is likely to be unique and can provide extra detail for identifying it as a soil source where erosion is occurring.

The Bulk $\delta^{13}C$ (‰) and Fatty acids $\delta^{13}C$ (‰) values of different land use and sediment has presented in the table 47 as fingerprint. These values further interpreted with Iso-source mixing model (fig. 13) to convert the CSSI values to soil proportions.

Table 47: The Bulk $\delta^{13}C$ (‰) and Fatty acids $\delta^{13}C$ (‰) values of different land use and sediment

Source/ land use	Coordinates N	Coordinates E	Bulk $\delta^{13}C$ (‰)	Fatty acids $\delta^{13}C$ (‰) C14 Myristic	C16 Palmitic	C18 Stearic	C20 Arachid	C22 Behenic	C24 Lignoceric
Forest	24°40'54.41"	90°27'44.92"	-24.52	-29.91	-17.76	-25.26	-31.12	-33.66	-28.47
Wheat	24°40'48.47"	90°27'40.02"	-23.33	-30.39	-23.97	-28.18	-24.30	-28.82	-26.28
Banana	24°41'00.09"	90°27'47.77"	-23.75	-29.76	-26.94	-27.70	-27.50	-31.25	-28.92
Onion	24°41'03.69"	90°27'45.69"	-23.84	-24.18	-28.14	-28.96	-27.54	-29.65	-26.07
Mustard	24°40'56.91"	90°27'37.99"	-23.58	-30.78	-26.41	-26.69	-27.58	-28.16	-24.29
Rice	24°41'06.19"	90°27'42.96"	-25.04	-26.66	-25.25	-25.40	-26.92	-30.89	-28.83
Sediment	24°40'55.25"	90°27'42.22"	-25.11		-28.61	-29.56	-28.79	-26.51	

The CSSI values of the FA biomarkers in an eroded sediment mixture are derived from the FA biomarkers in the source soils contributing to that mixture. If the CSSI values of the FA biomarkers in the source soils are known, their proportional contribution in the mixture can be estimated using a mixing model. For the CSSI technique, the mixing model used during 30 Protocols on the use of the CSSI Technique development was. New mixing models such as SIAR (Stable Isotope Analysis in 'R') and MixSIAR can also be used. A table of bulk stable isotope and CSSI values from representative potential source land-use soils is used as a library for the mixing model. Because the proportional contribution of each source soil is determined from the carbon content of the soil (%C), the model is run using bulk $\delta^{13}C$ as the primary isotope in the model. This allows the subsequent correction of the model output for the proportion of non-carbon material in the soil. The CSSI values of selected FA are used as the additional isotopes in the model to provide discrimination between different land-use sources from the same watershed. Increasing the number of FA used in the model enhances the power of discrimination between more similar land-uses.

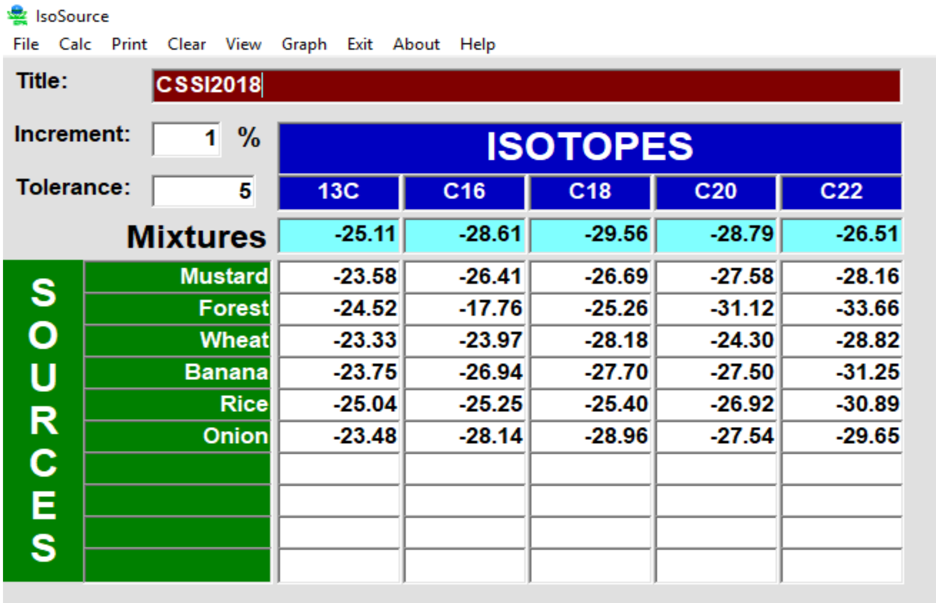


Fig 13: Iso-source mixing model

There is, however, a trade off in model run time and size of the memory required as the number of isotopes and sources is increased. This is less noticeable when using SIAR. An important consideration for modeling is that the FA used in the model must be present in the sediment mixture and all the sources being tested. If a FA is not present in a particular sample then an alternative FA should be selected that is present in all samples. Alternatively, a larger amount of that sample should be extracted to ensure that FA is measured in that sample.

The histograms (Fig. 14) of feasible solutions for a specific source relative to the sediment mixture being tested. This output confirms that this source is present in the mixture at forest as 0%-36%, wheat 0%-72%, mustard 0%-68%, rice 0%-70%, onion 0%-66% and banana 0%-64%. The corollary is that this source is not present at greater or lesser proportions.

The geometric mean value in this example forest, wheat, banana, onion, mustard, rice and onion is 18.1%, 11.2%, 16.9%, 17.9%, 17.5% and 18.4%, respectively, (fig. 15) which is the source proportion.

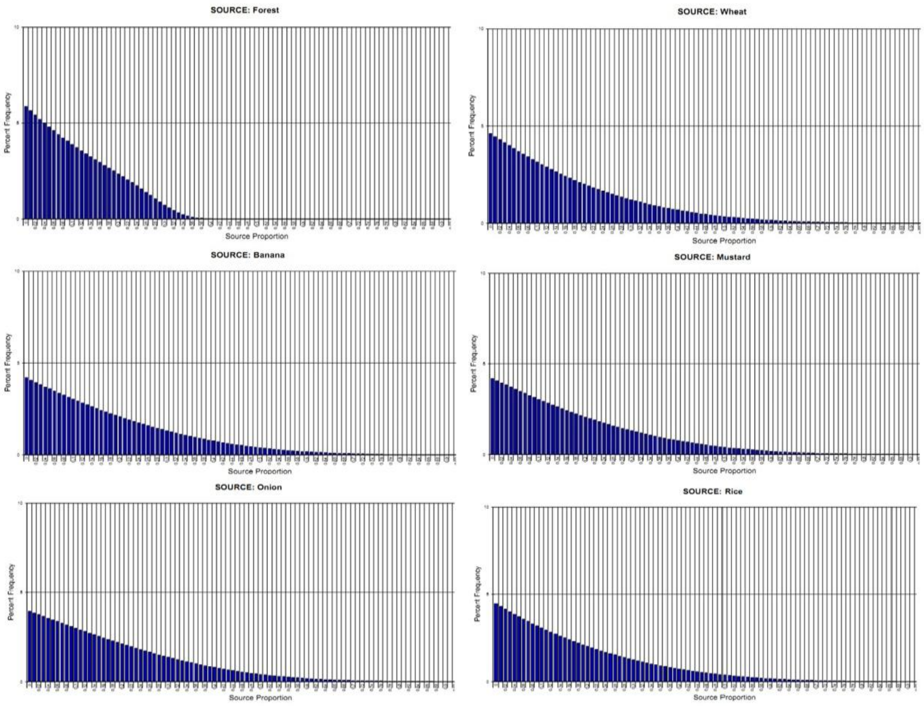


Fig.14: Histogram of feasible solution showing proportion of a specific source

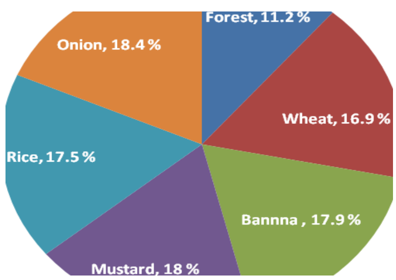


Fig.15: Pie graph showing source proportions in the sediment

Conclusion:

The unique isotopic values of the plant fatty acid biomarkers can be used to identify the origin/land-use of the soil. Because land-use is defined by the plant communities growing on it, contributing to sediment from erosion can be identified by the FA biomarker isotopic signatures (i.e., their CSSI values).

In this investigation, sedimentation in the basin is contributed by forest, wheat, banana, mustard, rice and onion land use as 11.2%, 16.9%, 17.9%, 18.0%, 17.5 and 18.4%, respectively, which shows that forest, is lowest and onion is highest contribution to soil erosion.

Present status of micronutrients in selected AEZs and balanced fertilization for sustainable crop production

Collection of soil samples

Soil sampling was done from different sites (from five soil series as: Manu, Pritimpasha, Bijipur, Chakla, Shankochili) of AEZ 22 based on the land type, soil series and cropping pattern. Altogether 100 soil samples from 0-15 cm and 15-30 cm depth were collected from intensively cropped areas. GPS reading was recorded for every site of soil collection. Some other information such as village, union, upazila, land type, soil series and land use were noted.

Analysis of soil samples

Soil samples were analyzed for some basic properties, macronutrients and micronutrients. The basic properties of soils included pH and organic matter contents, macronutrients including N, P, K, S, Ca & Mg contents and micronutrients including Zn, B, Cu, Fe, & Mn contents. All analysis was done following standard methods.

Results

Bench line survey on micronutrient status of soils across AEZ 22 showed that the Zn status of soil was found 29 % as 'low', 17% 'optimum', 29% 'medium', 6% 'high' and 19% as 'very high'. Similarly, the B status of 55% soils had 'low', 8% 'very low', 7% 'optimum' and 30% as 'medium' status.

Table 48. Soil properties of Northern and Eastern Piedmont Plain Soils (AEZ 22)

Sample No.	pH	OM (%)	P (mg kg^{-1})	K	Ca	Mg	S	B	Cu	Fe	Mn	Zn
				(cmol kg^{-1})			(mg kg^{-1})					
1	4.88	2.61	14.39	0.100	4.18	2.41	18.1	0.289	3.32	201.5	40.9	2.52
2	5.92	1.79	9.02	0.110	5.31	4.47	11.3	0.295	2.48	82.0	26.6	1.13
3	5.17	1.72	32.15	0.070	3.79	1.69	8.9	0.288	1.60	155.3	26.4	1.32
4	5.11	1.51	15.70	0.080	4.07	2.45	19.7	0.264	1.27	118.9	23.9	1.16
5	5.04	1.99	105.48	0.080	2.91	1.12	14.6	0.306	2.57	211.6	17.8	2.80
6	5.29	1.31	37.88	0.080	4.34	2.21	29.3	0.287	2.74	109.9	24.3	2.41
7	5.47	1.58	97.42	0.060	2.47	0.73	9.1	0.300	1.71	175.4	25.1	2.43
8	5.59	1.38	83.46	0.080	3.27	1.02	5.0	0.260	2.12	163.9	30.5	2.69
9	5.59	1.58	35.04	0.090	3.95	1.64	4.9	0.184	3.28	180.1	17.2	2.89
10	5.70	1.24	19.35	0.080	3.87	2.29	4.6	0.224	2.90	94.5	19.4	2.40

11	5.28	2.27	15.88	0.090	4.50	1.76	9.0	0.282	3.24	232.3	60.3	1.40
12	6.36	0.55	5.88	0.090	5.44	3.94	6.6	0.131	2.69	69.6	25.9	1.65
13	5.70	1.72	6.99	0.080	4.84	4.13	6.4	0.270	2.29	105.3	28.5	1.40
14	5.89	0.96	3.07	0.070	4.31	3.27	6.3	0.552	2.58	83.8	30.2	1.24
15	5.54	2.55	86.19	0.150	5.63	2.06	10.6	0.454	2.47	209.3	50.7	7.06
16	5.89	1.79	76.15	0.200	5.67	2.58	13.3	0.200	2.40	199.3	33.6	4.49
17	5.91	2.20	98.52	0.190	4.64	1.93	9.3	0.304	1.36	72.1	26.2	3.28
18	6.04	1.51	66.82	0.130	4.48	1.72	9.1	0.226	1.27	55.2	18.5	2.59
19	5.71	1.93	21.47	0.060	5.03	1.77	14.3	0.216	2.80	242.3	53.5	3.10
20	6.04	1.03	6.25	0.060	5.12	2.03	11.8	0.197	1.40	138.2	21.4	1.32
21	5.69	1.24	14.04	0.050	3.61	1.02	20.4	0.175	2.99	120.2	23.4	2.25
22	5.94	1.17	9.56	0.040	3.49	1.37	14.6	0.148	1.18	93.6	15.4	1.45
23	5.23	2.89	3.27	0.130	5.25	3.20	9.4	0.226	4.02	184.8	59.7	1.59
24	6.50	1.86	1.42	0.120	6.59	6.05	7.4	0.137	2.70	59.7	20.6	0.85
25	5.37	2.41	5.63	0.080	5.31	3.12	8.7	0.209	4.48	200.5	27.1	1.07
26	6.11	1.65	1.77	0.060	6.27	5.03	4.4	0.157	2.83	86.8	15.7	0.70
27	5.74	1.44	1.94	0.070	4.42	2.23	6.4	0.291	1.75	82.0	24.0	0.67
28	6.00	1.38	0.72	0.080	5.81	4.17	4.1	0.228	1.67	60.8	17.2	0.68
29	4.95	3.10	1.89	0.080	2.70	1.45	10.0	0.292	3.21	191.7	60.5	1.31
30	5.83	1.65	2.01	0.060	2.53	2.25	7.9	0.270	4.79	64.8	52.2	2.64
31	5.13	1.58	12.52	0.050	2.31	0.47	5.7	0.165	1.61	146.3	32.2	1.56
32	5.10	1.44	6.75	0.070	2.81	0.67	12.1	0.137	1.00	113.4	18.6	1.02
33	5.43	2.41	1.19	0.070	3.12	1.45	9.8	0.132	1.72	62.0	17.4	0.68
34	6.13	1.38	0.52	0.100	3.87	3.05	10.9	0.308	0.91	20.6	32.2	0.58
35	5.61	1.93	1.55	0.080	3.79	1.85	5.5	0.170	1.86	43.5	40.7	0.70
36	6.33	0.69	0.40	0.090	3.73	3.03	7.2	0.083	1.13	18.9	14.3	0.67
37	5.03	3.16	10.25	0.170	4.00	2.54	11.5	0.211	0.98	303.8	91.0	2.07
38	5.90	1.79	5.28	0.100	5.62	4.12	8.8	0.142	3.00	101.2	38.0	0.96
39	5.13	2.75	6.95	0.090	3.90	1.66	10.6	0.179	2.59	196.8	52.4	0.88
40	6.18	1.86	3.51	0.090	4.79	3.16	9.4	0.206	1.95	90.4	34.5	0.76
41	5.81	3.44	3.54	0.070	5.05	1.94	9.0	0.317	3.15	170.9	48.0	0.99
42	6.38	1.44	2.85	0.050	4.17	2.04	10.9	0.366	1.67	50.1	20.6	0.67
43	5.79	3.44	1.88	0.090	4.97	3.03	10.1	0.405	2.50	155.6	66.7	1.18
44	6.63	1.24	1.12	0.110	7.87	7.64	5.9	0.359	1.50	45.7	34.9	0.83
45	6.05	2.41	7.02	0.060	3.39	1.43	16.9	0.388	1.57	111.0	61.7	1.10
46	6.95	0.76	0.43	0.080	4.49	3.59	9.0	0.349	0.91	22.3	16.9	0.58
47	5.08	2.41	2.01	0.080	3.99	1.60	9.2	0.383	3.55	167.6	37.3	0.81
48	6.24	0.76	1.94	0.090	4.95	3.59	6.9	0.347	2.95	52.6	20.2	0.67
49	4.88	3.51	8.70	0.180	8.39	4.41	46.8	0.497	5.35	316.1	79.1	0.54
50	6.50	1.58	2.14	0.120	10.47	7.33	14.9	0.316	2.03	79.4	54.2	1.07
51	4.85	4.82	0.44	0.170	6.48	2.22	50.9	0.458	5.58	314.5	82.5	2.31
52	7.03	1.72	0.26	0.140	8.71	4.00	13.7	0.403	3.56	38.7	42.6	0.64

53	4.82	2.89	3.82	0.200	5.91	2.24	25.9	0.489	4.56	330.0	43.0	2.25
54	6.57	1.24	2.08	0.130	8.50	4.22	6.6	0.358	3.15	70.5	31.4	0.85
55	4.66	3.58	0.27	0.220	7.49	3.36	58.4	0.435	5.78	287.3	102.8	2.95
56	6.00	1.58	1.04	0.180	9.44	5.88	14.7	0.399	5.36	188.4	67.4	1.10
57	4.83	3.51	4.89	0.190	4.98	1.99	17.3	0.291	4.28	267.3	108.1	2.39
58	6.30	1.24	4.15	0.100	5.89	3.15	10.9	0.266	4.26	85.0	60.3	2.03
59	4.64	3.03	1.22	0.130	5.53	1.89	68.2	0.307	2.47	283.3	90.5	0.64
60	6.49	1.10	3.31	0.090	5.80	2.86	11.5	0.287	2.31	72.3	47.6	0.45
61	4.83	2.55	4.27	0.100	6.54	2.29	12.7	0.288	4.41	263.7	83.1	1.58
62	5.12	2.06	1.81	0.080	6.97	2.56	13.8	0.304	4.93	299.7	64.4	1.42
63	5.10	4.26	6.38	0.110	4.75	1.32	7.8	0.307	3.72	275.8	36.1	1.59
64	5.81	3.16	4.54	0.110	5.21	1.73	7.6	0.280	3.19	168.1	24.3	1.02
65	4.39	3.85	1.24	0.130	3.67	1.50	45.7	0.386	5.25	401.2	25.3	1.74
66	5.13	2.48	4.19	0.110	5.57	2.02	17.5	0.282	5.76	358.2	62.2	1.07
67	4.82	2.55	1.31	0.120	5.36	2.49	66.7	0.337	4.23	259.3	83.1	1.36
68	5.24	1.93	3.25	0.100	5.78	2.91	39.7	0.428	4.09	173.9	94.8	1.15
69	5.87	3.37	6.61	0.070	4.48	1.98	13.7	0.335	2.72	155.9	31.4	0.92
70	7.59	1.17	4.27	0.080	6.16	2.95	10.3	0.284	1.60	27.0	9.6	0.66
71	4.81	3.03	16.91	0.080	3.55	1.33	26.3	0.427	2.94	380.3	19.5	1.92
72	6.79	1.24	1.59	0.090	6.17	2.98	11.9	0.259	1.64	64.6	19.2	0.65
73	5.55	3.99	4.22	0.090	4.85	1.98	19.9	0.199	2.22	164.2	40.2	0.89
74	6.99	1.86	3.45	0.060	4.88	2.13	10.8	0.306	2.27	123.6	15.8	0.56
75	4.83	4.13	0.26	0.190	7.61	4.75	32.5	0.379	7.58	341.6	38.4	1.53
76	6.15	2.61	1.61	0.180	10.98	7.72	13.4	0.248	8.29	179.6	30.7	1.29
77	4.57	5.23	0.03	0.200	9.41	5.01	56.2	0.331	7.51	298.8	46.3	2.63
78	5.10	3.78	0.21	0.180	9.79	5.72	26.6	0.314	8.67	282.2	85.7	2.37
79	4.49	3.58	2.61	0.140	4.73	1.91	33.0	0.342	6.25	397.0	39.9	2.98
80	5.99	1.10	2.61	0.120	6.15	3.43	18.9	0.281	3.12	84.8	25.7	0.95
81	5.19	2.27	3.97	0.120	4.50	1.85	18.2	0.407	3.37	221.7	29.3	1.00
82	7.34	1.03	1.15	0.100	7.76	4.01	11.6	0.302	1.94	33.6	12.4	0.65
83	5.20	1.93	2.19	0.120	3.58	1.77	15.3	0.348	2.61	180.3	24.4	0.98
84	6.95	0.76	1.34	0.090	5.72	3.41	20.2	0.266	1.60	31.1	15.4	1.25
85	4.83	1.72	2.51	0.140	4.13	2.02	26.1	0.350	3.01	231.5	176.2	1.78
86	6.59	0.89	6.42	0.110	7.66	5.47	14.4	0.291	2.11	100.3	59.0	0.90
87	5.60	1.65	79.79	0.070	3.55	0.99	14.4	0.292	1.20	292.4	45.9	1.28
88	6.26	1.03	12.65	0.050	3.92	0.96	17.6	0.289	0.64	80.1	16.8	0.63
89	5.20	2.20	16.10	0.080	3.14	1.84	19.4	0.407	1.90	353.4	24.8	1.11
90	6.95	1.99	5.69	0.060	4.72	2.74	18.0	0.249	1.30	53.1	21.5	0.63
91	4.35	2.68	3.27	0.160	4.60	2.20	63.1	0.374	3.57	364.5	53.2	3.09
92	6.49	1.58	3.64	0.100	8.42	4.66	14.7	0.352	2.87	91.5	36.1	1.54
93	5.35	3.23	0.75	0.210	8.69	5.63	14.6	0.390	6.72	228.6	53.4	1.60
94	6.69	1.58	1.17	0.190	11.05	7.08	7.9	0.289	4.65	56.6	32.3	1.00

95	5.17	3.03	0.78	0.150	5.21	2.61	18.6	0.312	6.17	337.4	52.4	1.65
96	7.13	1.38	1.14	0.140	15.9	5.032	9.7	0.112	4.32	83.2	22.8	0.96
97	4.77	2.75	0.31	0.150	7.01	2.03	34.9	0.452	5.69	345.7	28.6	1.32
98	6.03	1.99	0.85	0.130	10.48	3.11	16.6	0.242	5.81	211.5	26.8	0.91
99	4.72	3.37	1.05	0.120	6.46	2.17	13.6	0.290	4.74	313.6	27.4	0.98
100	6.75	1.86	2.85	0.080	9.04	2.56	7.5	0.164	2.23	67.2	30.6	0.64

Field performance of Felon rhizobial inoculant on growth, nodulation and yield of Felon at Mymensingh and Magura

Field experiments were conducted at BINA HQ Farm Mymensingh and Magura substation to see the performance of Felon Rhizobial inoculant on growth, nodulation and yield of Felon in Rabi season of 2017-2018. There were five treatments viz. Felon Rhizobial inoculant FRI-1, FRI-2, FRI-m, Nitrogen 30kg/ha and uninoculated control. The experiments were laidout in randomized complete block design (RCBD) with three replications. Phosphorus, Potassium, Sulphur, Zinc and Boron were applied as basal application @ 20, 50, 18, 2 and 4 kg/ha. BARI felon-1 was used as test crop cultivar in the study. Data on growth and nodulation were recorded at vegetative stage of felon. Green pod yield was recorded at 5 days interval of starting of optimum fruit growth as vegetable up to end of pod grown. Data on grain yield was recorded at ripening and continued up to end of pod growing. Result showed that significant increase of plant growth, nodulation and yield were recorded due to inoculation of Rhizobial inoculation over uninoculated control (Table 49-52). Plant height was increased significantly due to rhizobial inoculant application at both the locations. Nodule number was increased 2 to 3 times due to inoculation at both locations. The highest nodule number was recorded per plant at Magura substation. Nodule dry weight was recorded the highest with an amount of 79 mg/plant. Felon rhizobial inoculant FRI-2 resulted as highest nodule producing inoculant at both locations. Significant higher grain and vegetable (green pod) were recorded with Felon rhizobial Inoculants at both locations. The highest grain yield was found with FRI-1 at Mymensingh (942 kg/ha) and with FRI-m (mixed culture) at Magura (1041 kg/ha). Vegetable yield was found highest with FRI-2 at Mymensingh (5.65 t/ha) and with mixed culture at magura (6.89 t /ha). Yield contributing parameters like pod number per plant, pod length, seed per pod and 100 seed weight were found significantly higher over uninoculated control both at Mymensingh and Magura.

Table. 49. Effect of Rhizobial inoculants on plant height, nodule number and nodule dry weight of Felon at Mymensingh and Magura

Treatments	**Plant height (cm)**		**Nodule number (No. plant^{-1})**		**Nodule dry weight (g plant^{-1})**	
	Mymensingh	**Magura**	**Mymensingh**	**Magura**	**Mymensingh**	**Magura**
Control	39.67 b	43.77 c	3.00 c	3.12 c	12.10 e	15.00 e
FRI-1	46.87 a	46.07 c	7.72 b	9.00 ab	47.53 c	31.67 c
FRI-2	46.73 a	55.33 ab	10.77 a	14.09 a	67.63 a	79.00 a
FRI-m	51.20 a	56.57 a	9.00 ab	11.09 ab	52.90 b	55.67 b
N30	50.30 a	47.63 bc	4.44 c	6.10 bc	17.33 d	21.00 d
Sig. level	*	**	**	**	**	**
CV(%)	**5.24**	**5.66**	**11.97**	**13.16**	**5.71**	**10.90**

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

Table. 50. Effect of Rhizobial inoculants on grain and vegetable yields of Felon at Mymensingh and Magura

Treatments	Grain yield (kg ha^{-1})		Vegetable yield (t ha^{-1})	
	Mymensingh	**Magura**	**Mymensingh**	**Magura**
Control	768 b	805 b	4.70 c	5.44 b
FRI-1	942 a	884 b	5.41 b	6.08 ab
FRI-2	898 a	917 b	5.65 a	6.54 a
FRI-m	894 a	1041 a	5.50 ab	6.89 a
N30	933 a	927 ab	5.56 c	6.52 a
Sig. level	*	*	*	**
CV(%)	**6.75**	**6.82**	**6.09**	**5.62**

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

Table 51. Effect of Rhizobial inoculants on pod number and pod length of Felon at Mymensingh and Magura

Treatments	Pod number (No. plant^{-1})		Pod length (cm)	
	Mymensingh	**Magura**	**Mymensingh**	**Magura**
Control	9.03 b	8.96 b	14.50 b	15.10 b
FRI-1	10.57 a	10.47 a	15.87 a	16.35 a
FRI-2	10.71 a	10.53 a	16.10 a	16.50 a
FRI-m	10.83 a	10.63 a	16.03 a	16.67a
N30	10.73 a	10.60 a	16.37 a	16.20 a
Sig. level	**	**	**	**
CV(%)	**2.22**	**3.85**	**2.25**	**2.25**

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

Table. 52. Effect of Rhizobial inoculants on seed per pod and 100 grain weight of Felon at Mymensingh and Magura

Treatment	Seed per pod (No. per seed)		100 grain weight (g)	
	Mymensingh	**Magura**	**Mymensingh**	**Magura**
Control	13.57 b	14.87 b	9.78 b	9.70 b
FRI-1	14.07 ab	16.17 a	10.17 a	10.37 a
FRI-2	14.63 ab	16.53 a	10.20 a	10.37 a
FRI-m	14.23 ab	16.67 a	10.30 a	10.30 a
N30	14.73 a	16.23 a	10.18 a	10.33 a
Sig. level	*	**	*	*
CV(%)	**2.45**	**2.46**	**1.34**	**2.13**

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

Conclusion

Felon rhizobial inoculants increased 15-25% grain yield and 14-24% vegetable (Green pod) yield of felon.

Biofertilizer Production and Distribution at BINA in 2017- 2018

A total of 504.5 kg biofertilizers were distributed to the farmers, extension workers, students, and other users of the country (Table 53) in 2017-2018 where production was total of 650.4 kg.

Table 53. Name and amount of biofertilizers produced at BINA and distributed to farmers

Name of biofertilizer	Amount of production (kg)	Amount of Distribution (kg)
Lentil	69.40	67.40
Soybean	137.00	104.60
Mungbean	277.20	219.50
Groundnut	115.00	69.00
Chickpea	46.50	41.20
Blackgram	2.00	1.40
Cowpea (Barbati)	13.80	1.40
Total	**650.40**	**504.50**

Training on benefits and applications of bioferitilizer in pulse and oilseed production

A total number of 139 farmers and extension workers were trained up on benefits and application of biofertilizer in pulse and oilseed production at Barisal and Rangpur (Table-54).

Table 54: Location and number of farmers and extension workers were trained up

Location	No. of participants		Total
	Farmers	SAAO/Equal posts	
Bina Substation, Barisal	75	10	85
Bina Substation, Rangpur	42	12	54
Total	**117**	**22**	**139**

Growth and nodulation study of strains of blackgram

A pot experiment was conducted for evaluating the influence of bradyrhizobial strains on nodulation and growth of blackgram cultivar in the glass house of Soil Science Division, BINA, Mymensingh in November 2017. There were thirteen treatments i.e. T_1=control, T_2= Strain 1, T_3= Strain 2, T_4= Strain 3, T_5= Strain 4, T_6= Strain 5, T_7= Strain 6, T_8= Strain 7, T_9= Strain 8 T_{10}= Strain 9, T_{10}= Strain 10, T_{12}= Strain 11 and T_{13}= Strain 12. Treatments were replicated three times. Symbiotic efficiency of the bacterial strains examined in pot culture condition (sterilized sand) using 12 strains. All 12 strains showed better nodulation and growth of blackgram compared to uninoculated control in pot condition. Nodule number, nodule dry weight, plant height, root length and shoot dry weight mungbean were influenced significantly due to inoculation. After 32 DAS of blackgram the data were collected. The highest nodulation was recorded in the treatment T_{12} followed by T_4 and T_{11}, the highest Nodule dry weight was recorded in the treatment T_{12} followed by T_4, the highest plant height was recorded in treatment T_9 followed by T_3 and T_{12}, the highest root length was recorded in treatment T_{10} followed by T_{12} and T_4 ,the highest shoot dry weight was recorded in treatment T_2 followed by T_8 and T_{12} and the highest root dry weight was recorded in treatment T_2 followed by T_3 ,T_4 ,T_{10} , and T_5 .

Table 55: Effect of *Bradyrhizobium* on the nodule number, nodule weight and growth of blackgram during 32 DAS

Treatments	Nodule no plant^{-1}	Nodule dry wt. (mg plant^{-1})	Plant height (cm)	Root length (cm)	shoot dry wt (gm plant^{-1})	Root dry wt (gm plant^{-1})
T_1=control	2.67 c	0.002	26.50	5.33 cd	0.093	9.50
T_2= Strain 1	10.50 b	0.004	26.38	5.93 bcd	0.133	12.17
T_3= Strain 2	11.33 b	0.003	27.24	5.75 cd	0.197	16.83
T_4= Strain 3	10.5 b	0.003	27.83	5.92 bcd	0.142	16.33
T_5= Strain 4	13.33 ab	0.007	27.75	7.05 ab	0.165	16.33
T_6=Strain 5	10.67 b	0.006	27.25	5.73 cd	0.135	15.83
T_7= Strain 6	13.17 ab	0.005	27.75	6.38 abcd	0.138	12.50
T_8=Strain 7	11.17 b	0.003	26.20	5.08 d	0.141	11.67
T_9= Strain 8	11.67 b	0.005	27.45	6.45 abc	0.191	14.00
T_{10}= Strain 9	9.83 b	0.006	28.53	6.28 abcd	0.185	15.50
T_{11}= Strain 10	11.17 b	0.006	26.92	7.23 a	0.183	16.33
T_{12}= Strain 11	12.17 b	0.003	27.35	5.53 cd	0.177	11.00
T_{13}= Strain 12	17.33 a	0.01	28.42	6.47 abc	0.192	14.67
CV	**22.39%**	**26.16%**	**7.10%**	**11.07%**	**7.22%**	**25.82%**

After 52 DAS of blackgram the highest nodulation and Nodule dry weight was recorded in the treatment T_9 followed by T_3 and the highest Nodule dry weight was recorded in the treatment T_{11} followed by T_8 and T_{12}, the highest plant height was recorded in treatment T_{12} followed by T_4 and T_8, the highest root length was recorded in treatment T_8 followed by T_5 ,the highest shoot dry weight was recorded in treatment T_{12} followed by $T_1$and T_3 and the highest root dry weight was recorded in treatment T_5 followed by T_3 and T_{12} .

Table 56: Effect of *Bradyrhizobium* on the nodule number, nodule weight and growth of blackgram during 52 DAS

Treatments	Nodule no plant^{-1}	Nodule dry wt. (mg plant^{-1})	Plant height (cm)	Root length (cm)	Shoot dry wt (gm plant^{-1})	Root dry wt (mg plant^{-1})
T_1=control	5.00	0.010	28.42	7.42 abcd	0.289	18.9
T_2= Strain 1	13.00	0.153	28.44	6.67 cd	0.387	20.39
T_3= Strain 2	8.00	0.139	27.12	6.25 d	0.336	20.61
T_4= Strain 3	13.33	0.172	29.09	6.71 bcd	0.186	16.37
T_5= Strain 4	10.67	0.137	30.05	7.53 abc	0.375	23.58
T_6=Strain 5	10.67	0.121	29.08	7.72 abc	0.182	26.83
T_7= Strain 6	9.00	0.123	27.55	7.42 abcd	0.328	17.33
T_8=Strain 7	10.00	0.169	28.31	6.78 bcd	0.328	18.67
T_9= Strain 8	11.00	0.194	29.50	8.39 a	0.322	17.55
T_{10}= Strain 9	13.67	0.170	29.35	6.72 bcd	0.345	20.72
T_{11}=Strain 10	10.67	0.121	27.49	6.52 cd	0.326	20.44
T_{12}=Strain 11	8.67	0.220	28.23	6.89 bcd	0.347	18.99
T_{13}=Strain 12	12.00	0.218	31.24	7.97 ab	0.428	26.17
CV	**31.11%**	**8.27%**	**9.86%**	**9.07%**	**5.79%**	**20.14%**

Entomology Division

Research Highlights

Yield and predatory spider population were compared in insecticide treated and untreated in rice field. Although higher yield of rice was recorded in aman season in insecticide treated field but identical in boro season in insecticide treated and untreated rice field. The predatory spider population were found higher in untreated rice field than the treated one.

Total numbers of infested and uninfested bottle gourd were 3 and 40 respectively. The lowest fruit infestation was found in the SIT Package 7.5%.

Red mites' infestation in the chilli field was monitored regularly in the experimental plots. But no remarkable red mite infestation was observed in the field.

IPM Package with (Sanitation + BSFB Phero+Spinosad (Success 2.5SC@4ml/10L of water) was the most effective against brinjal shoot and fruit borer. The lowest fruit infestation was found in the IPM Package (8.22%) and the highest fruit infestation was found in the control (85.11%).

Aphid infestation in the mustard field was monitored regularly in the experimental plots. But no remarkable aphid infestation was observed in the field.

Among the four mutant/variety (THDB, E-02, TN1 (Check), Habo and Binadhan-18) of rice the overall infestation by stem borer (% white head) throughout the cropping season was below the economic injury level (5% white head).

Tested five advanced mutants (B-11, MV-10, MV-20, MV-40 and B-10) of rice were found moderately susceptible to brown plant hopper under artificial infested condition.

The two mutants (CPM-8-300 and CPM-8-200) of chickpea were evaluated along with two varieties against pod borer under field conditions at two locations Chapainawabganj and Ishurdi. The lowest pod borer infestation was recorded in the line CPM-8-300 (2.08%) at Chapainawabganj. But no significant differences were observed among the mutants/varieties of chickpea with respect to pod borer infestation which ranged from 2.10%-10.06 at two locations.

Five advanced mutants (D1/25/33, D1/15/34, PK1/15/69, Mut-79-71 and Mut-3) along with one variety of groundnuts were evaluated against white fly and jassid under field conditions at Rangpur and Ishurdi. Numbers of jassids/plant were observed higher while numbers of white fly/plant were recorded very low among the tested groundnut lines/variety. Significantly the lowest numbers of jassid and white fly infestations were observed in the same mutant, Mut-3 (7.67) and (0.33) respectively.

Two advanced mutant (MBM-427-87-3 and MBM-656-51-2) of summer mungbean were evaluated along with two check varieties against pod borer under field conditions at three locations. The lowest percentage of pod borer infestation was observed in the mutant MBM-656-51-2 (2.17%) at Khishorganj.

Six advanced lines of lentil were evaluated against pod borer under field conditions. The percentage of pod borer infestation was observed very low and did not differ significantly among the tested mutants/varieties of lentil.

Two advanced lines of sesame (SMM-001, SMM-006) along with two check varieties were evaluated for tolerance to pod borer infestation under field conditions at BINA sub-station farm, Magura. No significant differences were observed among the lines/varieties with respect to pod borer infestation which ranged from 2.48-4.19%.

Two advanced lines of tomato along with one variety, Binatomato-7 were evaluated for tolerance to fruit borer under field conditions at BINA farm, Mymensingh, BINA sub-station farm, Ishurdi and Magura. Fruit infestations were very low and the percentage of infested fruits did not differ significantly among the tested tomato lines/varieties.

Five advanced lines of brinjal along with one variety, Islampuri were evaluated against brinjal shoot and fruit borer, jassid and white fly under field conditions at BINA farm, Mymensingh. Percentage of fruit infestation by brinjal shoot and fruit borer and number of jassids/plant were observed higher while number of white fly/plant were recorded very low among the tested brinjal lines.

Effects of insecticide on rice yield and predatory spiders

Yield and predatory spider population were compared in rice field treated with insecticide and without insecticide at BINA farm, Mymensingh during aman, 2017 and boro, 2017-18 season. Susceptible rice cultivar, TN1were planted in row to row and hill to hill both at 20cm distance. Granular insecticide, Virtako-40WG was sprayed at maximum tillering stage. The experiment was laid out in a completely randomized block design with three replications. Predatory spider population were collected by sweeping and caging after 2 days of spraying from treated and untreated plot (3m x 4m). Rice yield was adjusted at 12% moisture. Data were analyzed statistically and presented in Figure 1.

Statistically significant and increased yield of rice was recorded from insecticide (Virtako-40WG) treated plot in aman season whereas identical yield was recorded from the insecticide treated and untreated rice field in boro season (Figure 1). The spider populations were found higher in untreated rice field than those of insecticide treated plot.

Figure 1. Effects of insecticide on yield and predatory spiders in rice field during aman and boro season.

Effect of gamma radiation for controlling fruit fly (*Bactrocera cucurbitae*) of cucurbit vegetables

Six thousand, seven hundred sterile pupae were released in 600 sq m of bottle gourd cultivated field during kharif season of 2017-18 at BINA Farm Mymensingh. Sterile fruit fly were released in the bottle gourd field at five times with fifteen days interval. Data were recorded during fruiting stage and analyzed statistically and presented in Table 1.

Total number of infested and uninfested bottle gourd were 3 and 40 respectively. The lowest fruit infestation was found in the SIT Package 7.5%.

Table 1. Percent infestation of infested and uninfested bottle gourd and number of released sterile fruit fly at BINA farm, Mymensingh.

Date of fly released	No. of released sterile fruit fly (Pupae) in the bottle gourd field	No. of uninfested bottle gourd	No. of infested bottle gourd	% infestation
04-3-18	1000	5	1	
18-3-18	1600	10	1	
02-4-18	1300	11	0	7.5
17-4-18	1700	8	0	
03-5-18	1100	6	1	
Total	**6700**	**40**	**3**	**-**

Evaluation of different management approaches against the red mites of chilli

The experiment was laid out with three treatments tested against red mites under field condition during rabi season of 2017-18 at BINA Farm Mymensingh. The treatments were: T_1= Spraying of Ecomec 1.8EC@1ml/L, T_2= Spraying of Vertimec 18EC@1ml/L, T_3= Control. The experiment was conducted in RCBD with three replications. The tested variety was chilli (Binachilli-1). Data were recorded during fruiting stage.

Red mites infestation in the chilli field was monitored regularly in the experimental plots. But no remarkable red mite infestation was observed in the field. So, the treatments could not be applied and the results of effectiveness of IPM products against red mite of chilli could not be shown.

Evaluation of different management approaches against brinjal shoot and fruit borer (*Leucinodes orbonalis*)

The experiment was laid out with three treatments tested against brinjal shoot and fruit borer under field condition during kharif season of 2017-18 at BINA Farm Mymensingh. The treatments were: T_1= (Sanitation + BSFB Phero), T_2= (Sanitation + BSFBP hero+Spinosad), T_3= Control. The experiment was conducted in RCBD with three replications. The tested line was brinjal, IndM$_3$D$_{75}$P$_{27}$. Data were recorded during fruiting stage and analyzed statistically and presented in Table 2.

IPM Package with sanitation + BSFB Phero+Spinosad (Success 2.5SC@4ml/10L of water) was the most effective against brinjal shoot and fruit borer. The lowest fruit infestation was found in the IPM Package (8.22%) and the highest fruit infestation was found in the control (85.11%).

Table 2. Percent infestation of brinjal shoot and fruit borer with three different treatments

Treatments	BSFB infestation (%)
1. Sanitation + BSFB Phero	5.13
2. Sanitation+BSFB Phero+Spinosad (Success)	8.22
3. Control	85.11

Effectiveness of different management approaches against the aphid of mustard

The experiment was laid out with three treatments against mustard aphid under field condition during rabi season of 2017-18 at BINA Farm Mymensingh. The treatments were: T_1= Spraying of soap water at 2/3 times @5g/L, T_2= Spraying of bioneem plus @1ml/L at 7 days interval, T_3=

Control. The experiment was conducted in RCBD with three replications. The tested variety was Binasharisha-4. Data were recorded during vegetative, flowering and pod formation stage.

Aphid infestation in the mustard field was monitored regularly in the experimental plots. But no remarkable aphid infestation was observed in the field. So, the treatments could not be applied and the results of effectiveness of IPM products against mustard aphid could not be shown.

Screening of different advanced rice mutants against yellow stem borer (*Scirpophaga incertulas*)

Four advanced mutant/variety of rice, viz. THDB, E-02, Habo and Binadhan-18 were tested along with one check, TN1 against rice stem borer under field condition. The experiment was laid out in a randomized complete block design with three replications. No protective measure was taken to control the insect pest. Data were recorded during maximum tillering and heading stage and analyzed statistically and presented in Table 3.

Among the four mutant/variety of rice the overall infestation by stem borer (% white head) throughout the cropping season was below the economic injury level (5% white head).

Table 3. Mean infestation of different advanced rice lines against yellow stem borer

Mutant/Variety	White head infestation (%)
THDB	0.10
E-02	0.03
TN1 (Check)	0.13
Habo	0.20
Binadhan-18	0.15
$LSD_{0.05}$	**NS**

Susceptibility of different mutant/lines of rice to brown plant hopper (*Nilaparvata lugens*)

Five advanced mutants of rice, viz. B-10, B-11, MV-10, MV-20 and MV-40 were tested along with one resistant check T27A and a susceptible check TN1 against brown plant hopper under artificial infested condition. The experiment was laid out in a completely randomized design with three replications. Data were recorded during seedling stage, analyzed statistically and presented in Table 4.

Tested five advanced mutants of rice were found moderately susceptible to brown plant hopper under artificial infested condition.

Table 4. Mean infestation of different mutant/lines of rice to brown plant hopper

Mutants/Varieties	Damage Scale (0-9)	Level of resistance
B-11	5	MS
MV-10	5	MS
MV-20	5	MS
MV-40	5	MS
B-10	5	MS
TN1(Susceptible check)	7	S
T27A (Resistant check)	1	T

MS=Moderately Susceptible, T= Tolerant, S=Susceptible

Susceptibility of different mutant/lines of chickpea to pod borer (*Helicoverpa armigera*)

Two mutants of chickpea, viz. CPM-8-200 and CPM-8-300 were tested along with two check BARIsola-7 and Binasola-8 against pod borer under field condition. The experiment was laid out in a completely randomized block design with three replications during rabi season of 2017-18 at Ishurdi and Chapainawabganj. No protective measure was taken to control the insect pests. Data were recorded during fruiting stage and analyzed statistically and presented in Table 5.
The infestations by pod borer ranged from 9.18 to 10.06% at Ishurdi and 2.08 to 4.30% at Chapainawabganj although there was no significant difference among the tested lines/variety in this regard. The lowest pod borer infestation was observed in the line CPM-8-300 (2.08%) and the highest was in CPM-8-200 (4.30%) at Chapainawabganj.

Table 5. Mean infestation of different chickpea mutants to pod borer

Mutant/Lines	Pod borer infestation (%)	
	Ishurdi	Chapainawabganj
CPM-8-200	9.18	4.30
CPM-8-300	9.36	2.08
BARIsola-7 (Check)	10.06	2.10
Binasola-8 (Check)	9.96	2.77
$LSD_{0.05}$	**NS**	**NS**

Screening of different groundnut mutant/lines against jassid and white fly

Five advanced mutants and one check variety of groundnut were evaluated against white fly and jassid infestation in the field at BINA substation farm, Ishurdi and Rangpur. The experiments were laid out in a randomized complete block design with three replications. To assess the number of jassid/plant and number of white fly/plant. Data were taken by using cage (1 cage=40cm x 45cm=6 plants) at the vegetative stage. All the data were analyzed statistically and presented in Table 6.
The Infestations by jassid ranged from 13.00 to 27.47 at Rangpur and 7.67 to 11.13 at Ishurdi on the other hand infestations by white fly ranged from 0.33 to 1.00 at Ishurdi. Significant differences were observed among the five mutants/varieties with respect to white fly and jassid infestation at Rangpur and Ishurdi. The lowest no. of jassid and white fly infestation were observed in the same mutant Mut-3 (7.67) and (0.33) respectively.

Table 6. Mean infestation of different groundnut mutant/lines to jassid and white fly

Mutants/lines	No. of Jassid/plant		No of White fly/plant
	Rangpur	Ishurdi	Ishurdi
D1/25/33	22.60 ab	8.07 bc	0.40 bc
D1/15/34	27.13 a	11.13 a	0.67 abc
PK1/15/69	27.47 a	9.40 abc	1.00 a
Mut-79-71	19.20 ab	10.13 a	0.80 ab
Mut-3	13.00 b	7.67 c	0.33 c
Binachinabadam-4 (Check)	25.67 a	10.00 ab	0.93 a
$LSD_{0.05}$	**10.18**	**2.022**	**0.422**

Values in a column having common letter(s) do not differ significantly at 5% level of probability.

Susceptibility of different summer mungbean mutant/lines to pod borer (*Helicoverpa armigera*)

Two mutants of summer mungbean, viz. MBM-427-87-3 and MBM-656-51-2 were tested along with two check Binamoog-8 and BARImoog-6 against pod borer under field condition. The experiment was conducted in a randomized complete block design with three replications at Rajshahi, Barisal and Khishorganj. The field was exposed to natural attack of insect and no control measure was taken. Ten plants per plot were selected randomly for assessing the percentage of pod borer infestation before harvest. The data were analyzed statistically and presented in Table 7.

The infestations by pod borer ranged from 18.27 to 24.32% at Rajshahi, 6.01 to 10.46% at Barisal and 1.49 to 2.81% at Kishorganj. Significant differences were observed among the two mutants of summer mungbean with respect to pod borer infestation at Barisal and Khishorganj. The lowest pod borer infestation was observed in the mutant MBM-656-51-2 (2.17%) at Khishorganj.

Table 7. Mean infestation of different summer mungbean mutant/lines to pod borer

Mutants/lines	Pod borer infestation (%)		
	Rajshahi	**Barisal**	**Khishorganj**
MBM-427-87-3	24.32	10.38a	2.80a
MBM-656-51-2	23.18	6.23b	2.17a
BARImoog-6 (Check)	20.27	6.01b	2.81a
Binamoog-8 (Check)	18.27	10.46a	1.49b
$LSD_{0.05}$	**NS**	**3.156**	**1.211**

Values in a column having common letter(s) do not differ significantly at 5% level of probability.

Evaluation of different lentil mutant/lines against aphid and pod borer (*Helicoverpa armigera*)

Six advanced lines of lentil, viz. LM-185-2, LM-138-3, LM-24-3, LM-206-5, LM-99-8 and LM-18-9 were tested against pod borer under field condition. The experiment was conducted in a randomized complete block design with three replications during rabi season of 2017-18 at Ishurdi and Magura. No protective measurewas taken to control the insect pests. Pod infestation by pod borer was recorded from 10 randomly selected plants per plot. The data were analyzed statistically and presented in Table 8.

The infestations by pod borer ranged from 0.00 to 0.24% although there was no significant difference among the tested lines of lentil in this regard at two locations.

Table 8. Mean infestation of different lentil mutant/lines to pod borer

Mutants/lines	Pod borer infestation (%)	
	Ishurdi	**Magura**
LM-185-2	0.09	0.07
LM-138-3	0.08	0.24
LM-24-3	0.00	0.00
LM-206-5	0.24	0.10
LM-99-8	0.04	0.12
LM-118-9	0.04	0.11
BARI Masur-5 (Check)	0.06	0.20
Binamasur-8 (Check)	0.14	0.05
$LSD_{0.05}$	NS	NS

Susceptibility of different mutant/lines of sesame to pod borer and hairy caterpillar

Two advanced lines of sesame, viz. SMM-001 and SMM-006 were tested against pod borer under field condition at BINA sub-station farm, Magura. The experiment was conducted in a randomized complete block design with three replications during rabi season of 2017-18 at Magura. No protective measure was taken to control the insect pests. Pod infestation by pod borer was recorded from 10 randomly selected plants per plot. The data were analyzed statistically and presented in Table 9.

No significant differences were observed among the mutants/lines of sesame against pod borer infestations which were ranged from 2.48 to 4.19%.

Table 9. Mean infestation of different sesame mutant/lines to pod borer

Mutants/lines	Pod borer infestation (%)
	Magura
SMM-001	2.92
SMM-006	2.48
Binatil-2 (Check)	4.19
Binatil-3 (Check)	3.40
$LSD_{0.05}$	**NS**

Evaluation of advanced tomato lines for tolerance to tomato fruit borer under field condition

Two advanced lines of tomato viz. HM-2722 and Philli-2 with one check variety, Binatomato-7 were tested against fruit borer under field condition. The experiments were laid out in a completely randomized block design with three replications during rabi season of 2017-18 at three locations namely BINA farm Mymensingh, BINA sub-station farm, Ishurdi and Magura. No protective measures were taken to control the insect pests. Data were recorded during fruit stage and analyzed statically and presented in Table 10.

No significant differences were observed among the tomato lines/variety with respect to fruit borer infestations which were very low (0.45 to 3.86%) at three locations.

Table 10. Mean infestation of advanced lines tomato for tolerance to fruit borer at three locations under field condition

Line/variety	Percent fruit infested by fruit borer at		
	Mymensingh	Ishurdi	Magura
HM-2722	1.84	0.84	0.68
Philli-2	1.04	1.19	0.45
Binatomato-7	3.86	1.82	0.99
$LSD_{0.05}$	**NS**	**NS**	**NS**

Screening of different advanced lines of brinjal against brinjal shoot and fruit borer, jassid and white fly

Five advanced lines of brinjal with one check variety, Islampuri were evaluated against brinjal shoot and fruit borer, jassid and white fly under field conditions at BINA farm, Mymensingh. The experiment was laid out in a randomized complete black design with three replications. The unit plot size was 2.8 m x 1.8 m. The plants were exposed to natural infestation and no protective measures were taken against any insect pests. Data on percent fruit infested by shoot and fruit borer were collected from 5 randomly selected plants per plot. Data on number of jassids/plant and white fly were recorded by caging 5 randomly selected plants per plot. All the data were analyzed statistically.

Fruit infestation by brinjal shoot and fruit borer ranged from 12.90 to 43.03% although there was no significant difference among the tested lines/variety in this regard. The lowest number of jassids/plant (13.5) was recorded in the brinjal line $IshP_{14}$ followed by $IndD_{75}P_{29-3}$ while the highest of the same (28.23) was observed in the $IndD_{75}P_{27.}$ The overall infestations by white fly were very low among the tested lines/variety which ranged from 0.90 to 1.77 number of white fly/plant

Table 11. Mean infestation of brinjal lines/variety to brinjal shoot and fruit borer, jassid and white fly.

Advanced lines/varieties	% fruit infested by BSFB	No. of jassids /plant	No. of white fly/plant
$IshP_{14}$	28.65	13.50 c	1.23
$IndD_{75}P_{14}$	38.08	21.10 ab	1.77
$IndD_{75}P_{27}$	28.68	28.23 a	0.90
$IndD_{75}P_{29-2}$	31.18	21.43 ab	1.20
$IndD_{75}P_{29-3}$	43.06	15.03 bc	1.03
Islampuri	12.90	22.36 ab	1.20
$LSD_{0.05}$	**NS**	**6.98**	**NS**

Means in a column followed by same letter(s) do not differ significantly at 5% level by DMRT

Plant Pathology Division

Research Highlights (2017-18)

Among seven mutants derived from NERICA rice, mutant, N_4/250/P-2(6)-26 showed moderately resistant and 3 showed moderately susceptible reaction to bacterial blight in aus season, whereas all the mutants showed moderately resistant reaction to sheath blight.

Seven mutants and one advanced line of rice showed moderately susceptible reaction to bacterial leaf blight in aman season. Eight mutants/lines showed moderately resistant and 4 showed moderately susceptible reaction to sheath blight.

Eleven mutants and six advanced lines of rice were found moderately resistant to bacterial blight in boro season. One mutant was moderately resistant and ten showed moderately susceptible reaction to sheath blight.

Application of Biskachu (*Dieffenbachia* sp.) leaf extract gave the lowest disease severity against sheath blight of rice in both aman and boro season compared to the control.

Thirteen mutants/lines of wheat were found free from blast, nine from blight and six from rust disease in Meherpur among the 43 mutants/lines were evaluated.

Twenty eight mutants/lines of wheat were found free from blast and ten from rust disease in Mymensingh among 43 mutants/lines were evaluated.

The disease severity of wheat blast was the highest in spike initiation stage to early maturing stage.

Chickpea mutant, CPM (BR)-200 was found moderately susceptible to root rot and moderately resistance to botrytis gray mould.

Six advanced mutants of lentil were found moderately susceptible to root rot and four mutants were found moderately susceptible to stemphylium blight.

Four mungbean mutants were found moderately resistant to cercospora leaf spot.

Six sesame mutants were found to be moderately resistant to stem rot.

Three soybean mutants (SBM-9, SBM-15 and SBM-22) showed moderately susceptible reaction to collar rot whereas moderately susceptible to soybean mosaic.

Tomato mutant, TM-4 was found moderately resistant to late blight in natural conditions, whereas other 2 mutants and 2 lines showed moderately susceptible to the disease.

Seed treatment of jute and onion with garlic and neem extract significantly reduced seed borne fungal infection. In case of jute the reduction of *Colletotrichum corchori* was 76.9-74.1% and *Machrophomina phasealina* was 78.9-71.4%. In case of onion the reduction of *Fusarium spp.* was 78.4-77.7% and *Alternaria porri*74.9-70.4%.

Evaluation of mutants/ advanced lines of rice for bacterial blight and sheath blight during Aus season

Seven mutants derived from NERICA rice along with parents and susceptible check were assessed against bacterial blight (*Xanthomonas oryzae* pv. *oryzae*) and sheath blight (*Rhizoctonia solani*) resistance in Aus season of 2018 under inoculated field condition. The experiment was conducted in a randomized block design with three replications at BINA farm, Mymensingh. The unit plot size was 2 m x 2 m. The distance between lines and hills were 20 cm and 15 cm, respectively. Twenty five days old seedlings were transplanted in the field. The fertilizers were applied as per recommendations. Ten hills in each plot were inoculated at booting stage with 72 hours old culture of *Xanthomonus oryae* pv. *oryzae* by clipping method. Similarly, ten hills in each plot were inoculated at booting stage with seven days old culture of *Rhizoctonia solani*. Plants were assessed for bacterial blight and sheath blight severity after two and three weeks of inoculation respectively, following the scale developed at IRRI (2013).

All the plants of mutants/parents were infected with bacterial leaf blight. Mean severity of BLB was ranged from 2.7 to 8.4 (Table 1). Among the mutants/lines, N_4/250/P-2(6)-26 showed moderately resistant and 3 (mutants/parents) showed moderately susceptible reaction to bacterial blight. Mean incidences and severity of ShB ranged from 63.3-100% and 2.2-6.5, respectively (Table 1). All the mutants showed moderately resistant reaction to sheath blight. The check TN-1 showed susceptible reaction to both diseases.

Table 1. Mean incidence and severity of bacterial blight and sheath blight in some advanced mutants of rice during Aus season of 2018 at Mymensingh

Mutant/variety	Bacterial blight			Sheath blight		
	Incidence (%)	Severity (0-9)	Disease reaction	Incidence (%)	Severity (0-9)	Disease reaction
N_1/250/P-7-3-1-2-2	100.0	8.0	HS	70.0	2.6	MR
N_1/250/P-6-2-6-1	100.0	8.4	HS	100.0	3.0	MR
N_4/250/P-1(2)	100.0	3.6	MS	93.3	2.2	MR
N_4/250/P-2(6)-26	100.0	2.7	MR	93.3	2.7	MR
N_4/350/P-4(5)	100.0	6.5	S	76.7	2.9	MR
N_{10}/300/P-2-3-5-1	100.0	5.3	MS	63.3	2.3	MR
N_{10}/300/P-2-3-5-2	100.0	6.2	MS	66.7	2.3	MR
NERICA-1	100.0	8.2	HS	83.3	4.3	MS
NERICA-4	100.0	7.1	S	86.7	5.1	MS
NERICA-10	100.0	5.7	MS	90.0	3.7	MS
SH-1	100.0	7.2	S	100.0	4.1	MS
BR-26	100.0	6.8	S	96.7	4.0	MS
BRRI dhan48	100.0	6.5	S	86.7	3.8	MS
TN-1	100.0	7.9	HS	100.0	6.5	S
LSD $_{0.05}$	**NS**	**2.1**	**--**	**8.4**	**0.6**	**--**

MR = Moderately resistant, MS= Moderately susceptible, S= Susceptible, HS= Highly susceptible

Evaluation of mutants/ advanced lines of rice for bacterial blight and sheath blight during aman season

Five mutants, 7 advanced lines of rice along with three varieties and one susceptible check variety were assessed against bacterial blight (*X. oryzae* pv. *oryzae*) and sheath blight (*R. solani*) resistance in Aman season of 2017 under inoculated field condition. The experiments were conducted in a randomized block design with three replications at BINA farm, Mymensingh. The unit plot size was 2 m x 2 m. The distance between lines and hills were 20 cm and 15 cm, respectively. Thirty days old seedlings were transplanted in the field. The fertilizers were applied as per recommendations. Ten hills in each plot were inoculated at booting stage with *X. oryae* pv. *oryzae* by clipping method. Similarly, ten hills in each plot were inoculated at 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 ranged from 2.1-8.1 (Table 2). Among the mutants/lines, 7 showed moderately susceptible and 5 (mutants/variety) showed susceptible reaction to bacterial leaf blight. Mean severity of ShB ranged from 2.2-8.2 (Table 2). Eight mutants/lines showed moderately resistant and 4 showed moderately susceptible reaction to sheath blight. Moderately resistant mutants/lines will be tested under inoculated condition in next year.

Table 2. Mean incidence and severity of bacterial leaf blight and sheath blight in some advanced mutants/lines of rice during aman season of 2017 at Mymensingh

Mutant/variety	Bacterial leaf blight			Sheath blight		
	Incidence (%)	Severity (0-9)	Disease reaction	Incidence (%)	Severity (0-9)	Disease reaction
N_4/250/P-2(5)-11-2	100.0	6.1	MS	100.0	2.6	MR
N_4/350/P-4(5)	100.0	4.6	MS	100.0	2.8	MR
N_{10}/350/P-5-4	100.0	6.0	MS	100.0	3.1	MR
RM-kas-60 (C)-1	100.0	6.0	MS	100.0	2.2	MR
RM-kas-80 (C)-1	100.0	4.9	MS	100.0	2.5	MR
RC-2-4-1-2	100.0	6.1	MS	100.0	3.3	MR
B-10	100.0	6.1	MS	100.0	2.8	MR
B-11	100.0	7.3	S	100.0	4.9	MS
MV-10	100.0	7.1	S	100.0	6.2	MS
MV-20	100.0	6.6	S	100.0	5.4	MS
MV-40	100.0	6.8	S	100.0	3.2	MR
SH-1	100.0	6.6	S	100.0	5.5	MS
Binadhan-7	100.0	4.9	MS	100.0	5.9	MS
Binadhan-17	100.0	2.1	MR	100.0	3.1	MR
BRRI dhan56	100.0	6.1	MS	100.0	4.7	MS
TN-1	100.0	8.1	HS	100.0	8.2	HS
$LSD_{0.05}$	NS	1.9	--	NS	1.2	--

MR = Moderately resistant, MS= Moderately susceptible, S= Susceptible, HS= Highly susceptible

Evaluation of some promising mutants/advanced lines of rice for bacterial blight and sheath blight during boro season

Eleven promising mutants and 6 advanced lines along with 3 varieties and 1 susceptible check variety were assessed against bacterial leaf blight and sheath blight during boro season of 2017-18 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 28 January 2018. 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 showed significant difference among the mutants/lines. Mean incidences and severity of BLB ranged from 70.0-100% and 1.6-7.7, respectively (Table 3). All the mutants and advanced lines were found to be moderately resistant to bacterial blight. Mean severity of ShB ranged from 3.2-8.4 (Table 3).

Among the mutants/lines, 1 showed moderately resistant, 10 found moderately susceptible and 6 found susceptible reaction to sheath blight.

Table 3. Mean incidence and severity of bacterial blight and sheath blight of some mutants/advanced lines of rice during Boro season of 2017-18 at Mymensingh

Mutant/lines/variety	Bacterial leaf blight			Sheath blight		
	Incidence (%)	Severity (0-9)	Disease reaction	Incidence (%)	Severity (0-9)	Disease reaction
RM (2)-50(C)-2-1-1	80.0	1.6	MR	100.0	3.9	MS
RM-40(c)-4-2-8	100.0	2.3	MR	100.0	6.4	MS
SH-1	100.0	3.0	MR	100.0	6.7	S
B-10	80.0	1.5	MR	100.0	5.9	MS
B-11	93.3	2.0	MR	100.0	7.0	S
E-02	93.3	2.5	MR	100.0	6.7	S
THDB	100.0	2.5	MR	100.0	7.3	S
BPP-10-200-1	100.0	2.4	MR	100.0	4.5	MS
N_1/250/P-6-2-6-1	96.7	2.0	MR	100.0	5.1	MS
N_1/300/P-9-5	80.0	1.7	MR	100.0	5.1	MS
N_4/250/P-2(5)-11-2	90.0	1.8	MR	100.0	6.8	S
N_4/250/P-2(6)-26	100.0	2.4	MR	100.0	6.1	MS
N_4/250/P-1(2)	90.0	1.6	MR	100.0	6.8	S
N_4/350/P-4(5)	100.0	2.5	MR	100.0	5.7	MS
N_{10}/350/P-5-4	100.0	2.9	MR	100.0	5.6	MS
N_{10}/300/P-2-3-5-1	76.7	1.8	MR	100.0	6.3	MS
N_{10}/300/P-2-3-5-2	70.0	1.7	MR	100.0	3.2	MR
Binadhan-10	90.0	2.3	MR	100.0	6.3	MS
Binadhan-14	86.7	1.9	MR	100.0	6.6	S
BRRI dhan28	96.7	5.8	MS	100.0	6.9	S
TN-1	100.0	7.7	HS	100.0	8.4	HS
$LSD_{0.05}$	**6.5**	**2.3**	**--**	**NS**	**1.9**	**--**

MR= Moderately resistant, MS= Moderately susceptible, S= Susceptible

Eco-friendly Management of sheath blight of rice

Two experiments were conducted to assess the effect of botanicals (Biskachu and dhuttura leaf extract), *Trichoderma viridi* and their combination on sheath blight (*Rhizoctonia solani*) of rice during Aman season of 2017 and Boro season of 2018 under inoculated field condition at BINA farm , Mymensingh. The treatments were: T_1= Biskachu leaf extracts (*Dieffenbachia* sp.), T_2= Datura leaf extract, T_3= *Trichoderma viridi*, T_4= T_1+T_2+T_3 and T_5= Control. The experiments were conducted in a randomized block design with three replications. The unit plot size was 2 m x 1 m. The distance between lines and hills were 20 cm and 15 cm, respectively. Thirty days old seedlings were transplanted in the field. The fertilizers were applied as per recommendations. Ten hills in each plot were inoculated at booting stage with seven days old culture of *R. solani*. Plants were assessed for sheath blight severity after three weeks of inoculation following the scale (0-9) developed at IRRI (2013).

In Aman season mean incidences and severity of sheath blight ranged from 86.9-100% and 3.3-8.9, respectively (Table 4). In Boro season mean incidences and severity of sheath blight ranged from 77.4-96.7% and 1.9-7.8, respectively (Table 5). Among the treatments application of Biskachu leaf extract gave the lowest disease severity compared to the control in both seasons. The treatments could not significantly increase grain yield compared to the control.

Table 4. Effect of botanicals and *Trichoderma* on sheath blight of rice in Aman season of 2017

Treatments	Disease incidence (%)	Disease severity (0-9)	Plant height (cm)	Grain yield (t/ha^{-1})
T_1= Biskachu leaf extract	87.4	3.3	95.0	3.6
T_2= Dhuttura leaf extract	92.3	5.8	92.0	3.2
T_3= *Trichodermaviridi*	88.0	6.8	95.4	3.5
T_4= T_1+T_2+T_3	86.9	6.2	96.0	3.6
T_5= Control	100.0	8.9	92.3	3.1
LSD $_{0.05}$	**4.3**	**--**	**2.1**	**0.6**

Table 5. Effect of botanicals and *Trichoderma* on sheath blight of rice during Boro season of 2018

Treatments	Disease incidence (%)	Disease severity (0-9)	Plant height (cm)	Grain yield (t/ha^{-1})
T_1= Biskachu leaf extract	77.4	1.9	85.0	3.5
T_2= Dhutura leaf extract	80.0	2.8	86.6	3.3
T_3= *Trichodermaviridi*	85.5	3.9	85.4	3.4
T_4= T_1+T_2+T_3	82.4	3.2	86.2	3.5
T_5= Control	96.7	7.8	80.3	3.0
LSD $_{0.05}$	**3.2**	**--**	**1.4**	**0.7**

Evaluation of wheat germplasms against blast, blight and rust disease under natural field condition at Meherpur

Thirty three mutant and lines with 6 check varieties of wheat were evaluated against blast, blight and rust during the winter season of 2017-18 under natural condition at Meherpur and inoculated condition at Mymensingh. The experiments were conducted in randomized block design with three replications. The seeds were sown in rows on last week in November, 2017. Distances between rows and seeds were 30 cm and 5 cm, respectively.

At Meherpur, the mean incidence of blast, blight and rust ranged from 0-25, 0-40 and 0-100%, respectively (Table 6-8). The mean severity of blast, blight and rust ranged from 0-90, 0-40 and 0-95%, respectively (Table 6-8). Thirteen germplasms were found free from blast disease (BWM-4, BWM-5, BWM-6, BWM-7, BWM-9, BWM-10, BWM-15, BWM-17, BWM-19, BWM-20, BWM-21, BWM-22 and BWM-23). Nine mutant/lines were found free from blight incidence (BWM-5, BWM-6, BWM-7, BWM-9, BWM-10, BWM-19, BWM-20, BWM-22 and BWM-23). Six mutant/lines were found free from rust incidence (BWM-5, BWM-6, BWM-17, BWM-19, BWM-20 and BWM-23).

At Mymensingh, the mean incidence of blast, blight and rust ranged from 0-20, 2-70 and 0-95%, respectively (Table 9-11). The mean severity of blast, blight and rust ranged from 0-30, 3-60 and 0-50%, respectively (Table 9-11). Among the 43, twenty eight were found free from blast and ten were found free from rust disease. The lowest blight incidence was recorded in BARI Gom-33 (Table 9-11).

Table 6. Incidence and severity of wheat blast at Meherpur during 2017-18

Entry No.	Blast incidence (%)	Blast severity (%)	Entry No.	Blast incidence (%)	Blast severity (%)
BWM-1	1	10	BWM-23	0	0
BWM-2	2	25	BWM-24	3	15
BWM-3	2	20	BWM-25	6	45
BWM-4	0	0	BWM-26	12	70
BWM-5	0	0	BWM-27	11	60
BWM-6	0	0	BWM-28	18	70
BWM-7	0	0	BWM-29	11	60
BWM-8	1	10	BWM-30	6	50
BWM-9	0	0	BWM-31	11	60
BWM-10	0	0	BWM-32	12	75
BWM-11	8	60	BWM-33	25	90
BWM-12	15	70	BWM-34	4	30
BWM-13	3	35	BWM-35	3	40
BWM-14	2	10	BWM-36	11	60
BWM-15	0	0	BWM-37	6	40
BWM-16	2	20	BARI Gom-30	10	40
BWM-17	0	0	BARI Gom-21	10	30
BWM-18	4	35	BARI Gom-24	15	35
BWM-19	0	0	BARI Gom-26	15	20
BWM-20	0	0	BARI Gom-28	10	20
BWM-21	0	0	BARI Gom-33	5	20
BWM-22	0	0	-	-	-
Level of Significance	**--**	**--**		**5 %**	**5 %**

Table 7. Incidence and severity of wheat blight at Mymensingh during 2017-18

Entry No.	Blight incidence (%)	Blight severity (%)	Entry No.	Blight incidence (%)	Blight severity (%)
BWM-1	2	5	BWM-23	0	0
BWM-2	2	5	BWM-24	10	7
BWM-3	2	5	BWM-25	40	30
BWM-4	1	3	BWM-26	30	20
BWM-5	0	0	BWM-27	40	30
BWM-6	0	0	BWM-28	40	30
BWM-7	0	0	BWM-29	40	30
BWM-8	25	40	BWM-30	40	35
BWM-9	0	0	BWM-31	20	15
BWM-10	0	0	BWM-32	32	20
BWM-11	20	20	BWM-33	10	7
BWM-12	20	20	BWM-34	2	2
BWM-13	10	7	BWM-35	5	3
BWM-14	10	7	BWM-36	5	3
BWM-15	15	10	BWM-37	5	3
BWM-16	10	7	BARI Gom-30	5	5
BWM-17	10	7	BARI Gom-21	3	3
BWM-18	5	3	BARI Gom-24	5	5
BWM-19	0	0	BARI Gom-26	5	5
BWM-20	0	0	BARI Gom-28	5	15
BWM-21	5	3	BARI Gom-33	1	2
BWM-22	0	0	-	-	-
Level of Significance	**--**	**--**		**5 %**	**5 %**

Table 8. Incidence and severity of wheat rust at Meherpur during 2017-18

Entry No.	Rust incidence (%)	Rust severity (%)	Entry No.	Rust incidence (%)	Rust severity (%)
BWM-1	1	5	BWM-23	0	0
BWM-2	70	50	BWM-24	20	15
BWM-3	50	40	BWM-25	10	10
BWM-4	90	60	BWM-26	20	15
BWM-5	0	0	BWM-27	5	3
BWM-6	0	0	BWM-28	20	15
BWM-7	10	10	BWM-29	30	20
BWM-8	90	60	BWM-30	20	15
BWM-9	20	10	BWM-31	10	7
BWM-10	100	95	BWM-32	10	7
BWM-11	10	10	BWM-33	20	15
BWM-12	5	3	BWM-34	70	50
BWM-13	60	40	BWM-35	60	50
BWM-14	50	30	BWM-36	60	50
BWM-15	3	2	BWM-37	30	20
BWM-16	5	3	BARI Gom-30	80	70
BWM-17	0	0	BARI Gom-21	30	20
BWM-18	6	2	BARI Gom-24	10	7
BWM-19	0	0	BARI Gom-26	2	2
BWM-20	0	0	BARI Gom-28	50	40
BWM-21	10	7	BARI Gom-33	2	3
BWM-22	0	0	-	-	-
Level of Significance				**5%**	**5%**

Table 9. Incidence and severity of wheat blast at Mymensingh during 2017-18

Entry No.	Blast incidence (%)	Blast severity (%)	Entry No.	Blast incidence (%)	Blast severity (%)
BWM-1	1	5	BWM-24	0	0
BWM-2	3	10	BWM-25	0	0
BWM-3	10	30	BWM-26	0	0
BWM-4	0	0	BWM-27	0	0
BWM-5	0	0	BWM-28	0	0
BWM-6	0	0	BWM-29	0	0
BWM-7	0	0	BWM-30	0	0
BWM-8	5	5	BWM-31	0	0
BWM-9	0	0	BWM-32	0	0
BWM-10	0	0	BWM-33	0	0
BWM-11	20	10	BWM-34	0	0
BWM-12	3	10	BWM-35	0	0
BWM-13	5	20	BWM-36	0	0
BWM-14	3	10	BWM-37	0	0
BWM-15	0	0	BARI Gom-30	10	15
BWM-16	3	10	BARI Gom-21	10	10
BWM-17	0	0	BARI Gom-24	10	10
BWM-18	2	7	BARI Gom-26	20	30
BWM-19	0	0	BARI Gom-28	15	15
BWM-20	0	0	BARI Gom-33	5	3
BWM-21	0	0	-	-	-
BWM-22	0	0	-	-	-
BWM-23	0	0	-	-	-
Level of Significance				**5%**	**5%**

Table 10. Incidence and severity of wheat blight at Mymensingh during 2017-18

Entry No.	Blight incidence (%)	Blight severity (%)	Entry No.	Blight incidence (%)	Blight severity (%)
BWM-1	20	10	BWM-24	4	7
BWM-2	45	10	BWM-25	5	15
BWM-3	15	7	BWM-26	7	15
BWM-4	25	15	BWM-27	10	20
BWM-5	30	7	BWM-28	10	20
BWM-6	20	10	BWM-29	15	30
BWM-7	20	10	BWM-30	15	20
BWM-8	70	15	BWM-31	40	40
BWM-9	40	10	BWM-32	60	50
BWM-10	20	10	BWM-33	45	40
BWM-11	60	15	BWM-34	5	10
BWM-12	70	15	BWM-35	5	10
BWM-13	25	7	BWM-36	4	5
BWM-14	40	10	BWM-37	70	60
BWM-15	30	7	BARI Gom-30	10	15
BWM-16	40	10	BARI Gom-21	10	15
BWM-17	25	10	BARI Gom-24	15	15
BWM-18	40	20	BARI Gom-26	10	10
BWM-19	30	15	BARI Gom-28	10	15
BWM-20	40	10	BARI Gom-33	3	3
BWM-21	50	15	-	-	-
BWM-22	35	15	-	-	-
BWM-23	50	20	-	-	-
Level of Significance				*	*

Table 11. Incidence and severity of wheat rust at Mymensingh during 2017-18

Entry No.	Rust incidence (%)	Rust severity (%)	Entry No.	Rust incidence (%)	Rust severity (%)
BWM-1	0	0	BWM-24	5	5
BWM-2	0	0	BWM-25	5	5
BWM-3	5	10	BWM-26	5	5
BWM-4	5	5	BWM-27	1	3
BWM-5	0	0	BWM-28	5	5
BWM-6	0	0	BWM-29	10	5
BWM-7	0	0	BWM-30	10	5
BWM-8	80	50	BWM-31	5	5
BWM-9	25	30	BWM-32	3	5
BWM-10	95	40	BWM-33	10	7
BWM-11	20	30	BWM-34	40	20
BWM-12	10	20	BWM-35	30	15
BWM-13	30	15	BWM-36	30	20
BWM-14	10	10	BWM-37	15	5
BWM-15	0	0	BARI Gom-30	40	30
BWM-16	15	15	BARI Gom-21	20	15
BWM-17	10	10	BARI Gom-24	5	3
BWM-18	5	5	BARI Gom-26	1	1
BWM-19	0	0	BARI Gom-28	20	10
BWM-20	0	0	BARI Gom-33	1	1
BWM-21	3	20	-	-	-
BWM-22	0	0	-	-	-
BWM-23	3	10	-	-	-
LSD				**5%**	**5%**

Study on critical susceptible stage of wheat against blast

A pot experiment was conducted to evaluate the critical susceptible stage of wheat blast. The experiments were conducted in CRD with four replications at BINA farm during the winter season of 2017-18. Fifteen seeds were sown in each pot on 7 November 2017. The inoculum of blast (*Magnaporte oryzae*) collected from blast hotspot of Meherpur district and inoculated on susceptible variety of wheat (BARI Gom-25 and BARI Gom-26) at four growing stage (seedling stage, growing stage, pre-heading stage, pre-maturing stage).

The mean incidence of blast ranged from 0-100%. The highest blast incidence and severity was recorded at pre-heading stage to early maturing stage (Fig 1).

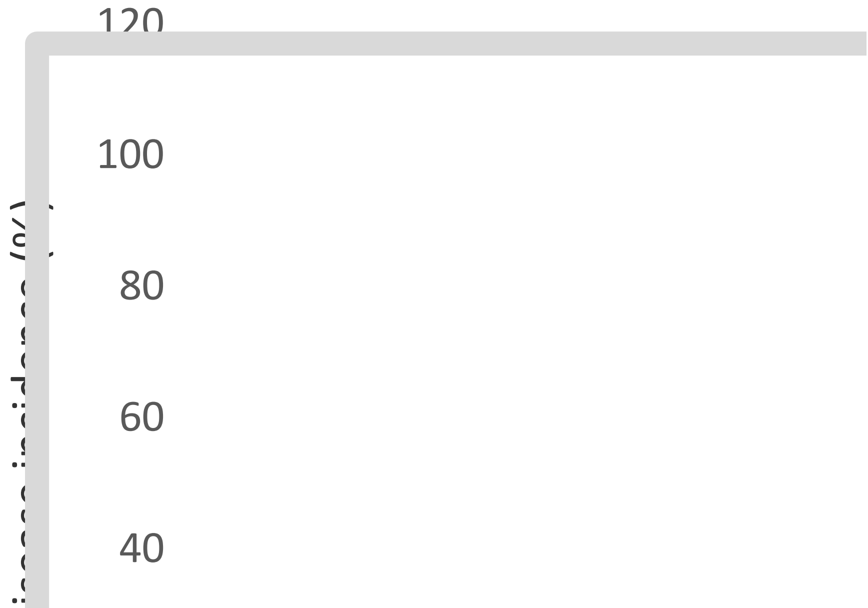


Fig.1. Critical susceptible stage of wheat blast

Table 12. The mean severity (%) of blast at different growth stages of wheat

Varieties	Blast severity (%)			
	Seedling stage	Growth stage	Pre-heading	Pre-maturing
BARI Gom-25	2	5	100	50
BARI Gom-26	3	7	100	60

Screening of M_3 population of jute

This experiment was carried out with a view to induce resistance against stem rot (*Macrophamina phaseolina*) of jute. Dry seeds of four varieties of tosha jute (*Corchorus olitorius*) (varieties: O-72, O-795, O-9897, O-3820 and JRO-524) were exposed to 100, 200, 300, 400, 450, 500 and 550 Gy from ^{60}Co source in Bangladesh Institute of Nuclear Agriculture (BINA) and M_3 seeds were produced from the irradiated seeds. M_3 seeds were sown on April 25, 2018 at BINA farm, Mymensingh. Plants were inoculated with 1 mm block inoculum of seven days old culture of *Macrophamina phaseolina*. The disease severity was measured in lesion length developed on the stem (Table 13).

All the populations were susceptible to stem rot. The result indicates that irradiation of jute seed with different doses could not improve disease susceptibility to stem rot.

Table 13. Response of jute mutants to stem rot disease at Mymensingh during 2017-18

Varieties	Lesion length (mm)							
	100Gy	200Gy	300Gy	400Gy	450Gy	500Gy	550 Gy	Control (no radiation)
O-72	33.3 (S)	39.0 (S)	34.4 (S)	39.0 (S)	34.5 (S)	38.0 (S)	35.8 (S)	37.0 (S)
O-795	38.8 (S)	41.2 (S)	37.5 (S)	34.1 (S)	35.7 (S)	31.3 (S)	34.3 (S)	36.5 (S)
O-9897	32.1 (S)	38.0 (S)	35.5 (S)	40.1 (S)	30.6 (S)	34.3 (S)	33.2 (S)	35.1 (S)
O-3820	33.3 (S)	35.2 (S)	39.3 (S)	36.0 (S)	34.0 (S)	33.4 (S)	30.5 (S)	34.4 (S)
JRO-524	34.2 (S)	36.3 (S)	38.0 (S)	37.2 (S)	36.0 (S)	32.3 (S)	34.3 (S)	39.2 (S)

Data in the parenthesis indicate disease reaction where S= Susceptible

Effect of plant extracts on seed-borne fungal infection of jute and onion

An experiment was carried out at Plant Pathology Laboratory, Bangladesh Institute of Nuclear Agriculture, Mymensingh to evaluate six different plant extracts against seed-borne fungi of jute and onion. Two varieties of jute, Tosha jute (*Corchorus olitorious*, var. O-9897) and deshi jute (*Corchorus capsularis*, var. BJRI Deshipat 7) and two varieties of onion (*Allium cepa*), Faridpuri and Taherpuri were used in the experiment. The treatments were: T_0 = Control, T_1 = Neem leaf extract (*Azadirachta indica)*, T_2 =Allamanda leaf extract (*Allamanda cathartica*), T_3 = Garlic extract (*Allium sativum*), T_4 = Bishkatali leaf extract (*Polygonum hydropiper*), T_5 = Mahagony leaf extract (*Swietenia mahagoni*). Seeds of onion and jute were dipped in the extracts (1:1 dilution) for 45 minutes. The extracts were drained out and the treated seeds were kept on filter paper. The seeds were allowed to be dried out for 15 minutes in the air. The treated and untreated seeds were plated for observation of seed borne fungi following the standard blotter method (ISTA). The experiments were conducted following completely randomized design (CRD) with six replications. The plates were incubated at 22^0C. The germination (%) of seeds from different treatments was counted. Different seed borne fungi were identified by observing the characteristics of fungi according to standard reference book.

Seed treatment with garlic clove extract and neem leaf extract could increase the percentage of germination over control. In jute increased germination over control was: by neem leaf, 47.4% and by garlic clove, 45.5% (Table 14). In onion increased germination over control was: by neem leaf, 49.2% and by garlic clove, 50.4% (Table 15). *Fusarium spp.*, *Aspergillus niger* and *Carvularia lunata* were common in both jute and onion seeds. In jute seeds, *Fusarium spp., Colletotrichum corchori and Macrophomina phaseolina* were dominant while in onion seeds, *Fusarium spp.* and *Alternaria porri* were dominant. Seed treatment with garlic extract and neem leaf extract significantly reduced seed-borne fungal infection in jute (the reduction of *C. corchori*: 76.9 to 74.1% and of *M. phaseolina*: 78.9 to71.4%) (Table 16) and in onion (the reduction of *Fusarium spp.*:78.4 to 77.7% and of *Alternaria porri* 74.9 to 70.4%) (Table 17).

Table 14. Effect of different plant extracts on germination of jute seed

Treatments	Tosha (*Corchorus olitorious)*		Deshi (*Corchorus capsularis)*	
	Germination (%)	Germination increased over control (%)	Germination (%)	Germination increased over control (%)
Control	66.2 d	--	65.4 c	--
Neem leaf	95.3 a	43.9 a	96.4 a	47.4 a
Mahagoni leaf	89.0 c	34.4 b	90.1 b	37.7 e
Bishkatali leaf	92.0 b	38.9 b	93.7 b	43.2 d
Allamanda leaf	92.6 b	42.9 a	92.1 b	40.8 c
Dhuttura leaf	95.5 a	44.2 a	95.0 a	45.2 b

Garlic clove	96.1 a	45.6 a	95.2 a	45.5 b
LSD $_{0.05}$	**2.60**	**2.52**	**2.7**	**1.93**

Each value represents the mean of five replications. In a column figures with same letter do not differ significantly.

Table 15. Effect of different plant extracts on seed germination of two varieties of onion

Treatments	**Taherpuri**		**Faridpuri**	
	Germination (%)	**Germination increased over control (%)**	**Germination (%)**	**Germination increased over control (%)**
Control	58.2 c	--	56.5	--
Neem leaf	84.5 a	45.1	84.3 a	49.2 a
Mahagoni leaf	80.1 b	37.6	77.8 b	37.6 c
Bishkatali leaf	81.5 b	40.0	79.0 b	39.8 c
Allamanda leaf	84.0 a	44.3	83.3 a	47.4 b
Dhuttura a leaf	80.3 b	37.9	76.4 b	35.2 c
Garlic clove	86.5 a	48.6	85.0 a	50.4 a
LSD $_{0.05}$	**2.82**	**2.02**	**2.74**	**1.83**

Each value represents the mean of five replications. In a column figures with same letter do not differ significantly.

Table 16. Infection of fungal pathogens associated with jute seeds (Tosha and Deshi) treated with different plant extracts

Treatments	**Infection of fungal pathogens (%)**									
	Colletotrichum corchori		***Macrophomina phaseolina***		***Fusarium spp.***		***Carvularia lunata***		***Aspergillus niger***	
	Tosha	**Deshi**	**Tosha**	**Deshi**	**Tosha**	**Deshi**	**Tosha**	**Deshi**	**Tosha**	**Deshi**
Control	28.2a	26.3a	22.4a	20.4a	35.7a	30.0a	8.3a	7.2a	8.5a	8.2a
Neem leaf	6.5c (76.9)	6.1c (76.8)	6.4b (71.4)	4.3c (78.9)	8.5c (76.1)	7.4c (75.3)	2.0b (75.9)	2.0b (72.2)	2.0b (76.5)	2.0b (75.6)
Mahagoni leaf	8.3b (70.3)	8.5b (67.6)	7.6c (66.3)	6.0b (70.5)	12.2b (65.8)	10.4b (65.3)	2.4b (71.1)	2.5b (65.3)	2.5b (70.6)	2.6b (68.2)
Bishkatali leaf	10.0b (64.5)	10.7b (59.3)	7.0c (76.9)	6.5b (73.0)	10.0b (71.9)	9.2b (69.3)	2.4b (71.1)	2.5b (65.3)	2.8b (67.0)	2.3b (71.9)
Allamanda leaf	10.0b (64.5)	8.4b (68.1)	7.2c (68.6)	5.3b (74.0)	12.4b (65.3)	10.0b (66.6)	2.2b (73.5)	2.4b (68.1)	2.8b (67.0)	2.6b (68.2)
Dhuttura leaf	7.4c (73.7)	8.7b (66.9)	6.4b (71.4)	4.6c (77.4)	8.3c (76.7)	7.3c (75.6)	2.0b (75.9)	2.0b (72.2)	2.0b (76.5)	2.6b (71.9)
Garlic clove	6.5c (76.9)	6.8c (74.1)	6.0b (73.2)	4.8c (76.4)	8.0c (77.5)	7.0c (76.6)	2.0b (75.9)	2.1b (70.1)	2.0b (76.5)	1.9b (76.8)
LSD $_{0.05}$	**1.62**	**1.58**	**1.30**	**1.28**	**1.22**	**1.54**	**0.51**	**0.58**	**0.50**	**0.52**

In a column figures with same letter do not differ significantly. Values in the parenthesis indicate reduction of fungal infection (%) comparing with control

Table 17. Infection of fungal pathogens associated with onion seeds (Taherpuri and Faridpuri) treated with different plant extracts

Treatments	Infection of fungal pathogens (%)							
	Fusarium spp.		*Alternaria porri*		*Aspergillus niger*		*Carvularia lunata*	
	Taherpuri	Faridpuri	Taherpuri	Faridpuri	Taherpuri	Faridpuri	Taherpuri	Faridpuri
Control	25.6a	27.8a	22.7a	20.3a	6.6a	5.0a	8.0a	8.1a
Neem leaf	5.8b (77.3)	6.2b (77.7)	6.9c (69.6)	6.0c (70.4)	1.2c (81.8)	1.1c (78.0)	1.3b (83.7)	1.0c (87.6)
Mahagoni leaf	9.0c (64.8)	8.4c (69.6)	10.3b (54.6)	8.3b (59.1)	2.2b (66.6)	2.6b (48.0)	2.1b (73.7)	2.5b (69.1)
Bishkatali leaf	8.4c (67.1)	9.5c (65.8)	11.4b (49.8)	9.0b (55.7)	2.4b (63.6)	2.8b (44.0)	2.4b (70.0)	2.3b (71.6)
Allamanda leaf	8.5c (66.7)	10.0c (64.0)	9.6b (57.7)	8.3b (59.1)	2.2b (66.6)	2.8b (44.0)	2.4b (70.0)	2.5b (69.1)
Dhuttura leaf	6.0b (76.6)	6.6b (76.2)	7.4c (67.4)	5.8c (71.4)	1.0 c (84.4)	1.0c (80.0)	1.0c (87.5)	1.0c (87.6)
Garlic clove	6.0b (76.6)	6.0b (78.4)	7.0c (69.2)	5.1c (74.9)	1.0c (84.4)	1.1c (78.0)	1.0c (87.5)	1.1c (86.4)
LSD $_{0.05}$	**1.78**	**1.16**	**1.44**	**1.31**	**0.56**	**0.43**	**0.37**	**0.32**

In a column figures with same letter do not differ significantly. Values in the parenthesis indicate reduction of fungal infection (%) comparing with control.

Evaluation of chickpea mutants against root rot and botrytis gray mould

Two advanced mutants along with two check varieties of chickpea were evaluated against root rot (*Fusarium* sp.) and botrytis gray mould (*Botrytis* sp.) at Magura during the winter season of 2017-18 under inoculated condition of root rot and natural condition of botrytis gray mould. The experiments were conducted in randomized complete block design with three replications. The seeds were sown in rows on last week of November, 2017. Distances between rows and seeds were 30 cm and 5 cm, respectively.

The mean severity of root rot and botrytis gray mould ranged from 35.0-40.5% and 3-5%, respectively. The mutant CPM (BR)-200 was moderately susceptible to root rot and moderately resistant to botrytis gray mould (Table 18) and the rest were moderately susceptible to susceptible.

Table 18. Diseases incidence and severity of root rot and botrytis gray mold on some mutants of chickpea

Mutants/ varieties	Root rot		Botrytis gray mould	
	Disease incidence (%)	Disease reaction	Disease severity (1-9)	Disease reaction
CPM-200	35.0	MS	3	MR
CPM-300	40.4	S	5	MS
Binasola-8	40.5	S	5	MS
BARI Chola-7	40.2	S	5	MS
LSD $_{(P\geq0.05)}$	**3.5**	**-**	**0.7**	**-**

MR= Moderately resistant, MS= Moderately susceptible, S= Susceptible

Evaluation of some promising mungbean mutants against cercospora leaf spot

Four promising mutant along with two varieties of mungbeanwere assessed for their resistance to cercospora leaf spot (*Cercospora sp.*) at BINA sub-station, Ishurdi and Magura in kharif-1 of 2017 under natural field condition. The experiments were conducted in a randomized complete block design with three replications. The seeds were sown on 25 March and the unit plot size was 3m × 3m. The recommended doses of fertilizer were applied and normal cultural practices were followed. The incidence and severities of CLS were recorded at pod ripening stage.
The mean incidencesof cercospora leaf spot ranged from 19.3 to 25.8% and 10.0 to 13.2%, respectivelyat Ishurdi and Magura (Table 19). The meanseverity of CLS ranged from 2.0-3.3 and 2.0 to 3.0, respectively at Ishurdi and Magura. All the mutants showed moderately resistant reaction tocercospora leaf spot.

Table 19. Mean incidence and severity of cercospora leaf spot of mungbean mutants at Ishurdi and Magura in 2018

Mutants/variety	Incidence (%)		Severity (0-8)	
	Ishurdi	Magura	Ishurdi	Magura
MB-51-2	21.7	11.3	2.7	2.0
MB-87-3	22.0	10.0	3.0	2.3
MB-07(g)-2	21.7	10.7	2.0	2.0
MB-07-y-2	19.3	11.3	2.3	2.3
BARI Mung-6	25.8	13.2	3.3	3.0
Binamoog-8	24.2	12.7	3.2	2.0
$LSD_{0.05}$	**7.8**	**3.5**	**1.0**	**0.7**

Evaluation of lentil mutants against root rot and stemphylium blight

Six advanced mutants along with four check varieties of lentil were evaluated against root rot (*Fusarium* sp.) and stemphylium blight (*Stemphylium sarciniformis*) at Magura and Ishurdi during the winter season of 2017-18. The experiments were conducted in randomized complete block design with three replications. The seeds were sown in rows on 2nd week of November 2017. Distance between rows and seeds were maintained 30 cm and 5 cm, respectively.

The mean incidence of root rot and stemphylium blight ranged from 30-50% and 18.1-45.2%, respectively. All the mutants were moderately susceptible to root rot (Table 20). The mean severity of stemphylium blight ranged from 3-4. The mutants LM-21-6, LM-138-3, LM-206-5and LM- 99-4were found moderately susceptible to stemphylium blight and the rest mutants were susceptible to the disease (Table 20).

Table 20. Disease reaction of root rot and stemphylium blight on lentil mutants at Magura and Ishurdi

Mutants/ varieties	Root rot		Stemphylium blight		
	Disease incidence (%)	Disease reaction	Disease incidence (%)	Disease severity (0-5)	Disease reaction
LM-21-6	35		30.3	3	MS
LM-118-9	35		25.3	4	S
LM- 138-3	40		25.5	3	MS
LM-206-5	35	MS	25.5	3	MS
LM-185-2	40		35.4	4	S
LM-99-4	40		18.1	3	MS
Binamasur-6	30		20.9	3	MS

Binamasur-7	40	30.2	4	S
Binamasur-5	50	45.2	3	MS
BARI Masur-5	30	25.2	3	MS
LSD $_{(P \geq 0.05)}$	**5.2**	**7.3**	**0.7**	**-**

MS = Moderately Susceptible, S = Susceptible

Field evaluation of rapeseed mutants/lines against alternaria blight

Five rapeseed mutants and two advanced lines along with three check varieties, Binasarisha-9, BARI Sarisha-15 and Tori-7 were tested against alternaria blight (*Alternaria brassicae*) under natural field condition at BINA farm, Mymensingh during the winter season of 2017-18. The experiments were conducted in a randomized complete block design with three replications. The unit plot size was 3m × 2m. Seeds were sown on 21 November, 2017. The severity scale 0-5 was followed for assessing the disease at early pod maturity stage.

Table 21. Response of mutants/lines/varieties of rapeseed to alternaria blight at Mymensingh during winter season of 2017-18

Mutants/variety	Leaf area diseased (%)	Disease severity (0-5)	Disease reaction
RM -03	30.0	4	S
RM -04	33.3	4	S
RM -05	39.0	4	S
RM-07	36.3	4	S
RM-10	35.1	4	S
RL-01	37.2	4	S
RL-03	38.0	4	S
Tori-7	39.0	4	S
Binasarisha-9	19.2	3	MS
BARI Sarisha-15	17.0	3	MS

MS= Moderately susceptible, S= Susceptible

All the mutants and lines of rapeseed were susceptible to alternaria blight. The check varieties Binasarisha-9 and BARI Sarisha-15 showed moderately susceptible reaction to the disease while Tori-7 was susceptible to alternaria blight (Table 21).

Evaluation of rapeseed mutants against alternaria blight

Disease incidence of alternaria blight (*Alternaria brassicae*) of eleven rapeseed mutants along with four check varieties were evaluated under natural field condition at BINA farm, Mymensingh during the winter season of 2017-18. The experiments were conducted in a randomized complete block design with three replications in collaboration with Plant Breeding Division, BINA. The severity scale 0-5 was followed for assessing the disease at early pod maturity stage.

Table 22. Response of rapeseed mutants to alternaria blight at Mymensingh during winter season of 2017-18

Mutants/variety	Leaf area diseased (%)	Disease severity (0-5)	Disease reaction
BARI Sarisha -15 (700 Gy)	44.2	4	S
BARI Sarisha -15 (650 Gy)	22.2	3	MS
BARI Sarisha-15 (control)	29.6	4	S
BARI Sarisha -14 (550 Gy)	27.0	4	S
BARI Sarisha -14 (600 Gy)	33.8	4	S
BARI Sarisha -14 (500 Gy)	42.8	4	S
BARI Sarisha -14 (control)	44.8	4	S

Binasarisha-9 (500 Gy)	44.6	4	S
Binasarisha-9 (550 Gy)	24.6	3	MS
Binasarisha-9 (600 Gy)	25.6	3	MS
Binasarisha-9 (650 Gy)	18.7	3	MS
Binasarisha-9 (700 Gy)	24.3	3	MS
Binasarisha-9 (control)	21.8	3	MS
Tori-7 (700 Gy)	43.3	4	S
Tori-7 (control)	38.2	4	S

The response of rapeseed mutants to alternaria blight is presented in table 22. In case of BARI Sarisha-15, one mutant [BARI Sarisha-15 (650 Gy)] showed moderately susceptible reaction where its control was susceptible to alternaria blight. In BARI Sarisha-14, all mutants and the control showed susceptible reaction to the disease. In Binasarisha-9, only Binasarisha-9 (500 Gy) showed susceptible reaction while other mutants showed moderately susceptible reaction to the disease like the control one. In Tori-7, there was no difference between the mutant [Tori-7 (700 Gy)] and the control.

Evaluation of sesame mutants against stem rot

Six mutants of sesame along with two varieties were assessed against stem rot (*Macrophomina phaseolina*) at BINA sub-station, Magura in 2018 under natural field condition. The experiment was conducted in a randomized complete block design with three replications. The seeds were sown in rows 30 cm apart on 25 March. The incidence and severity of stem rot was recorded maximum at pod maturing stage following the scale (0-5).

The mean incidence of stem rot ranged from 13.3 to 26.7%, the maximum disease infection was recorded in sesame mutant, SM-006. The mean severity ranged from 2.0 to 2.7 and all the mutants were found to be moderately resistant (Table 23).

Table 23. Mean incidences and severities of stem rot in some sesame mutants at Magura in 2018

Mutants/variety	Incidence (%)	Severity (0-5)
SM-001	13.3	2.7
SM-002	25.0	2.0
SM-005	22.0	2.6
SM-006	26.7	2.3
SM-067	23.3	2.0
SM-08	21.7	2.3
Binatil-1	19.3	2.0
Binatil-3	25.0	2.0
$LSD_{0.05}$	**4.9**	**0.5**

Field evaluation of soybean mutants against collar rot and soybean mosaic

Three mutants along with three check varieties of soybean were tested against collar rot (*Sclerotium rolfsii*) and soybean mosaic (Soybean mosaic virus). The experiments were conducted in randomized complete block design with three replications at BINA farm, Mymensingh and farmer's field at Noakhali. Seeds were sown on 08 January 2018 at Noakhali and 23 January 2018 at BINA farm, Mymensingh maintaining row to row distance 75 cm and line to line distance 30 cm. The unit plot size was 3.0 m × 2.0 m. The fertilizer was applied at recommended doses. The evaluation for collar rot disease was done under inoculated condition and data of soybean mosaic were recorded from natural field condition. 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 the scale (0-9).
The incidence of collar rot ranged from 28.9-53.7% and soybean mosaic 35-75% at Noakhali (Table 24). All the mutants were showed moderately susceptible reaction to collar rot and susceptible reaction to soybean mosaic.

Table 24. Disease reaction of three mutants and varieties of soybean against collar rot and soybean mosaic at Noakhali 2018

Mutants/ varieties	Collar rot			Soybean mosaic		
	Incidence (%)	Severity (0-9)	Disease reaction	Incidence (%)	Severity (0-9)	Disease reaction
SBM-9	34.8	6	MS	48.3	7	S
SBM-15	45.5	6	MS	70	7	S
SBM-22	28.9	6	MS	35	7	S
Binasoybean-2	34.7	6	MS	55	7	S
Binasoybean-3	47.7	6	MS	58	7	S
Binasoybean-4	53.7	8	S	75	7	S

MS= moderately susceptible, S= susceptible

The incidence of collar rot ranged from 22.5-43.1% and soybean mosaic 30-56.6% at BINA farm, Mymensingh (Table 25). All the mutants were showed moderately susceptible reaction to collar rot and soybean mosaic.

Table 25. Disease reaction of three mutants and varieties of soybean against collar rot and soybean mosaic at Mymensingh in 2018

Mutants/varieties	Collar rot			Soybean mosaic		
	Incidence (%)	Severity (0-9)	Disease reaction	Incidence (%)	Severity (0-9)	Disease reaction
SBM-9	40.7	6	MS	35.0	5	MS
SBM-15	22.5	6	MS	56.6	5	MS
SBM-22	35.2	6	MS	50.0	5	MS
Binasoybean-2	43.1	6	MS	41.6	5	MS
Binasoybean-3	24.8	6	MS	48.3	5	MS
Binasoybean-4	39.2	6	MS	30.0	5	MS

MS= moderately susceptible

Evaluation of tomato mutants and lines against late blight

Three mutants and two advanced lines of tomato along with twovarieties were evaluated against late blight (*Phytophthora infestans*) disease under natural field condition. The experiment was conducted at BINA farm, Mymensingh during winter season of 2017-18. The experiment was laid out in randomized complete block design with three replications. Unit plot size was 2 m × 2 m. Line to line and plant to plant spacing was 50 cm. Seedlings of 25 days old were transplanted on 16 November 2017. Disease incidence and severity were recorded at 55 and 75 days after transplanting, respectively.

All the plants were infected with late blight disease (Table 26). The disease severity ranged from 2 to 3. The mutant TM-4 was recorded as moderately resistant and others were moderately susceptible to late blight disease.

Table 26. Mean incidence and severity of late blight of mutants/varieties Tomato at Mymensingh during 2017-18

Mutants/line/variety	Incidence (%)	Severity (0-5 scale)	Disease reaction
TM-4	100	2	MR
TM-5	100	3	MS
TM-8	100	3	MS
Trumling red	100	3	MS
Cherolla	100	3	MS
Binatomato-7	100	2	MR
Binatomato-11	100	3	MS

MR = Moderately resistant, MS = Moderatelysusceptible.

Biological control of root rot caused by *Fusarium solani* using BINA-biofungicide

An experiment was conducted using BINA-biofungicide to control root rot caused by *Fusarium solani* of lentil, chickpea and soybean at BINA sub-station farm Magura following randomized complete block design with three replications during winter season of 2017-18. Replication to replication and plot to plot distance were 1 meter. Inter cultural operation and irrigation were applied when necessary. The data were collected on root rot incidence of lentil, chickpea and soybean (Table 27).

The incidence of root rot in treated plot of lentil, chickpea and soybean were 22.3%, 17.5% and 30.2%, respectively, where the incidence of the disease in untreated plot were 30.5%, 37.4% and 50.1%, respectively. The incidence of root rot in BINA-biofungicide treated plots were lower than the untreated plots (control). Grain weight of treated plot was also higher than untreated plot.

Table 27. Effect of BINA-Biofungicide on disease incidence (%) of root rot of lentil, chickpea and soybean

Treatments	Root rot incidence (%) on lentil	Disease decreased over control (%)	Root rot incidence (%) on chickpea	Disease decreased over control (%)	Root rot incidence (%) on soybean	Disease decreased over control (%)	Grain wt. (g/m^2)	
							Soybean	Chickpea
BINA-Biofungicide	22.3	26.9	17.5	53.2	30.2	39.7	170.9	150.5
Control	30.5	-	37.4	-	50.1	-	50.7	30.3
LSD $_{(P\geq0.05)}$	**7.5**		**10.3**		**12.5**		**35.0**	**45.3**

Agricultural Engineering Division

Research Highlights

Some sesame mutants survived under natural rainfall (which caused water-logged condition) and produced seed (M_3 generation). About 123 plants were selected based on desired plant characteristics for further evaluation against water-logging.

The average recharge rate at Ishwardi location was found as 48.9 mm/year under tracer technique and 59.2 mm under water balance method (which was 4.7 % and 5.6 % of yearly rainfall, respectively).

The water samples of different STD/STW (50 nos) of Chapainawabgonj Sadar are found suitable for irrigation and drinking purposes based on studied elements; considering FAO, WHO and GoB standard.

For Mustard cultivation, irrigation at early (15-17 DAS) and vegetative (28-30 DAS) stages produced the highest yield at Nalitabari under the prevailing climatic condition.

For saline irrigation management in wheat with 11-12 dS/m saline water, irrigation at CRI+ late tillering + booting-heading stages along with excess gypsum @90% (at CRI + booting-heading stages) may be the good practice for wheat cultivation.

For irrigation management of Aman rice mutants, the mutants N_4/250/P-1(2) (8) and N_4/250/P-2(6)-26(8) produced reasonable yield (365- 396 gm/m^2) under stress condition (in Mini-lysimeter/pot culture) compared to normal irrigation condition, which indicates their tolerance capacity under drought environment.

For irrigation management in soybean at Noakha district, seed priming for 18 hrs and then drying for 8 hrs + 30% excess gypsum application(in addition to recommended dose) produced the highest seed yield under the prevailing climatic condition (having rainfall at vegetative and pod formation stage).

In drainage management of sesame, 200 cm wide beds and 25 cm drain (12-15 cm deep) between the beds produced about double seed yield compared to no drain.

DEVELOPMENT OF WATER-LOGGED TOLERANT SESAME CULTIVAR

It is a national demand to develop water-logged tolerant (different durations at different growth stages) sesame cultivar. According to the demand of Honorable Agriculture Minister and consequently by the direction of BINA authority, we collected local land-races from different regions of the country (and also BINA sesame varieties) and irradiated at different doses of Gamma Rays with a view to obtain desirable mutants.

Growing M_3 generation of sesame mutants

The aim of the program was to develop water-logged tolerant sesame cultivar. The growing season was March, 2018 – June, 2018. The growing environments were: Lysimeter (shed by polythene) and field under natural rainfall condition.

Some mutants (M_2) which appeared to be water-log tolerance but long duration (125-145 days), radiated again in different doses (350 to 700 Gray; 52 nos. samples). Including some old (M_2) and newly radiated materials, 165 populations were sown in the first week of March 2018 in lysimeter and field, and successfully produced seed (M_3 and M_1 Population) under natural rainfall. About 123 plants were selected based on desired plant characteristics for further evaluation against water-logging. Characteristics of some mutants survived under natural rainfall are given in Table 1.1.

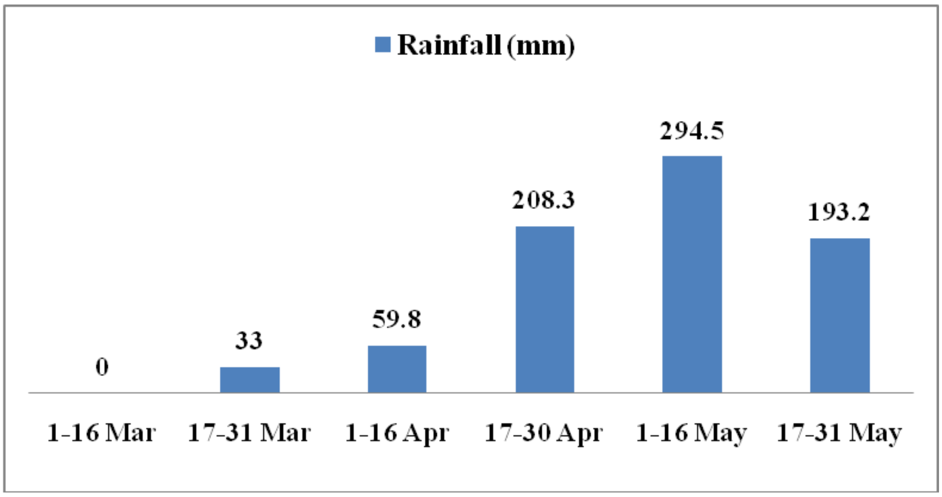


Fig 1.1: Rainfall distribution during the growing season (March-May 2018)

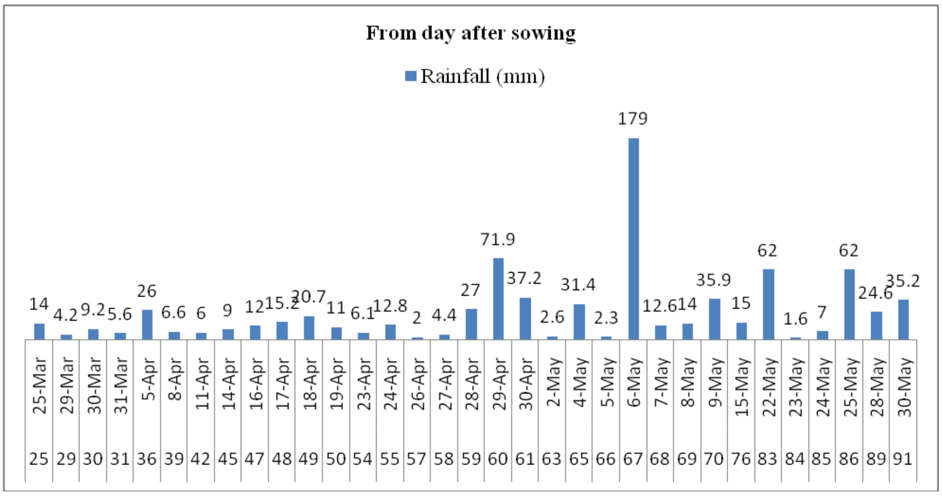


Fig 1.2: Rainfall distribution during the growing season (March-May 2018)

Table 1.1. Main features of some harvested mutants.

Mutant/Plant ID	Plant ht., cm	Branch/ plant	Siliqua/ Plant	Days to maturity
97P1	130	4-5	45	97
96P5	128	4-5	65	98
85P2	132	3-4	46	116
77 P1	123	3-4	37	98
77P2	118	3-5	51	102
72P5	130	4-5	66	117
42P1	97	4-6	61	107
41	129	4-5	54	103
67P3	125	4-5	53	101
202	109	4-6	34	102
218	122	4-6	51	92
225	118	3-4	46	95
228	128	3-5	62	93
235	130	3-4	71	94
239	105	3-5	32	92
243	115	3-4	72	98

STUDIES ON GROUNDWATER RECHARGE USING TRACER AND OTHER TECHNIQUES FOR SUSTAINABLE USE OF GROUNDWATER

Quantifying natural groundwater recharge using Tracer technique and water balance method at Ishwardi area

The objective was to estimate the yearly recharge under field condition. The recharge was estimated using tracer technique and water balance method.

Tracer method

Chloride tracer was applied as a pulse at 20cm depth within the soil profile (in the field). Infiltration of precipitation transports the tracer downward. The subsurface distribution of applied tracers was determined in October by digging a trench for sampling. The Cl concentration was determined by Mohr method, using micro-burette having 0.01 mm readable facility.

The vertical distribution of the tracer was used to estimate the velocity (v), and the recharge rate (R) was calculated as:

$$R = v\theta = \frac{\Delta z}{\Delta t}\theta \quad \text{....................(1)}$$

Where, Δz is the depth of the tracer peak, Δt is the time between tracer application and sampling, and θ is the average volumetric water content.

Water balance method

A simplified form of water balance equation (Yin et al., 2011) was used to estimate recharge:

$$P = R_0 + R + ET_a + \Delta SM \qquad \text{....................(2)}$$

where: P = rainfall (mm), R_0= surface runoff (mm), R = recharge, ET_a = actual evapo-transpiration (mm), and ΔSM= change in soil moisture (mm) for the specified time interval. Neglecting the change in soil moisture, and re-arranging, the recharge (R) can be expressed as:

$$R = P - R_0 - ET_a$$

Runoff estimation – a modified SCS method

The USDA-SCS runoff equation is (USDA-SCS 1985):

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

Where: Q= runoff (mm), P = rainfall (mm), S= potential maximum retention after runoff begins (mm). The potential retention (*S*) can range from zero on smooth, impervious surface to infinity in deep gravel.

In the present study, a modified form of USDA-SCS method is used [subtracting the 'actual evapotranspiration (ET_a)' from 'Rainfall (P)' in equation (3)]:

$$Q = \frac{[(P - ETa) - 0.2S]^2}{(P - ETa) + 0.8S} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

Based on the field condition during the monsoon rainfall (i.e. grassy/cropped), the 'S' value is considered as 3.0 cm; and monthly values of runoff (and hence monthly recharge) was calculated.
ET_a calculation.

Daily reference crop evapotranspiration (ET_0) was calculated using '*ET_0 Calculator*' software of FAO (FAO, 2012). Traditionally, actual crop evapotranspiration (ET_a) is calculated as:

$$ET_a = ET_0 \times K_c \times K_s = (ET_0 \times K_c) \times K_s = ET_p \times K_s$$

where: ET_0 is the reference crop evapotranspiration (mm), K_c is the crop coefficient, K_s is the soil moisture stress factor (or dryness factor), ET_p is the potential crop evapotranspiration.

From daily values, monthly values of ET_a were calculated. Based on the 'dryness (or water deficit)' and 'wetness (or water surplus)' condition (i.e. P - ET_p, P is the rainfal), the monthly actual crop evapotranspiration (ET_{am}) was calculated as:

$$\begin{aligned} ET_{am} &= ET_{mp}, \quad \text{If } P_m > ET_{mp} \qquad (\text{i.e. } K_s = 1) \\ &= P_m, \quad \text{If } P_m < ET_{mp} \qquad \ldots\ldots\ldots\ldots\ldots(5) \end{aligned}$$

where: P_m is the monthly rainfall, ET_{mp} is the monthly potential evapotranspiration.

The distribution of rainfall throughout the year is depicted in Fig. 2.1. The pattern of tracer concentration is depicted in Fig. 2.2.

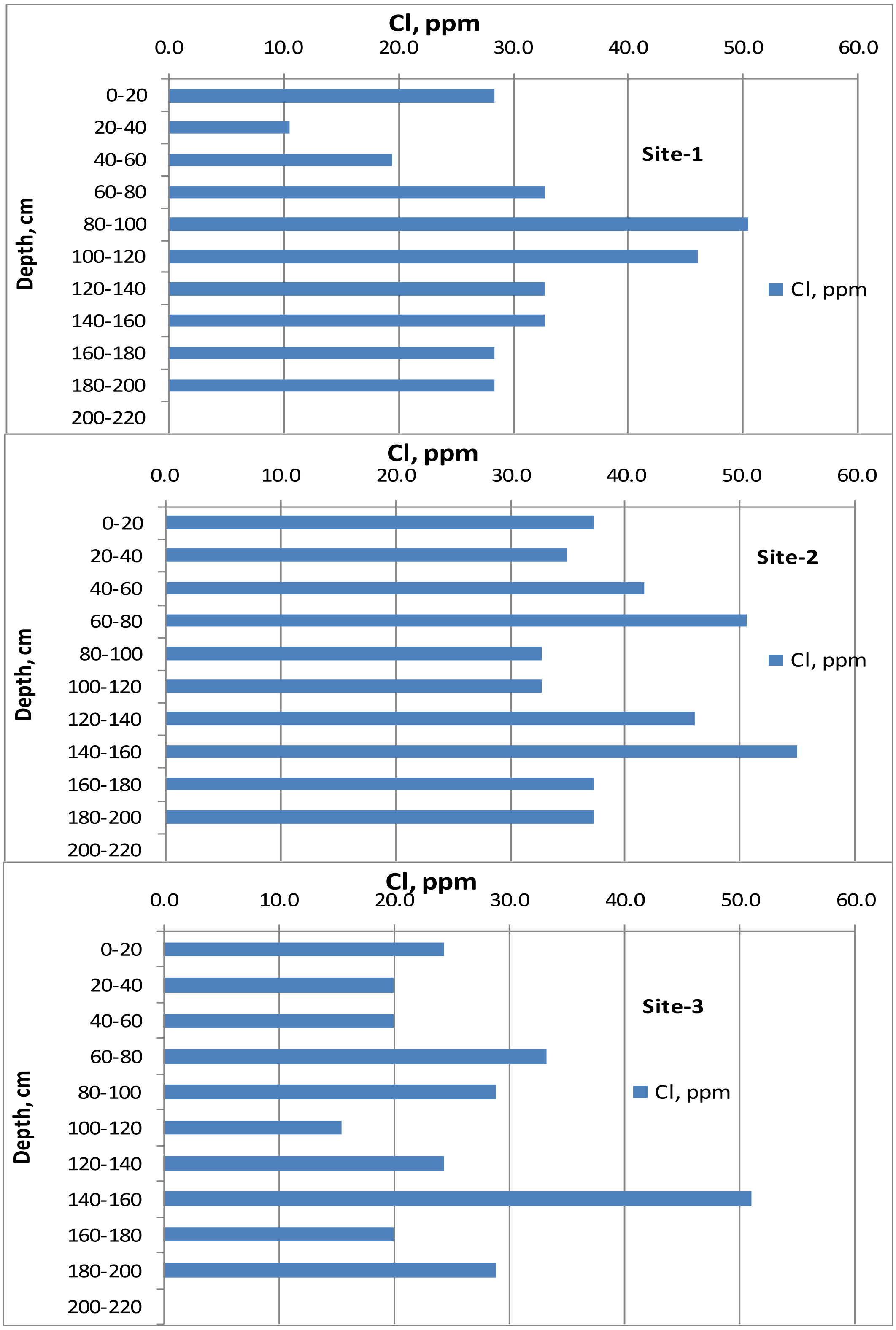


Fig.2.1. Tracer concentration profile at different sites

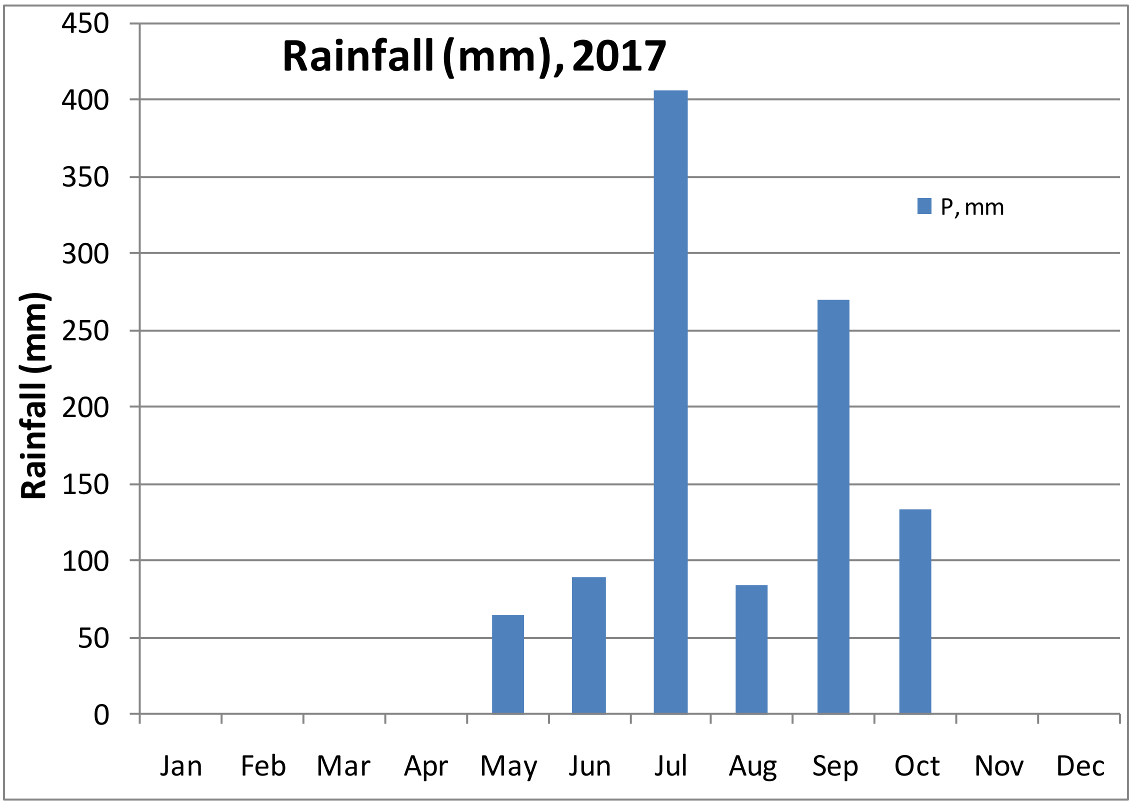


Fig.2.2. Rainfall distribution at Ishwardi throughout the year

The recharge rate found using tracer and water balance method for the year 2017 at 3 spots/sites are summarized in Table 2.1.

Table 2.1. Recharge rates under different methods and years

Sites	Rainfall, mm	Recharge rate, $mm.yr^{-1}$		Recharge rate, % of rainfall	
		Tracer	Water balance	Tracer	Water balance
1		55		3.25	
2	1050	57	59.2	5.28	5.6
3		34.2		5.43	
Average		**48.9**	**59.2**	**4.7**	

The recharge rate found using tracer technique ranged from 34.2 mm to 57 mm under the rainfall of 1050 mm, which in terms of percentage of rainfall, ranged from 3.2 to 5.43%.

The recharge rate found using water balance method was 59.2 mm, which in terms of percentage of rainfall, was 5.6%.

Investigation of groundwater quality at Chapainawabgonj Sadar Upazila

The study was conducted at Nawabgonj Sadar upazila under Chapainawabgonj district to investigate the quality of water and make suggestion for different uses.

The water samples were collected in the starting of irrigation period (Jan 30 -11 February 2018) and at peak of the irrigation period (23-30 April 2018) of Boro season. Different cations, anions, heavy metals (Zn, F) and different parameters such as: EC, pH, Sulfate, Chromium LR, Nitrite

LR, Phosphate LR, TDS, Total Cl were determined. Zn, F, Total Cl, Sulfate, Chromium LR, Nitrite LR, Phosphate LR were determined by using HI 83099 COD Multiparameter Photometer. EC, pH, TDS were determined by using Lovibond Water Testing Tintometer.

Interpretation for Irrigation:

The values of Zn, Cr, F were found below the maximum concentration value level recommended by the FAO (1985), WHO (2011), GOB (1997) & DPHE. If we consider FAO guideline based on TDS value, the water are suitable for irrigation at all locations. But the pH value is little bit higher (FAO guideline range of pH 6.5-8.4) at the starting period of irrigation at all locations. But at the end of the irrigation period the pH value is lower than the FAO recommended maximum concentration of 8.4 at all locations.

Interpretation for drinking:

The values of Zn, Cr, F were found below the maximum concentration level recommended by the FAO (1985), WHO (2011), GOB (1997) & DPHE. In the present WHO guideline (WHO 2011; fourth edition), the guideline values have not been established for the naturally occurring chemicals Br, Cl, Fe, Mn, K, Na, SO4, pH, TDS. The WHO mentioned the reason for not establishing a guideline value that, the element occur in drinking water at concentrations well below those of health concern and may affect acceptability of drinking water. The values of TDS Sulphate, Nitrate, and Phosphate were found below the maximum concentration level recommended by the DPHE. But the pH value is little bit higher in January at all locations.

Table 3.1. Water quality parameters at different locations of Chapai Nawabgonj Sadar Upazila.

Union	**pH**		**EC (µS/cm)**		**Zinc (mg/L)**		**TDS (ppm)**		**Total Chlorine (mg/L)**		**Fluoride (mg/L)**		**Sulfate (mg/L)**		**Chromium LR (ug/L)**		**Nitrite LR (mg/L)**		**Phosphate LR (mg/L)**	
	Jan'18	April'18	Jan'18	April'18	Jan'18	April'18	Jan'18	April'18	Jan'18	April'18	Jan'18	April'18	Jan'18	April'18	Jan'18	April'18	Jan'18	April'18	Jan'18	April'18
Jhilim	8.642	8.039	606.08	694.77	0.03	0.08	326.21	343.56	0.13	0.10	0.54	0.66	2.31	4.62	16.62	18.31	0.16	0.02	0.36	0.44
Baliadanga	8.802	8.124	493.00	547.60	0.03	0.06	275.52	271.22	0.09	0.10	0.63	0.48	3.00	2.00	8.00	0.00	0.03	0.03	0.17	0.29
Gobratola	8.775	7.823	631.67	655.08	0.03	0.02	325.33	325.72	0.19	0.09	0.62	0.60	17.92	17.92	10.33	0.42	0.11	0.02	0.24	0.28
Islampur	8.781	8.042	511.40	557.80	0	0	270.92	275.70	0.21	0.14	0.45	0.56	7.00	5.50	12.10	5.10	0.09	0.02	0.39	0.43
Sundarpur	8.601	7.899	642.70	774.40	0.01	0.01	370.49	382.39	0.18	0.13	0.24	0.48	3.00	2.00	13.10	0.00	0.13	0.02	0.16	0.25
No restriction for irrigation (FAO 1985)	6.5-8.4		<0.7 dS/m		<2 ppm		<450 ppm													
Permi. Limit for Irrigation (GOB 1997)	6-8.5		1.2 dS/m		10 ppm		450 ppm													
Permi. Limit for drinking (WHO 2011)	NEG		NEG		NEG		NEG				1.5 mg/l		NEG		.05 mg/l		50		6	
Permi. Limit for drinking (GOB 1997) & DPHE	6.5-8.5		0.6-1 dS/m		5		1000				1 mg/l		400		.05 mg/l		10		NEG	

NEG = Not established guideline value.

In conclusion, it can be said that, the water samples are suitable for irrigation and drinking purposes based on studied elements, considering FAO, WHO and GoB standards.

IRRIGATION MANAGEMENT FOR FIELD CROPS

Irrigation management for Mustard at Nalitabari for higher yield and water productivity

The objective was to determine optimum irrigation requirement for higher yield of Mustard. The experiment was carried out at BINA Sub-station at Nalitabari during the period from 20 November 2017 to February 2018. The test varieties were V_1 = Binasarisha-9 and V_2 = Binasarisha-10. The experimental design was RCBD with 3 replications. The imposed irrigation treatments were:

T_1 = Control (Farmers practice /no irrigation)
T_2 = Irrigation at early stage (15-17 days after sowing (DAS))
T_3 = Irrigation at vegetative stage (28–30 DAS)
T_4 = Irrigation at flowering stage (45–55 DAS)
T_5 = Irrigation at early (15-17 DAS) and vegetative stage (28-30 DAS)
T_6 = Irrigation at early (15-17 DAS), vegetative (28-30 DAS) and flowering stage (45-55 DAS)

The statistical analysis was performed using statistical software of IRRI, "STAR".

There was a rainfall of about 45 mm just after 4 days of sowing.

The mean effects of irrigation treatments and cultivars on yield and yield attributing characters of Mustard cultivars are summarized in Table 4.1. The cultivars showed significant difference except plant height. The irrigation treatments showed insignificant difference except seed per pod. Treatment T_5 (Irrigation at early (15-17 DAS) and vegetative stage (28-30 DAS)) produced highest yield (1.46 t ha^{-1}) among the treatments. Interaction effects of irrigation treatments and cultivars on grain yield of Mustard are shown in Table 4.2. In interaction effect, treatment T_5 produced the highest grain yield in both the cultivars. Irrigation frequency, total irrigation and yield in t ha^{-1} under different treatments are shown in Table 4.3.

Table 4.1. Mean effects of irrigation treatments and cultivars on yield and yield attributing characters of Mustard cultivars *

Treatment	Plant height (cm)	No. of pod/ plant	Pod length (cm)	Seed/ Pod	Grain yield (t ha^{-1})	1000 grain wt. (gm)
T_1	100.13	112.43	7.21	20.73 ab	1.30	3.47
T_2	97.50	104.38	7.35	18.33 a	1.29	3.51
T_3	95.18	94.83	6.96	19.70 ab	1.24	3.40
T_4	102.63	106.68	7.75	21.97 a	1.19	3.40
T_5	**100.47**	**119.95**	**8.30**	**18.87 ab**	**1.46**	**3.53**
T_6	103.67	108.37	7.67	21.14 ab	1.22	3.43
F-test at (5%)	**NS**	**NS**	**NS**		**NS**	**NS**
Cultivars						
V_1	101.44	89.82 b	8.68 a	24.89 a	1.37 a	3.84 a
V_2	98.42	125.73 a	6.41 b	15.36 b	1.22 b	3.08 b
F-test at (5%)	**NS**					

* Means with the same letter are not significantly (statistically) different at 5% probability level by Tukeys's Honest Significant Difference (THSD) test.

Table 4.2. Interaction effects of irrigation treatments and cultivars on grain yield of Mustard

Treatment	Grain yield of different cultivars (t ha^{-1})	
	V1	V2
T_1	1.37	1.27
T_2	1.41	1.16
T_3	1.30	1.19
T_4	1.32	1.07
T_5	**1.57**	**1.35**
T_6	1.13	1.31
F-test at (5%)	**NS**	**NS**

Table 4.3. Irrigation frequency, irrigation date (DAS), total irrigation and yield under different treatments

Irrigation Treatment	No. of irrigation applied (nos.)	Irrigation date (days after sowing, DAS)	Total irrigation amount (cm)	Yield, t ha^{-1}
T_1	-	-	-	1.30
T_2	1	20	4	1.29
T_3	1	22	4	1.24
T_4	1	55	4.5	1.19
T_5	2	20, 40	7.25	1.46
T_6	3	20, 40, 55	10.35	1.22

For Mustard cultivation, irrigation at early and vegetative stages produced the highest seed yield under the prevailing climate.

Evaluation of some Aman mutants (M4) for different 'soil moisture stress'/'drought tolerance level' (in Pot culture)

The objective was to study the response of rice mutants to different level of soil moisture stress. The experiment was conducted in container (Container size: 1.5 m x 1 m x 0.28 m) at BINA HQ, Mymensingh. The scheduled treatments were: T_1 = Control (normal irrigation, 3 days AWD); T_2= Supplemental irrigation when ASM drops below 85% (throughout the growing season); T_3= Up to booting stage, irrigation at SM= 0.85 ASM; for the remaining period, irrigation at SM= 0.60 PASM; T_4 = Irrigation at 0.85 ASM (throughout the growing season), treatment beginning at 17 days after transplanting. Treatments were imposed after establishment (3 weeks from transplanting) except T_4.

The cultivars were: V_1 = N_4/250/P-1(2) (8) and V_2 = N_4/250/P-2(6)-26(8). Two series of containers (2 replicates) were used. The design was RCBD, with split-plot. The seedlings (25 days old) were transplanted on 17 August 2017, and harvested on 24 October 2017. The statistical analysis was performed using statistical software of IRRI, "STAR".

The mean effects of irrigation treatments and cultivars on yield and yield attributing characters of rice cultivars are summarized in Table 5.1. The cultivars showed insignificant difference, except tiller/plant. The irrigation treatments showed significant difference in grain yield and tiller/plant. Interaction effects of irrigation treatments and cultivars on grain yield of rice are shown in Table. 5.2. Irrigation frequency, total irrigation, water savings and water footprint under different treatments are shown in Table 5.3. The cultivars V_1 and V_2 produced reasonable yield under stress condition (T_4) compared to normal irrigation condition (T_1) (Table. 5.2), indicating their tolerance capacity under drought. The cultivar can survive until the field moisture drops around wilting point. Under stress condition (T_4), to produce 1 kg of rice, 655.55 Litter water is required, while normal irrigation (T_1) required 996.91 Litter. The experiment will be repeated in the next year to confirm the results.

Table 5.1. Mean effects of irrigation treatments and cultivars on yield and yield attributing characters of rice cultivars

Treatments	Plant height (cm)	Tiller/ plant	Panicle length (cm)	seed/ panicle (Filled grain) (Nos.)	Unfilled grain (Nos.)	Grain yield ($gm.m^2$)	1000 grain wt. (gm)	Straw yield, $gm.m^2$
T_1	110.45	9.60 b	24.45	104.35	28.35	405.92 a	19.55	486.73
T_2	99.38	9.28 bc	24.08	105.33	22.94	302.95 b	19.25	427.23
T_3	97.20	7.70 c	24.00	93.7	28.00	328.19 b	18.90	409.37
T_4	91.80	11.40 a	24.53	114.13	19.45	380.85 a	18.55	454.77
F-test at (5%)	**NS**		**NS**	**NS**	**NS**		**NS**	**NS**
Cultivars								
V_1	99.58	9.88 a	24.36	102.90	26.03	362.41	19.13	464.48
V_2	99.84	9.11 b	24.16	105.85	23.34	346.55	19.00	424.56
F-test at (5%)	**NS**		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Means with the same letter are not significantly (statistically) different at 5% probability level by Tukeys's Honest Significant Difference (THSD) test.

Table 5.2. Interaction effects of irrigation treatments and cultivars on grain yield of rice

Treatments	Grain yield of different cultivars (gm. m^2)	
	V1	**V2**
T_1	412.47	399.38
T_2	294.14	311.78
T_3	347.03	309.34
T_4	396.00	365.71
F-test at (5%)	**NS**	**NS**

Table 5.3. Irrigation frequency, total irrigation, water savings and water footprint under different treatments

Irri. Treat -ment	Irri. up to establish-ment, (cm)	No. of irri. After treatment started (nos.)	Total irrigation amount (cm)	water savings (%, compared to T1)	Irri. date (days after transplanting, DAT)	Yield, t/ha	WF, Litter/kg
T_1	18	05	40.47	-	25, 32, 39, 46, 54	4.06	996.91
T_2	18	02	25.47	37.06	43, 56	3.03	840.62
T_3	18	03	26.40	34.75	40, 49, 57	3.28	804.41
T_4	17.5	02	24.97	38.29	42, 55	3.81	655.55

The cultivars V_1 and V_2 [V_1 = N_4/250/P-1(2) (8) and V_2 = N_4/250/P-2(6)-26(8)] produced reasonable yield under stress condition compared to normal irrigation condition, which indicates their tolerance capacity under drought.

Irrigation management for some Aman rice mutants (M4) under field condition

The Objectives were to study the response of rice mutants to drought condition, and to develop appropriate irrigation management strategy for the mutants.

The experiment was carried out under field condition, BINA HQ, Mymensingh. The seedlings (26 days old) were transplanted on 25 August 2017, and harvested on 29 October 2017. The cultivars were V_1 = N_{10}/300/P-2(1)-4-1(7), V_2 = N_{10}/300/P-2(1)-4-1(5), V_3 = N_{10}/300/P-2(1)-4-1(1) and V_4 = N_{10}/300/P-2(1)-4-1(8). The experimental design was RCBD, with 3 replications. The imposed irrigation treatments were:

T_1 = Control [normal levee (Farmer's practice), and rainfed]
T_2 = 20 cm height levee around the plot, and rainfed
T_3 = 20 cm height levee around the plot, and supplemental irrigation during booting to soft-dough, if PASM drops below 85%

The mean effects of irrigation treatments and cultivars on yield and yield attributing characters of rice cultivars are summarized in Table 6.1. The cultivars showed significant difference in grain yield, seed/panicle and plant height. The irrigation treatments showed insignificant difference in grain yield and all yield attributing characters because of field condition. It was difficult to maintain treatment (T_3) properly due to excess rainfall (Fig. 6.1). The highest yield (4.45 t/ha) was recorded in treatment T_2.

Table 6.1. Mean effects of irrigation treatments and cultivars on yield and yield attributing characters of rice cultivars

Treatment	Plant height (cm)	Tiller/ plant	Panicle length (cm)	seed/ panicle (Filled grain)(Nos.)	Unfilled grain (Nos.)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1	119.55	6	25.87	118	73	4.39	5.37
T_2	119.68	6	26.57	119	71	4.45	5.42
T_3	120.05	6	26.40	117	69	4.41	5.05
F-test (5%)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Cultivars							
V_1	126.32a	6	25.12a	104 b	72	4.52 a	5.84
V_2	128.24a	6	26.46a	111ab	73	4.37 a	4.78
V_3	117.22c	6	23.46b	1205a	67	3.96 b	5.26
V_4	118.47b	6	25.76a	1233a	64	3.99 b	5.39
F-test (5%)		**NS**			**NS**		**NS**

Means with the same letter are not significantly (statistically) different at 5% probability level by Tukeys's Honest Significant Difference (THSD) test.

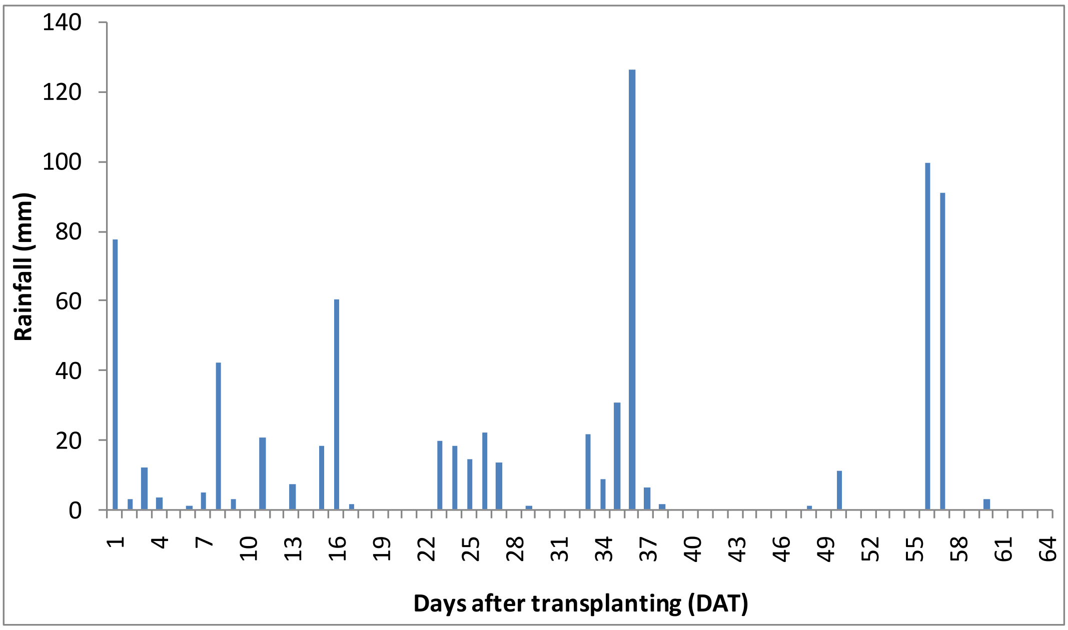


Fig. 6.1: Rainfall distribution over the experiment from day after transplanting

The cultivars showed significant difference in grain yield, seed/panicle and plant height. The irrigation treatments showed insignificant difference in grain yield and all yield attributing characters because of field condition. The experiment will be repeated in the next year to confirm the results.

Evaluation of some Aman rice mutants (M4) for different 'soil moisture stress' /'drought tolerance level' (in Lysimeter)

The objective was to study the response of rice mutants to different level of soil moisture stress. The experiment was conducted in Raised Bed Lysimeter (1.2 m x 1 m x 0.62 m) at BINA HQ, Mymensingh. The scheduled treatments were: T_1 = Control (normal irrigation, 3 days AWD); T_2= Supplemental irrigation when ASM drops below 85% (throughout the growing season); T_3= Up to booting stage, irrigation at SM= 0.85 ASM; for the remaining period, irrigation at SM= 0.60 PASM; T_4 = Irrigation at 0.85 ASM (throughout the growing season), treatment beginning at 25 days after transplanting. Treatment was imposed after establishment (2 weeks from transplanting). The cultivars were: V1 = N_{10}/300/P-2(1)-4-1(7), V2 = N_{10}/300/P-2(1)-4-1(5), V3 = N_{10}/300/P-2(1)-4-1(1) and V4 = N_{10}/300/P-2(1)-4-1(8). Two series of containers (2 replicates) were used. The design was RCBD, with split-plot. The treatments were in the main plot cultivars in the sub plot. The seedlings (26 days old) were transplanted on 26 August 2017 and harvested on 28 November 2017. The statistical analysis was performed using statistical software of IRRI, “STAR”.

The mean effects of irrigation treatments and cultivars on yield and yield attributing characters of rice cultivars are summarized in Table 7.1. The cultivars showed significant difference except tiller/plant, unfilled grain and straw yield. The irrigation treatments showed insignificant difference in grain yield and all yield attributing characters. Interaction effects of irrigation treatments and cultivars on grain yield of rice (insignificant for all cases) are shown in Table. 7.2. Irrigation frequency, total irrigation, water savings and water footprint under different treatments are shown in Table 1.3. The cultivars produced reasonable yield under stress conditions compared to normal irrigation condition (T_1) (Table. 7.2), indicating their tolerance capacity under drought. The cultivar can survive until the field moisture drops around wilting point. Under stress condition (T_4), to produce 1 kg of rice, 732.5 litre water is required, while normal irrigation (T_1) required 1100.9 litres.

Table. 7.1. Mean effects of irrigation treatments and cultivars on yield and yield attributing characters of rice cultivars

Treatment	Plant height (cm)	Tiller/ plant	Panicle length (cm)	seed/ panicle (Filled grain)(Nos.)	Unfill grain (Nos.)	Grain yield (gm.m^2)	Straw yield (gm.m^2)
T_1	119.72	6.25	25.44	113.22	71.7	436.86	564.58
T_2	121.65	6.52	26.57	118.95	72.1	409.79	539.6
T_3	126.6	6.12	26.40	118.37	57.62	422.80	516.65
T_4	120.25	6.32	25.54	106.95	59.59	416.41	541.66
F-test (5%)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Cultivars							
V_1	127.22a	6.25	26.18a	102.2 b	71.7	452.3a	564.58
V_2	129.55a	6.52	26.77a	110.7ab	72.1	437.17a	431.68
V_3	112.00c	6.13	24.87b	119.55a	57.62	396.55b	516.65
V_4	119.45b	6.32	26.14a	125.03a	59.59	399.86b	541.66
F-test (5%)		**NS**			**NS**		**NS**

Means with the same letter are not significantly (statistically) different at 5% probability level by Tukeys's Honest Significant Difference (THSD) test.

Table 7.2. Interaction effects of irrigation treatments and cultivars on grain yield of rice

Treatment	Grain yield of different cultivars (gm.m^2)			
	V1	**V2**	**V3**	**V4**
T_1	512.04	454.41	394.06	386.95
T_2	460.03	416.49	384.95	377.7
T_3	410.17	474.39	387.01	429.67
T_4	426.98	403.38	420.2	415.11
F-test at (5%)	**NS**	**NS**	**NS**	**NS**

Table 7.3. Irrigation frequency, total irrigation, water savings and water footprint under different treatments

Irri. Treat -ment	Irri. up to establish-ment, (cm)	No. of irri. After treatment started (nos.)	Total irrigation amount (cm)	water savings (%, compared to T_1)	Irri. date (days after transplanting, DAT)	Yield (t ha^{-1})	Water Frootprint (Lit. kg^{-1})
T_1	18	06	48	-	27, 41, 48, 54, 68,75	4.36	1100.9
T_2	18	02	31	35.4	55, 75	4.09	756.5
T_3	18	02	35.3	26.4	53, 72	4.23	835.7
T_4	17.5	02	30.5	36.5	55,72	4.16	732.5

From the result of the present study, it can be concluded that the cultivars can produce reasonable yield under stress condition compared to normal irrigation condition, which indicates their tolerance capacity under drought environment. The experiment will be repeated in the next year to confirm the results.

Irrigation management in Onion cultivation for higher seed yield and water productivity

The objective was to determine optimum irrigation requirement of Onion for higher yield and water productivity. The experiment was carried out in BINA Sub-station at Ishurdi during the period from 20 December 2017 to 18 May 2018. The test cultivars were L_1 = BP_2/75/2 and L_2 = BP_2/100/2. The experimental design was RCBD, with 3 replications. The imposed irrigation treatments were:

T_1 = Control (Farmers practice)
T_2 = Irrigation at early (15-17 DAS) and vegetative stage (28-30 DAS)
T_3 = Irrigation at early (15-17 DAS), vegetative (28-30 DAS) and bulb formation stage (45-55 DAS)
T_4 = Irrigation at 15 days interval
T_5 = Irrigation at 20 days interval
T_6 = Irrigation at 25 days interval

Experiment was executed according to treatments, but due to rainstorm most of the Umbel broken. Existing umbels were collected from each replication. Average seed yield under different treatments are showed in **Table 8.1.** For line L_1, the treatment T_3 produced the highest seed yield, which is statistically similar to T_4 and T_6. The effects of treatments on seed yield of line L_2 are insignificant.

Interaction effect of treatments and lines on umbel number and corresponding yield, and yield/umbel are insignificant (**Table 8.2**).

The number of irrigation applied, amount and day after sowing are showed in **Table 8.3**. The highest amount of irrigation water was required in T_4 and the lowest in T_1.

Table 8.2. Average seed yield under different treatments

Treatment	**Seed yield (kg.ha^{-1})**	
	L_1	**L_2**
T_1	143.94 b	171.81 a
T_2	217.27 b	120.11 a
T_3	555.56 a	318.98 a
T_4	332.77 ab	273.18 a
T_5	198.15 b	319.44 a
T_6	357.72 ab	259.26 a

Note: Means with the same letter are not statistically different by Tukey's Honest Significant Difference (HSD) test at 5% level.

Table 8.2. Interaction effect of treatment and line on umbel number and corresponding yield, yield/umbel and seed yield

Treatment	**Line**	**Umbel no.**	**Yield (gm)**	**Yield/Umbel (gm)**
T_1	L_1	44	19	0.43
	L_2	31	16	0.52
T_2	L_1	23	15	0.65
	L_2	25	9	0.36
T_3	L_1	9	15	1.67

	L_2	23	22	0.96
T_4	L_1	32	32	1.00
	L_2	22	18	0.82
T_5	L_1	27	16	0.59
	L_2	24	23	0.96
T_6	L_1	27	29	1.07
	L_2	27	21	0.78

Table 8.3. The number of irrigation, irrigation amount and irrigation applied DAS.

Treatment	No. irrigation	Irrigation amount (cm)	Irrigation applied day after sowing (DAS)
T_1	2	7.2	28, 47
T_2	2	7.2	16, 30
T_3	3	10.6	16, 30, 50
T_4	6	20.4	16, 30, 44, 60, 75, 90
T_5	5	17	21, 40, 61, 80, 100
T_6	3	11.2	25, 50, 75

The experiment should be repeated for the next year to confirm the result.

DRAINAGE MANAGEMENT

Response of sesame cultivars to different drainage provisions

The objective was to study the effect of different drainage spacings on sesame yield. The experiment was carried out at Lysimer field, BINA HQ, Mymensingh during the period of March 2018 to June 2018. The test varieties were V_1 = Binatil-2, V_2 = Binatil-3, V_3 = Binatil-4. Experimental design was RCBD, with 3 replications. The imposed drainage treatments were:

T_1 = Control (normal flat land, no special drain)
T_2 = 100 cm wide beds and 20 cm drain (15 cm depth) between the beds
T_3 = 150 cm wide beds and 20 cm drain (15 cm depth) between the beds
T_4 = 200 cm wide beds and 25 cm drain (15 cm depth) between the beds

The statistical analysis was performed using statistical software of IRRI, "STAR".
The mean effects of drainage treatments and cultivars on yield of sesame are summarized in Table 9.1. The cultivars showed significant difference in grain yield. Maximum yield (820 kg/ha) was obtained from V_1 (Binatil-2) and it is more capable to produce yield under drainage provision than that of V_2 (Binatil-3) and V_3 (Binatil-4). The treatments demonstrated significant effect on grain yield. Maximum yield was obtained in T_4 (901.26 kg/ha) where 200 cm wide beds and 25 cm drain between the beds was provided; whereas in T_1 (normal flat land, no special drain) 450 kg/ha was obtained. The rainfall in experiment period (March to May 2018) is shown in Fig. 9.1 and Fig.9.2. During the period of experiment, total 789 mm (268 mm in April and 488 mm in May 2018) rainfall was occurred specially in vegetative and flowering stages of sesame. Sesame is very water sensitive crop and is unable to survive in water logged condition. Without any water log effect, normal yield of Binatil-2, Binatil-3 and Binatil-4 are ranged from 1000 to 1400 Kg/ha. In this experiment, yield ranged from 450 to 901 kg/ha under excess rainfall and four drainage treatments. Interaction effects of drainage treatments and cultivars on grain yield of sesame are shown in Table. 9.2.

Table 9.1. Mean effects of drainage treatments and cultivars on yield of sesame cultivars

Treatment	Grain yield (kg/ha)
T_1	450 b
T_2	784 a
T_3	841 a
T_4	901 a
F-test at (5%)	
Cultivars	
V_1	820 a
V_2	761 ab
V_3	651 a
F-test at (5%)	

Means with the same letter are not significantly (statistically) different at 5% probability level by Tukeys's Honest Significant Difference (THSD) test.

Table 9.2. Interaction effects of drainage treatments and cultivars on grain yield of sesame.

Treatment	Grain yield of different cultivars ($Kg.ha^{-1}$)		
	V_1	V_2	V_3
T_1	452	453	447
T_2	841	865	646
T_3	877	848	798
T_4	1109	878	717
F-test at (5%)	**NS**	**NS**	**NS**

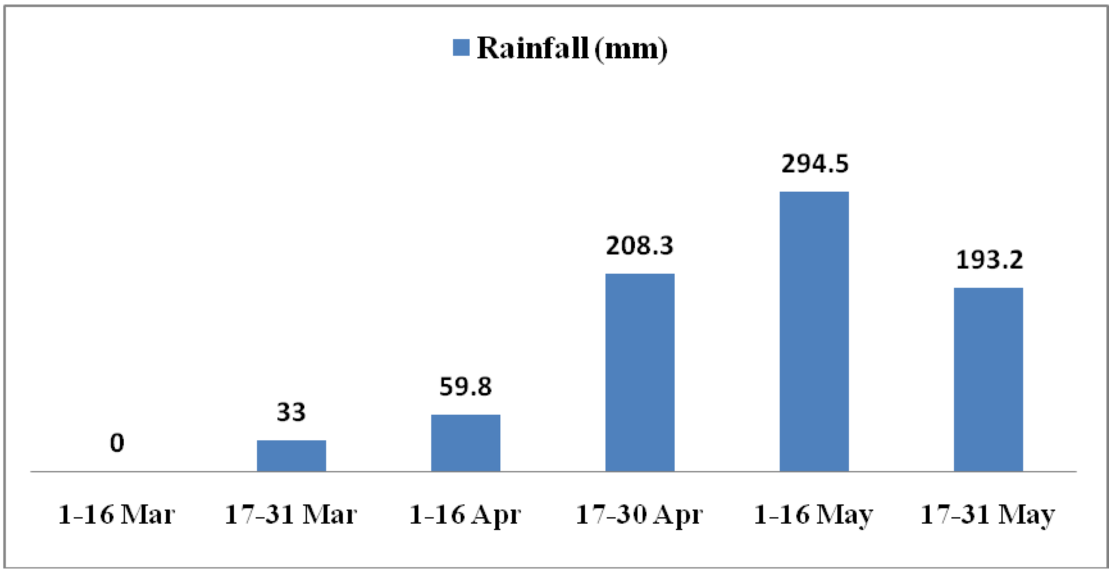


Fig.9.1: Rainfall distribution during experiment period (March-2018 to May-2018)

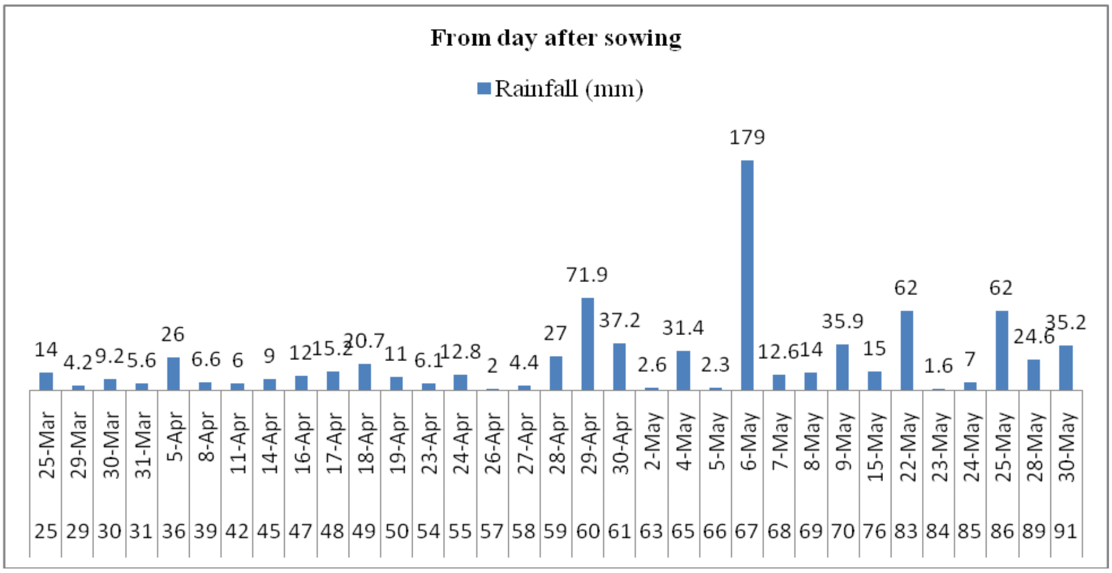


Fig. 9.2: Rainfall distribution during experiment period (March-2018 to May-2018)

The seed yield of treatment T_1 (normal flat land, no special drain) is 450 kg/ha which is about half of the yield of T_4 (901 kg/ha) (in which 200 cm wide beds and 25 cm drain between the beds) with natural rainfall. So drainage provision is congenial to obtain yield and survive against rainfall. To confirm the result, the experiment will be repeated in the next year.

SALINITY MANAGEMENT

Irrigation management and chemical amendment for soybean cultivars under saline condition

Objectives:

Methods

The experiment was conducted in the farmer's field at Noakhali, To identify critical stage of soybean with respect to salinity, and to develop appropriate irrigation management practice for higher yield of soybean.

The scheduled treatments were: T_1 = Control (farmer's practice/ no irrigation, no seed priming) ; T_2 = One irrigation at early/*vegetative stage* (20-22 DAS) ; T_3= One irrigation at *flowering stage* (45 DAS) ; T_4 = One irrigation *at early stage* + one irrigation at *flowering stage* ; T_5 = One irrigation *early stage* + one irrigation at *pod formation stage* (65 DAS); T_6 = No irrigation, w*ith seed priming (18 hrs soaking in water*, *and then drying for 8 hrs)* + 30% excess Gypsum; T_7 = No irrigation + Foliar application of *Salicylic Acid* (100 ppm, 20 DAS) + Sodium Silicate (100 ppm, at 45 DAS ; T_8 = 25% excess Gypsum and K + One irrigation at *early stage* + Foliar application of Sodium Silicate (100 ppm, at 45 DAS); T_9 = Foliar application of *Salicylic Acid* at 20 DAS + One irrigation at *flowering stage* + Sodium Silicate at 60 DAS (100 ppm)

The varieties were, V_1 = Binasoybean-3; V_2 = Binasoybean-5; V_3= BARI Soybean 6 (as Check). Three replicates were used. The plot size was 6 m × 3 m and total area were 814 m^2 (37 m × 22 m) The design was RCBD, with split-plot. The seeds were sown on 1st February 2018, and harvested on 7th May 2018. The statistical analysis was performed using statistical software of IRRI, "STAR".

There was rainfall at vegetative, pod formation and ripening stages of the crop (57, 86 and 98 days after sowing), 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 10.1. The cultivars showed significant difference except plant height. The treatments showed insignificant difference in grain yield and all the yield attributing characters. The interaction effect of treatment and variety was insignificant. Salinity of soil during the soybean production period is shown in Table 10.2. The cultivars produced reasonable yield under the prevailing condition. The experiment will be repeated in the next year to confirm the results.

Table 10.1. Mean effects of irrigation treatments and cultivars on yield and yield attributing characters of soybean cultivars

Treatment	Plant height (cm)	Branch/ plant	Pod/ plant	Grain yield (gm/m^2)
T_1	32.20	2.80	60.90	327.50
T_2	33.54	2.83	56.17	326.00
T_3	33.99	3.13	74.83	311.00
T_4	32.63	3.16	64.36	315.66
T_5	33.56	3.07	63.10	310.16
T_6	36.40	3.13	63.76	329.16
T_7	32.76	3.20	61.53	323.33
T_8	34.66	3.07	62.90	325.33
T_9	35.60	3.26	64.00	312.67
T_1	32.20	2.80	60.90	327.50
F-test at (5%)	**NS**	**NS**	**NS**	**NS**
Cultivars				
V_1	33.63	2.96 b	64.59 a	297.72 b
V_2	32.63	2.78 b	57.52 b	324.89 a
V_3	35.53	3.48 a	68.41 a	337.67 a
F-test (5%)	**NS**	**-**	**-**	**-**

Means with the same letter are not significantly (statistically) different at 5% probability level by Tukeys's Honest Significant Difference (THSD) test.

Table 10.2. Salinity of soil during the soybean production period

Treatments	Soil Ec(µS/cm)			
	Early Stage	Flowering Stage	Pod Formation stage	Harvest
T1	1856		1790	1188
T2	3646	4717	941	
T3	3469	875		
T4	2508	702		889
T5	2049	897	5058	
T6	2788	1204		887
T7	2370	690	3065	
T8	2772			
T9	2178			

Under the prevailing climatic condition (having rainfall at vegetative, pod formation and ripening stages), seed priming for 18 hrs and then drying for 8 hrs + 30% excess gypsum application (in addition to recommended dose) produced the highest seed yield.

Effects of different irrigation approaches on wheat production under different salinity level at farmer's field in Bangladesh (*FAO-IAEA/CRP/BGD-17732***)**

The experiment was carried out in the farmer's field at Vatkhali, Shamnogor, Satkhira, during the period from December 2017 to April 2018. The objective was to identify appropriate irrigation management practice for wheat under saline condition. The test varieties were Binagom-1 and BARIghom-25. The experimental design was RCBD, with 4 replications. The imposed irrigation treatments were:

T_1 = Irrigation at CRI+ late tillering + booting-heading with existing saline water (with recommended fertilizer dose*)

T_2 = Irrigation at CRI+ late tillering + booting-heading with existing saline water, with excess gypsum @90% (CRI + booting-heading)

T_3 = Irrigation at CRI+ late tillering + booting-heading with 11-12 dS/m saline water, with excess gypsum @90% (CRI + booting-heading)

T_4 = Irrigation at CRI+ late tillering + booting-heading with 11-12 dS/m saline water, with excess gypsum @50% (CRI + booting-heading) and + excess K @50% (CRI + booting-heading)

*Recommended dose: Urea-TSP-MoP-Gypsum-ZnSo4-Boric acid, as: 220-150-140-85-6-6 kg/ha

Where, CRI = Crown Root Initiation

The seeds were sown on 4 December, 2017, and harvested on first week of April, 2018. All cultural practices (e.g. weeding, thinning, insecticide spray) were done when needed. Soil moisture and salinity data were monitored at 10 days interval. The irrigation treatments were imposed according to schedule. Yield and yield parameters were recorded at harvest time. The statistical analyses were performed using "STAR" statistical software of IRRI.

There was 16mm, 36mm and 10mm rainfall after 8, 9 and 10 days of sowing (DAS). The pattern of soil salinity throughout the growing season under different treatments is depicted in Fig.11.1.
The mean effects of irrigation treatments on yield parameters and grain yield are presented in Table 11.1.The treatments showed insignificant difference in yield parameters, except plant height. Treatment T_3 (Irrigation at CRI+ late tillering + booting-heading with 11-12 dS/m saline water, with excess gypsum @90% (CRI + booting-heading)) produced the highest grain yield (2.77 t/ha). The cultivars showed insignificant difference in yield parameters, except seed/spike and grain yield.

The crop water use and water productivity under different treatments are summarized in Table 11.2. The water productivity showed the highest value in T_3 treatment followed by T_1.
In saline area, Irrigation at CRI+ late tillering + booting-heading with 11-12 dS/m saline water, along with excess gypsum @90% (CRI + booting-heading) may be the good practice for wheat cultivation.

Table 11.1. Mean effects of treatments on yield parameters and grain yield of wheat at Satkhira

Treatments	plant height (cm)	tiller/plant (nos.)	spike length (cm)	seed/spike (nos.)	1000 grain wt. (gm)	Grain yield (t ha^{-1})	straw yield (t ha^{-1})
T_1	83.91 b	5.73	15.10	42.88	41.13	2.33	2.45
T_2	85.48 ab	5.70	14.94	44.73	41.06	2.42	2.49
T_3	***88.13 a***	***6.20***	***15.25***	***44.75***	***40.06***	***2.77***	***2.37***
T_4	88.63 a	6.16	15.44	45.00	43.25	2.72	2.36
THSD (5%)		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Cultivars'							
V_1	86.43	6.06	15.08	45.44 a	34.72	2.44 b	2.42
V_2	86.64	5.84	15.28	43.24 b	48.03	2.68 a	2.42
THSD (5%)	**NS**	**NS**	**NS**	**-**	**NS**	**-**	**NS**

Note: THSD = Tukeys's Honest Significant Difference Test

Means with the same letter are not statistically different at 5% probability level.

Table 11. 2. Water use and water productivity of wheat under different treatments

Treatments	Irrigation amount (cm)	Effective rainfall (cm)	Change in soil moisture (cm)	Water Requirement (cm)	Yield (t ha^{-1})	Water productivity (Kg.ha^{-1}cm^{-1})
T_1	13	8.4	2.12	23.52	2.33	99.06
T_2	13	8.4	1.86	23.26	2.42	104.04
T_3	13	8.4	1.91	23.31	2.77	118.83
T_4	13	8.4	1.88	23.28	2.72	116.84

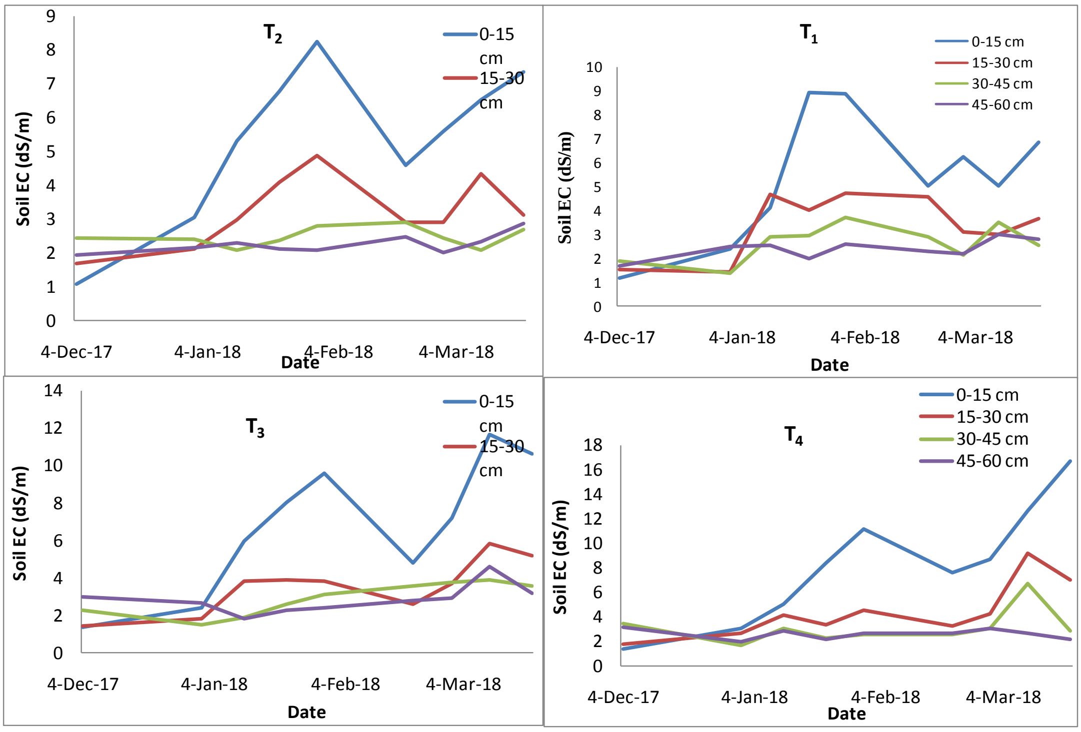


Fig.11.1. EC of soil during growing period (T_1, T_2, T_3, and T_4)

Effects of Irrigation Management and amendments in Boro rice under Saline condition (Lysimeter study)

The experiment was carried out in BINA Sub-station at Satkhira (Lysimeter) during the period from 7 January 2018 to 19 May 2018. To objective was to identify appropriate irrigation and other management practices for higher yield in saline area. The test varieties were V_1=Binadhan-8 and V_2=Binadhan-10. The experimental design was RCBD, with 3 replications. The imposed irrigation treatments were:

T_1 = Irrigation at 0 Days after disappearance of ponded water (DAD) with 8-10 dS/m saline water at all stages (no amendment, i.e. Control)

T_2 = Irrigation with 8-10 dS/m saline water + Sodium Silicate (as basal) + excess gypsum @50% of recommended dose ** (at Vegetative + panicle initiation stage)

T_3 = Irrigation with 8-10 dS/m saline water + excess gypsum @50% of recommended (at Vegetative panicle initiation stage) +Foliar application of Sodium Silicate (75 ppm, at 20, 40, 60 days after transplanting (DAT)

T_4= Irrigation with 8-10 dS/m saline water + excess gypsum and K @50% of recommended (at Vegetative + panicle initiation stage) +Foliar application of Sodium Silicate (75 ppm, at 20, 40, 60 DAT)

T_5=Irrigation with 11-12 dS/m saline water + excess gypsum and K @50% of recommended (at Vegetative + panicle initiation stage) +Foliar application of Sodium Silicate (75 ppm, at 20, 40, 60 DAT)

T_6= Irrigation with 11-12 dS/m saline water + Sodium Silicate (as basal) + excess gypsum and K @50% of recommended (at Vegetative + panicle initiation stage) + Foliar application of Salicylic Acid (75 ppm; at 20, 40, 60 DAT)

Note: "Washout" of salt by irrigation, when soil salinity exceeds 10 dS/m

** Recommended dose (for Binadhan-8, 10): Urea, TSP, MoP, Gypsum, and Zinc @ 217, 110, 70, 45, and 4.5 kg/ha

The seedlings were transplanted on 7 February 2018 at Lysimeter, Satkhira sub-station. After establishment, treatments were followed. Due to inappropriate setting of drainage tap at bottom of the Lysimeter unit box, irrigation water was drained out quickly, and hence treatments could not be implemented properly.

Among 18 sub-plot (Box), 2 boxes (R_2T_6 and R_2T_5) were damaged after starting treatment due to excess drain out of irrigation water (Fig. 12.1). Due to partially drainage, the following treatments were able to produce yield. The experiment will be repeated in the next year.

Table. 12.1: Treatment wise yield in t/ha of the experiment

Treatment	Yield ($t\ ha^{-1}$)
$R_1T_3V_2$	3.82
$R_1T_4V_2$	3.37
$R_2T_1V_2$	4.54
$R_2T_3V_1$	3.39
$R_2T_3V_2$	4.79
$R_3T_3V_1$	3.54
$R_3T_3V_2$	3.96
$R_3T_4V_2$	4.82

Agronomy Division

Research Highlights

Study on determination of optimum seed rate for growth and yield of lentil lines/variety, LM-183-1 produced highest seed yield (2.03 t ha^{-1}) at 30 kg ha^{-1} seed rate at Ishurdi followed by LM-138-3 (1.93 t ha^{-1}) at Chapai Nawabgonj.

Study on determination of optimum sowing date and spacing for growth and yield of mungbean lines/variety, Binamung-8 produced maximum seed yield (1157 kg ha^{-1}) at followed by MBM-656-51-2 (1055 kg ha^{-1}) at 20 cm row spacing in Feb 15 sowing.

In aus season, among different transplanting time, March 20 produced maximum yield (4.71 t ha^{-1}) by Nerica mutant N_4/350/P-4(5) in Chapai Nawabgonj followed by BRRI dhan48 (4.61 t ha^{-1}).

In aman season, among different transplanting time, Aug.13 produced maximum yield (5.43 t ha^{-1}) by Binadhan-17 in Ishurdi and Nerica mutant N_{10}/350/P-5-4 produced (4.98 t ha^{-1}) at July 20 transplanting in Chapai Nawabgonj.

In aman season, among different mutants of kasalath, mutant line, RU-Kas-60(C)-1 produced highest grain yield (4.9 t ha^{-1}) at 20 cm×15 cm spacing at Ishurdi.

Study on determination of optimum spacing in rabi season, Binapiaz-1 produced maximum bulb yield (9.3 t ha^{-1}) at 10 cm×10 cm spacing followed by Binapiaz-2 (8.7 t ha^{-1}) at Rangpur.

Study on determination of optimum spacing in kharif-1 season, Binapiaz-1 produced maximum bulb yield (7.4 t ha^{-1}) transplanting at 20 cm×10 cm spacing which is followed by Binapiaz-2 (6.5 t ha^{-1}) at Rangpur.

In boro season, Binadhan-10 was evaluated under three transplanting methods at saline prone area. The highest grain yield (7.3 t ha^{-1}) was produced in ridge and furrow method where gypsum rate was 150 kg ha^{-1} (75 kg ha^{-1} basal + 75kg ha^{-1} at 7 weeks after transplanting (G_3) followed by (6.7 t ha^{-1}) basal application of 150 kg ha^{-1} gypsum.

Among herbicide treatments, highest grain yield (5.1 t ha^{-1}) was found with the application of Triafemon followed by Pretilachlor (4.7 t ha^{-1}) in boro season.

In boro season, four rice varieties viz. Binadhan-5, Binadhan-6, Binadhan-10 and Binadhan-18 were evaluated under high temperature (30^0c) at flowering stage. The highest grain yield were found in Binadhan-6 (65.64 and 62.94 g pot^{-1}) both ambient and high temperature followed by Binadhan-5 (59.14 and 55.76 g pot^{-1}).

Determination of optimum seed rate for growth and yield of lentil mutant line/variety

The experiment was conducted at BINA substation, Ishurdi and Chapai Nawabgonj during 2017-18 to evaluate the effect of optimum seed rate (20 kg ha^{-1}, 25 kg ha^{-1}, 30 kg ha^{-1} and 35 kg ha^{-1}) on the growth and yield contributing characters of two advanced lentil lines/variety viz. LM-138-3, LM-183-1 along with one check variety Binamasur-5. The experiment was laid out in 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 Statistical computer program according to the design used for the experiment. Least significant difference (LSD) was used to compare variations among the treatments.

Among different advance lines/variety, LM-138-3 produced highest seed yield (1.93 t ha^{-1}) followed by LM-183-1 (1.90 t ha^{-1}) (Table 01). Highest yield was contributed by highest pods plant^{-1} and 1000 seed weight. Mean effect of different seed rate showed significant results on seed yield. Among different seed rate, 30 kg ha^{-1} showed highest seed yield (1.98 t ha^{-1}). The interaction results of mutant/variety and seed rate, revealed that the yield of LM-183-1 was the highest (2.02 t ha^{-1}) at 30 kg ha^{-1}. The interaction effect of mutant/variety and location, showed that LM-183-1 produced the maximum seed yield (1.98 t ha^{-1}) in Ishurdi followed by LM-138-3 (1.94 t ha^{-1}) Ishurdi. The interaction effect of seed rate, variety and location showed that at 30 kg ha^{-1}, LM-138-3 produced highest yield (2.03 t ha^{-1}) in Ishurdi (Table 01). The data recorded on crop duration revealed that the advanced mutant line LM-138-3 required the least average 95 days and Binamasur-5 required maximum average 101 days.

Table 01. Determination of optimum seed rate for growth and yield of lentil lines during 2017-2018 at BINA substation, Ishurdi and Chapai Nawabgonj

Treatment	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})	Straw yield (t ha^{-1})	Crop duration (days)
Varieties									
LM-138-3	40.3	6.9	80.5	62.3	1.8	22.0	1.93	2.66	95
LM-183-1	36.6	6.8	76.4	65.2	1.8	21.9	1.90	2.63	96
Binamasur-5	38.5	6.9	75.6	66.1	1.8	21.7	1.87	2.58	101
$LSD_{0.05}$	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**-**
Seed Rates									
20 kg ha^{-1}	39.4	7.5	68.8	68.9	1.8	22.2	1.83	2.54	
25 kg ha^{-1}	39.2	6.9	74.7	67.0	1.8	22.1	1.92	2.66	
30 kg ha^{-1}	38.3	6.7	81.0	63.8	1.8	21.8	1.98	2.75	
35 kg ha^{-1}	37.1	6.3	85.6	58.5	1.7	21.4	1.86	2.56	
$LSD_{0.05}$	**NS**	**NS**	**1.7**	**NS**	**NS**	**NS**	**0.08**	**NS**	
Location									
Ishurdi (L_1)	42.7	7.0	79.2	63.3	1.8	22.0	1.93	2.68	
Chapai Nawabgonj (L_2)	34.3	6.8	75.8	65.7	1.8	21.7	1.87	2.58	
Level of significance	*****	**NS**	**NS**	**NS**	**NS**	**NS**	*****	*****	
Varieties × Seed rates									
V_1S_1	40.9	7.5	71.2	65.6	1.8	22.5	1.85	2.60	
V_1S_2	42.1	7.0	79.3	63.4	1.8	22.3	1.95	2.72	

V_1S_3	40.3	6.7	84.0	62.1	1.7	21.8	1.99	2.74
V_1S_4	37.8	6.3	87.5	58.2	1.7	21.3	1.88	2.60
V_2S_1	38.0	7.5	69.0	67.6	1.8	22.0	1.82	2.51
V_2S_2	36.7	6.6	72.2	69.7	1.8	22.0	1.91	2.63
V_2S_3	36.3	6.5	79.2	65.9	1.8	21.9	2.02	2.83
V_2S_4	**35.5**	6.6	85.3	57.7	1.7	21.6	1.85	2.55
V_3S_1	39.3	7.6	66.3	73.5	1.7	22.0	1.81	2.50
V_3S_2	38.9	7.0	72.5	67.8	1.8	22.0	1.90	2.62
V_3S_3	38.1	6.9	79.9	63.3	1.8	21.7	1.94	2.68
V_3S_4	37.8	6.1	83.8	59.7	1.7	21.2	1.83	2.53
$LSD_{0.05}$	**3.0**	**0.9**	**2.9**	**5.3**	**NS**	**0.5**	**0.14**	**0.19**
Varieties × location								
V_1L_1	44.7	6.8	82.9	60.6	1.8	22.1	1.94	2.71
V_1L_2	35.9	7.0	78.1	64.0	1.8	21.8	1.89	2.61
V_2L_1	40.3	6.9	77.6	63.7	1.8	22.1	1.98	2.69
V_2L_2	32.9	6.7	77.1	66.7	1.7	21.7	1.86	2.56
V_3L_1	43.0	7.2	75.3	65.7	1.7	21.9	1.90	2.62
V_3L_2	34.0	6.6	74.2	66.4	1.8	21.6	1.84	2.55
$LSD_{0.05}$	**2.6**	**0.6**	**3.5**	**4.2**	**NS**	**0.5**	**NS**	**NS**
Seed rates × location								
S_1L_1	42.4	7.4	87.0	68.5	1.8	22.3	1.89	2.63
S_1L_2	36.4	7.6	84.1	69.3	1.8	22.1	1.77	2.44
S_2L_1	43.4	6.9	82.5	65.1	1.8	22.2	1.95	2.70
S_2L_2	35.1	6.8	79.6	68.8	1.8	22.0	1.89	2.61
S_3L_1	42.8	6.8	76.0	61.9	1.8	22.1	2.02	2.81
S_3L_2	33.7	6.6	73.3	65.6	1.7	21.5	1.95	2.69
S_4L_1	42.1	6.7	71.3	57.7	1.7	21.5	1.85	2.55
S_4L_2	32.0	6.0	66.3	59.3	1.7	21.3	1.86	2.57
$LSD_{0.05}$	**3.0**	**0.7**	**4.1**	**4.8**	**NS**	**0.5**	**0.08**	**NS**
Varieties × Seed rates × location								
$V_1S_1L_1$	44.3	7.3	75.0	64.1	1.8	22.7	1.90	2.70
$V_1S_1L_2$	37.5	7.7	67.3	67.1	1.8	22.4	1.81	2.49
$V_1S_2L_1$	47.3	6.8	81.7	61.4	1.8	22.4	1.97	2.81
$V_1S_2L_2$	36.8	7.1	77.0	65.4	1.7	22.2	1.90	2.63
$V_1S_3L_1$	45.3	6.6	85.7	59.9	1.7	22.1	2.03	2.78
$V_1S_3L_2$	35.3	6.9	82.3	64.3	1.7	21.5	1.96	2.70
$V_1S_4L_1$	41.7	6.3	89.3	57.0	1.7	21.3	1.86	2.57
$V_1S_4L_2$	34.0	6.3	85.7	59.4	1.8	21.2	1.91	2.64
$V_2S_1L_1$	40.7	7.3	72.3	66.1	1.8	22.1	1.91	2.64
$V_2S_1L_2$	35.3	7.7	65.7	69.0	1.8	21.9	1.72	2.38
$V_2S_2L_1$	40.3	6.7	72.7	67.7	1.8	22.3	1.93	2.66
$V_2S_2L_2$	33.0	6.6	71.7	71.7	1.7	21.8	1.88	2.60
$V_2S_3L_1$	40.0	6.6	79.3	64.4	1.9	22.1	2.01	2.89
$V_2S_3L_2$	32.7	6.3	79.0	67.4	1.7	21.7	1.96	2.77
$V_2S_4L_1$	40.3	7.1	86.0	56.5	1.7	21.8	1.88	2.59
$V_2S_4L_2$	30.7	6.1	84.7	58.8	1.7	21.5	1.82	2.52
$V_3S_1L_1$	42.2	7.7	66.7	75.3	1.7	22.2	1.86	2.56
$V_3S_1L_2$	36.3	7.5	66.0	71.7	1.8	21.9	1.77	2.44
$V_3S_2L_1$	42.5	7.2	73.7	66.3	1.8	22.1	1.91	2.64
$V_3S_2L_2$	35.3	6.7	71.3	69.3	1.8	21.9	1.89	2.61
$V_3S_3L_1$	43.2	7.2	82.5	61.5	1.8	22.0	1.93	2.77
$V_3S_3L_2$	33.0	6.6	77.3	65.1	1.7	21.4	1.87	2.59
$V_3S_4L_1$	44.3	6.6	85.7	59.7	1.7	21.4	1.82	2.51
$V_3S_4L_2$	31.3	5.6	82.0	59.7	1.8	21.1	1.84	2.54
$LSD_{0.05}$	**5.1**	**1.2**	**7.0**	**8.3**	**NS**	**0.9**	**0.13**	**0.21**
CV%	**7.9**	**10.3**	**5.4**	**7.7**	**4.6**	**2.5**	**4.19**	**4.79**

Determination of optimum dates of sowing and spacing on yield and yield contributing characters of mungbean mutants/variety at BINA Sub-station Barishal and Ishurdi

Two advanced mutant lines were evaluated compared with two check variety with three levels of row spacing at BINA Sub-station, Barishal and Ishurdi. The objective was to evaluate the yield performances of mutant lines as affected by different dates of sowing different and spacing. Four different dates of sowing were at Jan. 15, Feb. 01, Feb. 15, and Mar. 01. Three levels of row spacing were 20 cm, 25 cm and 30 cm. The advanced mutant lines were MBM-656-51-2, MBM-427-87-3 and the check variety BARI Mung8 and Binamung-8. Data on yield and yield components were recorded at harvest and analyzed statistically following the design used for the experiment and the means were judged by LSD. The results are discussed below separately.

The effect of sowing date on seed yield was the highest at Feb. 15 (988 kg ha^{-1}) whereas Mar.01 sowing produced the lowest seed yield (503 kg ha^{-1}) (Table 02). The seed yield of 25 cm row spacing was the highest (792.6 kg ha^{-1}) whereas 30 cm row spacing produced the lowest seed yield (720 kg ha^{-1}) (Table 02). Among the mutant lines/varieties, MBM-656-51-2 produced the highest seed yield (794 kg ha^{-1}) followed by Binamung-8 and BARI Mung8. The interaction effect of sowing date, mutants/variety showed that MBM-656-51-2 produced the maximum seed yield (1002 kg ha^{-1}) followed by BARI Mung8 (953 kg ha^{-1}) same sowing date at Feb 15. The interaction effect of sowing date and row spacing showed that sowing at Feb. 15 and 20 cm row spacing produced the maximum seed yield (1066 kg ha^{-1}) followed by sowing at Feb 15 (993 kg ha^{-1}) 20 cm row spacing. The interaction effect of variety and row spacing Binamung-8 produced maximum seed yield (850 kg ha^{-1}) at 25cm row spacing followed by BARI Mung8 (850 kg ha^{-1}) at 20cm row spacing. The interaction effect of sowing time variety and row spacing showed maximum seed yield (1157 kg ha^{-1}) at 20cm row spacing by Binamung-8 followed by MBM-656-51-2 (1055 kg ha^{-1}) at 20cm row spacing at same date of sowing (Feb 15). The data recorded on crop duration from sowing to maturity revealed that the advanced mutant line MBM-656-51-2 required the least average 72 days and BARI Mung8 required maximum average 79 days (Table 02).

Table 02. Effect of different dates of sowing and spacing on yield and yield contributing characters of mungbean mutants/variety in BINA Substation Barishal and Ishurdi

Treatment	Populations m^{-2} (no)	Plant height (cm)	Branches $Plant^{-1}$ (no)	Pods $Plant^{-1}$ (no)	Pod Length (cm)	Seeds Pod^{-1} (no)	1000 seed wt.(g)	Seed yield (t ha^{-1})	Crop duration (days)
Location(s)									
Barishal	22.3	44.3	0.4	20.8	8.6	10.6	48.2	664.0	
Ishurdi	52.9	55.9	2.6	33.5	8.0	10.1	41.1	853.3	
Level of sig.	*	*	*	*	*	*	*	*	
Date of Sowing									
Jan. 15 (D_1)	30.3	37.6	1.0	12.6	8.1	10.3	46.2	647.1	
Feb. 01(D_2)	35.4	44.8	0.7	14.6	8.4	10.4	45.3	896.4	
Feb. 15(D_3)	38.6	54.4	4.4	37.5	8.2	10.1	44.8	988.0	
Mar. 01(D_4)	46.0	63.6	0.1	43.8	8.5	10.4	42.4	503.3	
$LSD_{0.05}$	**2.4**	**2.0**	**1.1**	**4.7**	**0.2**	**0.2**	**1.1**	**117.1**	
Mutants/varieties									
MBM-656-51-2	37.4	49.9	1.7	25.9	8.8	10.3	43.1	794.0	72

(V_1)									
MBM-427-87-3(V_2)	37.4	48.0	1.3	27.8	8.5	10.3	48.2	710.9	75
BARI Mung8(V_3)	37.8	51.7	1.4	26.4	8.4	10.3	43.4	752.0	79
Binamung-8(V_4)	37.8	50.8	1.7	28.4	8.5	10.4	43.9	762.8	76
LSD$_{0.05}$	**NS**	**1.7**	**NS**	**NS**	**0.2**	**NS**	**0.9**	**NS**	
Row spacing									
20 cm (S_1)	44.3	50.2	1.5	27.9	8.3	10.3	44.8	763.1	
25 cm (S_2)	37.6	50.5	1.6	26.9	8.3	10.2	44.6	792.6	
30 cm (S_3)	31.0	49.6	1.6	26.7	8.3	10.4	44.5	720.4	
LSD$_{0.05}$	**1.8**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	
Date of Sowing × Mutants/varieties									
D_1V_1	29.7	36.1	1.0	12.6	7.8	10.2	46.3	518.9	
D_1V_2	29.7	36.4	1.0	10.7	7.9	10.2	47.5	585.5	
D_1V_3	31.6	37.7	1.1	13.7	8.4	10.4	44.5	678.9	
D_1V_4	30.2	40.3	1.0	13.3	8.5	10.6	46.5	805.2	
D_2V_1	35.9	44.6	0.6	14.2	7.9	10.3	43.9	966.2	
D_2V_2	34.6	44.0	0.7	14.5	8.6	10.6	46.6	870.5	
D_2V_3	35.6	45.8	0.6	14.7	8.6	10.4	45.0	889.9	
D_2V_4	35.7	45.0	0.8	15.1	8.5	10.5	45.5	859.0	
D_3V_1	39.2	52.9	5.0	38.0	7.4	10.2	42.1	1002.1	
D_3V_2	37.7	52.0	4.3	37.4	8.7	10.1	50.1	909.3	
D_3V_3	38.2	57.9	4.7	36.3	8.4	10.4	43.6	953.5	
D_3V_4	39.4	54.7	3.4	38.5	8.4	9.9	43.2	947.0	
D_4V_1	44.7	66.1	0.3	38.8	8.1	10.3	40.0	509.0	
D_4V_2	47.6	59.6	0.9	48.7	8.8	10.4	48.7	478.5	
D_4V_3	45.9	65.4	0.7	41.0	8.4	10.1	40.5	515.8	
D_4V_4	45.9	63.3	1.7	46.8	8.6	10.5	40.2	509.9	
LSD$_{0.05}$	**5.4**	**4.3**	**2.4**	**10.4**	**0.5**	**0.4**	**2.3**	**256.6**	
Date of Sowing × Row spacing									
D_1S_1	34.8	37.7	0.9	11.5	8.1	10.3	46.0	560.2	
D_1S_2	30.5	38.2	1.0	12.6	8.1	10.4	46.6	698.8	
D_1S_3	25.5	37.0	1.1	13.6	8.2	10.3	45.9	682.3	
D_2S_1	41.4	43.8	0.6	13.2	8.4	10.4	45.6	921.3	
D_2S_2	35.0	45.0	0.7	15.5	8.4	10.4	44.7	906.8	
D_2S_3	30.0	45.7	0.7	15.2	8.3	10.5	45.6	861.0	
D_3S_1	44.8	54.7	4.9	40.2	8.3	10.1	45.0	1066.9	
D_3S_2	38.9	53.3	3.9	35.2	8.1	9.9	44.9	993.4	
D_3S_3	32.2	55.1	4.2	37.3	8.3	10.4	44.3	903.6	
D_4S_1	56.0	64.6	-0.6	46.5	8.3	10.3	42.7	503.9	
D_4S_2	45.8	65.7	0.7	44.3	8.7	10.2	41.9	571.1	
D_4S_3	36.3	60.6	0.3	40.8	8.4	10.6	42.5	434.8	
LSD$_{0.05}$	**4.6**	**3.8**	**2.1**	**9.0**	**0.5**	**0.3**	**2.0**	**222.2**	
Mutants/varieties × Row spacing									
V_1S_1	42.9	48.8	1.4	24.7	7.7	10.4	42.6	771.4	
V_1S_2	37.9	50.9	1.5	25.7	7.8	10.1	43.1	777.8	
V_1S_3	31.2	50.0	2.3	27.3	7.9	10.3	43.6	697.9	
V_2S_1	43.3	50.2	1.3	32.2	8.5	10.2	49.0	700.1	
V_2S_2	37.3	47.7	1.1	24.7	8.5	10.3	47.5	778.1	
V_2S_3	31.6	46.0	1.4	26.6	8.5	10.4	48.2	654.6	
V_3S_1	44.7	50.2	1.2	24.6	8.5	10.3	43.7	806.8	
V_3S_2	37.8	53.9	1.4	28.3	8.5	10.2	43.7	763.6	
V_3S_3	30.9	50.9	1.7	26.4	8.4	10.5	42.8	775.7	
V_4S_1	46.1	51.4	1.9	29.9	8.5	10.3	43.9	774.0	

V_4S_2	37.1	49.6	2.3	28.8	8.6	10.3	43.9	850.8
V_4S_3	30.2	51.4	0.9	26.6	8.4	10.5	43.8	753.5
$LSD_{0.05}$	**3.7**	**3.0**	**NS**	**7.1**	**0.4**	**0.3**	**1.5**	**175.7**
Sowing time × Mutants/varieties × Row spacing								
$D_1V_1S_1$	34.2	35.0	0.8	11.2	7.3	10.3	45.1	423.6
$D_1V_1 S_2$	29.3	37.8	1.0	12.1	8.0	10.1	47.6	536.8
$D_1V_1 S_3$	25.5	35.6	1.2	14.5	8.2	10.2	46.2	596.2
$D_1V_2 S_1$	34.5	37.5	1.0	10.9	8.3	10.2	47.3	508.3
$D_1V_2 S_2$	28.8	37.1	0.9	10.4	7.5	10.4	46.6	635.0
$D_1V_2 S_3$	25.7	34.5	1.0	10.8	7.9	9.8	48.5	613.1
$D_1V_3 S_1$	35.8	36.4	0.9	11.7	8.1	10.2	45.2	600.8
$D_1V_3 S_2$	33.2	37.9	1.1	14.4	8.4	10.6	44.8	693.7
$D_1V_3 S_3$	25.7	38.7	1.2	15.0	8.5	10.4	43.5	742.1
$D_1V_4 S_1$	34.8	41.7	1.0	12.4	8.6	10.6	46.4	708.2
$D_1V_4 S_2$	30.8	39.9	1.1	13.6	8.6	10.7	47.5	929.9
$D_1V_4 S_3$	25.0	39.2	1.1	14.0	8.2	10.6	45.5	777.5
$D_2V_1S_1$	41.5	44.3	0.5	12.8	7.8	10.2	43.6	1023.3
$D_2V_1 S_2$	37.0	43.4	0.6	15.4	7.8	10.5	43.1	966.9
$D_2V_1 S_3$	29.2	46.1	0.6	14.4	8.1	10.3	45.0	908.2
$D_2V_2 S_1$	40.8	43.1	0.6	13.1	8.6	10.5	46.6	921.3
$D_2V_2 S_2$	34.8	45.1	0.6	15.5	8.7	10.5	46.1	904.0
$D_2V_2 S_3$	28.2	43.7	0.8	15.0	8.5	10.7	47.2	786.1
$D_2V_3 S_1$	40.3	45.0	0.6	13.0	8.6	10.4	45.9	839.1
$D_2V_3 S_2$	34.2	45.9	0.7	15.8	8.8	10.4	44.4	932.9
$D_2V_3 S_3$	32.3	46.4	0.7	15.3	8.2	10.4	44.8	897.8
$D_2V_4 S_1$	42.8	42.8	0.7	14.1	8.5	10.4	46.1	901.4
$D_2V_4 S_2$	33.8	45.6	1.0	15.2	8.3	10.4	45.1	823.6
$D_2V_4 S_3$	30.3	46.6	0.7	16.1	8.6	10.6	45.3	852.1
$D_3V_1S_1$	43.7	54.0	4.9	39.9	7.6	10.1	42.0	1055.5
$D_3V_1 S_2$	40.0	52.3	4.5	35.7	7.3	10.0	42.2	1010.4
$D_3V_1 S_3$	33.8	52.2	5.6	38.5	7.4	10.5	42.1	940.2
$D_3V_2 S_1$	41.3	53.0	4.5	43.0	8.7	9.8	51.8	940.6
$D_3V_2 S_2$	39.3	48.7	3.4	34.1	8.7	10.2	50.0	956.9
$D_3V_2 S_3$	32.3	54.4	4.9	35.2	8.7	10.4	48.5	830.5
$D_3V_3 S_1$	45.0	58.4	4.7	34.3	8.4	10.6	43.6	1157.1
$D_3V_3 S_2$	39.0	58.0	4.8	35.5	8.3	10.2	44.4	953.4
$D_3V_3 S_3$	30.7	57.4	4.7	39.1	8.5	10.3	42.8	920.1
$D_3V_4 S_1$	49.2	53.3	5.5	43.7	8.5	9.9	42.6	1014.6
$D_3V_4 S_2$	37.3	54.3	2.9	35.5	8.3	9.4	43.1	1052.7
$D_3V_4 S_3$	31.8	56.4	1.7	36.3	8.5	10.3	44.0	923.6
$D_4V_1S_1$	52.4	62.0	-0.8	35.0	8.0	10.8	39.8	583.1
$D_4V_1 S_2$	45.4	70.2	-0.1	39.6	8.3	10.0	39.3	596.9
$D_4V_1 S_3$	36.4	66.2	1.9	42.0	8.0	10.2	41.0	346.9
$D_4V_2 S_1$	56.4	67.4	-1.1	62.0	8.3	10.2	50.4	430.3
$D_4V_2 S_2$	46.4	60.0	-0.4	39.0	9.1	10.2	47.2	616.4
$D_4V_2 S_3$	40.0	51.5	-1.1	45.3	9.0	10.9	48.5	388.6
$D_4V_3 S_1$	57.7	61.2	-1.1	39.3	8.6	10.0	40.2	530.3
$D_4V_3 S_2$	45.0	73.8	-1.1	47.6	8.3	9.7	41.4	474.2
$D_4V_3 S_3$	35.0	61.2	0.2	36.0	8.3	10.7	40.0	542.8
$D_4V_4 S_1$	57.7	67.8	0.6	49.6	8.3	10.2	40.4	472.0
$D_4V_4 S_2$	46.4	58.8	4.2	51.0	9.1	10.8	39.7	596.9
$D_4V_4 S_3$	33.7	63.4	0.2	40.0	8.3	10.5	40.5	460.8
$LSD_{0.05}$	**9.2**	**7.5**	**4.2**	**18.0**	**0.9**	**0.7**	**4.0**	**444.4**
CV (%)	**15.3**	**9.3**	**167.6**	**41.3**	**7.0**	**4.2**	**5.6**	**36.4**

Effect of date of transplanting on the yield and yield contributing characters of Nerica rice mutants/variety in Aus season at drought prone area

Two advanced mutant lines were evaluated compared with one check variety with four dates of transplanting during aus season at drought prone areas of BINA Sub-station, Ishurdi and Chapai Nawabgonj. The objective was to evaluate the yield performances of mutant lines as affected by different dates of transplanting. The four dates of transplanting were March 20, April 05, April 20, May 05 and the advanced mutant lines were N_4/350/P-4(5), N_{10}/350/P-5-4 and the check variety BRRI dhan48. Twenty five days old seedlings were transplanted in a randomized complete block design with three replications. The unit plot size was 3 m×4 m. Data on yield and yield components were recorded at harvest and analyzed statistically following the design used for the experiment and the means were compared with LSD. The results are discussed below separately.

The effect of dates of transplanting on grain yield of March 20 was the highest (4.46 t ha^{-1}) whereas May 05 produced the lowest grain yields 3.85 t ha^{-1} (Table 03). Among the Nerica mutant lines/varieties, BRRI dhan48 produced the highest grain yield (4.44 t ha^{-1}) followed by N_4/350/P-4(5) (4.31 t ha^{-1}). The interaction effect of date and variety showed that BRRI dhan48 produced the maximum yield (4.73 t ha^{-1}) at April 20 followed by N_4/350/P-4(5) (4.51 t ha^{-1}). The interaction effect of date and location in Chapai Nawabgonj at March 20 produced the maximum yield (4.63 t ha^{-1}) followed by Chapai Nawabgonj at April 05 (4.52t ha^{-1}). The interaction effect of variety and location N_4/350/P-4(5) produced maximum yield (4.42 t ha^{-1}) in Chapai Nawabgonj followed by BRRI dhan48 in Chapai Nawabgonj (4.35 t ha^{-1}). The interaction effect of date, variety and location transplanting date at March 20, N_4/350/P-4(5) produced maximum yield (4.71 t ha^{-1}) in Chapai Nawabgonj followed by March 20, BRRI dhan48 in Chapai Nawabgonj (4.67 t ha^{-1}). The data recorded on crop duration from transplanting to maturity revealed that the advanced mutant line N_4/350/P-4(5) required the least average 106 days and the BRRI dhan48 required maximum average 116 days (Table 03).

Table 03. Effect of date of transplanting on the yield and yield contributing characters of Nerica rice mutant/variety in Aus season at drought prone area

Treatments	Plant height (cm)	Total tillers hill^{-1} (no)	Effective tillers hill^{-1} (no)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000 seed wt. (g.)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Crop Duration (Days)
Dates of transplanting										
March 20 (D_1)	95.7	12.8	12.1	22.5	115.8	14.1	21.2	4.46	5.71	
April 05 (D_2)	94.3	12.6	11.6	22.2	117.8	10.9	21.5	4.44	5.77	
April 20 (D_3)	95.4	11.7	11.0	22.6	117.2	12.9	20.9	4.40	5.52	
May 05 (D_4)	84.6	12.2	10.7	23.2	116.8	12.2	20.5	3.85	5.10	
$LSD_{0.05}$	**NS**	**NS**	**NS**	**NS**	**NS**	**1.5**	**NS**	**NS**	**NS**	
Mutants/Varieties										
N_4/350/P-4(5) (V_1)	94.0	12.8	11.9	22.1	113.2	11.6	21.3	4.31	5.58	106
N_{10}/350/P-(4) (V_2)	89.3	12.3	11.3	22.8	120.8	13.1	20.9	4.11	5.40	107
BRRI dhan48 (V_3)	94.1	11.9	10.8	23.0	116.6	12.8	20.9	4.44	5.60	116

LSD$_{0.05}$	**NS**	**NS**	**NS**	**NS**	**NS**	**2.5**	**NS**	**NS**	**NS**	**-**
Location										
Ishurdi (L_1)	88.1	12.3	11.3	22.4	112.6	13.5	20.8	4.23	5.54	
Chapai Nawabgonj(L_2)	96.9	12.4	11.4	22.8	121.2	11.5	21.3	4.34	5.51	
Level of sig.	*****	**NS**	**NS**	**NS**	*****	*****	**NS**	**NS**	**NS**	
Dates ×Varieties										
D_1V_1	96.5	13.8	12.7	22.2	110.8	12.4	21.8	4.39	5.76	
D_1V_2	93.0	13.2	12.5	22.2	114.0	14.8	21.1	4.30	5.51	
D_1V_3	97.5	11.6	11.0	23.1	122.7	15.1	20.8	4.48	5.85	
D_2V_1	95.5	13.2	12.5	22.1	115.4	11.1	21.8	4.51	5.78	
D_2V_2	90.6	13.1	11.9	22.2	118.5	10.6	21.6	4.36	5.76	
D_2V_3	96.7	11.4	10.3	22.4	119.3	10.9	21.2	4.45	5.78	
D_3V_1	98.6	12.1	11.1	22.1	115.6	10.2	21.1	4.39	5.56	
D_3V_2	90.0	10.3	9.8	23.2	128.5	14.9	20.6	4.10	5.36	
D_3V_3	97.8	12.8	12.0	22.5	107.5	13.5	20.9	4.73	5.66	
D_4V_1	85.5	12.3	11.2	22.1	111.1	12.5	20.4	3.94	5.21	
D_4V_2	83.8	12.5	11.1	23.6	122.3	12.2	20.5	3.70	4.97	
D_4V_3	84.5	11.8	9.9	23.9	117.0	11.8	20.7	3.90	5.11	
LSD$_{0.05}$	**NS**	**NS**	**NS**	**NS**	**NS**	**4.9**	**NS**	**0.41**	**NS**	
Dates ×Location										
D_1L_1	85.4	12.8	12.0	21.9	108.8	14.7	20.7	4.28	5.62	
D_1L_2	106.0	12.9	12.2	23.1	122.8	13.6	21.7	4.63	5.80	
D_2L_1	87.2	12.5	11.6	22.1	104.2	12.9	21.2	4.35	5.96	
D_2L_2	101.3	12.6	11.6	22.3	131.3	8.8	21.9	4.52	5.59	
D_3L_1	95.3	11.7	10.9	22.4	117.6	12.8	20.8	4.41	5.45	
D_3L_2	95.6	11.8	11.0	22.8	116.8	13.0	20.9	4.39	5.60	
D_4L_1	84.6	12.2	10.8	23.3	119.6	13.8	20.4	3.88	5.14	
D_4L_2	84.6	12.2	10.7	23.1	114.0	10.5	20.7	3.81	5.06	
LSD$_{0.05}$	**NS**	**NS**	**NS**	**NS**	**5.9**	**3.6**	**NS**	**0.34**	**0.38**	
Varieties×Location										
V_1L_1	89.3	12.9	11.9	21.7	107.4	12.1	21.1	4.19	5.54	
V_1L_2	98.7	12.8	11.9	22.5	119.1	11.1	21.5	4.42	5.61	
V_2L_1	85.8	12.0	11.2	22.6	116.7	14.3	20.	4.07	5.44	

							7		
V_2L_2	92.9	12.6	11.4	23.0	125.0	11.9	21.2	4.15	5.36
V_3L_1	89.3	12.0	10.9	23.0	113.6	14.2	20.6	4.33	5.64
V_3L_2	99.0	11.7	10.7	22.9	119.7	11.5	21.2	4.35	5.57
$LSD_{0.05}$	**NS**	**NS**	**NS**	**NS**	**5.1**	**3.1**	**NS**	**0.29**	**0.33**
Dates×Varieties×Location									
D_1V_1 L_1	83.7	13.7	12.4	21.0	99.2	11.7	21.1	4.06	5.55
$D_1V_1L_2$	109.3	13.9	13.1	23.3	122.3	13.1	22.5	4.71	5.96
$D_1V_2L_1$	85.9	12.2	11.7	21.3	104.7	16.4	20.9	4.13	5.49
$D_1V_2L_2$	100.1	14.2	13.2	23.1	123.2	13.2	21.3	4.47	5.53
$D_1V_3L_1$	86.7	12.4	11.7	23.4	122.5	15.9	20.2	4.63	5.80
$D_1V_3L_2$	108.4	10.7	10.3	22.7	122.8	14.3	21.3	4.67	5.90
D_2V_1 L_1	89.3	13.5	12.7	21.5	106.8	11.5	22.1	4.52	5.86
$D_2V_1L_2$	101.7	12.9	12.3	22.7	124.1	10.7	21.5	4.49	5.70
$D_2V_2L_1$	83.7	13.1	12.2	22.1	102.3	14.0	20.9	4.23	5.94
$D_2V_2L_2$	97.4	13.1	11.6	22.3	134.7	7.2	22.3	4.49	5.58
$D_2V_3L_1$	88.7	11.1	9.8	22.7	103.4	13.2	20.7	4.29	6.07
$D_2V_3L_2$	104.7	11.7	10.7	22.0	135.3	8.7	21.7	4.60	5.48
D_3V_1 L_1	98.5	12.1	11.0	22.2	115.5	11.2	21.2	4.28	5.45
$D_3V_1L_2$	98.7	12.1	11.1	22.0	115.7	9.3	21.1	4.50	5.66
$D_3V_2L_1$	90.0	10.3	9.7	23.2	132.7	13.3	20.5	4.18	5.29
$D_3V_2L_2$	90.0	10.4	9.8	23.1	124.3	16.5	20.7	4.01	5.43
$D_3V_3L_1$	97.3	12.7	12.0	21.8	104.7	13.7	20.7	4.48	5.62
$D_3V_3L_2$	98.2	12.8	12.1	23.1	110.4	13.3	21.0	4.67	5.70
D_4V_1 L_1	85.7	12.3	11.3	22.1	108.0	13.9	19.9	3.91	5.31
$D_4V_1L_2$	85.3	12.3	11.2	22.1	114.2	11.1	20.8	3.97	5.12
$D_4V_2L_1$	83.6	12.4	11.1	23.7	127.0	13.6	20.5	3.75	5.05
$D_4V_2L_2$	84.0	12.5	11.0	23.5	117.7	10.9	20.5	3.64	4.90
$D_4V_3L_1$	84.3	11.9	9.9	24.1	123.7	14.0	20.8	3.97	5.05
$D_4V_3L_2$	84.7	11.7	9.9	23.7	110.3	9.6	20.7	3.82	5.18

$LSD_{0.05}$	**NS**	**NS**	**NS**	**NS**	**10.2**	**6.2**	**NS**	**0.59**	**0.65**	
CV%	**7**	**4.6**	**4.6**	**3.1**	**5.2**	**29.6**	**1.9**	**8.13**	**7.02**	

Effect of date of transplanting on the yield and yield contributing characters of Nerica rice mutant/variety in Aman season

Two advanced mutant lines were evaluated compared with one check variety with three dates of transplanting during aman season at drought prone areas of BINA Sub-station, Ishurdi and Chapai Nawabgonj. The objective was to evaluate the yield performances of mutant lines as affected by different dates of transplanting. Three dates of transplanting were July 20, July 30 and August 13. The advanced mutants lines were N_4/350/P-4(5), N_{10}/350/P-5-4, and the check variety were Binadhan-17. Twenty five days old seedlings were transplanted in a randomized complete block design with three replications. The unit plot size was 3 m×4 m. Data on yield and yield components were recorded at harvest and analyzed statistically following the design used for the experiment and the means were compared with LSD. The results are discussed below separately.

The effect of dates of transplanting on grain yield of August 13 transplanting was the highest (5.10 t ha^{-1}) whereas July 30 transplanting produced the lowest grain yields (4.24 t ha^{-1}) (Table 04). Among the mutant lines/varieties, Binadhan-17 produced the highest grain yield (4.94 t ha^{-1}) followed by N_4/350/P-4(5) (4.57 t ha^{-1}). The interaction effect of date and variety showed that Binadhan-17 produced the maximum yield (5.56 t ha^{-1}) at Aug. 13 followed by N_4/350/P-4(5) (4.92 t ha^{-1}). The interaction effect of date and location transplanting date at Aug. 13 produced the maximum yield (5.23 t ha^{-1}) in Ishurdi which followed by transplanting at Aug. 13 produced (4.96 t ha^{-1}) in Chapai Nawabgonj. The interaction effect of variety and location Binadhan-17 produced maximum yield (5.06 t ha^{-1}) in Ishurdi followed by Binadhan-17 in Chapai Nawabgonj (4.82 t ha^{-1}). The interaction effect of date, variety and location transplanting date at Aug. 13, Binadhan-17 produced maximum yield (5.70 t ha^{-1}) in Ishurdi followed by transplanting date Aug. 13, Binadhan-17 in Chapai Nawabgonj (5.43 t ha^{-1}). The data recorded on crop duration from transplanting to maturity revealed that the advanced mutant line N_4/350/P-4(5) required the least average 108 days and the Binadhan-17 required maximum average 119 days. (Table 04).

Table 04. Mean of agronomic characters of Nerica rice mutants/varieties as affected by date of transplanting in aman season at drought prone areas

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. 20 (D_1)	98.9	14.1	12.1	23.9	111.3	16.5	21.3	4.68	6.64	
July. 30 (D_2)	102.3	11.7	10.9	23.4	130.3	13.5	21.5	4.24	5.91	
Aug. 13 (D_3)	103.1	11.2	10.3	23.5	131.4	13.5	22.1	5.10	5.87	
$LSD_{0.05}$	**NS**	**NS**	**1.0**	**NS**	**8.2**	**4.2**	**0.7**	**0.63**	**0.77**	
Mutants/Variety										
N_4/350/P-4(5) (V_1)	100.9	12.9	11.6	23.3	114.6	13.5	22.8	4.57	6.20	108
N_{10}/350/P-5-4 (V_2)	98.8	12.2	11.0	23.4	107.6	15.4	21.2	4.51	5.86	109
Binadhan-17 (V_3)	104.6	11.8	10.7	24.0	150.8	14.5	21.0	4.94	6.35	119
$LSD_{0.05}$	**NS**	**NS**	**0.8**	**NS**	**5.6**	**4.2**	**NS**	**0.31**	**0.31**	**-**
Location										

Ishurdi (L_1)	101.3	12.8	11.7	24.1	124.2	14.0	21.5	4.79	6.23
Chapai Nawabgonj(L_2)	101.6	11.9	10.5	23.1	124.5	15.0	21.8	4.56	6.05
Level of sig.	**NS**	*****	*****	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Dates ×Variety									
D_1V_1	96.6	15.6	13.4	23.7	99.8	16.7	22.0	4.39	6.51
D_1V_2	95.3	14.7	12.4	23.3	101.4	16.9	21.4	4.59	6.40
D_1V_3	104.7	11.9	10.6	24.7	132.7	15.9	20.7	4.87	7.00
D_2V_1	102.0	11.8	11.2	23.3	114.5	11.9	22.3	4.41	5.78
D_2V_2	100.8	11.3	10.5	23.3	108.7	14.3	21.2	4.12	5.85
D_2V_3	104.2	11.9	11.0	23.7	167.7	14.2	20.9	4.19	5.98
D_3V_1	104.2	11.3	10.2	23.1	129.5	12.0	24.0	4.92	6.32
D_3V_2	100.3	10.7	10.1	23.7	112.7	15.0	21.3	4.80	5.34
D_3V_3	104.8	11.6	10.5	23.7	152.2	13.4	21.0	5.56	6.08
$LSD_{0.05}$	**NS**	**NS**	**1.3**	**NS**	**9.8**	**7.2**	**0.8**	**0.54**	**0.53**
Dates × Location									
D_1L_1	98.0	15.0	13.0	24.5	110.2	16.3	21.0	4.79	6.74
D_1L_2	99.8	13.2	11.2	23.3	112.4	16.7	21.7	4.57	6.54
D_2L_1	102.3	12.0	11.6	23.8	130.2	12.9	21.2	4.35	5.96
D_2L_2	102.3	11.3	10.2	23.0	130.4	14.0	21.7	4.14	5.78
D_3L_1	103.4	11.3	10.5	24.0	132.3	12.8	22.2	5.23	6.00
D_3L_2	102.8	11.1	10.1	23.0	130.6	14.2	22.1	4.96	5.82
$LSD_{0.05}$	**NS**	**NS**	**0.7**	**NS**	**4.8**	**NS**	**NS**	**0.29**	**NS**
Variety × Location									
V_1L_1	101.9	13.4	12.3	23.7	112.9	13.2	22.7	4.69	6.30
V_1L_2	100.0	12.4	10.9	23.0	116.3	13.9	22.8	4.46	6.11
V_2L_1	96.4	12.6	11.6	23.8	106.6	14.6	21.1	4.62	5.95
V_2L_2	101.2	11.8	10.4	23.1	108.6	16.2	21.4	4.39	5.77
V_3L_1	105.4	12.2	11.3	24.8	153.2	14.3	20.6	5.06	6.45
V_3L_2	103.7	11.4	10.1	23.2	148.4	14.7	21.3	4.82	6.26
$LSD_{0.05}$	**NS**	**NS**	**0.7**	**NS**	**4.8**	**1.8**	**NS**	**0.29**	**NS**
Dates × Variety × Location									
$D_1V_1 L_1$	94.4	17.3	14.9	24.0	98.0	16.7	21.8	4.50	6.61
$D_1V_1L_2$	98.9	13.9	11.9	23.3	101.7	16.7	22.1	4.28	6.41
$D_1V_2 L_1$	93.0	15.5	13.3	23.7	101.4	16.4	21.1	4.70	6.50
$D_1V_2L_2$	97.7	13.9	11.4	23.0	101.4	17.4	21.7	4.98	6.31
$D_1V_3 L_1$	106.7	12.1	10.9	25.7	131.3	15.9	20.2	4.88	7.10
$D_1V_3L_2$	102.7	11.8	10.3	23.7	134.0	15.9	21.2	4.85	6.89
$D_2V_1 L_1$	103.7	11.8	11.6	23.3	110.0	11.5	22.1	4.52	5.86
$D_2V_1L_2$	100.3	11.8	10.7	23.2	119.0	12.2	22.5	4.30	5.69
$D_2V_2 L_1$	99.0	11.6	11.4	23.7	107.1	14.0	20.9	4.23	5.94
$D_2V_2L_2$	102.7	11.0	9.7	22.9	110.3	14.7	21.0	4.02	5.76
$D_2V_3 L_1$	104.3	12.6	11.9	24.3	173.3	13.2	20.7	4.29	6.07
$D_2V_3L_2$	104.0	11.3	10.1	23.0	162.0	15.2	21.7	4.09	5.89
$D_3V_1 L_1$	107.7	11.2	10.3	23.7	130.7	11.2	24.3	4.92	6.41
$D_3V_1L_2$	100.7	11.5	10.1	22.5	128.3	12.9	23.7	4.79	6.22
$D_3V_2 L_1$	97.3	10.8	10.2	24.0	111.3	13.3	21.2	4.94	5.42
$D_3V_2L_2$	103.3	10.7	10.1	23.3	114.0	16.7	21.5	4.66	5.25
$D_3V_3 L_1$	105.3	12.0	11.1	24.3	155.0	13.7	21.0	5.70	6.18
$D_3V_3L_2$	104.3	11.3	10.0	23.0	149.3	13.1	21.0	4.93	5.99
$LSD_{0.05}$	**NS**	**NS**	**1.3**	**NS**	**8.2**	**NS**	**NS**	**0.50**	**NS**
CV%	**4.8**	**5.4**	**6.7**	**2.5**	**6.2**	**12.7**	**3.3**	**9.13**	**13.52**

Effect of spacing on yield and yield contributing characters of Kasalath rice mutants/variety in Aman season BINA Sub-station Ishurdi, Rangpur and BINA HQ Mymensingh

Two advanced mutant lines were evaluated compared with one check variety with three spacing during aman season at BINA Sub-station, Ishurdi, Rangpur and BINA HQ Mymensingh. The objective was to evaluate the yield performances of mutant lines as affected by different levels of spacing. Three levels of spacing were 20 cm×15 cm, 20 cm×20 cm and 20 cm×25 cm. The advanced mutant lines were RU-Kas-60(C)-1, RU-Kas-80(C)-1 and the check variety BRRI dhan49. Twenty five days old seedlings were transplanted in a randomized complete block design with three replications. The unit plot size was 3 m×4 m. Data on yield and yield components were recorded at harvest and analyzed statistically following the design used for the experiment and the means were judged by LSD. The results are discussed below separately.

The grain yield of 20 cm×15 cm spacing was the highest (4.8 t ha^{-1}) whereas 20 cm×25 cm spacing produced the lowest grain yields (4.3 t ha^{-1}) (Table 05). Among the mutant lines/varieties, RU-Kas-60(C)-1 produced the highest grain yield (4.7 t ha^{-1}) followed by RU-Kas-60(C)-1 and BRRI dhan49. The effect of spacing on grain yield 20 cm×15 cm was the highest (4.8 t ha^{-1}) whereas July 30 transplanting produced the lowest grain yields (4.24 t ha^{-1}) (Table 05). Among the mutant lines/varieties, Binadhan-17 produced the highest grain yield (4.94 t ha^{-1}) followed by N_4/350/P-4(5) (4.57 t ha^{-1}). The interaction effect of date and variety showed that Binadhan-17 produced the maximum yield (5.56 t ha^{-1}) transplanting at Aug. 13 followed by N_4/350/P-4(5) (4.92 t ha^{-1}). The interaction effect of date and location showed that transplanting in Aug. 13 produced the maximum yield (5.23 t ha^{-1}) at Ishurdi. Among different mutants of kasalath, the mutant line RU-Kas-60(C)-1 produced the highest grain yield (4.9 t ha^{-1}) at 20 cm×15 cm spacing at Ishurdi followed by RU-Kas-80(C)-1 at 20 cm×15 cm spacing (4.7 t ha^{-1}) at Ishurdi. The data recorded on crop duration from transplanting to maturity revealed that BRRI dhan49 required the least average 113 days and the advanced mutant line RU-Kas-60(C)-1 required maximum average 121 days (Table 05). Mean of agronomic characters of kasalath mutants as affected by row spacing in aman season.

Table 05. Effect of different row spacing on the yield and yield contributing characters of Kasalath rice mutants/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
Spacing										
20cm×15cm (S_1)	107.5	10.4	9.6	25.1	112.6	7.7	22.5	4.8	5.8	
20cm×20cm (S_2)	106.3	9.7	9.0	25.0	111.4	7.7	22.5	4.5	5.8	
20cm×25cm (S_3)	101.5	10.5	9.8	21.9	118.7	7.0	22.3	4.3	5.5	
$LSD_{0.05}$	**1.5**	**0.3**	**0.3**	**NS**	**NS**	**NS**	**NS**	**0.2**	**NS**	
Mutants/Varieties										
RU-Kas-60(C)-1	109.0	9.6	8.9	23.0	117.8	7.6	22.4	4.7	5.8	121
RU-Kas-80(C)-1	104.6	11.5	10.7	25.1	110.5	9.0	22.5	4.5	5.4	120
BRRIdhan-49	101.6	9.6	8.8	23.9	114.4	5.8	22.4	4.4	5.9	113

$LSD_{0.05}$	**NS**	**NS**	**0.8**	**1.1**	**NS**	**NS**	**NS**	**NS**	**NS**
Locations									
Ishurdi (L_1)	104.7	9.6	8.9	23.9	114.8	7.6	22.5	4.7	6.0
Rangpur(L_2)	104.3	10.4	9.6	24.2	114.6	7.1	22.4	4.6	5.8
Mymensingh(L_3)	106.2	10.7	9.9	23.9	113.3	7.7	22.3	4.4	5.3
$LSD_{0.05}$	**3.8**	**0.3**	**0.3**	**0.5**	**3.3**	**NS**	**NS**	**NS**	**NS**
Variety × Spacing									
V_1S_1	106.6	9.9	9.1	25.3	114.3	8.4	22.7	4.8	6.2
V_1S_2	106.9	10.7	9.7	25.1	112.8	7.7	22.2	4.7	5.9
V_1S_3	109.0	10.6	10.0	25.0	110.6	7.1	22.7	4.4	5.4
V_2S_1	106.7	9.0	8.4	24.6	111.0	7.1	22.7	4.7	6.1
V_2S_2	105.3	9.9	9.1	25.6	113.0	8.3	22.4	4.6	5.9
V_2S_3	106.8	10.1	9.4	24.8	110.2	7.8	22.4	4.3	5.4
V_3S_1	100.9	9.8	9.1	21.8	119.3	7.5	22.3	4.7	5.8
V_3S_2	100.7	10.6	10.0	22.1	117.9	5.4	22.6	4.6	5.5
V_3S_3	102.9	11.2	10.4	21.7	119.0	8.1	22.0	4.3	5.2
$LSD_{0.05}$	**NS**	**0.7**	**0.6**	**1.3**	**6.8**	**2.5**	**NS**	**0.1**	**0.3**
Variety × Location									
V_1L_1	110.4	9.9	9.1	24.1	115.4	7.6	22.5	4.8	6.0
V_1L_2	108.2	11.5	10.8	26.3	110.9	9.0	22.8	4.6	5.5
V_1L_3	103.8	9.9	8.9	25.0	111.4	6.6	22.2	4.5	6.0
V_2L_1	107.3	9.2	8.5	23.7	115.8	8.1	22.4	4.7	6.0
V_2L_2	108.1	10.6	9.8	26.4	106.4	9.1	22.7	4.4	5.6
V_2L_3	103.3	9.2	8.6	24.9	112.1	6.0	22.4	4.5	5.8
V_3L_1	109.2	9.6	9.0	21.1	122.2	7.1	22.2	4.6	5.6
V_3L_2	97.4	12.2	11.4	22.6	114.2	9.0	21.9	4.5	5.2
V_3L_3	97.8	9.7	9.0	22.0	119.6	4.8	22.7	4.4	5.7
$LSD_{0.05}$	**6.7**	**0.5**	**0.6**	**0.9**	**5.8**	**1.4**	**NS**	**0.1**	**0.2**
Spacing×Location									
S_1L_1	108.0	8.7	8.2	22.9	123.6	7.5	22.6	4.9	6.2
S_1L_2	104.1	11.3	10.5	24.8	109.7	8.5	22.7	4.4	5.7
S_1L_3	102.0	8.7	8.0	24.0	111.2	6.9	22.3	4.7	6.2
S_2L_1	107.8	9.7	9.0	23.1	116.3	7.1	22.	4.7	5.9

							4		
S_2L_2	103.4	11.8	10.9	25.4	112.4	8.6	22.3	4.7	5.5
S_2L_3	101.7	9.7	8.9	24.2	114.9	5.7	22.4	4.5	5.9
S_3L_1	111.2	10.3	9.5	22.9	113.5	8.1	22.2	4.5	5.4
S_3L_2	106.2	11.3	10.6	25.0	109.3	10.0	22.3	4.4	5.2
S_3L_3	101.2	10.3	9.6	23.6	116.9	4.8	22.6	4.2	5.4
$LSD_{0.05}$	**NS**	**0.6**	**0.5**	**0.8**	**4.8**	**1.4**	**NS**	**0.2**	**0.2**
Variety×Spacing×Location									
$V_1S_1L_1$	108.0	9.1	8.6	24.3	122.3	7.9	22.6	4.9	6.3
$V_1S_1L_2$	108.0	11.5	10.6	26.2	113.3	9.3	23.3	4.6	5.7
$V_1S_1L_3$	103.7	9.1	8.2	25.3	107.4	7.9	22.1	4.8	6.5
$V_1S_2L_1$	108.7	10.3	9.2	23.7	114.5	7.2	22.1	4.8	6.1
$V_1S_2L_2$	107.7	11.9	11.1	26.7	113.3	9.7	22.2	4.8	5.6
$V_1S_2L_3$	104.3	10.0	9.0	25.0	110.5	6.1	22.2	4.5	6.1
$V_1S_3L_1$	114.7	10.3	9.5	24.3	109.5	7.7	22.6	4.6	5.5
$V_1S_3L_2$	109.0	11.1	10.7	26.0	106.0	8.0	23.0	4.3	5.2
$V_1S_3L_3$	103.3	10.5	9.6	24.7	116.3	5.7	22.4	4.3	5.5
$V_2S_1L_1$	109.3	8.3	7.7	23.0	121.1	7.1	22.7	4.7	6.4
$V_2S_1L_2$	106.3	10.5	9.6	25.8	103.7	7.1	22.9	4.3	5.9
$V_2S_1L_3$	104.3	8.3	7.9	24.9	108.1	7.1	22.4	4.6	6.1
$V_2S_2L_1$	105.7	9.1	8.5	24.3	114.2	8.1	22.5	4.5	6.0
$V_2S_2L_2$	107.3	11.1	10.2	27.0	112.3	9.8	22.5	4.6	5.6
$V_2S_2L_3$	103.0	9.4	8.5	25.3	112.7	7.0	22.3	4.5	6.0
$V_2S_3L_1$	107.0	10.1	9.4	23.7	112.0	9.0	22.1	4.5	5.5
$V_2S_3L_2$	110.7	10.3	9.5	26.4	103.2	10.3	22.6	4.4	5.3
$V_2S_3L_3$	102.7	10.0	9.4	24.4	115.5	4.0	22.4	4.2	5.4
$V_3S_1L_1$	106.7	8.6	8.2	21.3	127.4	7.5	22.4	4.7	5.8
$V_3S_1L_2$	98.0	11.9	11.2	22.3	112.3	9.2	22.0	4.5	5.4
$V_3S_1L_3$	98.0	8.8	7.9	21.9	118.2	5.7	22.4	4.6	6.1
$V_3S_2L_1$	109.0	9.8	9.2	21.3	120.3	6.1	22.6	4.6	5.6
$V_3S_2L_2$	95.3	12.3	11.5	22.7	111.7	6.1	22.	4.7	5.3

							3		
$V_3S_2L_3$	97.7	9.8	9.2	22.2	121.6	4.0	22.8	4.4	5.7
$V_3S_3L_1$	112.0	10.5	9.7	20.7	119.1	7.7	21.7	4.4	5.2
$V_3S_3L_2$	99.0	12.5	11.7	22.7	118.7	11.7	21.3	4.4	5.0
$V_3S_3L_3$	97.7	10.5	9.8	21.8	119.1	4.7	22.9	4.2	5.3
$LSD_{0.05}$	**NS**	**1.2**	**NS**	**1.5**	**6.1**	**2.3**	**NS**	**0.2**	**0.4**
CV%	**6.7**	**6.3**	**6.7**	**3.9**	**5.3**	**19.2**	**2.8**	**3.1**	**4.3**

Determination of proper spacing for optimum growth and yield of Onion varieties in Rabi season at BINA sub-station Rangpur

Two varieties were evaluated compared with one check variety with three spacing during rabi season of 2017-18 at BINA Sub-station, Rangpur. The objective was to evaluate the yield performances of Binapiaz-1 and Binapiaz-2 as affected by different levels of spacing. Three levels of spacing were 10 cm × 10 cm, 20 cm × 10 cm and 20 cm×15 cm. The onion varieties were of Binapiaz-1, Binapiaz-2 and the check variety Taherpuri. Twenty five days old seedlings were transplanted in a split plot design with three replications. The unit plot size was 5 m × 4 m. Data on yield and yield components were recorded at harvest and analyzed statistically following the design used for the experiment and the means were compared with LSD. The results are discussed below separately.

Among the varieties, Binapiaz-1 produced the highest bulb yield (7.6 t ha^{-1}) followed by Binapiaz-2 (7.0 t ha^{-1}). The bulb yield of 10 cm ×10 cm spacing was the highest (9 t ha^{-1}) whereas 20 cm×10 cm spacing produced the lowest grain yields (4.3 t ha^{-1}). The interaction effect of variety, spacing showed that Binapiaz-1 produced the maximum yield (9.3 t ha^{-1}) at 10 cm ×10 cm spacing followed by Binapiaz-2 (8.7 t ha^{-1}). The data recorded on crop duration from sowing to maturity revealed that Taherpuri required the least average 103 days and the Binapiaz-1 required maximum average 112 days (Table 06).

Table 06. Determination of proper spacing for optimum growth and yield of Onion varieties in Rabi season at BINA sub-station Rangpur during 2017-18

Treatments	**Plant height (cm)**	**Leaf $plant^{-1}$ (no.)**	**Bulb diameter (mm)**	**Neck diameter (mm)**	**Leaf fresh weight ($g\ m^{-2}$)**	**Leaf dry weight ($g\ m^{-2}$)**	**Bulb fresh weight ($g\ m^{-2}$)**	**Bulb dry weight ($g\ m^{-2}$)**	**Bulb yield ($t\ ha^{-1}$)**	**Crop duration (days)**
Varieties										
Binapiaz-1 (V_1)	39.2	7.4	79.6	10.5	1849	462	956	765	7.6	112
Binapiaz-2 (V_2)	40.4	7.3	77.8	10.1	1864	466	870	696	7.0	110
Taherpuri (V_3)	41.4	6.9	77.0	10.5	1638	410	830	614	6.1	103
$LSD_{0.05}$	**NS**	**NS**	**3.0**	**NS**	**171**	**43**	**106**	**85**	**0.8**	**-**
Spacings										
10 cm×10 cm (S_1)	37.7	7.1	76.5	10.0	2933	733	1280	904	9.0	

20 cm×10 cm (S_2)	40.8	7.3	80.2	10.9	1419	355	744	595	6.0
20 cm×15 cm (S_3)	42.5	7.2	77.6	10.3	1000	250	532	426	4.3
$LSD_{0.05}$	**NS**	**NS**	**3.0**	**NS**	**171**	**43**	**106**	**85**	**0.8**
Variety× Spacing									
$V_1 S_1$	37.1	7.4	78.4	10.4	3200	800	1141	933	9.3
$V_1 S_2$	40.1	7.6	83.7	10.9	1379	345	780	624	6.2
$V_1 S_3$	40.5	7.3	76.7	10.3	970	242	547	437	4.4
$V_2 S_1$	37.6	7.2	76.0	9.4	3133	783	1344	1075	8.7
$V_2 S_2$	40.5	7.6	76.5	10.8	1397	349	708	566	5.7
$V_2 S_3$	43.2	7.2	80.9	10.2	1062	266	558	447	4.5
$V_3 S_1$	38.5	6.7	75.2	10.3	2467	617	1254	1003	8.0
$V_3 S_2$	41.9	6.9	80.5	11.0	1481	370	743	595	5.9
$V_3 S_3$	43.8	7.1	75.3	10.4	967	242	492	394	3.9
$LSD_{0.05}$	**NS**	**NS**	**5.2**	**NS**	**296**	**74**	**183**	**146**	**1.5**
CV (%)	**5.5**	**9.5**	**3.9**	**10.1**	**10**	**10**	**12**	**12**	**11.9**

Determination of proper spacing for optimum growth and yield of Onion varieties in Kharif-1 season at BINA sub-station Rangpur

Two varieties were evaluated with three spacing during Kharif-1 season at BINA Sub-station, Rangpur. The objective was to evaluate the yield performances of Onion varities as affected by different spacing. Four levels of spacing were 20 cm × 10 cm, 20 cm ×15 cm, 30 cm×10 cm and 30 cm×20 cm. The onion varieties were Binapiaz-1, Binapiaz-2. Twenty five days old seedlings were transplanted in a split plot design with three replications. The unit plot size was 5 m×4m. 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 the varieties, Binapiaz-1 produced the highest bulb yield (5.02 t ha^{-1}) followed by Binapiaz-2 (4.55 t ha^{-1}). The bulb yield of 20 cm ×10 cm spacing was the highest (6.93 t ha^{-1}) where as 20 cm×15 cm spacing produced the second highest bulb yields (4.96 t ha^{-1}). The interaction effect of variety and spacing showed that Binapiaz-1 produced the maximum yield (6.95 t ha^{-1}) at 20 cm×10 cm spacing followed by Binapiaz-2 (6.22 t ha^{-1}). The data recorded on crop duration from sowing to maturity revealed that Binapiaz-1 and Binapiaz-2, required maximum average 92 days (Table 07).

Table 07. Determination of proper spacing for optimum growth and yield of onion varieties in Kharif-1 season at BINA sub-station Rangpur during 2017-18

Treatments	Plant height (cm)	Leaf plant^{-1} (no.)	Bulb diameter (mm)	Neck diameter (mm)	Leaf fresh weight (g m^{-2})	Leaf dry weight (g m^{-2})	Bulb fresh weight (g m^{-2})	Bulb dry weight (g m^{-2})	Bulb yield (t ha^{-1})	Crop duration (days)
Variety										
Binapiaz-1(V_1)	33.3	6.3	39.4	6.1	946	247	553	501.5	5.02	92
Binapiaz-2 (V_2)	33.1	6.4	38.9	5.9	905	236	498	454.5	4.55	92
Level of sig.	**NS**	**NS**	**NS**	**NS**	*	*	*	*		-
Spacing										
20 cm×10 cm (S_1)	33.2	6.5	38.6	6.2	1416	354	775	693.3	6.93	
20 cm×15 cm	33.6	6.5	40.1	6.3	954	238	545	496.3	4.96	

(S_2)									
30 cm×10 cm (S_3)	33.3	6.2	39.4	6.0	942	258	529	486.7	4.87
30 cm×20 cm (S_4)	33.1	6.6	38.9	5.7	470	117	254	235.7	2.36
$LSD_{0.05}$	**NS**	**0.5**	**2.2**	**0.8**	**189**	**60**	**70**	**63.7**	**0.64**
Variety× Spacing									
V_1 S_1	31.6	6.4	39.2	6.5	1433	358	825	735.0	6.95
V_1 S_2	34.0	6.3	41.9	6.4	986	246	584	531.3	5.31
V_1 S_3	34.0	6.5	38.3	6.0	921	275	546	501.0	5.01
V_1 S_4	33.9	6.3	38.4	5.8	446	111	257	238.7	2.39
V_2 S_1	34.7	6.6	38.0	5.9	1400	350	725	651.7	6.22
V_2 S_2	33.2	6.6	38.2	6.1	922	230	505	461.3	4.61
V_2 S_3	32.5	5.9	40.4	6.0	963	241	512	472.3	4.72
V_2 S_4	32.2	6.9	39.3	5.6	494	123	251	232.7	2.33
$LSD_{0.05}$	**NS**	**0.8**	**3.1**	**1.1**	**268**	**85**	**99**	**90.1**	**0.90**
CV (%)	**5.9**	**6.8**	**4.6**	**10.2**	**16**	**20**	**10**	**10.8**	**10.76**

Improving the yield of boro rice through furrow transplanting method and application of gypsum under salinity condition

The experiment was conducted at Farmer's field of Binarpota Satkhira, Bangladesh during boro season, 2017-18. The objective was to find out the suitable management of transplanting arrangement for productivity improvement of rice under natural salinity condition. The experiment was laid out in a split-split plot design with three replications. The unit plot size was 5 m × 4 m. Thirty five days old seedlings were transplanted 2/3 seedlings hill^{-1}. Binadhan-10 was evaluated under thru transplanting methods i.e., M_0: Control (No Slope/flat land), M_1: Ridge and furrow (each furrow 30 cm wide accommodating 3 lines transplanting), M_2: ridge and furrow (each furrow 60 cm wide accommodating 5 lines transplanting). Four rates of gypsum i.e., gypsum 0 kg ha^{-1}(G_0), 75 kg ha^{-1} (G_1), 150 kg ha^{-1} as basal (G_2) and 150 kg ha^{-1} (75 kg ha^{-1} as basal + 75 kg ha^{-1} at 42 DAT (G_3). The recorded data were analyzed using the Analysis of Variance Technique. The mean differences were resort by LSD Test.

Transplanting method had significant effect on most of the plant parameters (Table 08). The highest grain yield (6.6 t ha^{-1}) was produced in ridge and furrow (each furrow 30 cm wide accommodating 3 lines transplanting) and lowest yield (5.8 tha^{-1}) in control (flat land) method. In case of gypsum rates, 150 kg ha^{-1} (75 kg ha^{-1} as basal + 75 kg ha^{-1} at 42 DAT (G_3) gypsum produced the highest grain yield (7.3 t ha^{-1}) followed by 150 kg ha^{-1} gypsum application as basal (7.0 t ha^{-1}). The plant height, number of total tillers hill^{-1}, panicle length, number of filled grains panicle^{-1} and thousand grain weight were higher in the 150 kg ha^{-1} (75 kg ha^{-1} as basal +75 kg ha^{-1} at 42 DAT (G_3) application of gypsum than basal 150 kg ha^{-1} application of gypsum. Interaction between transplanting method and gypsum application showed that the highest grain yield in ridge & furrow (each furrow 30 cm wide accommodating 3 lines transplanting) method with 150 kg ha^{-1} gypsum (75kg ha^{-1} as basal +75 kg ha^{-1} at 42 DAT) (7.7 t ha^{-1}) followed by ridge & furrow (each furrow 60 cm wide accommodating 5 lines transplanting) 150 kg ha^{-1} gypsum application as basal (7.4 t ha^{-1}) (Table 08).

Table 08. Yield and yield contributing characters as affected by transplanting method, rates of gypsum application in boro season during 2017-18 at Farmer's field of Binarpota, Satkhira

Treatments	Plant height (cm)	Total tillers hill^{-1} (no)	Effective tillers hill^{-1} (no)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains Panicle^{-1} (no.)	1000 Seed wt. (g.)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
Transplanting method									
Control (Flat land) (M_1)	102.3	12.8	12.0	26.0	132.8	5.3	24.2	5.8	9.3
Ridge & Furrow 30cm (M_2)	100.9	13.0	12.0	26.8	137.6	4.9	24.2	6.6	9.8
Ridge & Furrow 60cm (M_3)	101.3	12.6	11.9	25.9	134.9	6.1	24.4	6.4	9.1
$LSD_{0.05}$	**NS**	**NS**	**NS**	**1.8**	**17.0**	**NS**	**1.4**	**0.4**	**0.9**
Level of Gypsum									
0 kg gypsum ha^{-1} (G_0)	102.4	13.3	12.5	26.2	132.2	6.0	24.4	5.4	8.5
75kg gypsum ha^{-1} (G_1)	102.1	12.7	12.0	26.3	136.7	5.1	23.8	6.2	9.2
150 kg gypsum ha^{-1} (G_2) (basal)	100.7	12.4	11.4	26.2	138.8	5.3	24.5	7.0	9.8
150 kg gypsum ha^{-1} (G_3) (75 kg basal + 75 kg 42 DAT)	100.8	12.8	11.9	26.3	132.7	5.3	24.4	7.3	10.2
$LSD_{0.05}$	**NS**	**NS**	**1.0**	**0.9**	**19.5**	**NS**	**1.5**	**0.7**	**1.0**
Method × Rates of Gypsum									
M_1G_0	104.2	12.5	11.8	25.8	145.2	3.7	25.2	5.3	8.0
M_1G_1	102.2	11.9	11.4	25.9	132.1	5.4	24.9	6.3	9.1
M_1G_2	99.5	12.8	11.9	25.9	129.2	4.3	24.9	6.7	9.1
M_1G_3	103.5	13.9	13.0	26.6	124.8	7.9	24.9	6.8	10.8
M_2G_0	100.6	14.1	13.2	26.9	117.9	6.7	24.4	5.3	8.3
M_2G_1	102.1	12.2	11.3	27.8	138.1	3.9	24.3	6.0	9.3
M_2G_2	101.2	13.2	11.8	26.3	146.4	4.4	24.3	7.2	10.8
M_2G_3	99.8	12.5	11.6	26.1	148.1	4.4	24.2	7.7	10.7
M_3G_0	102.4	13.4	12.6	25.8	133.7	7.7	23.8	5.7	9.0
M_3G_1	102.0	13.9	13.2	25.4	139.9	5.9	23.6	6.3	9.1
M_3G_2	101.6	11.0	10.5	26.4	140.7	7.3	23.3	6.9	9.3
M_3G_3	99.0	12.0	11.2	26.1	125.1	3.5	23.3	7.4	9.0
$LSD_{0.05}$	**NS**	**1.8**	**NS**	**1.5**	**33.7**	**NS**	**2.5**	**1.2**	**1.7**
CV%	**7.2**	**8.0**	**8.7**	**6.4**	**14.6**	**11.5**	**6.1**	**10.6**	**10.8**

Effect of different herbicides on weed infestation and yield in Boro rice

A field experiment was conducted at the Agronomy field Laboratory of the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh under wet land condition during January to May 2018. Eleven selected herbicides i,e; H_0 =Control, H_1 = Two hand weeding (30 days after transplanting and 45 days after transplanting), H_2 = Bensulfuran methyl + Acetachlor, H_3 = 2-4, D amine, H_4 = Pretilachlor, H_5= Bispyriback-sodium, H_6= Pyrazosulfuran ethyl, H_7= Triafemon, H_8= Pendimethyline, H_9 = Metsulfuran methyl, H_{10} = Butachlor, H_{11}= Penoxulum, H_{12} = Pyrazosulfuran ethyl + Pretilachlor. The aim was to see 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. In case of manual weeding treatment, it was included 2 weeding at 30 and 45 DAT, respectively whereas in weed free treatment weeding was done by hand when they were found. The size of the individual plot was 4 m x 3 m. Treatments were assigned in unit plots at random. Weed density was collected from each plot at vegetative stage of rice by using 0.5m x 0.5m quadrate. The weeds within the quadrate were counted species wise and converted to number m^{-2} multiplying by four. After counting the weed density the weeds inside each quadrate were uprooted, cleaned and separated in species wise. After these dried first in the sun and then in an electric oven for 72 hours at a temperature of 80^0C. The dry weight of each species was taken with an electric balance and expressed in g m^{-2}. Data on crop yield were collected at proper maturity stages of the crop. All the recorded data were compiled and analyzed using M-STAT program of computer and the means were judged by LSD.

Table 09. Particulars of weed species in the weeded plots of the experiment at vegetative growth

Sl. no.	Local name	Scientific name	Family	Morphological type	Life cycle
1.	Shama	*Echinochloa colomum*	Gramineae	Grass	Annual
2.	Gaicha	*Paspalum distichum*	Gramineae	Grass	Perennial
3.	Panikachu	*Monochoria vaginalis*	Pontederiaceae	Broad-leaved	Perennial
4.	Arail	*Leersia hexandra L.*	Gramineae	Grass	Annual
5.	Chechra	*Scirpus mucronatusL.*	Cyperaceae	Sedge	Perennial
6.	Zhilmorich	*Sphenoclea zeylanica*	Sphenocleaceae	Broad-leaved	Annual
7.	Shushnishak	*Marsilea quadrifolia*	Marsileaceae	Sedge	Annual
8.	Holdemutha	*Cyperus difformis.*	Cyperaceae	Sedge	Annual
9.	Khude Shama	*Echinochloa colona*	Gramineae	Grass	Annual
10.	Keshuti	*Eclipta alba*	Asteraceae	Sedge	Annual
11.	Baro chucha	*Cyperus iria*	Cyperaceae	Sedge	Perennial
12.	Chechra	*Scirpus maritimus*	Cyperaceae	Sedge	Annual

Twelve weed species belongs to six families namely Gramineae, Pontederiaceae, Cyperaceae, Asteraceae, Marsileaceae and Sphenocleaceae were found to grow in the experimental plots (Table 09). Among them two were broad- leaved, four were grasses and five were sedges. It was found that the density and dry weight of weeds varied considerably in different weed control treatments (Table 10). The highest weed species density was found in the weedy check treatment, showing the highest weed species density value 8 m^{-2} and the lowest weed density value 2 m^{-2} was found in the treatment with the recommended dose of Penoxulum (Table 10). The highest weed density was found in the weedy check treatment, showing the highest weed density value 35.7 m^{-2} and the lowest weed density value 7.8 m^{-2} was found in the treatment with the recommended dose of Triafemon (Table 10). The weed management practices at vegetative stage had a significant effect on the total fresh and dry weight (m^{-2}). The highest weed fresh weight 124.9 g m^{-2} was observed in control treatment and the lowest weed fresh weight 38.9 g m^{-2} was observed with Penoxulum (Table 10). The highest weed dry weight was found in the weedy check condition, showing the highest weed dry weight values of (54.5 gm^{-2}) and the lowest (15.4gm^{-2}) was found in the condition of the recommended dose of Metsulfuran methyl treatment (Table 10).

Table 10. Effect of herbicide on weed species, weed density, fresh and dry weight at vegetative stage

Treatment	Species (no. m^{-2})	Density (no. m^{-2})	Fresh wt. (g m^{-2})	Dry wt. (g m^{-2})
H_0 =Control	8.0	35.7	124.9	54.5
H_1 = Two hand weeding	3.0	14.3	46.6	21.8
H_2 = Bensulfuran methyl + Acetachlor	2.7	12.2	49.0	21.9
H_3 = 2-4, D amine	2.3	12.8	41.0	17.8
H_4 = Pretilachlor	3.7	12.2	46.4	20.3
H_5 = Bispyriback-sodium	4.7	17.3	69.1	31.2
H_6 = Pyrazosulfuran ethyl	2.3	11.2	50.2	22.4
H_7 = Triafemon	4.0	7.8	54.0	24.3
H_8 = Pendimethyline	2.7	13.3	41.2	18.5
H_9 = Metsulfuran methyl	3.0	13.3	35.4	15.4
H_{10} = Butachlor	3.7	16.8	47.8	21.1
H_{11} = Penoxulum	2.0	11.2	38.9	17.0
H_{12} = Pyrazosulfuran ethyl + Pretilachlor	3.0	14.8	53.3	26.4
$LSD_{0.05}$	**3.2**	**15.0**	**26.2**	**12.9**
CV(%)	**8.6**	**10.6**	**9.0**	**11.8**

Among the different herbicide treatment highest grain yield (5.1 t ha^{-1}) was found with the treatment Triafemon followed by Pretilachlor (4.7 t ha^{-1}). The results suggest that Binadhan-14 variety could be grown with Triafemon followed by the treatments of Pretilachlor to maximize yield of Boro rice (Table 11).

Table 11. Effect of herbicide and weed management on the yield and yield contributing characters of Boro rice

Treatments	Plant height (cm)	Total tiller $plant^{-1}$ (no.)	Effective tillers $plant^{-1}$ (no.)	Panicle length (cm)	Filled grains $panicle^{-1}$ (no.)	Unfilled grains $panicle^{-1}$ (no.)	1000 seed wt. (g)	Grain yield (tha^{-1})	Straw yield (tha^{-1})
H_0	85.3	8.2	6.3	20.6	74.3	31.4	23.9	3.6	4.9
H_1	84.9	13.0	11.1	20.7	95.5	30.7	24.4	4.3	6.1
H_2	85.9	12.2	11.3	21.0	96.0	27.5	24.6	4.2	5.3
H_3	81.9	11.2	9.6	21.1	90.3	29.3	25.0	3.8	4.8
H_4	84.7	13.5	11.6	20.5	86.1	24.7	24.1	4.7	5.4
H_5	85.3	12.3	11.0	20.5	78.9	30.7	24.0	4.1	5.4
H_6	84.5	11.9	9.9	20.7	97.3	22.5	24.5	4.0	5.1
H_7	83.1	14.5	13.3	21.1	83.7	38.7	24.7	5.1	5.6
H_8	82.9	10.9	9.7	19.9	91.3	33.7	24.0	3.7	4.8
H_9	71.6	10.5	7.6	16.3	61.3	21.1	23.1	4.1	4.9
H_{10}	84.7	13.1	11.7	20.3	86.4	29.0	24.4	3.8	4.8
H_{11}	85.0	12.9	11.7	20.2	94.3	22.3	24.2	3.6	4.7
H_{12}	82.5	11.3	10.3	20.7	89.7	34.3	24.4	4.5	6.1
$LSD_{0.05}$	**9.1**	**3.1**	**2.6**	**NS**	**12.5**	**NS**	**NS**	**1.2**	**0.9**
CV(%)	**6.5**	**15.0**	**14.6**	**3.3**	**8.4**	**10.8**	**2.4**	**10.9**	**10.2**

Effect of high temperature on the productivity of T. aman rice variety in growth chamber under ambient atmospheric condition, ambient atmospheric condition + 5^0C at flowering stage

A pot experiment was conducted with four BINA developed aman rice varieties i.e. Binadhan-7, Binadhan-11, Binadhan-17 and Binashail in a plant growth chamber at Bangladesh Institute of Nuclear Agriculture (BINA) to assess the effect of high temperature on the yield and yield attributes. Two treatments were: T_1 (ambient atmospheric condition) and T_2 (ambient atmospheric condition + 5^0C) for 7 days and then plants were allowed to grow at ambient temperature up to maturity. Each pot contains 8 kg of soils. Two seedlings was transplanted in a pot. The experiment was laid out in a Completely Randomized Design where each treatment was replicated four times. Recommended doses of fertilizers were applied and cultural practices were done whenever required. Data on yield and yield attributes were recorded at maturity. Results revealed that Binadhan-17 produce higher yield (44.8 g hill $^{-1}$) followed by Binadhan-11 (27.6 g hill^{-1}) (Table 12) due to highest number of filled grains panicle^{-1}. The interaction effect of variety and atmospheric condition Binadhan-17 produce higher yield both ambient atmospheric condition (46.8 g hill^{-1}) and ambient atmospheric condition + 5^0C (42.8 g hill $^{-1}$) (Table 12). The interaction effect of variety and atmospheric condition Binadhan-11 produce lower yield at ambient atmospheric condition + 5^0C (23.3 g hill $^{-1}$) which is followed by 23.6 (g hill^{-1}). (Table 12).

Table 12: Yield and yield attributes of aman rice varieties under ambient atmospheric condition, ambient atmospheric condition + 5^0C at flowering stage

Treatments	Plant height (cm)	Total tiller Pot^{-1} (no)	Effective tiller Pot^{-1} (no)	Panicle length (cm)	Filled grain panicle^{-1} (no)	Unfilled grain panicle^{-1} (no)	1000 seed wt. (g)	Grain wt. (g) pot^{-1}	Straw wt. (g) pot^{-1}
Atmospheric condition									
Ambient atmospheric condition (T_1)	106.3	12.3	10.8	22.0	131.9	18.9	23.3	33.2	44.0
Ambient atmospheric condition + 5^0C (T_2)	106.7	11.9	10.7	22.0	120.1	29.7	22.5	28.7	38.0
Level of significance	**NS**	**NS**	**NS**	**NS**	*****	******	**NS**	*****	*****
Variety									
Binadhan-7 (V_1)	97.3	12.3	11.3	16.5	97.2	16.0	22.6	24.8	32.8
Binadhan-11 (V_2)	94.5	12.2	11.2	20.7	111.9	29.2	21.9	27.6	36.5
Binadhan-17 (V_3)	96.8	13.8	12.0	24.0	160.2	26.4	23.8	44.8	59.4
Binashail (V_4)	137.2	10.2	8.5	26.7	134.6	25.8	23.2	26.7	35.3
$LSD_{0.05}$	**NS**	**NS**	**NS**	**NS**	**25.6**	**6.0**	**NS**	**6.1**	**8.2**
Variety × Atmospheric condition									
V_1 T_1	98.0	11.7	10.7	16.3	100.9	8.7	22.7	24.5	32.4
V_1 T_2	96.7	13.0	12.0	16.6	93.5	23.3	22.4	25.1	33.3
V_2 T_1	95.3	13.0	12.0	20.6	118.5	25.6	22.4	31.9	42.2
V_2 T_2	93.7	11.3	10.3	20.8	105.3	32.7	21.4	23.3	30.9
V_3 T_1	97.7	14.0	11.7	24.0	168.3	20.9	24.3	46.8	62.2
V_3 T_2	96.0	13.7	12.3	24.1	152.1	31.8	23.4	42.8	56.6
V_4 T_1	137.3	10.7	9.0	27.0	139.6	20.4	23.7	29.7	39.4
V_4 T_2	137.0	9.7	8.0	26.3	129.5	31.2	22.8	23.6	31.3
$LSD_{0.05}$	**NS**	**NS**	**NS**	**NS**	**16.4**	**19.9**	**NS**	**15.9**	**16.2**
CV(%)	**5.5**	**1.6**	**1.7**	**2.0**	**36.2**	**8.5**	**0.5**	**8.6**	**11.6**

Effect of high temperature on the productivity of boro rice variety in growth chamber under ambient atmospheric condition, ambient atmospheric condition + 5^0C at flowering stage

A pot experiment was conducted with four BINA developed aman rice varieties i.e. Binadhan-5, Binadhan-10, Binadhan-14 and Binadhan-19 in a plant growth chamber at Bangladesh Institute of Nuclear Agriculture (BINA) to assess the effect of high temperature on the yield and yield attributes. Two treatments were: T_1 (ambient atmospheric condition) and T_2 (ambient atmospheric condition + 5^0C) for 7 days and then plants were allowed to grow at ambient temperature up to maturity. Each pot contains 8 kg of soils. Two seedlings were transplanted in a pot. The experiment was laid out in a Completely Randomized Design where each treatment was replicated four times. Recommended doses of fertilizers were applied and cultural practices were done whenever required. Data on yield and yield attributes were recorded at maturity. Results revealed that Binadhan-14 produce higher yield (45.7 g hill $^{-1}$) followed by Binadhan-10 (37.0 g hill^{-1}) due to highest number of filled grains panicle^{-1} (Table 13). The interaction effect of variety and atmospheric condition Binadhan-14 produce higher yield in both ambient atmospheric condition (48.2 g hill $^{-1}$) and ambient atmospheric condition + 5^0C (46.2 g hill $^{-1}$) (Table 13). The interaction effect of variety and atmospheric condition Binashail produce lower yield at ambient atmospheric condition + 5^0C (23.9 g hill^{-1}) (Table 13).

Table 13: Yield and yield attributes of boro rice varieties under ambient atmospheric condition, ambient atmospheric condition + 5^0C at flowering stage

Treatments	Plant height (cm)	Total tillers pot^{-1} (no)	Effective tillers pot^{-1} (no)	Panicle length (cm)	Filled grains panicle^{-1} (no)	Unfilled grains panicle^{-1} (no)	1000 seed wt. (g)	Grain wt. (g) pot^{-1}	Straw wt. (g) pot^{-1}
Atmospheric condition									
Ambient atmospheric condition(T_1)	105.8	14.8	13.5	24.6	123.3	13.1	23.8	36.9	54.6
Ambient atmospheric condition + 5^0C(T_2)	106.0	15.1	13.9	24.9	109.9	25.7	23.3	33.1	49.4
Level of significance	**NS**	**NS**	**NS**	**NS**	*****	******	**NS**	**NS**	*****
Variety									
Binadhan-5 (V_1)	106.3	12.0	9.2	25.6	134.2	23.7	22.7	33.0	58.8
Binadhan-10 (V_2)	107.5	11.8	10.0	25.0	131.2	21.8	23.9	37.0	64.3
Binadhan-14 (V_3)	102.2	17.5	14.0	22.6	103.9	15.7	24.4	45.7	48.9
Binadhan-19 (V_4)	107.5	10.5	8.7	25.8	97.1	16.4	23.2	26.2	35.9
$LSD_{0.05}$	**NS**	**NS**	**NS**	**NS**	**8.6**	**4.0**	**NS**	**4.8**	**NS**
Variety × Atmospheric condition									
$V_1 T_1$	107.0	12.0	9.3	25.6	142.9	14.5	22.7	34.2	59.0
$V_1 T_2$	105.7	11.0	10.0	25.5	125.5	32.9	22.8	32.9	58.6
$V_2 T_1$	107.3	11.3	10.3	25.0	141.3	11.8	24.5	39.6	67.8
$V_2 T_2$	107.7	11.3	9.7	25.0	121.0	31.7	23.3	34.4	60.7
$V_3 T_1$	100.3	16.0	14.3	23.0	107.0	13.6	24.9	48.2	52.3
$V_3 T_2$	104.0	15.0	13.7	22.2	100.8	17.8	24.0	46.2	45.5
$V_4 T_1$	108.3	9.0	8.0	24.8	102.1	12.7	23.4	28.5	39.0
$V_4 T_2$	106.7	10.0	8.3	26.8	92.2	20.2	23.0	23.9	32.7
$LSD_{0.05}$	**NS**	**NS**	**NS**	**NS**	**6.0**	**16.5**	**NS**	**3.7**	**NS**
CV(%)	**107.0**	**14.0**	**13.3**	**25.6**	**142.9**	**14.5**	**22.7**	**43.2**	**59.0**

Adaptive Research and Extension Division

Research Highlights

During 2017-18 a total of 385 adaptive trials/block farming with BINA developed different crop varieties were conducted at the farmers' field in collaboration with the Department of Agriculture Extension (DAE) and in-charge of different BINA sub-stations.

In block farming with submergence tolerant rice variety Binadhan-11 produced average grain yield 4.28 t ha^{-1}, which was 5.96% higher than the popular and other submergence tolerant cultivar. Flash flood prone areas of Bangladesh are suitable for massive extension of Binadhan-11. Block farming with salt tolerant Binadhan-10 produced average grain yield of 5.61 t ha^{-1} and matured in 136 days, Farmers were found very much interested to cultivate Binadhan-10 due to its better performance in both saline and non saline soils. They also made request to BINA authority to conduct more demonstrations for farmers' motivation and their better understanding about the variety. Block farming with Binadhan-14 produced average grain yield of 4.78 t ha^{-1} and matured in 120 days, which was almost 20 days shorter duration than the check variety, BRRI dhan28. Popularity of Binadhan-14 is tremendously increasing due to its better grain yield, shorter duration and late transplanting capababilities, which facilitates rabi crop cultivation between aman and boro rice. Adopting this variety an additional rabi crop can be easily cultivated. Adaptive trials with early T. aman rice varieties Binadhan-7 and Binadhan-17 produced average seed yield 4.94 and 5.40 t $ha^{-1,}$ respectively. There were almost no difference among the varieties in respect of yield and duration. Binadhan-17 performed better almost all the locations.

Adaptive trials with Binasarisha-9 and Binasarisha-10 produced average seed yield of 1.49 and 1.38 t ha^{-1}, respectively. There were almost no difference in respect of duration and yield of tested varieties. Block farming with Binatil-2 produced average seed yield of 1.49 t ha^{-1}. Farmers showed their interest to cultivate Binatil-2 for its higher seed yield, oil content, attractive seed and oil colour. Adaptive trials with Binatil-1, Binatil-2 and Binatil-3 produced average seed yield of 0.58, 0.80 and 0.79 t ha^{-1}, respectively which was almost same as check variety Atshira (0.76 t ha^{-1}). Binatil-2 showed better performances in respect of duration and seed yield. Further trials would be needed to identify the suitable area for large-scale extension of this variety.

Block farming with Binamasur-5 produced average seed yield of 1.47 t ha^{-1} and matured in 105 days. Popularity of Binamasur-5 increasing due to its better yield, less infestation of diseases, specially in Magura. For adopting this variety, an additional rabi crop can easily be cultivated by introducing late boro variety, Binadhan-14. In case of mungbean variety, block farmings with Binamoog-8 produced average seed yield of 1.40 t ha^{-1}, which was 41.13 percent higher compared to cheek cultivar. Farmers of those districts were found enthusiastic to cultivate this variety for its higher seed yield and shiny color of seeds.

Block farming with Binadhan-14 were carried out in order to establish BINA technology villages around BINA headquarter. Binadhan-14 produced average grain yields of 4.04 t ha^{-1}. Maturity period of Binadhan-14 was 117 days. Binasarisha-9 produced grain yield of 1.63 t ha-^{1}. Binatil-2 produced average grain yields of 0.98 t ha^{-1}. Maturity period of Binatil-2 was 119 days. Binamasur-5 produced average grain yields of 1.16 t ha^{-1}. Maturity period of Binamasur-5 was 106 days. An extra HYV rabi crop could be easily cultivated adopting Binadhan-7 in aman season having higher yield of aman rice and late boro rice like Binadhan-14. A cropping pattern of "Binadhan-7→Binasarisha-9/10→Binadhan-14" has demonstrated very suitable and highly profitable.

In order to promotion of BINA generated crop varieties, a total of two farmers and Sub-Assistant Agricultural Officers (SAAO) training courses were organized during this period, and 95 male and female farmers including 40 SAAOs were also trained on cultivation of BINA developed improved crop varieties across the country.

A total of 5 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.

For technology transfer through printed media, publications were made on 2 types of leaflets totaling 10000 copies during this period. Besides these, Two TV programme was telecasted to popularize some BINA crop varieties.

ON FARM RESEARCH AND TECHNOLOGY TRANSFER

Adaptive trial/Block farming with rice varieties developed by BINA

Block Farming with submergence tolerant aman rice variety, Binadhan-11 compared to popular cultivar in different locations

During aman season of 2017-18, 60 block farming with submergence tolerant aman rice Binadhan-11 were conducted at the farmer's fields in different locations in collaboration with the DAE. The main objectives were to evaluate the performance of this variety at different flood prone areas and widening its adoption by the farmers. Area of each plot was one acre. Spacing between line-to-line and plant-to-plant was 20 cm × 15 cm. All fertilizers were applied by farmers as per recommendation. Transplanting dates ranged from 15 July to 15 August, 2017 and age of seedlings was 20 to 25 days. Based on the available reports of block farming plots are presented in Table 1.

Table 1. Performance of submergence tolerant aman rice (Binadhan-11) compared to popular cultivar in different locations during 2017-18

District	Upazilla	No. of Demon.	Duration (days)		Yield (t ha^{-1})		Yield increased over control (%)
			Binadhan-11	BRRI dhan52	Binadhan-11	BRRI dhan52	
Sherpur	Nokla	2	115	134	4.25	5.85	-27.35
	Sadar	2	120	142	4.45	4.25	4.71
	Nalitabari	3	119	124	4.23	3.43	23.32
	Jhinaigati	2	125	140	9.1	3.01	202.33
Rangpur	Gongachora	3	109	119	4.25	4.02	5.72
	Sadar	3	120	150	4.02	4.91	-18.13
	Kawnia	3	119	129	2.95	3.12	-5.45
Gaibandha	Fulchori	3	128	140	4.32	3.97	8.82
	Gobindagonj	3	131	137	4.62	4.08	13.24
	Sundorgonj	3	115	139	2.63	4.11	-36.01
Jamalpur	Sarishabari	2	130	138	4.37	4.09	6.85
	Madargonj	2	124	145	4.75	5.11	-7.05
	Melandaha	2	129	151	4.41	5.12	-13.87
	Bokshigonj	2	120	151	4.42	5.08	-12.99
Netrokona	Sadar	2	125	144	2.75	3.25	-15.38
	Purbadhola	2	132	150	5.07	5.32	-4.70
	Mohongonj	3	120	143	4.67	4.47	4.47
	Barhatta	2	132	156	4.51	4.02	12.19
Kishoregonj	kotiadi	3	114	113	3.19	2.37	34.60
	Kuliarchar	3	128	136	3.34	3.31	0.91
	Sadar	3	130	141	4.15	4.78	-13.18
Mymensingh	Sadar	3	115	145	4.08	3.57	14.29
	Haluaghat	2	131	151	3.75	4.63	-19.01
	Dhobaura	2	121	142	4.45	5.25	-15.24
	Total	**60**					
	Mean		**123**	**140**	**4.28**	**4.21**	**5.96**

The data of Table 1 revealed that Binadhan-11 produced average grain yield of 4.28 t ha^{-1}, which was 5.96percent higher compared to check varieties. Maturity period of Binadhan-11 was 123 days. Popular variety, BRRI dhan52 was used as check. Binadhan-11 showed better yield performance in both submerged and normal condition. That's why almost in all the locations, farmers were found much keen to cultivate Binadhan-11 in the upcoming years. The results of

Binadhan-11 revealed that this variety is suitable for massive extension in all the districts mentioned above.

Block farming with salt tolerant boro rice variety (Binadhan-10) compared to popular cultivar in different locations

During boro season of 2017-18, 40 block farming with Binadhan-10 were conducted at the farmer's fields in different locations in collaboration with the DAE. Area of each demonstration plot was one acre. Spacing between line-to-line 20 cm and plant-to-plant was 15 cm. All fertilizers were applied by farmers as per recommendation. Transplanting dates ranged from 10 to 31 January 2018 and age of seedlings was 40 to 50 days. Based on the available reports, data of block farming plots are presented in Table 2.

Table 2. Performance of salt tolerant boro rice (Binadhan-10) compared to popular cultivar in different locations during 2017-18

District	Upazilla	No. of Demon.	Duration (days)		Yield (t ha^{-1})		Yield increased over control (%)
			Binadhan-10	BRRI dhan47	Binadhan-10	BRRI dhan47	
Patuakhali	Kolapara	4	129	131	5.55	4.62	20.13
	Golachipa	4	130	145	4.48	4.9	-8.57
Bagerhat	Rampal	4	138	141	6.68	4.5	48.44
	Morelgonj	4	135	138	5.78	4.58	26.20
Jhalokathi	Sadar	4	135	132	6	4.56	31.58
	Nolcity	4	136	133	6	4.55	31.87
Barisal	Sadar	4	128	139	5.3	5.75	-7.83
	Gawrnadi	4	157	135	5.27	4.40	19.77
Cox's Bazar	Technaf	4	133	144	5.39	4.73	13.95
	Chokoria	4	134	145	5.61	4.89	14.72
	Total	**40**					
	Mean		136	138	5.61	4.75	**19.03**

Data in the Table 2 revealed that Binadhan-10 Produced average grain yields of 5.61 t ha^{-1}. Maturity period of this variety was 136 days. Check variety was BRRI dhan47 which produced average gain yield of 4.75 t ha^{-1}. Farmers were found very much interested to cultivate Binadhan-10 due to its better performance in both saline and non saline soils. They also made request to BINA authority to conduct more demonstrations for farmers' motivation and their better understanding about the variety. Farmers of above all districts were found keen to cultivate Binadhan-10. It needs more trials in different locations for identifying other suitable areas of Binadhan-10 cultivation and thereby massive extension.

Block farming with late boro rice variety (Binadhan-14) compared to popular cultivar in different locations

During boro season of 2017-18, 50 block farming with late boro rice Binadhan-14 were conducted at the farmer's fields in different locations in collaboration with the DAE. Area of each demonstration plot was one acre. Spacing between line-to-line 20 cm and plant-to-plant was 15 cm. All fertilizers were applied by farmers as per recommendation. Transplanting dates ranged from 15 February to 15 March 2018 and age of seedlings was 20 to 25 days. Based on the available reports, data of demonstration plots are presented in Table 3.

Table 3. Performance of late boro rice (Binadhan-14) compared to popular cultivar in different locations during 2017-18

District	Upazilla	No. of Demon.	Duration (days)		Yield (t ha^{-1})		Yield increased over control (%)
			Binadhan-14	BRRI dhan28	Binadhan-14	BRRI dhan28	
Bogra	Sherpur	4	108	132	5.25	4.63	13.39
	Sadar	4	109	134	5.15	5.05	1.98
Gaibandha	Sadar	4	119	108	4.25	4.31	-1.39
	Gobindogonj	4	158	148	3.36	3.00	12.00
Magura	Sadar	6	117	131	5.12	4.97	3.02
	Salikha	8	112	139	5.52	5.72	-3.50
Jhenaidah	Kaligonj	4	120	141	5.61	4.97	12.88
Mymensingh	Gouripur	6	118	131	3.96	3.83	3.39
Dinajpur	Sadar	4	110	131	6.53	5.70	14.56
	Birgonj	6	127	132	6.22	5.65	10.09
	Total	**50**					
	Mean		**120**	**133**	**5.10**	**4.78**	**6.64**

The data of table 3 revealed that Binadhan-14 produced average grain yields of 5.10 t ha^{-1}, which was 6.64 percent higher compared to check varieties. Maturity period of Binadhan-14 was 120 days. Two popular cultivars were used as check, which was BRRI dhan28. It was a late sowing boro variety which promoted an extra HYV oilseed, pulse and potato varieties easily before boro cultivation, facilitating to attain self-sufficiency in oilseed, pulse and vegetable production.

Adaptive Trials with early T. aman rice varieties compared to check variety

During aman season of 2017-18, 10 adaptive trials with Binadhan-7 and Binadhan-17 were conducted at farmers' plots in 3 districts in collaboration with DAE. The objectives were to demonstrate and evaluate the performance of Binadhan-7 and Binadhan-17 for its dissemination and encourage the farmers for adopting these varieties as well as making available seeds for the farmers for the next seasons. Unit plot size of individual Adaptive Trial was 1 bigha at all the locations. Seed beds were prepared during end of June to mid of July and transplanting was completed with mid July to mid August 2017. The check variety was BRRI dhan56 in all the locations. Fertilizers were applied as per recommendation. Data were recorded on crop duration and grain yield. The results are presented in Table 4.

Table 4. Performance of early T. aman rice varieties in different locations during 2017-178

District	Upazilla	No. of Expt.	Duration (days)		Yield (t ha^{-1})	
			Bina dhan-7	Bina dhan-17	Bina dhan-7	Bina dhan-17
Mymensingh	Sadar	4	112	116	4.58	4.25
Rangpur	Sadar	2	114	115	4.87	5.61
Magura	Sadar	4	112	119	5.38	6.35
	Total	**10**				
	Mean		**113**	**117**	**4.94**	**5.40**

The results presented in Table 4 shows that average duration and yield of Binadhan-7and Binadhan-17 were 113 and 117 days and 4.94 and 5.40 t ha$^{-1,}$ respectively. It is indicating that there were almost no difference among the varieties in respect of yield and duration except Binadhan-17.

Adaptive Trials with mustard variety, Binasarisha-9 and Binasarisha-10 compared to local variety

During the rabi season of 2017-18, 10 adaptive trials were conducted with Binasarisha-9 and Binasarisha-10 in 2 different districts in collaboration with the DAE. The main objectives were to demonstrate the performance of Binasarisha-9 and Binasarisha-10 to evaluate their location specific suitability and widen adoption by the farmers. Unit plot size of adaptive trials was one bigha at all the locations. Seeds were sown during October to November 2017 at the rate of 7.5 kg ha^{-1}. The local check varieties were 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 Table 5.

Table 5. Performance of Binasharisa-9, Binasharisa-10 compared to BARI sharisa-14 in different locations during 2017-18

District	Upazilla	No. of Expt.	Duration (days)			Yield (t ha^{-1})			Yield increased over control (%)	
			Bina sarisha -9	Bina sarisha-10	BARI Sarisha-14	Bina sarisha -9	Bina sarisha-10	BARI Sarisha-14	Bina sarisha -9	Bina sarisha-10
Mymensingh	Gowripur	6	83	77	84	1.64	1.56	1.61	1.86	-3.11
Magura	Sadar	4	82	75	81	1.49	1.38	1.47	1.36	-6.12
	Total	**10**								
	Mean		**82**	**75**	**81**	**1.49**	**1.38**	**1.47**	**1.36**	**-6.12**

The data presented in Table 5 indicated that Binasarisha-9 and Binasarisha-10 and BARI sharisha-14 produced average seed yield of 1.49, 1.38 and 1.47 t ha^{-1} with duration of 82, 75 and 81, respectively. The results indicated that there were almost no difference in respect of duration and yield of tested varieties. However, considering the duration of tested varieties indicated that farmers of all the locations easily include those varieties as an extra crop between T. aman and boro rice for increasing cropping intensity from 200% to 300%.

Block farming with groundnut variety Binachinabadam-4 compared to popular cultivar in different locations

During Kharif-1 season of 2017-18, 20 block farming with variety Binachinabadam-4 were conducted at farmers' plots in 3 districts in collaboration with DAE. The objectives were to demonstrate and evaluate the performance of Binachinabadam-4 for their dissemination and encourage the farmers for adopting these varieties as well as making available seeds for the farmers for the next season. Unit plot size of individual block farming was one bigha at all the locations. Seeds were sown during February to March 2018. The local check variety was Dhaka-1. Fertilizers were applied as per recommendation. Pesticides were also sprayed as and when necessary to control insects and pests. Data were recorded on crop duration and seed yield. The results are presented in Table 6.

Table 6. Performance of Binachinabadam-4 in different locations during 2017-18

District	Upazilla	No. of Demon.	Duration (days)		Yield (t ha^{-1})		Yield increased over control (%)
			Binchinabadam-4	Check	Binchinabadam-4	Check	
Jhinaidaha	Mohespur	8	107	113	1.4	1.22	14.75
Gazipur	Kapashia	5	120	124	2.22	1.51	47.02
Gaibandha	Kaligonj	7	115	0.00	1.15	.98	17.35
	Total	**20**					
	Mean		**114**	**119**	**1.59**	**1.24**	**26.37**

The data of Table 6 revealed that Binchinabadam-4 produced average seed yield of 1.59 t ha^{-1}, which was almost similar to popular check variety Dacca-1 (1.24 t ha^{-1}). The duration of Binchinabadam-4 was also similar to Dhaka-1 indicating that both were the popular in farmers' field.

Block farming with groundnut variety Binachinabadam-5 compared to popular cultivar in different locations

During Kharif-1 season of 2017-18, 5 block farming with variety Binachinabadam-5 were conducted at farmers' plots in 1 district in collaboration with DAE. The objectives were to demonstrate and evaluate the performance of Binachinabadam-5 for their dissemination and encourage the farmers for adopting these varieties as well as making available seeds for the farmers for the next season. Unit plot size of individual block farming was one bigha at all the locations. Seeds were sown during February to March 2018. The local check variety was Dacca-1. Fertilizers were applied as per recommendation. Pesticides were also sprayed as and when necessary to control insects and pests. Data were recorded on crop duration and seed yield. The results are presented in Table 7.

Table 7. Performance of Binachinabadam-5 in different locations during 2017-18

District	Upazilla	No. of Demon.	Duration (days)	Yield (t ha^{-1})
			Binachinabadam-5	Binachinabadam-5
Mymensingh	Bhaluka	5	112	1.5

Adaptive trail of lentil variety Binachinabadam-7, Binachinabadam-8 and Local front size variety in different locations in collaboration with DAE

During Kharif-1 season of 2017-18, 20 block farming with variety Binachinabadam-7, Binachinabadam-8 and Dhaka-1 were conducted at farmers' plots in 4 districts in collaboration with DAE. The objectives were to demonstrate and evaluate the performance of Binachinabadam-7, Binachinabadam-8 and Dhaka-1for their dissemination and encourage the farmers for adopting these varieties as well as making available seeds for the farmers for the next season. Unit plot size of individual block farming was one bigha at all the locations. Seeds were sown during February to March 2018. The local check variety was Dhaka-1. Fertilizers were applied as per recommendation. Pesticides were also sprayed as and when necessary to control insects and pests. Data were recorded on crop duration and seed yield. The results are presented in Table 8

Table 8. Performance of Binachinabadam-7, Binachinabadam-8 compared to local variety in different locations during 2017-18

District	Upazilla	No. of Expt.	Duration (days)			Yield (t ha^{-1})			Yield increased over control (%)	
			Bina china badam-7	Bina china badam -8	Check	Bina china badam -7	Bina china badam-8	Check	Bina china badam-7	Bina china badam-8
Mymensingh	Sadar	5	116	121	117	2.13	2.16	1.92	10.94	12.50
Kishoregonj	Bhairab	5	114	118	117	2.31	2.29	2.16	6.15	6.02
Bhola	Charfeshion	5	110	115	120	2.42	2.23	2.20	10.00	1.36
Noakhali	Shubarnochar	5	113	117	114	2.12	2.21	2.05	3.41	7.80
	Total	**20**								
	Mean		**113**	**118**	**117**	**2.25**	**2.22**	**2.08**	**7.63**	**6.92**

The data in Table 8 indicated that almost no difference was observed in duration of Binachinabadam-7, Binachinabadam-8 and check variety. The highest seed yield 2.42 t ha^{-1} of Binamasur-8 was recorded at charfashon upazila of Bhola district.

Block farming with Binatil-2 compared to local check variety

During Kharif-1 season of 2017-18, 30 block farming with variety Binatil-2 were conducted at farmers' plots in 4 districts in collaboration with DAE. The objectives were to demonstrate and evaluate the performance of Binatil-2 for their dissemination and encourage the farmers for adopting these varieties. Unit plot size of individual block farming was one bigha at all the locations. Seeds were sown during February to March 2018. The local check variety was Atshira. Fertilizers were applied as per recommendation. Pesticides were also sprayed as and when necessary to control insects and pests. Data were recorded on crop duration and seed yield. The results are presented in Table 9.

Table 9. Performance of Binatil-2 compared to popular cultivar in different locations during 2017-18

District	Upazilla	No. of Demon.	Duration (days)		Yield (t ha^{-1})		Yield increased over control (%)
			Binatil-2	Check	Binatil-2	Check	
Faridpur	Sadar	5	84	84	1.25	0.93	34.41
Madaripur	Rajoir	5	92	94	1.54	1.3	18.46
Kushtia	Khoksha	15	84	93	1.46	1.2	21.67
Dinajpur	Fulbari	5	92	99	1.7	0.90	88.89
	Total	**30**					
	Mean		**88**	**93**	**1.49**	**1.08**	**40.86**

The data of Table 9 revealed that Binatil-2 produced average seed yield of 1.49 t ha^{-1}, which was almost similar to popular check variety Atshira (1.08 t ha^{-1}). The duration of Binatil-2 was also similar to Atshira indicating that both were the popular in farmers' field.

Farmers' Observation Trials of sesame varieties in different locations

During kharif-1 season of 2017-18, 10 adaptive trials with 3 sesame varieties i.e, Binatil-1, Binatil-2 and Binatil-3 were arranged at farmers' plots in 3 districts in collaboration with DAE. The objectives were to demonstrate and evaluate the performance of with Binatil-1, Binatil-2 and Binatil-3 for its dissemination and encourage the farmers for adopting these varieties as well as making available seeds for the farmers for the next seasons. Unit plot size of individual plot was one bigha at all the locations. Seeds were sown during mid February to March, 2018 in kharif-1 season. The local check variety was Atshira in all the locations. Fertilizers were applied as per recommendation. Data were recorded on crop duration and grain yield. The results are presented in Table 10.

Table 10. Performance of Binatil-1, Binatil-2 and Binatil-3 compared to Atshira in different locations during 2017-18

District	Upazilla	No. of Expt.	Duration (days)				Yield (t ha^{-1})				Yield increased over control (%)		
			Binatil-1	Binatil-2	Binatil-3	Atshira	Binatil-1	Binatil-2	Binatil-3	Atshira	Binatil-1	Binatil-2	Binatil-3
Mymensingh	Sadar	3	94	90	87	93	.44	.9	.9	.66	-33.33	36.36	36.36
Faridpur	Madhukali	4	95	99	93	104	.5	.6	.6	.72	-30.56	-16.67	-16.67
Magura	Sadar	4	92	98	90	101	0.81	0.89	0.87	0.89	-8.99	0.00	-2.25
	Total	**11**											
	Mean		**94**	**96**	**90**	**99**	**0.58**	**0.80**	**0.79**	**0.76**	**-24.29**	**6.57**	**5.82**

The results presented in Table 10 showed that average duration and yield of Binatil-1, Binatil-2, Binatil-3 and Atshira were 94, 96, 90 and 99 days and 0.58, 0.80, 0.79 and 0.76 t $ha^{-1,}$ respectively. It is indicating that Binatil-3 showed better performances both in respect of duration and seed yield. That's why, farmers' of all locations preferred Binatil-3. However, for identification of best variety its need further trials to conclude.

Block farming of lentil variety Binamasur-5 in different locations in collaboration with DAE

A total of 20 block farming with Binamasur-5 were set up at the farmer's fields in 5 upazila under 5 districts. The main objectives were to demonstrate and evaluate the performance of Binamasur-5 compared to check variety across the locations and encourage the farmers to continue the variety in their fields. The area for each of the demonstration plots was one acre. Data on crop duration, insect and disease infestation and seed yield were recorded. The results are presented in Table 12.

Table 12. Performance of Binamasur-5 compared to popular cultivar in different locations during 2017-18

District	Upazilla	No. of Demon.	Duration (days)	Yield (t ha^{-1})
Jassore	Bagharpara	10	103	1.46
Magura	Sadar	4	106	1.45
Jhenaidah	Kaligonj	2	107	2.02
Mymensingh	Gowripur	2	107	1.17
Netrakona	Purbadhala	2	105	1.25
	Total	**20**		
	Mean		**105.60**	**1.47**

The data in Table 12 indicated that almost no difference was observed in duration of Binamasur-5 and the check variety. The highest seed yield (2.02 t ha^{-1}) was recorded at Kaligonj upazila of Jhenaidah district.

Block farming of lentil variety in different locations in collaboration with DAE

A total of 14 block farming with Binamasur-6 were set up at the farmers' fields in 3 upazila under 3 districts. The main objectives were to demonstrate and evaluate the performance of Binamasur-6 compared to check variety across the locations and encourage the farmers to continue the variety in their fields. The area for each of the demonstration plots was one acre. Data on crop duration, insect and disease infestation and seed yield were recorded. The results are presented in Table 13.

Table 13. Performance of Binamasur-6 compared to popular cultivar in different locations during 2016-17

District	Upazilla	No. of Demon.	Duration (days)	Yield (t ha^{-1})
Jashore	Bagharpara	10	89	1.56
Magura	Sadar	3	108	1.43
Jhenaidah	Kaligonj	2	106	1.62
	Total	**15**		
	Mean		**101**	**1.54**

The data in Table 13 indicated that almost no difference was observed in duration of Binamasur-6 and the check variety. The highest seed yield (1.62 t ha^{-1}) was recorded at Kaligonj upazila of Jhenaidah district

Adaptive trail of lentil variety Binamasur-7, Binamasur-8 and Binamasur-9 and BARI masur-6 in different locations in collaboration with DAE

A total of 10 block farming with Binamasur-7, Binamasur-8, Binamasur-9 and BARI masur-6 were set up at the farmer's fields in 4 upazila under 3 districts. The main objectives were to demonstrate and evaluate the performance of Binamasur-7, Binamasur-8 and Binamasur-9 compared to BARI masur-6 across the locations and encourage the farmers to continue the variety in their fields. The area for each of the demonstration plots was one acre. Data on crop duration, insect and disease infestation and seed yield were recorded. The results are presented in Table 14.

Table 14. Performance of lentil varieties in different locations during 2017-18

District	Upazilla	No. of Expt.	Duration (days)				Yield (t ha^{-1})				Yield increased over control (%)		
			Binamasur-7	Binamasur-8	Binamasur-9	BARI masur-6	Binamasur-7	Binamasur-8	Binamasur-9	BARI masur-6	Binamasur-7	Binamasur-8	Binamasur-9
Gopalgonj	Kashainy	4	108	107	107	108	1.26	1.42	1.61	1.35	1.35	-6.67	3.70
	Sadar	2	105	104	104	104	1.2	1.33	1.42	1.35	1.25	-4.00	4.00
Faridpur	Madhukhali	4	106	105	105	105	1.71	1.85	1.76	1.77	1.31	15.27	6.87
Magura	Sadar	2	108	101	104	103	1.29	1.41	1.15	1.16	1.16	11.21	21.55
	Total	**10**											
	Mean		**106**	**103**	**104**	**104**	**1.40**	**1.53**	**1.44**	**1.43**	**1.24**	**7.49**	**10.81**

The data in Table 14 indicated that almost no difference was observed in duration of Binamasur-7, Binamasur-8 and Binamasur-9 and the check variety. The highest seed yield 1.85 t ha^{-1} of Binamasur-8 was recorded at Madhukhali upazila of Faridpur district.

Block farming of Binamoog-8 in different locations in Collaboration with DAE

A total of 35 block farming with mungbean variety, Binamoog-8 were conducted at farmers' fields in four districts. The Department of Agriculture Extension (DAE) was the main collaborator in making the demonstrations successful. The objectives were to demonstrate and evaluate the performance of Binamoog-8 for its dissemination and adoption among the farmers. The area of each of the demonstrations was one bigha. The trials were conducted under farmers' own management. Data on crop duration and seed yield are presented in Table 15.

Table 15. Performance of Binamoog-8 compared to popular cultivar in different locations during 2017-18

District	Upazilla	No. of Demon.	Duration (days)		Yield (t ha^{-1})		Yield increased over control (%)
			Binamoog-8	Check	Binamoog-8	Check	
Barisal	Bakherganj	15	66	76	0.93	0.80	16.25
Patuakhali	Baufal	15	58	74	1.54	0.76	102.63
Dinajpur	Fulbari	5	67	71	1.76	1.38	27.54
Magura	Sadar	5	64	67	1.37	1.16	18.10
	Total	**35**					
	Mean		**64**	**72**	**1.4**	**1.03**	**41.13**

It is revealed from the Table 15 Binamoog-8 produced average seed yield of 1.4 t ha^{-1}, which was 41.13 percent higher than the control variety BARI moog-6 (1.03 t ha^{-1}). The highest seed yield 1.76 t ha^{-1} of Binamoog-8 was recorded at Fulbari upazila of Dinajpur district. Farmers show their positive attitude to cultivate this variety.

Establishment of BINA-Technology Pilot Area (BINA-Village)

In order to establish BINA-Tech. village, Block farming and other extension work were done in collaboration with the Department of Agricultural Extension (DAE) at the farmer's fields in surrounding areas of BINA Head quarter. Results of overall promotional activities related to BINA-Technology village establishment at different locations are presented in Table 16.

Block demonstration with BINA developed different crop varieties in surrounding areas of BINA Head quarter, Mymensingh

During 2017-18 50 blocks demonstrations were conducted with BINA developed three crop varieties at Austradhor and Kolladia villages under sadar and Gouripur upozila of Mymensingh district. Results of demonstrations are presented in Table 16.

Table 16. Performances of some BINA released varieties in Mymensingh district during 2017-18

Variety	Upazilla	Total No. of Demon.	Average Duration in days	Yield ($t\ ha^{-1}$)
Rice	Sadar	2	116	4.12
Binadhan-14	Gouripur	20	118	3.95
Total		**21**		
Mean			**117**	**4.04**
Oilseeds				
Binasarisha-9	Gouripur	22	84	1.63
Binasarisha-10	Sadar	2	75	1.21
Binatil-2	Sadar	3	90	0.98
Pulse				
Binamasur-5	Gouripur	1	106	1.16
Grand Total		**50**		

Mymensingh district is mostly suitable for rice cultivation and that of partly for mustard growing. Results in Table 16 depict that rice variety of Binadhan-14 produced average grain yield of 4.04 $t\ ha^{-1}$, Binasarisha-9 produced average grain yields of 1.63 $t\ ha^{-1}$, Binasarisha-10 produced average grain yields of 1.21 $t\ ha^{-1}$, Binatil-2 produced average grain yields of 0.98 $t\ ha^{-1}$ and Binamasur-5 produced average grain yields of 1.16 $t\ ha^{-1}$.

Training on the use of BINA developed technologies

In order to technology promotion, 2 training courses were organized during the period of 2017-18. A total of 40 DAE personnel (Sub-assistant Agriculture Officers, SAAO) and 95 female and male farmers were trained on establishment of demonstration & seed preservation method of BINA developed Pulse and Oilseed varieties. Details of the training and workshops are presented in Table 17.

Table 17. Farmers and SAAO Training on the use of BINA developed technologies during 2017-2018

Sl No	Topic	Place of Training	No. of participants	Source of fund
1.	Farmers training on "Establishment of demonstration & seed preservation method of BINA developed Pulse and Oilseed varieties	Magura	95	Poribortito abohaoa.... Project
2.	SAAO training on "Establishment of demonstration & seed preservation method of BINA developed Pulse and Oilseed varieties	Magura	40	Poribortito abohaoa.... Project

Field Day

In order to motivate the farmers to adopt BINA developed varieties/technologies, 5 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 18.

Table 18. Field days organized at the farmers fields on different crop varieties during 2017-2018

Sl. No.	Crops	Varieties	Date	Locations	Participants
1	Mustard	Binasarisha-9	07.02.2017	Gouripur, Mymensingh	200
		Binasarisha-10	08.02.2017	Gouripur, Mymensingh	200
	Rice	Binadhan-7 & Binadhan-17	28.09.2017	Shibrampur, Magura	200
		Binadhan-11	07.11.2017	Sadar, Kishoreganj	200
		Binadhan-11	07.11.2017	Kotiadi, Kishoreganj	200

Publications and photographic enrichment

For technology transfer through printed media, publications were made on two types of leaflets/folder total 10000 copies during this period. Besides these, two programme were telecast to popularize some BINA crop varieties. Details of the publication activities and electronics media exposure are presented in Table 19 and Table 20.

Table 19. List of booklet/leaflets made on different crop varieties and electronic media exposure during 2017-18

Sl. No.	Name of crops/varieties	Name of publication	Languag e	Copies printed
1.	Binadhan-17	Leaflet/Folder	Bangla	5000
2.	A list of BINA released varieties			5000
			Total =	**10000**

Table 20. Electronic media exposure on different crop varieties during 2017-18

Sl. No.	Name of crops/ varieties	Name of the channel	Location	Remarks
1.	Binasarisha-9 & Binasarisha 10	Masranga	Gouripur, Mymensingh	It was very effective for Awareness creation
2.	Binadhan-11	N TV	Kishoregonj	

Biotechnology Division

Research Highlights

Genetic Engineering

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

One novel salinity and drought tolerant genes *OsNHX2* has been transferred to the high yielding rice variety.

Optimization of *in vitro* regeneration protocol of rice for genetic transformation was done.

Optimization of *in vitro* regeneration and acclimatization protocol of tomato for genetic transformation was done.

Molecular breeding

In T. Aman 2017 five parents were grown for crossing purpose for tidal tolerant rice variety development through MAS and a total of 132 F_1 seeds were harvested during the period.

For salt tolerant variety development through MAS four parents were grown and about 450 F_1 seeds were harvested in Boro 2017-18 seasons.

In order to breaking yield ceiling and high yield variety development, 64 BC_1F_1 and 42 F_1 seed were collected three different cross combinations.

DNA fingerprinting of rice and beneficial microbes

Thirty rice genotypes including BINA developed high yielding rice varieties/advanced lines and local rice have characterized using SSR markers.

Nitrogen fixing twenty two rhizobial strains from mimosa have been characterized using morphological and genetic characteristics.

Genetic Engineering

Transfer of salinity and drought tolerant gene *OsNHX2* in rice cultivar through *Agrobacterium* mediated transformation technique

Objective:

To develop abiotic stress tolerant rice variety

Transfer of *OsNHX2* entry clone in expression/destination vector pB2WG7

Expression vector is used to introduce a specific gene into a target cell which promotes cell's mechanism for protein synthesis to produce protein encoded by inserted gene. It is a basic tool in biotechnology for the production of proteins in target cells. Different types of expression vectors are available for the expression of cloned genes in plant cells. We used the expression vector pB2WG7 which is well known for Basta selection. The pB2WG7 expression vector contains 35S promoter from cauliflower mosaic virus and it has herbicide (Basta) resistant genes. Previously developed *OsNHX2* entry clones were transferred/recombined in the expression vector pB2WG7 using LR clonase and following the protocol described in Gateway cloning procedure which is known as LR reaction. The LR reaction products are then transformed in the *E. coli* strain by heat shock method. After transformation, all transformation products were spread on LB agar plates containing 75µgmL^{-1} spectinomycin to select positive colonies. Positives colonies from antibiotic selection were then further confirmed by colony PCR using *OsNHX*$_2$ gene specific primers. (Fig. 1) .

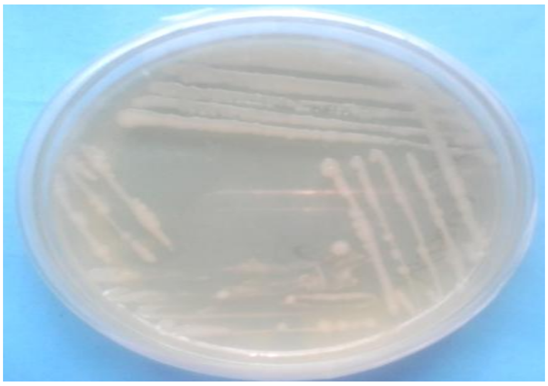


Fig. 1: Confirmation in *Agrobacterium* by antibiotic selection

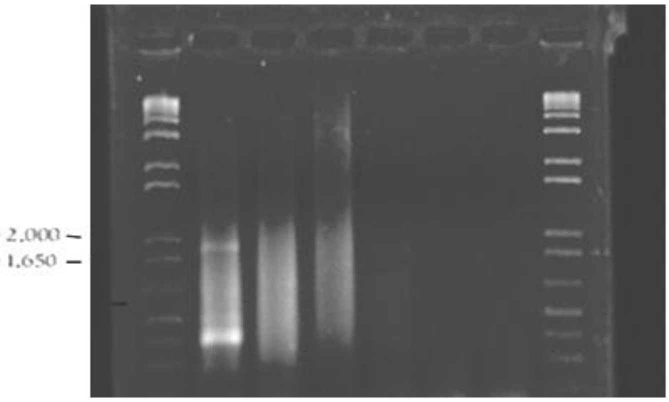


Fig. 2: Confirmation by colony PCR

Transformation of *OsNHX2* gene constructs in *Agrobacterium*

Agrobacterium strain GV3101was used for transforming our gene constructs. The GV3101 was used because this strain works excellent with all dicots and also with monocots. Plasmids from positive colonies of previously developed *OsNHX2* gene constructs were isolated using Qiagen Plasmid isolation Kit and then used to transform in *Agrobacterium* strain GV3101 by heat shock method. After transformation, transformed products were then grown on LB medium containing three antibiotics viz. spectinomycin, gentamycin and refampicin. The colonies, grown on LB medium containing three antibiotics were considered as positive colony contained our gene of interest. Positive colonies were then confirmed by colony PCR using *OsNHX2* gene specific primers (Fig. 2). After confirmation, positive colonies of *Agrobacterium* strain GV3101 were cryo-preserved in 50% glycerol (1:1 ratio) and store in -80^0C freezer for further use.

Rice transformation by *Agrobacterium* strain GV3101 harboring *OsNHX2* gene

Experiments were conducted to establish efficient gene transformation protocol for rice and to find effective method for *Agrobacterium* mediated transformation for developing transgenic rice variety (s) with enhanced stress tolerance. Mature embryos were used to induce rice callus and gene transformation.

Induction of embryogenic calli from mature embryo

Seeds sterilization and callus initiation

Mature, healthy and diseases free dehusked high yielding seeds were surface sterilized with 70% ethanol and then with 3% sodium hypochloride solution and then disinfectant from sterilized seeds were removed by 7-9 washes with sterile distilled water. Surface sterilized seeds were then cultured on callus induction medium (MS salts: Murashige and Skoog, 1962) modified by IRRI at 25°C under continuous light for 10 days. After 10 days, the embryogenic calli were developed and ready for co-cultivation (Fig.3).

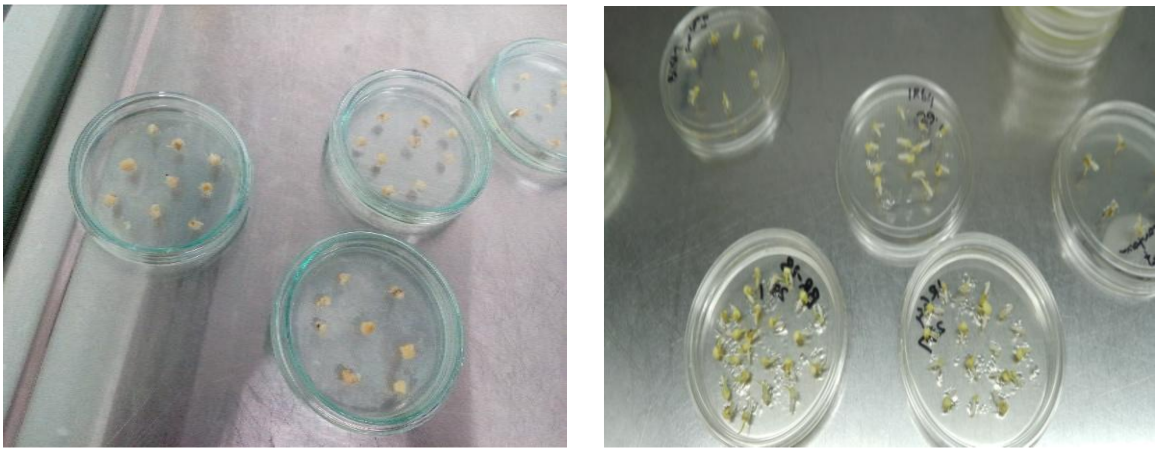


Fig. 3.: Callus induction and transformation using *Agrobacterium*

Preparation of gene constructs/*Agrobacterium* strains for callus infection / co-cultivation
Gene constructs of *OsNHX2 gene* from glycerol stocks were taken from -80^0C freezer and then streaked on AB medium containing three antibiotics selection markers. The streaked cultures were then incubated in an incubator at 28^0C for three days at dark conditions. The colonies, containing target gene were grown after three days in AB medium (Fig. 4). Then a loop full of *Agrobacterium* culture from isolated colonies were taken and suspended in 40 mL infection media (containing

20gL^{-1} sucrose, 10gL^{-1} glucose, 500 mgL^{-1} casamino acid, 876 100m$g^{-}L^{-1}$ glutamine 260 mgL^{-1} aspartic acid, 174 mgL^{-1} arginine 100µM acetosyringone (pH 5.2). in a Falcon tube. *Agrobacterium* cultures were then mixed with infection medium using 10 mL micropipette. The optical density of *Agrobacterium* cells in infection medium was adjusted at 0.1 by adding sterile infection medium for calli transformation. The calli from induction media were then transferred into the Falcon tube containing *Agrobacterium* broth and mixed gently for 1-1.5 minutes. After mixing, excess *Agrobacterium* containing media were discarded in a disinfection media and callus were put on sterile Whatman filter paper to remove excess *Agrobacterium* suspension from calli surface. After removing excess *Agrobacterium* solution, calli were then transferred to another filter paper moist with infection medium and then transferred on co-cultivation media for three days at 25^0C at dark conditions.

Growing transformed calli on selection medium

After three days of co-cultivation, callus were transferred into a Falcon tube and washed with sterile distilled water for 5-6 times to remove excess *Agrobacterium* from calli surface. Final wash were made with sterile distilled water containing 250mgL^{-1} cefotaxime to kill *Agrobacterium* strains present on calli surface. The washed calli were then transferred into selection media to grow the calli for 21 days under continuous light. Based on construct nature, selection materials (Basta 5mgL^{-1}) were used in selection media to select positive transformed calli (Fig. 4).

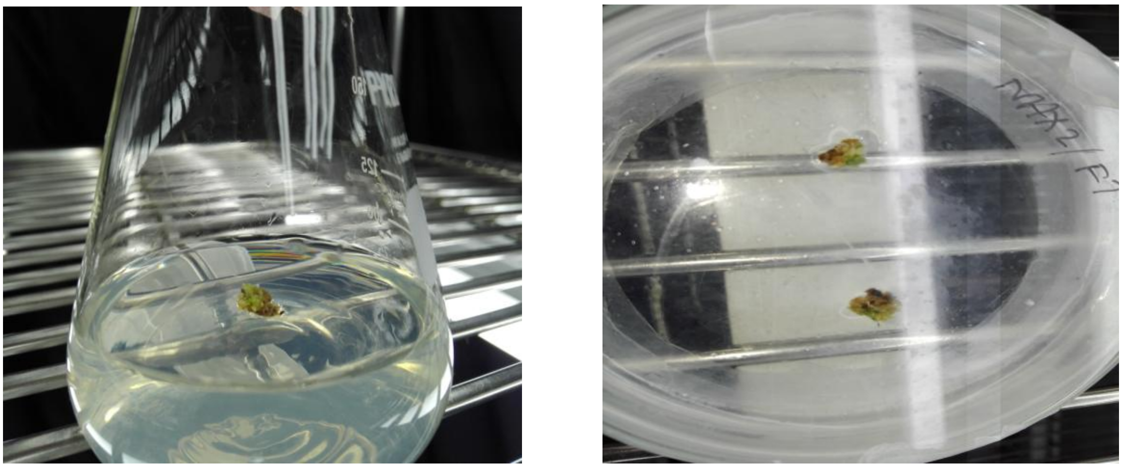


Fig. 4: Regenerated transformed calli

After seven days of co-cultivation, immature embryos were then placed on sterile filter paper and removed the elongated shoots with scalpel. Immature embryos were then dried by sterile filter paper. The dried immature embryos were then transferred A202 resting media for three days under continuous light. After resting period, immature embryos were transferred to selection media for ten days at 30^0C under continuous light. After 10 days, immature embryos were then transferred in newvA203 selection media for another 10 days at 30^0C under continuous light. The embryogenic calli were then transferred in fresh A203 medium after 10 days and were kept at 30^0C under continuous light for final selection.

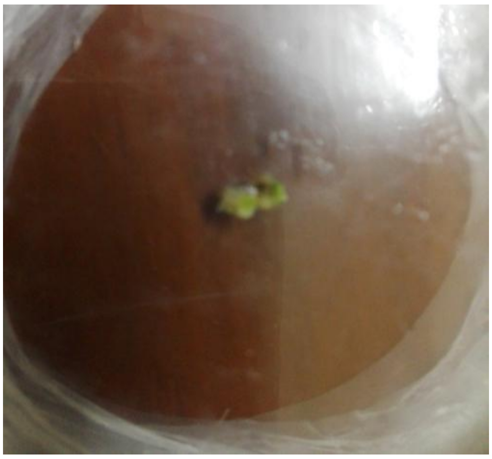


Fig. 5: Regenerated callus at early stage

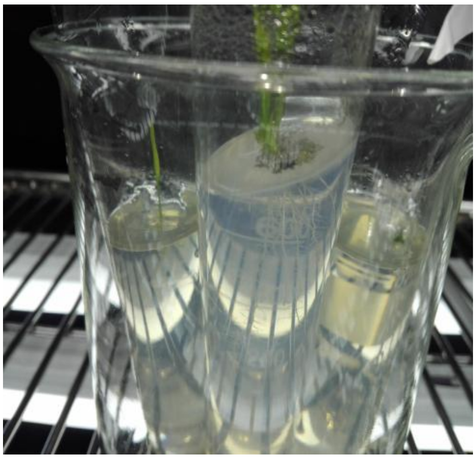


Fig. 6: Regener] ated plantlet

Results

During selection process, the calli were kept on the medium for a minimum period of 21 days in order to differentiate the transformed calli from the non transformed calli. After 21 days, very few calli were availed to survive in selection media.

This study revealed that the *Agrobacterium* strain GV3101 can efficiently infect embryo from mature seeds because more transformed plantlets were obtained from mature (Fig. 7).

Overexpression of salinity and drought tolerant *OsARS and OsCAL* genes into rice through *Agrobacterium* mediated gene transformation

Experiments were conducted to establish efficient gene transformation protocol for rice and to find effective method for *Agrobacterium* mediated transformation for developing transgenic rice variety with enhanced stress (abiotic) tolerance. Here, the genes *OsARS and OsCAL* were used for transforming the high yielding rice cultivar. We used mature embryo to induce rice callus and gene transformation.

Induction of embryogenic calli from mature embryo

Mature, healthy and diseases free dehusked rice seeds were firstly washed three to five times with sterile distil water and then then sterilized with 70% ethanol for 1 to 2 minute. After that again sterilized 50% hypochloride solution including 2 to 3 droop of Tween20 and then disinfectant from sterilized seeds were removed by 7-9 washes with sterile distilled water. Surface sterilized seeds were then cultured on callus induction medium (MS salts: Murashige and Skoog medium Duchefa, Biochemie) containing B5 vitamins, 30 gL^{-1} sucrose, 2.0 mgL^{-1} 2,4-dichlorophenoxyacetic acid (2,4-D), at 25^0C in the dark. After three week the proliferating calli were subcultured onto the same medium and cultured for another three week. White and hard embryogenic calli were appeared at this stage. The embryogenic calli of 5-6mm diameter were subcultured on to the same medium 5 days before infection with agrobacterium. The infected calli were transferred onto an MS cocultivation medium (MS salts, B5 vitamins, 30 gL^{-1} maltose, 10 gL^{-1} glucose 100 µM acetosyringone, 3.0 gL^{-1} phytagel) before transfer of calli, the whatman no.1 filter paper was wetted with 1 mL of AA-AS medium. Infected calli were incubated at 25^0C for 3 days in the dark. After three days infected calli were washed 4-5 times with sterile distilled water and finally once with aqueous solution containing cefotaxime (250mgL^{-1}) and streptomycin (250$mgL^{-1)}$, blotted on sterile tissue paper, and transferred to MS selection medium containing cefotaxime (250mgL^{-1}) and streptomycin (250mgL^{-1}). After 12 days in the selection medium, healthy portions of calli were sub cultured onto the fresh selection medium, twice at three week intervals. After three rounds of selection actively growing pieces of calli were transferred to MS regeneration medium containing 300 mgL-1 casamino acid, 3.0 mgl^{-1} 6-benzylaminopurine (BAP), 1.5 mgL^{-1} α-naphthaleneacetic acid (NAA), 250 mgL^{-1} cefotaxime and 250 mgL^{-1} streptomycin.

Fig 7. Production of transgenic rice plants from embryogenic calli. (a) Seed plating on MS Media (b) Embryogenic calli (c) Embryogenic calli subculture on Media (d) *Agrobacterium tumefaciens* (harbouring *OsARS* and *OsCAL* genes) co-cultivation of embryogenic calli. (e) Putative transgenic regenerated green plants.

Optimization of *in vitro* regeneration and acclimatization protocol of tomato for genetic transformation

Objectives

- To determine suitable concentrations and combinations of surface disinfectant for surface sterilization
- To determine the suitable concentrations and combinations of plant growth regulators for high frequency plantlet regeneration
- To determine the suitable method for enhancing plantlet establishment at field conditions

Experimental material

The BARI Tomato-16 was used in this study. Tissue culture media
Murashige and Skoog (MS) medium from Duchefa, Netherland with 3% sucrose along with various concentrations of different growth hormones were used. For seed germination, MS basal medium with 3% sucrose was used which was solidified with 0.4% gelrite. For callus initiation, cotyledon and hypocotyledon explants were cultured on MS media supplemented with different concentrations and combinations of various growth regulators: Indol-3 acetic acid (IAA) and 6-benzyl amino purin (BAP): IAA + BAP: 0.1 + 0.5 mgL-1 , 0.2 + 0.5 mgL-1 , 0.5 + 0.5

mgL^{-1}, 0.1 + 1 mgL^{-1}, 0.2 + 1 mgL^{-1}, 0.5 +1 mgL^{-1}, 0.1 + 2 mgL^{-1}, 0.2 + 2 mgL^{-1}, 0.5 + 2 mgL^{-1}.

Seed germination

Healthy seeds were taken in eppendorf tube and washed two times with distilled water. Then seeds were surface sterilized with 70% ethanol and different concentration of NaOCl (1.0%, 2.0%, 2.5%, 3.0% and 5.0%). After placing the sterilized seeds on media (petridish) those were then kept in dark for four days. The petridishes were then shifted to growth room for 10 days at 25°C under 16 hrs light and 8 hrs dark cycles.

Preparation of explants and their maintenance

Under aseptic condition, 10 days old microplants from germinated seeds (4 to 5 cm long) were taken out from the petridishes. Cotyledons and hypocotyls were aseptically cut into small pieces with the help of fine sterilized scissors. The cotyledons and hypocotyls were used as the source of explants. Attempts have been made for the induction of organogensis using different explants in MS medium supplemented with IAA (0.1, 0.2, and 0.5 mgL^{-1}) and BAP (0.5, 1.0 and 2.0 mgL^{-1}). The cotyledons were cut into 15 mm^2, 17 mm^2, 20 mm^2, 22 mm^2 and 25 mm^2 pieces using sterilized fine scissors. Each piece of explants was inoculated into a petridish by gently pressed into the surface of the sterilized culture medium with various combinations and concentrations of IAA and BAP. The petridishes containing explants were then placed in a dark room with controlled temperature at 25°C under 16 hrs light and 8 hrs dark cycles. The growth room was illuminated with 1.83 m florescent tubes (4.83 ft C84 1 DFL/Phillips) which gave broad spectrum of light especially in the red wavelength with a light intensity of 1500 Lux. Similar way, the hypocotyls were cut into pieces of 12 mm^2, 14 mm^2, 16 mm^2, 18 mm^2 and 20 mm^2 and inoculated into a petridish and placed in a dark room maintaining same temperature and light that of hypocotyls with various combinations and concentrations of plant growth regulators (PGR). The pertridishes were then sealed with parafilm. The petridishes were checked daily to note the response and the development of contamination. The explants were grown carefully under aseptic condition at growth room and transferred into new media inside the laminar flow cabinet when required putting into same IAA and IBA concentrations. Callus initiated after 10 to 14 days of explants incubation. The developed calli were also kept under 16/8 hrs photoperiod at 25 ± 2°C. Plantlets developed from calli in this medium after 14 to 21 days.

Subculture of the callus for shoots and root regeneration

Two weeks after incubation of the explants they attained convenient size. They were then transferred aseptically from the petridish with a sterilized forceps inside the laminar air flow cabinet and were placed again on freshly prepared sterilized medium containing appropriate hormonal supplements of IAA and BAP for shoot initiation. The sub-culturing media used in this study were: MS containing different combinations and concentrations of IAA (0.1, 0.2, and 0.5 mgL^{-1}) and BAP (0.5, 1.0 and 2.0 mgL^{-1}). The sub-cultured conical flasks were then incubated at 25 ± 2°C with 16 hrs photoperiod. The observations were noted regularly.

The sub-cultured calli contained proliferated and differentiated shoots. When these shoots were grown about 3-4 cm in length, they rescued aseptically from the cultured conical flasks, separated from each other and again cultured on another flasks with freshly prepared root induction medium to induced root. The flasks containing plantlets were incubated under 16/8 hrs photoperiod. Day to day intended observations were recorded.

Pot experiment

The experiment was laid-out in the completely randomized design (CRD) with 3 replications. To assess the effects of different treatments, the data recorded were:

i) Percentage of seed germination: The number of seed germination after seven days was recorded by using following formula: Germination (%) = (number of seed germinated/number of seed platted) ×100;
ii) Percentage of contamination: The number of contaminations over days was recorded by using following formula: Contamination (%) = (number of seed contaminated/number of seed platted) ×100;
iii) Percentage of callus formation; Callus formation (%) = (number of callus formed/number of explants platted) ×100

Data analysis

The data recorded above were subjected to analysis as per the design used. Analysis of variance for different records above was performed and means were compared by the Minitab package.

Result and Discussion

Effect of NaOCl concentrations and sterilization time on surface sterilization of seed

In vitro culture of cell, tissue, organ and also embryo culture, has been a vital technique for mass multiplication of plants, elimination of plant diseases through meristematic tissue culture technique. Contamination of plant tissue cultures by different microorganisms, such as bacteria and fungi, reduces their productivity and can completely prevent their cultivation. Therefore, sterilization of seeds is important to get aseptically grown seedlings with maximum germination under *in-vitro* condition. In present experiment significantly ($p<0.005$) higher germination rate (86.67%) was found when the seeds were washed with 1% sodium hypochloride and sterilization time was 10 minute (Table1 and Figure8). But in this case contamination rate (86.67%) was observed the highest; for this reason it cannot be used for surface sterilization in regeneration purpose as asceptic condition is the prerequisite for tissue culture. Surface sterilization of seeds with 2% sodium hypochloride for 15 minutes was observed the highest rate of germination (83.33%) with no contamination was occurred (Table1 and Figure 8). Same result was also found when the seeds were surface sterilized with 3% sodium hypochloride for 10 minutes. Therefore, it is found that when seeds were surface sterilized with the increasing concentration of sodium hypochloride and sterilization time, no contamination was observed but reduction of germination rate was occurred. That's why it should be more useful to use 2% sodium hypochloride for 15 minutes in surface sterilization, because in this case less amount of chemical is required.

Table 1. Effect of NaOCl and sterilization time on contamination and germination of seed

SL No	NaOCl conc. (%)	Sterilization time (min.)	Contamination (%)	Germination (%)
1	0	0	100	63.33
2	1	10	86.67a	86.67a
3	1	15	83.33a	80.0ab
4	1	20	46.67b	83.33ab
5	2	10	10.00c	80.0 ab
6	2	15	0.00c	83.33 ab

7	2	20	0.00c	80.0 ab
8	3	10	0.00c	83.33 ab
9	3	15	0.00c	80.0 ab
10	3	20	0.00c	76.67 abc
11	4	10	0.00c	73.33abc
12	4	15	0.00c	70.0bc
13	4	20	0.00c	63.33cd
14	5	10	0.00c	70.0bc
15	5	15	0.00c	63.33cd
16	5	20	0.00c	53.33d
CV			174.02	13.69

In column, figures followed by same letter(s) do not differ significantly ($p>0.005$).

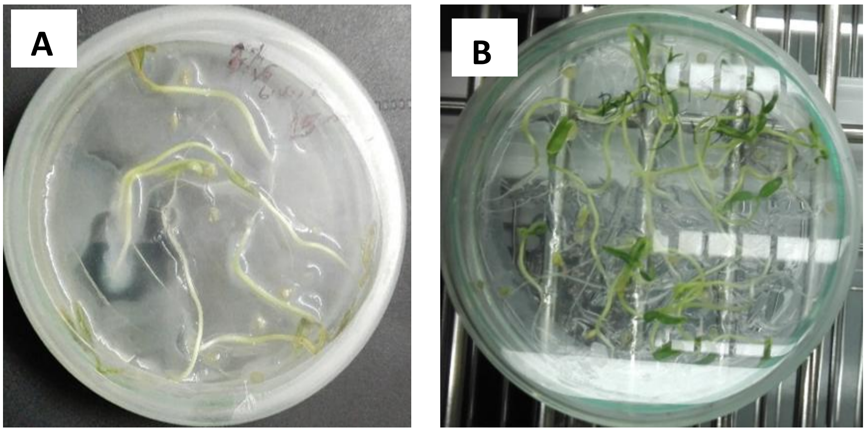


Fig 8. Different concentration of NaOCl and sterilization time on germination of seed
A: 0% Sodium hypochloride+without sterilization; B: 1% Sodium hypochloride + 10 minute sterilization

Effect of Auxin (IAA) and Cytokinin (BAP) concentrations in callus formation

The hormonal balance between auxins (IAA) and cytokinins (BAP) can regulate the formation of roots, shoots and callus tissue *in vitro.* In this study, the rate of callus formation from cotyledon was significantly ($p<0.005$) higher in MS media containing 0.5 mgL^{-1} IAA + 0.5 mgL^{-1} BAP and the lowest callus formation was found in the MS media containing 0.1 mgL^{-1} IAA + 1.0 mgL^{-1} BAP (Figure 9 and Figure 10). Callus formation from hypocotyl was significantly ($p<0.005$) higher in MS media containing 0.5 mgL^{-1} IAA + 2.0 mgL^{-1} BAP and the minimum rate of callus formation was observed in the MS media containing 0.1 mgL-1 IAA + 0.5 mgL-1 BAP (Table 2). Liu *et al.* (2003) reported similar results while working with leaf and stem explants with 2.5 mgL^{-1} BAP + 0.2 mgL^{-1} IAA. In present experiment the highest rate of callus was formed from hypocotyl when 2.0 mgL^{-1} BAP with 0.5 mgL-1 IAA was used in MS media that partially agree. Callus formation was also higher from hypocotyl (83%) than cotyledon (76.33%).

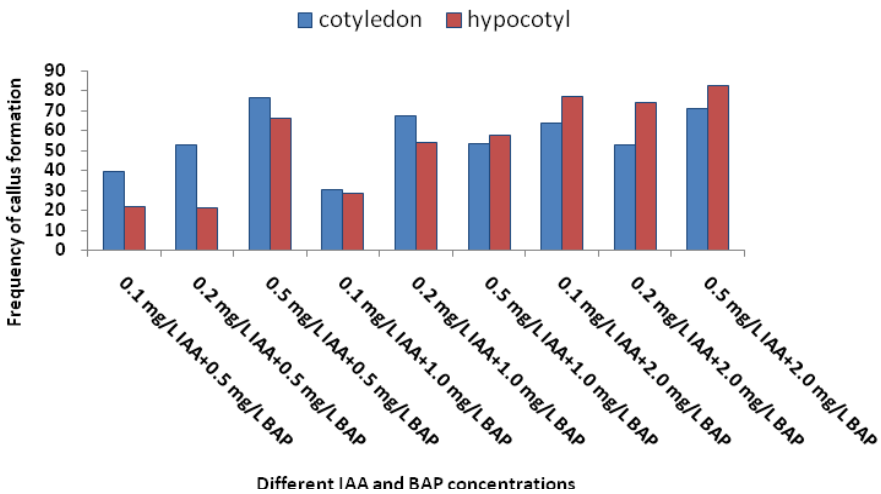


Fig. 9. Effect of different IAA and BAP concentrations in callus formation

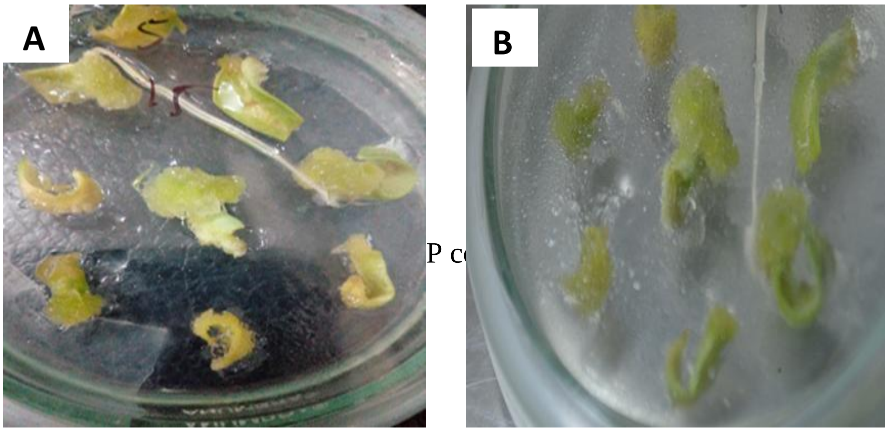


Fig. 10: A. callus formed from cotyledon (0.1 mgL-1 IAA + 1.0mgL-1 BAP); B: callus formed from hypocotyls (0.5 mgL-1 IAA + 2.0mgL-1 BAP)

Effect of size of cotyledon and hypocotyl explants on callus formation

In our study the maximum callus formation (69.0%) was found when cotyledon size was 22 mm^2 and the minimum rate (52.33%) was observed in 17 mm^2 (Table5 and Fig.5). The Maximum rate (88.33%) and minimum rate (76.67%) of callus formation was also observed when hypocotyl size was 18 mm^2 and 12 mm^2 respectively (Table 6). Callus formation was also the highest from hypocotyl than cotyledon (Table2 and Figure 4). Curuk *et al* (2002) reported that young hypocotyl explants showed rapid shoot regeneration. Cell aggregate size (total cell mass) is also important in determining organogenetic competence, cell division and further response of an explant (Compton, 2000). Different concentrations of auxins and cytokinins either singly or in combinations had a distinct effect on callus induction from both explants. Pal *et al*. (2007) reported that *in vitro* callus induction depends on the endogenous concentration of plant growth regulator as well as exogenously supplied growth regulator. Osman *et al* (2010) reported that callus response was markedly affected by the types of explants (hypocotyl and leaves) and growth regulators used. Moreover, Nikam and Shitole (1998) reported that the growth regulator requirements for callus induction vary depending on the source of explant. Manawadu *et al.* (2014) reported that the highest callus formed from hypocotyl than other explants which supports the result of our experiment.

Table 2. Size of cotyledon and hypocotyl explants on callus formation

SL No.	Size of cotyledons (mm^2)	Callus formation (%)	Size of hypocotyls (mm^2)	Callus formation (%)
1	15	56.67ab	12	76.67b
2	17	52.33b	14	76.67b
3	20	53.33b	25	81.67ab
4	22	69.0a	16	86.67ab
5	25	62.33ab	18	88.33a
CV		**12.76**		**7.08**

In a column, figure followed by same letter (s) do not differ significantly (p>0.005).

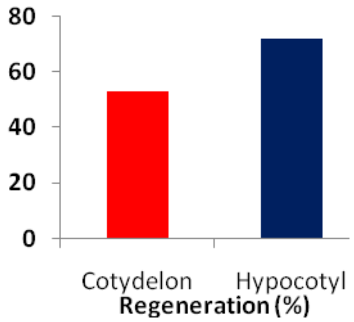


Fig 11. Comparison between cotyledon and hypocotyl on regeneration

Effect of MS media containing different concentrations of IAA and BAP on length of shoots, roots and number of leaves after 30 days

Variation in length of shoots, roots and number of leaves may occur due to the difference in varieties and also due to the difference in the media composition. Maximum number of leaves (17.33) was found in the MS media containing 0.2 mgL^{-1} IAA + 2.0 mgL^{-1} BAP and minimum (10.67) in media containing 0.2 mgL^{-1} IAA + 1.0 mgL^{-1} BAP (Table 3 and Figure .5). The highest shoot length (11.33 cm) and root length (7.0 cm) was found in the MS media containing 0.5 mgL^{-1} IAA + 0.5 mgL^{-1} BAP and the minimum length of shoot (6.33cm) and root (5.0cm) was found in the MS media containing 0.5 mgL^{-1} IAA + 1.0mgL^{-1} BAP (Table 3 and Figure 11). The maximum number of leaves and highest length of roots were observed in the MS media containing 0.2mgL^{-1} IAA + 2.0 mgL^{-1} BAP and different previous study reported that increasing concentration of IAA enhance the length of shoot and number of leaves.

Table 3. Length of shoots, roots and no. of leaves after 30 days

Combination		No of leaves	Length of shoot (cm)	Length of root (cm)
IAA (mgL-1)	BAP (mgL^{-1})			
0.5	0.5	12.0bc	11.33a	7.0a
0.2	1.0	10.67c	9.0ab	5.33a
0.5	1.0	11.0bc	6.66bc	5.66a
0.1	2.0	15.33ab	8.66bc	5.33a
0.2	2.0	17.33a	6.33c	5.0a
0.5	2.0	12.67bc	7.33bc	6.33a
CV(%)		**20.50**	**22.16**	**16.42**

In the column, figures followed by same letter (s) do not differ significantly (p>0.005).

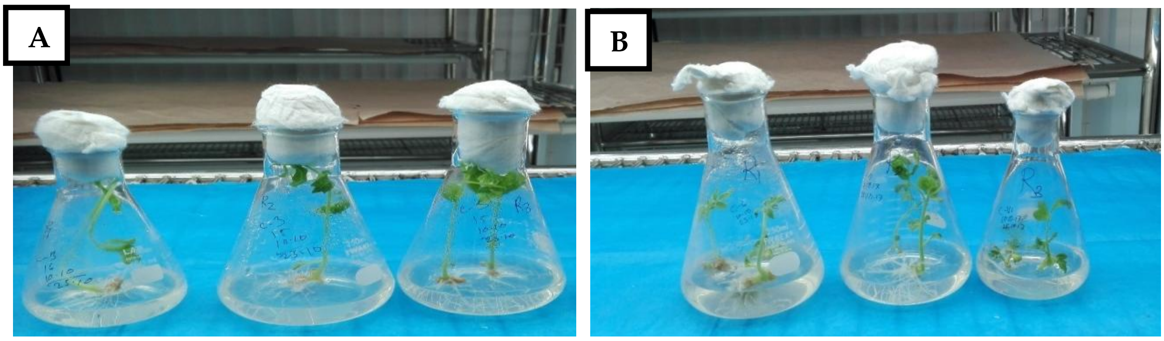


Fig. 12. Effect of different concentrations of auxin (IAA) and cytokinin (BAP) on number of leaves, length of shoot and root. A: Media containing 0.5 mgL-1 IAA + 0.5 mg/ L BAP; B: Media containing 0.5 mgL-1 IAA+ 1.0 mg/ L BAP

Acclimatization and flowering

The plants obtained from regeneration were carefully uprooted from the flask. Then the media remained in the roots were gently washed with tap water. After washing, the plantlets were transferred to the pots, where the pots were filled with 10 kg sterilized soil. For hardening, these were wrapped with polythene bag for 72 hrs and kept at shaded conditions. Then the pots were opened, watered and transferred to the normal environment. Day to day carefully observation was done. The number of established plants was higher which were produced from 0.5 gL^{-1} IAA + 0.5 gL^{-1} BAP hormonal combinations. It was also found that after 15 days of transferring to the soil from the growth media, the plants that grow in this combination had highest number of leaves (22.0) and plant height (8.33 cm). On the other hand the lowest number of leaves (7.33) and plant height (5.66 cm) was observed in the plants which were produced from 0.5 gL^{-1}IAA + 2.0 gL^{-1}BAP and 0.5 gL^{-1} IAA + 1.0 gL^{-1} BAP, respectively (Table 4 and Fig. 11, Fig. 12). After transfer to soil the plants which were come from different combinations of IAA and BAP required different amounts of time for flower initiations. Significant difference was also present in time requirement for flowering and in the above combination (0.5 gL^{-1} IAA + 0.5 gL^{-1} BAP) required only 29 days for flower initiation (Table 5 and Fig.14-15), which was quite less than others. The maximum time (38.33 days) was required for flowering at combination 9. This might be happened due to the influence of different concentration of auxin and cytokinin in growing media. After transfer to the soil the plant height and number of leaves in plant was also maximum in that combination and the lowest number of days was also required for flowering that indicates this combination is the best for tomato regeneration from explants as auxin and cytokinin have effects on plant livability and production performance. Thus, the combination (0.5 gL^{-1} IAA + 0.5 gL^{-1} BAP) was best for callus formation, shoot regeneration, root formation, number of leaves, length of shoot and root, acclimatization and flowering than other combinations. Hence, these combinations can be used in tomato regeneration and subsequently for *Agrobacterium* mediated genetic transformation of tomato.

Table 4. Acclimatization of plantlets after 15 days

Sl No.	Combination		No of leaves	Plant height (cm)
	IAA (mgL-1)	BAP (mgL-1)		
1	0.5	0.5	22.0a	8.33a
2	0.2	1.0	16.67ab	6.33bc
3	0.5	1.0	13.0bc	5.66c
4	0.1	2.0	17.67ab	6.66abc
5	0.2	2.0	16.66ab	8.33a
6	0.5	2.0	7.33c	7.66ab

CV	**31.79**	**16.27907**

In a column, figures followed by same letter(s) do not differ significantly (p>0.005).

Table 5. Flowering of plantlets

Sl No	Combination		Days required for flowering
	IAA (mgL-1)	BAP (mgL-1)	
1	0.5	0.5	29.33b
2	0.2	1.0	35.67a
3	0.5	1.0	36.33a
4	0.1	2.0	35.67a
5	0.2	2.0	34.33ab
6	0.5	2.0	38.33a
	CV		**17.83**

In column, figures followed by same letter(s) do not differ significantly (p>0.005).

Fig. 13: Fig. Hardening of the regenerated plants before exposing to the normal environment

Fig 14. Flowering at tissue potted soils

Fruiting

Following flowering the established plants were started fruiting. Watering and other intercultural operations were done carefully. It was also found that the plants that were grown from 0.5 g/L IAA + 0.5 g/L BAP hormonal combination produced highest no of fruits (75). On the other hand the plants that were grown from 0.2 g/L IAA + 1.0 g/L BAP hormonal combination produced the lowest no of fruits (53). After fully maturation the fruits were harvested. Significant difference was also preset in weight of fruits and average weight of fruits. The maximum weight of fruits

(3350.08) and average fruit weight (52.35) was present in those plants that were grown from 0.2 g/L IAA + 2.0 g/L BAP hormonal combination. On the other hand the lowest average fruit weight (41.52) was present in those plants that were grown from 0.5 g/L IAA + 0.5 g/L BAP hormonal combination. Here it is cleared that though the no of fruits was highest in combination 3 but the fruit weight was lowest in this combination. This might be happened due to the influence of auxin and cytokinin in growing media.

Table 6: No. of fruits, weight of fruits and average fruit weight after harvesting

Combination No.	No. of fruits	Weight of fruits (g)	Average fruit weight (g)
C-3	75	3113.74	41.52
C-5	53	2632.04	49.66
C-6	60	3083.13	51.39
C-7	69	3267.62	47.36
C-8	64	3350.08	52.35
C-9	63	2632.63	41.79

Fig. 15. Plant with fruits

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

In T. Aman'2017 five parents were grown for crossing purpose. Out of these, two were donor parents viz. Binadhan-11, BRRI dhan52 and three were recipient parent's viz. Sadamota, Dudkalm and Lalmota. Both of the parent's i.e. recipients and donor plants were grown in three sets with an interval of ten days for synchronizing the flowering. Thirty days old single seedlings were transplanted in a 5.5m × 2m row plot with 20cm × 20cm spacing. Fertilizers application, weeding and other intercultural operation were done as per BINA recommended rice production practices. Usual methods of emasculation and pollination were done. At maturity F_1 seeds were collected, dried and stored in paper bags with proper labeling. During the reporting period a total of 132 F_1 seeds were obtained from five cross combinations. These seeds will be used for future backcrossing program for development of high yielding, tidal tolerant and early maturing advance rice lines.

Table 7: List of cross combination for F_1 seeds production, T.aman 2017

Sl. No.	Crosses	No. of seeds harvested
1	Dudkalam X Binadhan-11	50
2	Sadamota X Binadhan-11	32
3	Sadamota X BRRIdhan52	25
4	Lalmota X Binadhan-11	20
5	Lalmota X BRRIdhan52	5
	Total number of F_1 seeds	**132**

DNA extraction and PCR activity were done for primers survey. During the reporting period a total of 48 SSR primers were surveyed and 18 primers (RM302, RM490, RM3825, RM312, RM3475, RM562, RM8094, RM10694, RM10793, RM3412, RM493, RM158, RM237, RM452, RM475, RM71, RM324 and RM573) were showed polymorphism (Fig 16). This polymorphic primer will be used for F_1 confirmation.

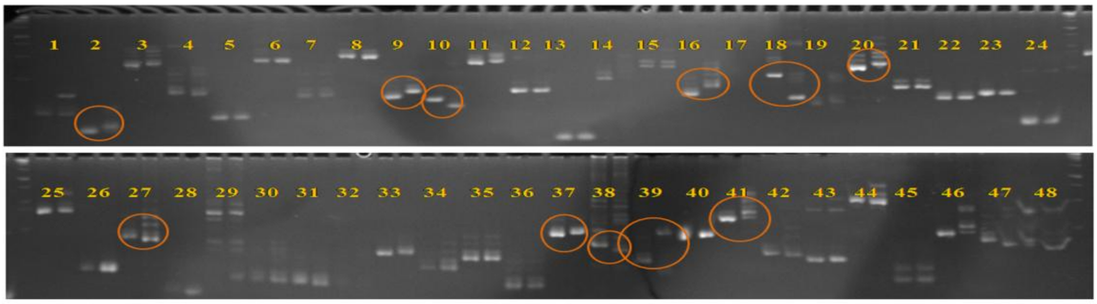


Fig16: Primer Survey for F1 Conformation

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

Development of salt tolerant rice varieties through marker assisted backcrossing

In Boro'2017-18 for salt tolerance variety development four parents were grown in a try for F_1 production. Thirty days old single seedlings were transplanted in a 5.5m × 2.0m row plot with 20cm × 20cm spacing both plant to plant and line to line. Fertilizers application, weeding and other intercultural operation were done as per BINA recommended rice production practices. Usual methods of emasculation and pollination were done. At maturity stage about 450 F_1 seeds were collected from five cross combination. The collected seed will be grown next Boro season. For F_1 conformation primer survey works is on-going.

Table 8. List of crosses for F_1 population0 development

Sl. No.	Crosses	No. of seeds harvested	Objectives
1	BRRI dhan48 × Binadhan-10	110	High grain yield with salt tolerance
2	BRRI dhan48 × Binadhan-8	80	High grain yield with salt tolerance
3	BRRI dhan58 × Binadhan-10	120	High grain yield with salt tolerance
4	BRRI dhan58 × Binadhan-8	90	High grain yield with salt tolerance

5	BRRI dhan58 × FL478	50	High grain yield with salt tolerance
	Total number of $BC_1 F_1$ seeds	**450**	

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

Wild species of crop plants are increasingly being used to improve various agronomic traits including yield in cultivars. Advanced backcross QTL analysis has been used to identify naturally occurring favorable QTL alleles for yield. In this research, Binadhan-16 and Binadhan-7 used as recurrent parents. Two advanced backcross populations BC_2F_2 will be developed through cross between Binadhan-16*3/*O.rufipogon* and Binadhan-7*3/*O.rufipogon*. Two accessions of *O. rufipogon* (103403 and 10589) have been used as donor parents.

Population development

In T. Aman 2016, a total of 68 BC_2F_1 plant were transplanted in a try. Out of these only 14 BC_1F_1 plant were selected through MAS techniques. But unfortunately it was not possible to cross and developed BC_2F_1 population. We collected only 14 BC_1F_3 populations. The collected F_3 seed grown in Boro2016-17 season and out of these only six population select best their homogeneity, better agronomic performance and also high yielding performance.

On the other hand, in T. Aman 2017, again taking initiative for develop the BC_1F_1/ F_1 population. During the reporting period about 64 BC_1F_1 and 42 F_1 seed were develop three different cross combination.

Table 9. List of crosses For BC_1F_1/ F_1 population developed during T. aman/2017 seasons

Sl. No.	Crosses	Populations	No. of seeds harvested
1	Binadhan-16 X *O. rufipogon* *(acc. No.* 103403*)*	BC_1F_1	64
2	Binadhan-16 X *O. rufipogon* *(acc. No.*10589)	F1	7
3	Binadhan-7 X *O. rufipogon* *(acc. No.*103403)	F1	37
	Total number of BC_1F_1/ F_1 seeds		**108**

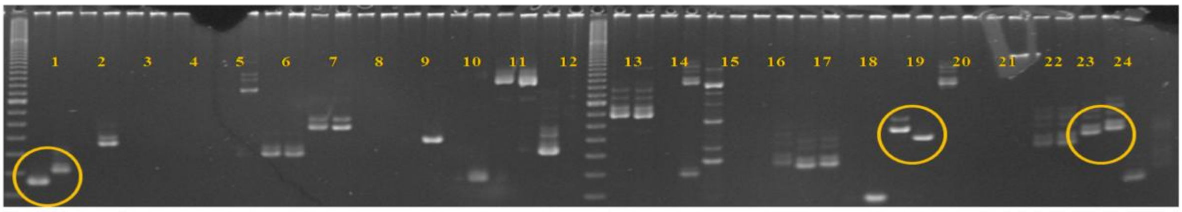


Fig 17. SSR primer survey of F_1 and background selection for Binadhan-16 and *O.rufipogon* population

Legend: 1=RM1; 2=RM283; 3=RM237; 4=RM259; 5=RM431; 6=RM495; 7=RM499; 8=RM5; 9=RM243; 10=RM158; 11=RM312; 12=RM165; 13=RM238; 14=RM140; 15=RM246; 16=RM522; 17=RM315; 18=RM292; 19=RM302; 20=RM493; 21=RM3412; 22=; 23=RM10748; 24= RM562

After that at this time some polymorphic primers were surveyed in favor of foreground and background selection. A total of 148 SSR primers were surveyed and about 70 polymorphic primers were showed polymorphism. These polymorphic primers will be used the next generation selection.

Genetic characterization of BINA developed rice varieties

Objectives

- To characterize BINA developed crop varieties
- To get information for patent development
- To know the genetic relationship among BINA developed crop varieties
- To increase our knowledge for further development of BINA developed varieties

Methods

Table 10. List of primers used for survey for DNA fingerprint analysis

Primers name	Repeat motive	Chromosome number	Primers name	Repeat motive	Chromosome number
RM 5	(GA)14	1	RM 475	(TATC)8	2
RM 493	(CTT)9	1	RM 514	(AC)12	3
RM 594	(GA)n	1	RM 211	(TC)3A(TC)18	3
RM 3475	(CT)22	1	RM 186	(CGG)5	3
RM 158	(GGC)9	1	RM 3827	(GA)21	3
RM 237	(CT)18	1	RM 517	(CT)15	3
RM 211	(TC)3A(TC)18	1	RM 3	(GA)2GG(GA)25	3
RM 1	(GA)26	1	RM 338	(CTT)6	3
RM 495	(CTG)7	1	RM 156	(CGG)8	3
RM 154	(GA)21	1	RM 489	(ATA)8	3
RM 259	(CT)17	1	RM 526	(TAAT)5	3
RM 283	(GA)18	1	RM 545	(GA)30	3
RM 324	(CAT)21	2	RM 36	(GA)23	3
RM 166	(T)12	2	RM 16706	(GA)20	4
RM 6	(AG)16	2	RM 252	(CT)19	4
RM 266	(GA)19	2	RM 401	(CT)15	4
RM 208	(CT)17	2	RM 518	(TC)15	4
RM 178	(GA)5(AG)8	2	RM 5953	(CAC)6	4
RM 573	(GA)11	2	RM 119	(GTC)6	4
RM 7276	(ATCT)10	2	RM 413	(AG)11	5
RM 525	(AAG)12	2	RM 169	(GA)12	5
RM 289	G11(GA)16	5	RM 18	(GA)4AA(GA)(AG)16	7
RM 32	(TC)3A(CT)9 (TC)5	5	RM 234	(CT)25	7
RM 122	(GA)7A(GA) 2A(GA)11	5	RM 118	(GA)8	7
RM 178	(GA)5(AG)8	5	RM 125	(GCT)8	7
RM 153	(GAA)9	5	RM 346	(CTT)18	7
RM 161	(AG)20	5	RM 7601	(TGGA)7	7
RM 12375	(TA)11	5	RM 481	(CAA)12	7
RM 253	(GA)25	6	RM 351	(CCG)9(CGAAG)	7

				4	
RM 586	(CT)23	6	RM 429	(TG)10	7
RM 584	(CT)14	6	RM 248	(CT)25	7
RM 587	(CTT)18	6	RM 134	(CCA)7	7
RM 510	(GA)15	6	RM 1362	(AG)25	7
RM 541	(TC)16	6	RM 331	[(CTT)4GTT]2(CTT)11	8
RM 527	(GA)17	6	RM 3452	(CT)19	8
RM 585	(TC)45	6	RM 337	(CTT)4-19-(CTT)8	8
RM 111	(GA)9	6	RM 223	(CT)25	8
RM 435	(ATG)7	6	RM 210	(CT)23	8
RM 30	(AG)9A(GA)12	6	RM 544	(TC)9	8
RM 204	(CT)44	6	RM 42	(AG)6-(AG)2T(GA)5	8
RM 136	(AGG)7	6	RM 407	(AG)13	8
RM 336	(CTT)18	7	RM 5493	(TC)24	8
RM 51	(GA)13	7	RM 447	(CTT)8	8
RM 256	(CT)21	8	RM 5926	(ATT)21	9
RM 310	(GT)19	8	RM 328	(CAT)5	9
RM 25	(GA)18	8	RM 105	(CCT)6	9
RM 3231	(CT)12	8	RM 215	(CT)16	9
RM 72	(TAT)5C(ATT)15	8	RM 258	(GA)21(GGA)3	10
RM 126	(GA)7	8	RM 244	(CT)4(CG)3C(CT)6	10
RM 44	(GA)16	8	RM 222	(CT)18	10
RM 344	(TTC)2-5-(CTT)3-(CTT)4	8	RM 271	(GA)15	10
RM 515	(GA)11	8	RM 219	(CT)17	10
RM 3825	(GA)21	8	RM 474	(AT)13	10
RM 205	(CT)25	9	RM 222	(CT)18	10
RM 107	(GA)7	9	RM 271	(GA)15	10
RM 242	(CT)26	9	RM 219	(CT)17	10
RM 296	(GA)10	9	RM 474	(AT)13	10
RM 5799	(AGC)9	9	RM 228	(CA)6(GA)36	10
RM 23668	(ACG)10	9	RM 147	(TTCC)5(GGT)5	10
RM 23679	(AGAA)10	9	RM 229	(TC)11(CT)5C3(CT)5	11
RM 3609	(GA)13	9	RM 224	(AAG)8(AG)13	11
RM 23770	(AAT)20	9	RM 167	(GA)16	11
RM 23778	(ATAA)20	9	RM 144	(ATT)11	11
RM 1233	(AG)15	9	RM 330	(CAT)5	11
RM 120	(GA)9TAG(ATC)4	11	RM 20	(ATT)14	12
RM 209	(CT)18	11	RM 12	(GA)21	12
RM 286	(GA)16	11	RM 5338	(TC)12	12
RM 536	(CT)16	11	RM 260	(CT)34	12
RM 206	(CT)21	11	RM 102	(GGC)7(CG)6	12
RM 21	(GA)18	11	RM 19	(ATC)10	12
RM 519	(AAG)8	12	RM 316	(GT)8-(TG)9(TTTG)4(TG)4	12
RM 277	(CT)10	12	RM 512	(TTTA)5	12

PCR conditions: 99^{0}C at 3 minutes, (94^{0}C for 1 minute, 55^{0}C for 1 minute, 72^{0}C for 1.5 minute) X35 cycle and final extension 72^{0}C for 1 minute

Table 11. List of selected primers used for DNA fingerprint analysis

Primers name	Repeat motive	Chromosome number
RM 584	(CT)14	6
RM 136	(AGG)7	6
RM 351	(CCG)9(CGAAG)4	7
RM 107	(GA)7	9
RM 242	(CT)26	9
RM 23778	(ATAA)20	9
RM 222	(CT)18	10
RM 219	(CT)17	10
RM 147	(TTCC)5(GGT)5	10
RM 228	(CA)6(GA)36	10
RM 144	(ATT)11	11
RM 209	(CT)18	11

Iratom 24

Shape of the ligule of penultimate leaf was split. Flag leaf of the variety was erect, stem length 41-60 cm and panicle length 18.5 cm. Number of the effective tillers per plant 29, maturity period was 140-145 days, grain weight of 1000 fully developed grains is 12 gm and decorticated grain shape 2.1. The grain yield is 6.5 tha^{-1} in Boro and 3.5 tha^{-1} in Aus season.

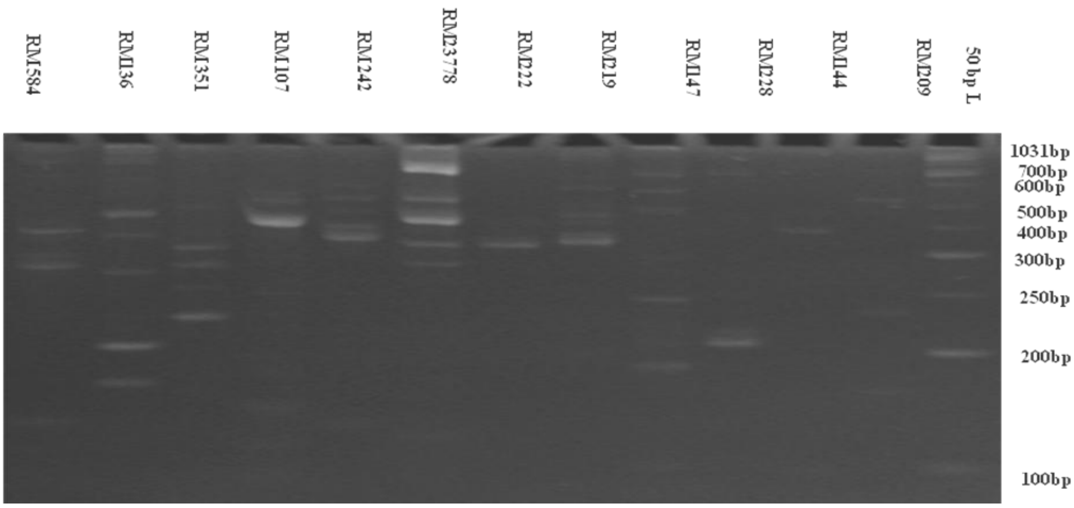


Figure 18: DNA fingerprint of Iratom24

To characterize this variety twelve primers were used. Primers are RM 584, RM, 136, RM 351, RM 107, RM 242, RM 23778, RM 23778, RM 222, RM 219, RM147, RM228, RM144, RM209. Among the primers RM136 produced the highest number of brands (13) from the chromosome 6 ranging from 1031bp to 75bp and RM 144 produced the lowest number of bands in chromosome number 11 ranging from 300 bp to 100bp.

Binasail

Shape of the ligule of penultimate leaf was split. Flag leaf of the variety was horizontal, stem length 81-110 cm and panicle length was 19.5 cm. Number of the effective tillers per plant was 18, the time for maturity was 135-140 days, and grain weight of 1000 fully developed grains was 16 gm and decorticated grain shape 1.7**.** The grain yield was 4.2 t/ha in Aman season.

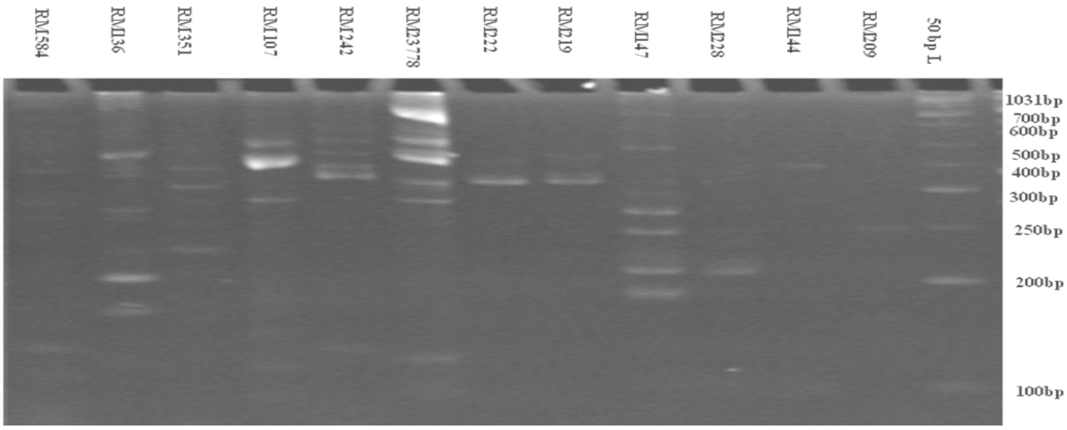


Figure 19: DNA fingerprint of Binashail

To characterize this variety twelve primers are used. Primers were RM 584, RM, 136, RM 351, RM107, RM242, RM23778, RM222, RM219, RM147, RM228, RM144 and RM209. Among the primers RM147 produced the highest number of bands (12) from the chromosome 10 ranging from 1031bp to 100bp and RM 144 produced lowest number of brands in chromosome number 11 ranging from 400bp to 100bp. The primer RM 147 may be the best primer for this variety.

Binadhan-4

Shape of the ligule of penultimate leaf was split. Flag leaf of the variety was erect, stem length 61-80 cm and panicle length 21 cm. Number of the effective tillers per plant 22, maturity period was 130-135 days, grain weight of 1000 fully developed grains was 24 gm and decorticated grain shape 2.1. The grain yield was 4.7 t/ha in Aman season.

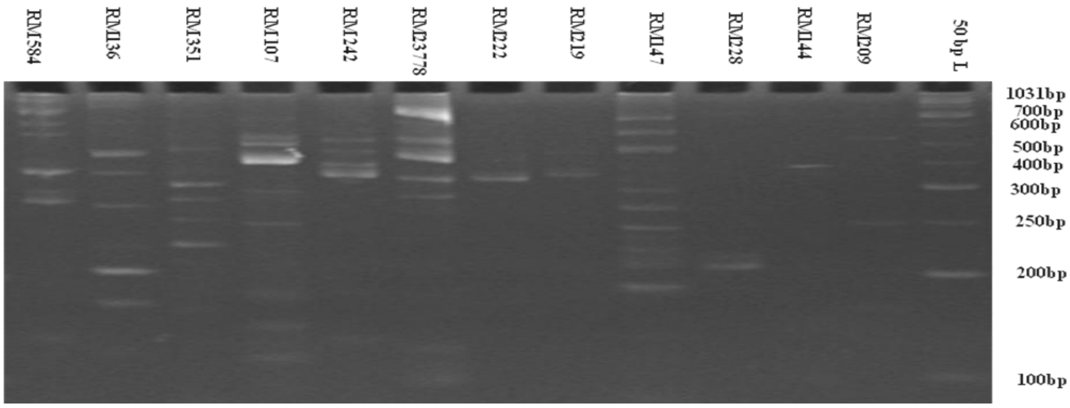


Figure 20: DNA fingerprint of Binadhan 4

To characterize this variety twelve primers are used. Primers are RM 584, RM, 136, RM 351,RM 107, RM 242, RM 23778, RM 23778, RM 222, RM 219,RM147, RM228, RM144, RM209. Among the primers RM147 produced the highest number of brands (11) from the chromosome 10 ranging from 900bp to 100bp and RM 144 produced the lowest number of brands (2) in chromosome number 11 ranging from 400bp to 100bp . The primer RM 147may be the best primer for this variety.

Binadhan-5

Shape of the ligule of penultimate leaf was split. Flag leaf of the variety was erect, stem length 81-110 cm and panicle length 23 cm. Number of the effective tillers per plant 23, maturity period was 150-155 days, grain weight of 1000 fully developed grains is 18 gm and decorticated grain shape 2.1. The grain yield is 7.0 t/ha in Boro season.

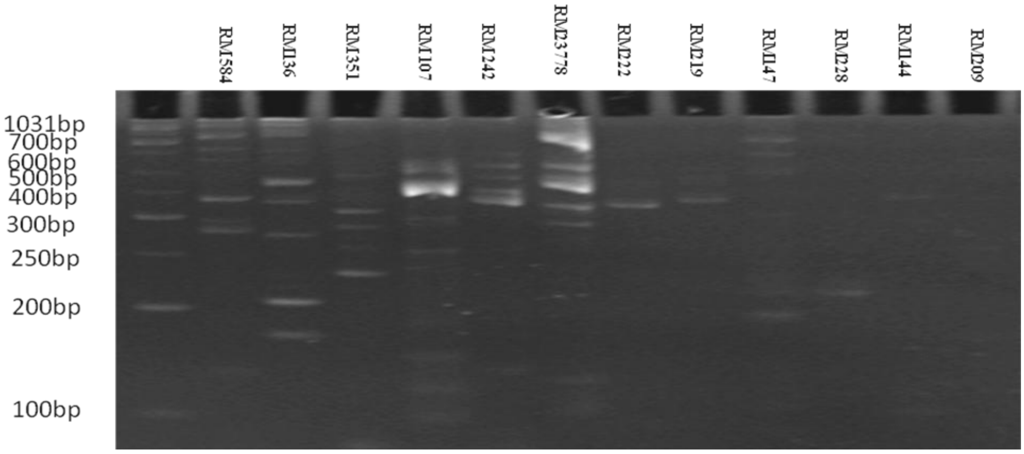


Figure 21: DNA fingerprint of Binadhan 5

To characterize this variety twelve primers are used. Primers are RM 584, RM, 136, RM351, RM107, RM242, RM23778, RM222, RM219, RM147, RM228, RM144 and RM209. Among the primers RM136 produced the highest number of brands (12) from the chromosome 6 ranging from 1031bp to 150bp and RM 144 produced lowest number of brands (2) in chromosome number 11 ranging from 400bp to 100bp. The primer RM 136 may be the best primer for this variety.

Binadhan-6

Shape of the ligule of penultimate leaf is split. Flag leaf of the variety is semi erect, stem length 81-110 cm and panicle length 27 cm. Number of the effective tillers per plant 22, maturity period was 160-165 days, grain weight of 1000 fully developed grains is 27.4 gm and decorticated grain shape 2.4. The grain yield is 7.5 t/ha in Boro season.

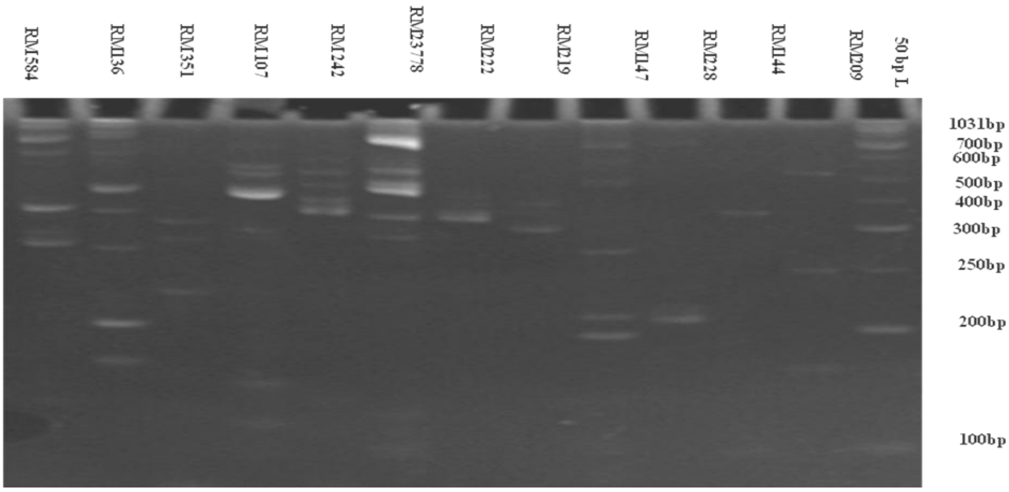


Figure 22: DNA fingerprint of Binadhan 6

To characterize this variety twelve primers were used. Primers are RM 584, RM, 136, RM 351,RM 107, RM 242, RM 23778, RM 23778, RM 222, RM 219,RM147, RM228, RM144, RM209. Among the primers RM136 produced the highest number of brands (13) from the chromosome 6 ranging from 1031bp to 150bp and RM 144 produced lowest number of brands in chromosome number 11 ranging from 350bp to 100bp.

Binadhan-7

Shape of the ligule of penultimate leaf was Acute. Flag leaf of the variety was semi erect, stem length 61-80 cm and panicle length 21.5 cm. Number of the effective tillers per plant 36, maturity period was 110-120 days, grain weight of 1000 fully developed grains is 20 gm and decorticated grain shape 4.3.The variety known as early Aman. The grain yield is 4.8 t/ha in Aman season.

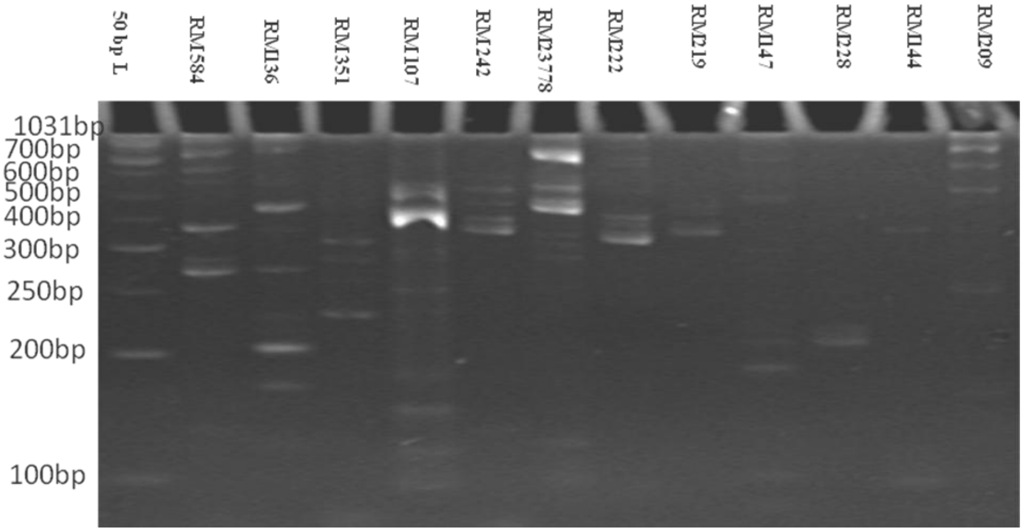


Figure 23: DNA fingerprint of Binadhan 7

To characterize this variety twelve primers are used. Primers are RM584, RM136, RM351, RM107, RM242, RM23778, RM222, RM219, RM147, RM228, RM144 and RM209. Among the primers RM147 produced the highest number of brands (16) from the chromosome 10 ranging from 1031bp to 50bp and RM 144 produced lowest number of brands (2) in chromosome number 11 ranging from 400bp to 100bp.

Binadhan-8

Shape of the ligule of penultimate leaf is split. Flag leaf of the variety is semi erect, stem length 61-80 cm and panicle length 18.9 cm. Number of the effective tillers per plant 31, maturity period was 130-135 days in Boro and 125-130 days in Aman season, grain weight of 1000 fully developed grains is 22.9 gm and decorticated grain shape 2.5.The variety is known as saline tolerant where it can give 4.0 t/ha yield. The grain yield is 5.5 t/ha in Aman season and 7.5t/ha in Boro season.

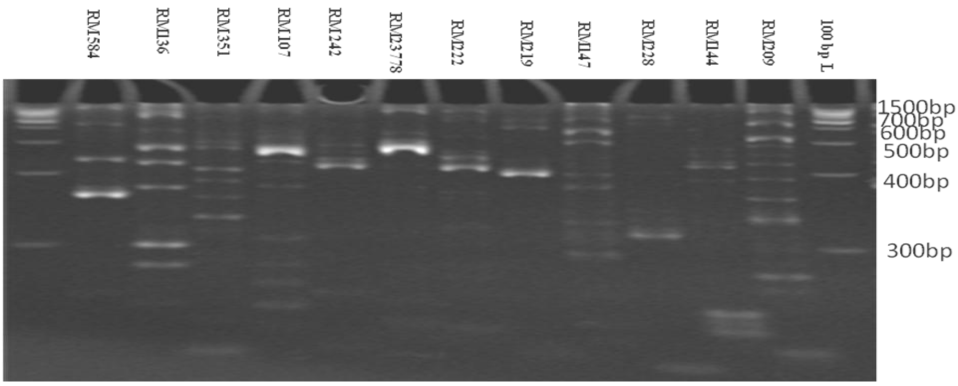


Figure 24: DNA fingerprint of Binadhan 8

To characterize this variety twelve primers are used. Primers are RM584, RM136, RM351, RM107, RM242, RM 23778, RM 222, RM 219, RM147, RM228, RM144, and RM209. Among the primers RM209 produced the highest number of brands (12) from the chromosome 11 ranging from 1500bp to 200bp and RM219 produced lowest number of brands (5) in chromosome number 10 ranges from 300bp to 50bp.

Binadhan-9

Shape of the ligule of penultimate leaf was split. Flag leaf of the variety was semi erect, stem length 61-80 cm and panicle length 17.9 cm. Number of the effective tillers per plant 37, maturity period was 125-130 days, grain weight of 1000 fully developed grains is 13.4 gm and decorticated grain shape 1.5. The variety is known as aromatic rice. The grain yield is 3.7 t/ha in Amon season.

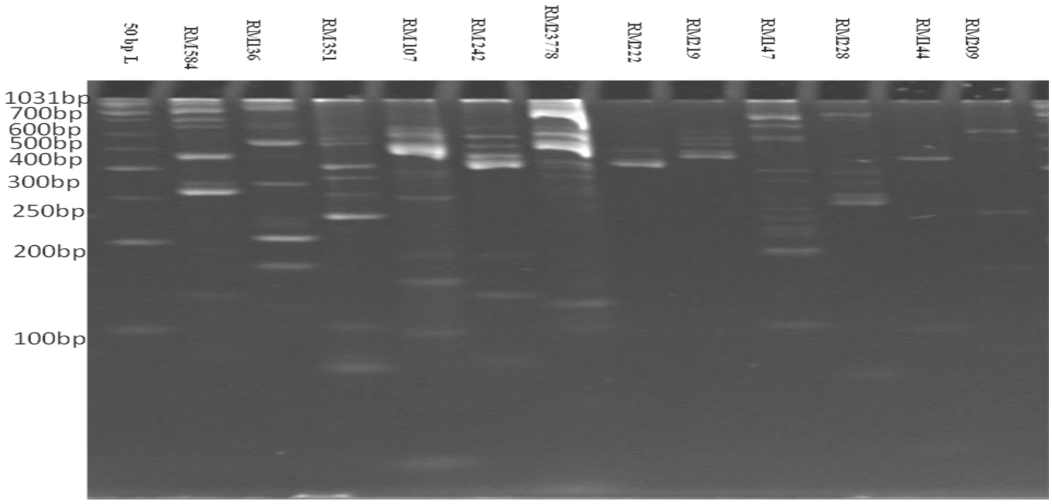


Figure 25: DNA fingerprint of Binadhan 9

To characterize Binadhan-9, twelve primers were used. Primers were RM584, RM136, RM351, RM107, RM242, RM23778, RM222, RM219, RM147, RM228, RM144 and RM209. Among the primers RM23778 produced the highest number of brands (22) from the chromosome 9 ranging from 1031bp to 75bp and RM 144 produced lowest number of brands in chromosome number 11 ranging from 500bp to 100bp .

Binadhan-10

Shape of the ligule of penultimate leaf were split. Flag leaf of the variety were semi erect, stem length 81-110 cm and panicle length 21.5 cm. Number of the effective tillers per plant 36, maturity period was 125-135 days, grain weight of 1000 fully developed grains is 27.6 gm and decorticated grain shape 4.2. The variety is known as saline tolerant where it can give 5.5 t/ha yield. The maximum grain yield was 8.0 t/ha in Boro season.

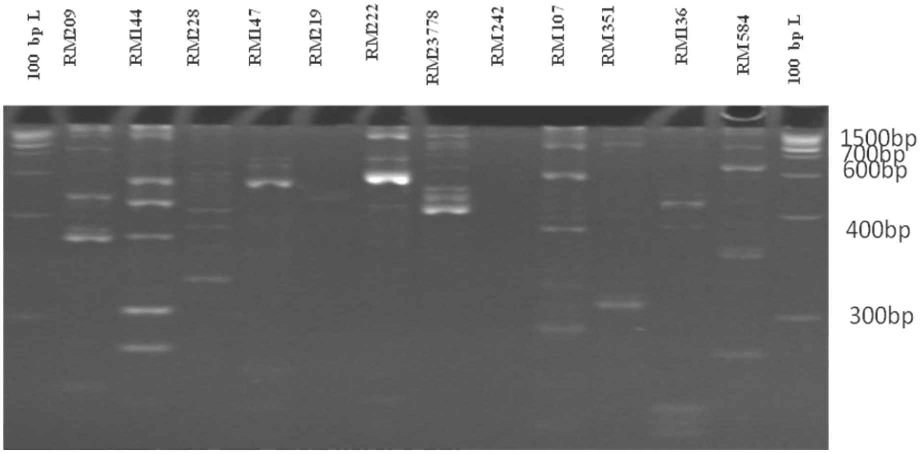


Figure 26: DNA fingerprint of Binadhan 10

To characterize this variety twelve primers were used. Primers were RM584, RM136, RM351, RM107, RM242, RM23778, RM222, RM219, RM147, RM228, RM144 and RM209. Among the primers RM147 produced the highest number of brands (14) from the chromosome 10 ranging from 1031bp to 100bp and RM242 produced lowest number of brands (3) in chromosome number 9 ranges from 500bp to 50bp.

Binadhan-11

Shape of the ligule of penultimate leaf was split. Flag leaf of the variety was semi erect, stem length 61-80 cm and panicle length 18.7 cm. Number of the effective tillers per plant 25, time of maturity 125 days, grain weight of 1000 fully developed grains is 24 gm and decorticated grain shape 3.4. The variety is known as Submergence tolerant where it can give 4.5 t/ha yield. The maximum grain yield is 5.5 t/ha in Aman season.

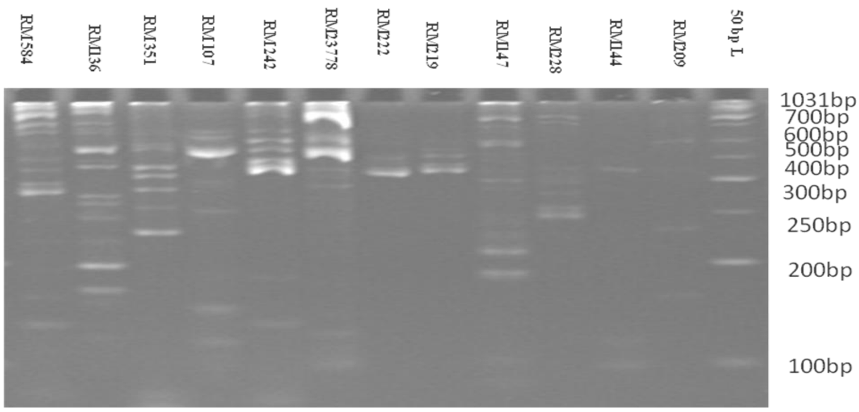


Figure 27: DNA fingerprint of Binadhan 11

To characterize this variety twelve primers were used. Primers were RM584, RM136, RM351, RM107, RM242, RM23778, RM222, RM219, RM147, RM228, RM144 and RM209. Among the primers RM147 produced the highest number of bands (14) from the chromosome 10 ranging from 1500bp to 200bp and RM242 produced lowest number of brands(3) in chromosome number 9 ranges from 350bp to 100bp .

Binadhan-12

Shape of the ligule of penultimate leaf was acute. Flag leaf of the variety was semi erect, stem length 61-80 cm and panicle length 19.8 cm. Number of the effective tillers per plant 21, time of maturity 135 days, grain weight of 1000 fully developed grains is 26.7 gm and decorticated grain shape 3.2. The variety is known as Submergence tolerant where it can give 4.0 t/ha yield. The maximum grain yield is 4.5 t/ha in Aman season.

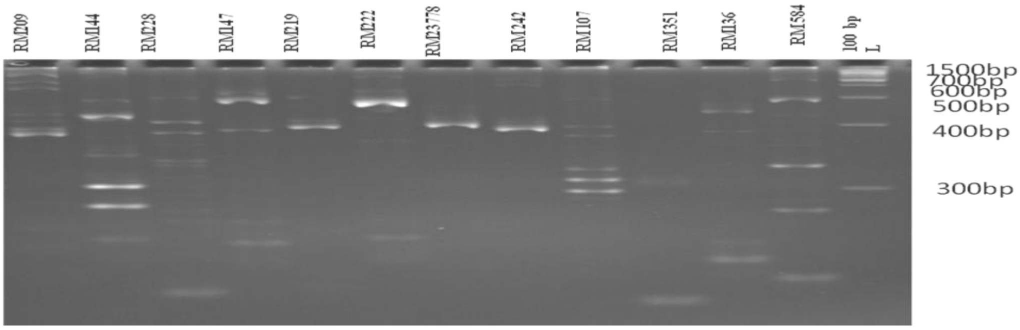


Figure 28: DNA fingerprint of Binadhan 12

To characterize this variety twelve primers were used. Primers were RM584, RM136, RM351, RM107, RM242, RM23778, RM222, RM219, RM147, RM228, RM144 and RM209. Among the primers RM584 produced the highest number of brands (16) from the chromosome 6 ranging from 1031bp to 100bp and RM144 produced lowest number of bands (3) in chromosome number 11 ranges from 400bp to 100bp.

Binadhan-13

Shape of the ligule of penultimate leaf was split. Flag leaf of the variety was semi erect, stem length 81-110 cm and panicle length 24 cm. Number of the effective tillers per plant 45, time of maturity 140 days, grain weight of 1000 fully developed grains is 13.9 gm and decorticated grain shape 1.7. The variety is known as aromatic Rice. The maximum grain yield is 3.5 t/ha in Aman season.

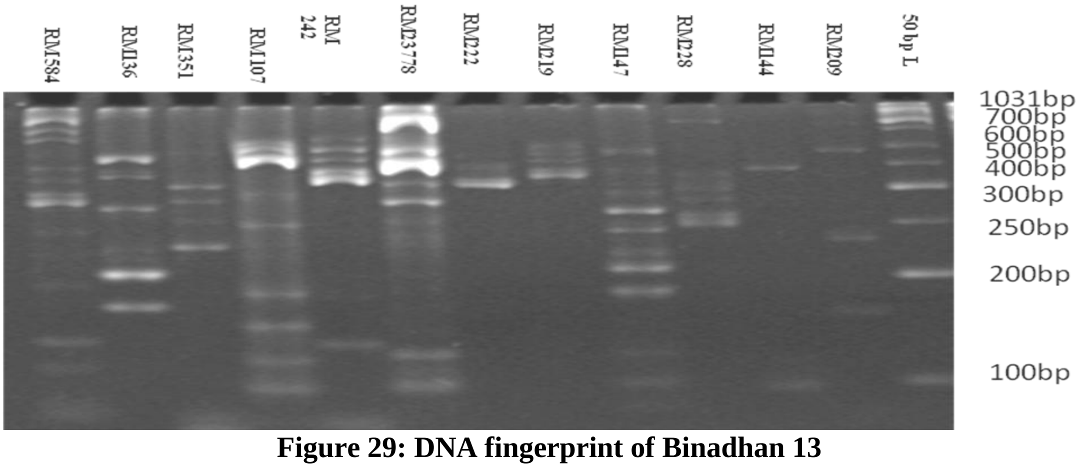


Figure 29: DNA fingerprint of Binadhan 13

To characterize this variety twelve primers are used. Primers are RM584, RM136, RM351, RM107, RM242, RM 23778, RM 222, RM 219, RM147, RM228, RM144 and RM209. Among the primers RM351 produced the highest number of bands (13) from the chromosome 7 ranging from 500bp to 200bp and RM228 produced lowest number of brands(2) in chromosome number 10 ranges from 300bp to 100bp .

Binadhan-14

Shape of the ligule of penultimate leaf was split. Flag leaf of the variety was semi erect, stem length 41-60 cm and panicle length 21.5 cm. Number of the effective tillers per plant 21, time of maturity 125 days, grain weight of 1000 fully developed grains is 19.9 gm and decorticated grain shape 2.8. The is late variety. The maximum grain yield is 6.9 t/ha in Boro season.

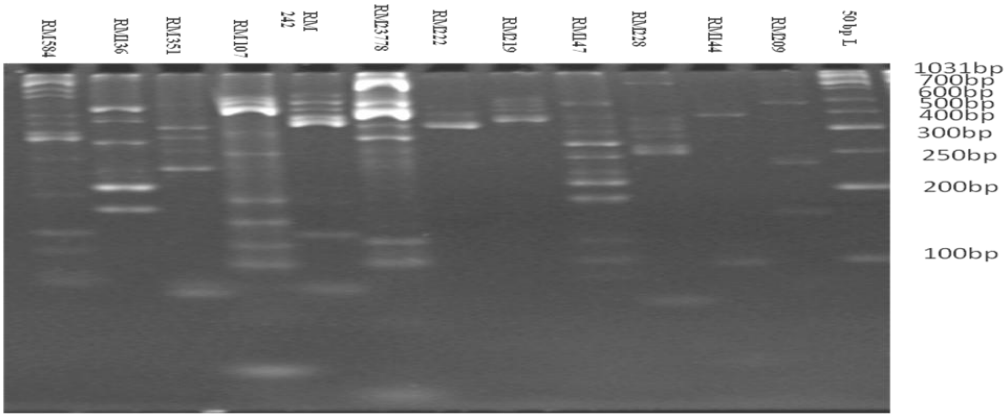


Figure 30: DNA fingerprint of Binadhan 14

To characterize this variety twelve primers were used. Primers were RM584, RM136, RM351, RM107, RM242, RM 23778, RM 222, RM 219, RM147, RM228, RM144 and RM209. Among the primers RM584 produced the highest number of brands (14) from the chromosome 6 ranging from 1031bp to 100bp and RM144 produced lowest number of brands (2) in chromosome number 11 ranges from 400bp to 100bp.

Binadhan-15

Shape of the ligule of penultimate leaf was split. Flag leaf of the variety was semi erect, stem length 41-60 cm and panicle length 17.5 cm. Number of the effective tillers per plant 26, maturity period was 125 days, grain weight of 1000 fully developed grains is 17.5 gm and decorticated grain shape 1.3. The variety is known as aromatic rice. The maximum grain yield was 4.8t/ha in Aman season.

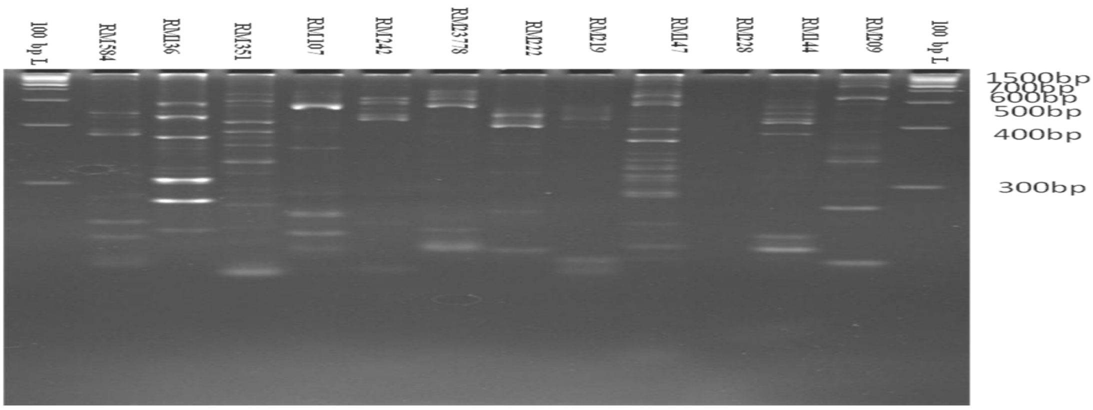


Figure 31: DNA fingerprint of Binadhan 15

To characterize this variety twelve primers were used. Primers were RM584, RM136, RM351, RM107, RM242, RM 23778, RM 222, RM 219, RM147, RM228, RM144 and RM209. Among the primers RM147 produced the highest number of bands (22) from the chromosome 10 ranging from 1500bp to 100bp and RM144 produced lowest number of bands (2) in chromosome number 11 ranges from 220bp to 50bp.

Binadhan-16

Shape of the ligule of penultimate leaf was split. Flag leaf of the variety was semi erect, stem length 41-60 cm and panicle length 18.5 cm. Number of the effective tillers per plant 26, maturity period was 105 days, grain weight of 1000 fully developed grains is 17.7 gm and decorticated grain shape 1:3. The variety is known as early Aman. The maximum grain yield was 5.5 t/ha in Aman season.

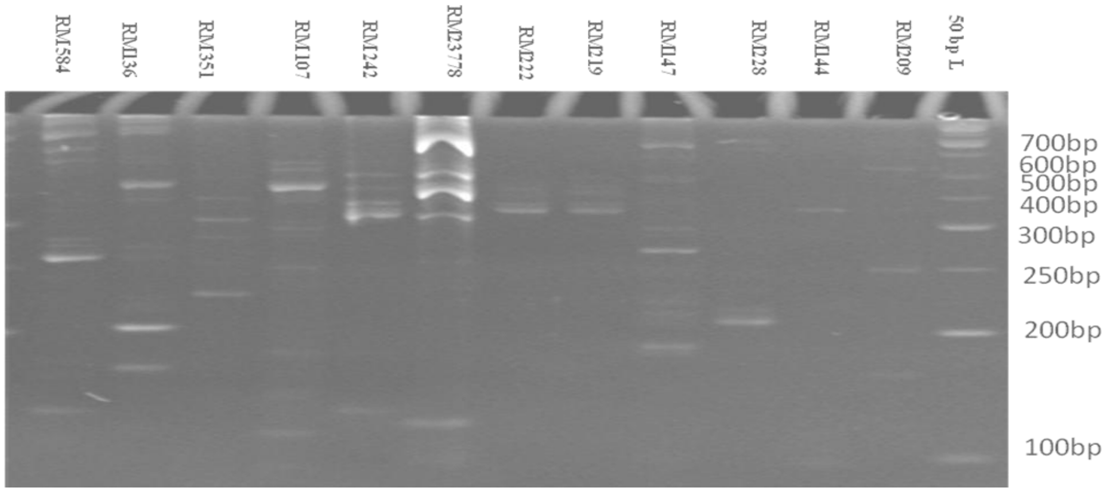


Figure 32: DNA fingerprint of Binadhan 16

To characterize this variety twelve primers were used. Primers were RM584, RM136, RM351, RM107, RM242, RM 23778, RM 222, RM 219, RM147, RM228, RM144 and RM209. Among the primers RM107 produced the highest number of bands (13) from the chromosome 9 ranging from 500bp to 100bp and RM144 produced lowest number of bands (2) in chromosome number 11 ranges from 350bp to 100bp .

Binadhan-17

Shape of the ligule of penultimate leaf was split. Flag leaf of the variety was semi erect, stem length 81-110 cm and panicle length 18.5 cm. Number of the effective tillers per plant 48, maturity period was 105 days, grain weight of 1000 fully developed grains is 16.8 gm and decorticated grain shape 3.1. The maximum grain yield is 8 t/ha in Aman season. This is known as a Green Super Rice variety.

To characterize this variety twelve primers were used. Primers were RM584, RM136, RM351, RM107, RM242, RM 23778, RM 222, RM 219, RM147, RM228, RM144 and RM209. Among the primers RM136 produced the highest number of bands (13) from the chromosome 6 ranging

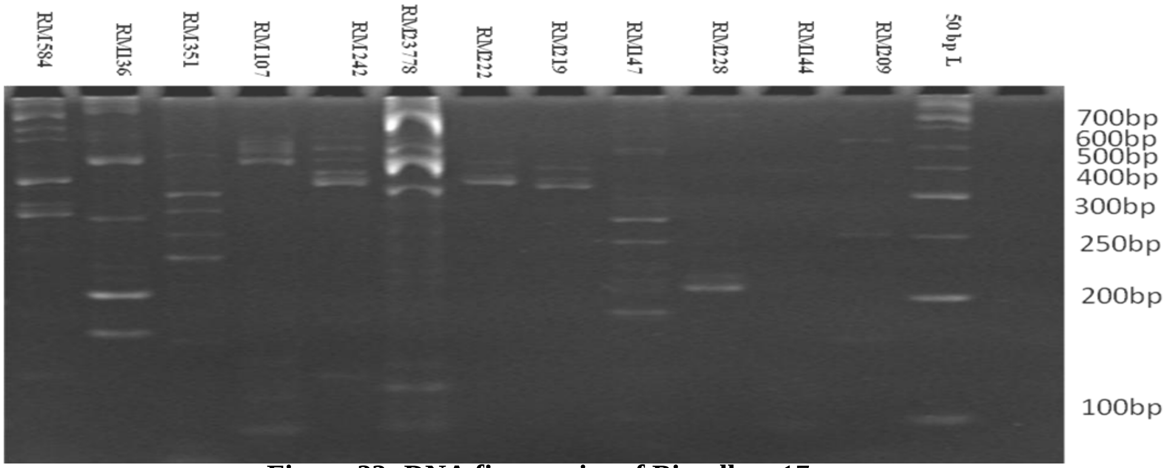


Figure 33: DNA fingerprint of Binadhan 17

from 1500bp to 200bp and RM228 produced the lowest number of bands (2) in chromosome number 10 ranges from 300bp to 100bp.

Binadhan-18

Shape of the ligule of penultimate leaf was split. Flag leaf of the variety was semi erect, stem length 41-60 cm and panicle length was 22.8 cm. Number of the effective tillers per plant 33,

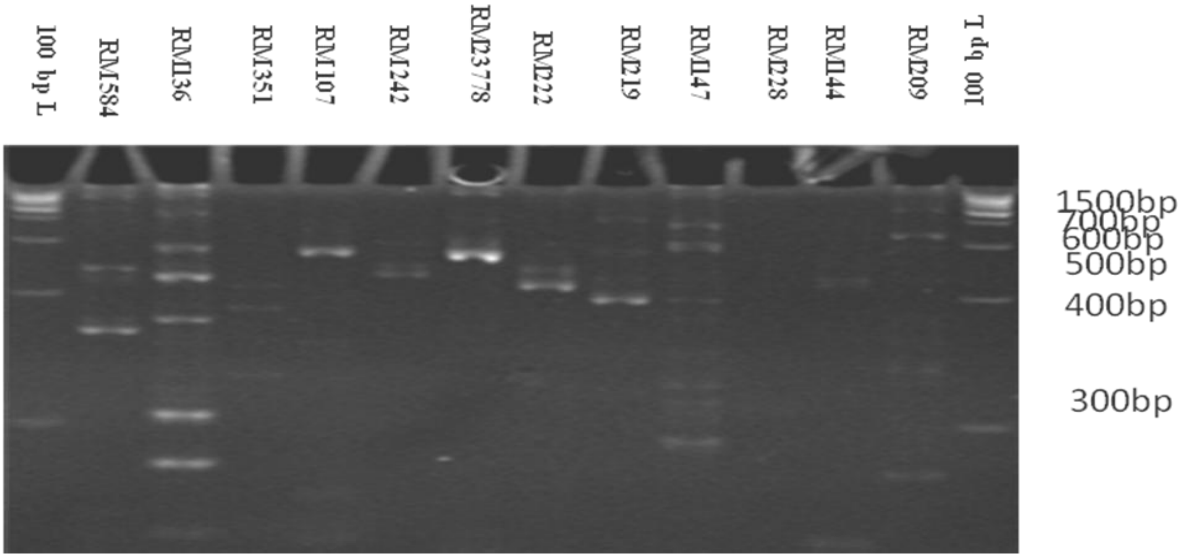


Figure 34: DNA fingerprint of Binadhan 18

time of maturity 153 days, grain weight of 1000 fully developed grains is 26.5 gm and decorticated grain shape 3.1. The maximum grain yield is 10.5 t/ha in Boro season. To characterize this variety twelve primers were used. Primers were RM584, RM136, RM351, RM107, RM242, RM 23778, RM 222, RM 219, RM147, RM228, RM144 and RM209. Among the primers RM23778 produced the highest number of bands (14) from the chromosome 9 ranging from 800bp to 100bp and RM144 produced lowest number of bands (2) in chromosome number 11 ranges from 500bp to 100bp.

Binadhan-19

Shape of the ligule of penultimate leaf was split. Flag leaf of the variety was semi erect, stem length 61-80 cm and panicle length 16.5 cm. Number of the effective tillers per plant 15, maturity period was 100 days, grain weight of 1000 fully developed grains was 22.4 gm and decorticated grain shape 3.7. The variety is known as drought tolerant. The maximum grain yield was 5.5 t/ha in Aman season and the maximum grain yield was 5 t/ha in Aus season. To characterize this variety twelve primers were used. Primers were RM584, RM136, RM351, RM107, RM242, RM 23778, RM 222, RM 219, RM147, RM228, RM144 and RM209. Among the primers RM136 produced the highest number of brands (16) from the chromosome 6 ranging from 1500bp to 200bp and RM228 produced lowest number of bands (2) was in chromosome number 10 ranges from 300bp to 100.

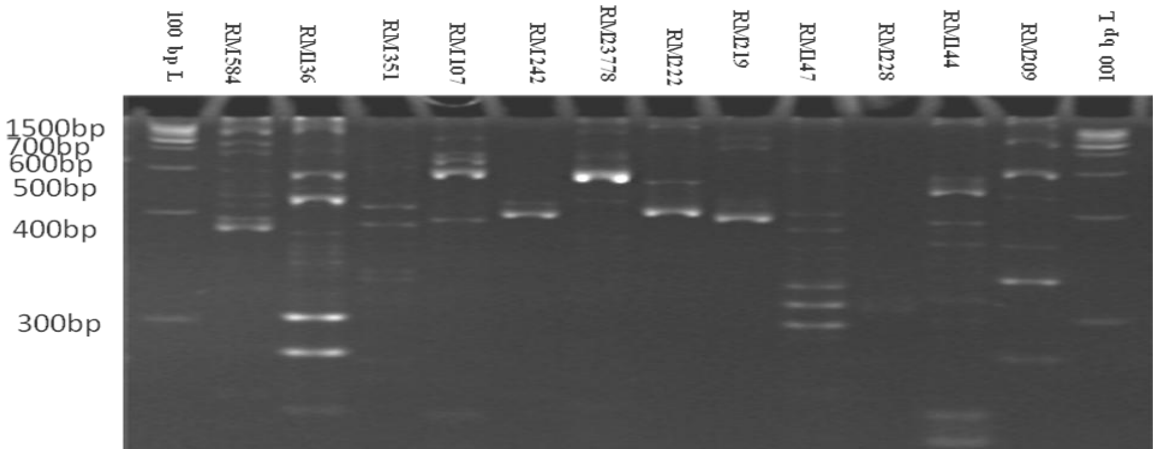


Figure 35: DNA fingerprint of Binadhan 19

Binadhan-20

Shape of the ligule of penultimate leaf was split. Flag leaf of the variety was semi erect, stem length 81-110 cm and panicle length 25 cm. Number of the effective tillers per plant 13, maturity period was 130 days, grain weight of 1000 fully developed grains is 24.5 gm and decorticated grain shape 3.6.The variety is known as Zn enriched. The maximum grain yield is 7.18 t/ha in Aman season. To characterize this variety twelve primers were used. Primers were RM584, RM136, RM351, RM107, RM242, RM 23778, RM 222, RM 219, RM147, RM228, RM144 and RM209. Among the primers RM23778 produced the highest number of bands (18) from the chromosome 9 ranging from 1031bp to 100bp and RM144 produced lowest number of bands (2) was in chromosome number 11 ranges from 400bp to 100.

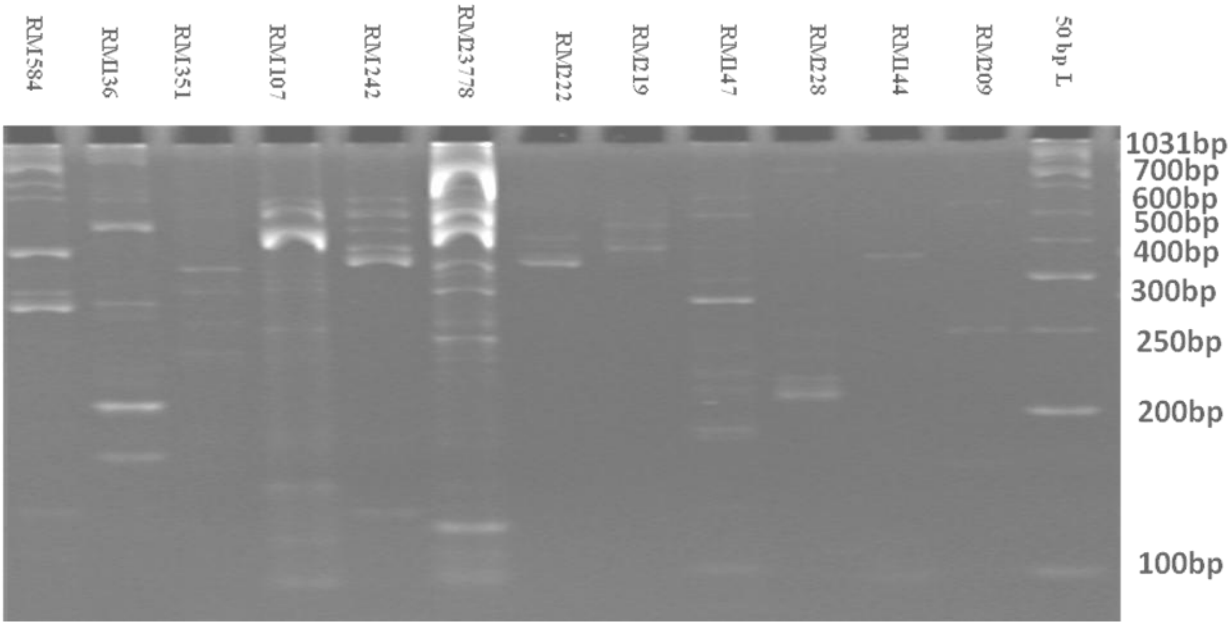


Figure 36: DNA fingerprint of Binadhan 20

MV20

Shape of the ligule of penultimate leaf was split. Flag leaf of the variety was semi erect, stem length 61-80 cm and panicle length was 23 cm. Number of the effective tillers per plant was 18, maturity period was 130 days, grain weight of 1000 fully developed grains is 18.9 gm and decorticated grain shape 3.1. To characterize this variety twelve primers were used. Primers were RM584, RM136, RM351, RM107, RM242, RM 23778, RM 222, RM 219, RM147, RM228, RM144 and RM209. Among the primers RM147 produced the highest number of bands (16) from the chromosome 10 ranging from 500bp to 100bp and RM144 produced lowest number of bands (3) in chromosome number 11 ranges from 400bp to 100bp.

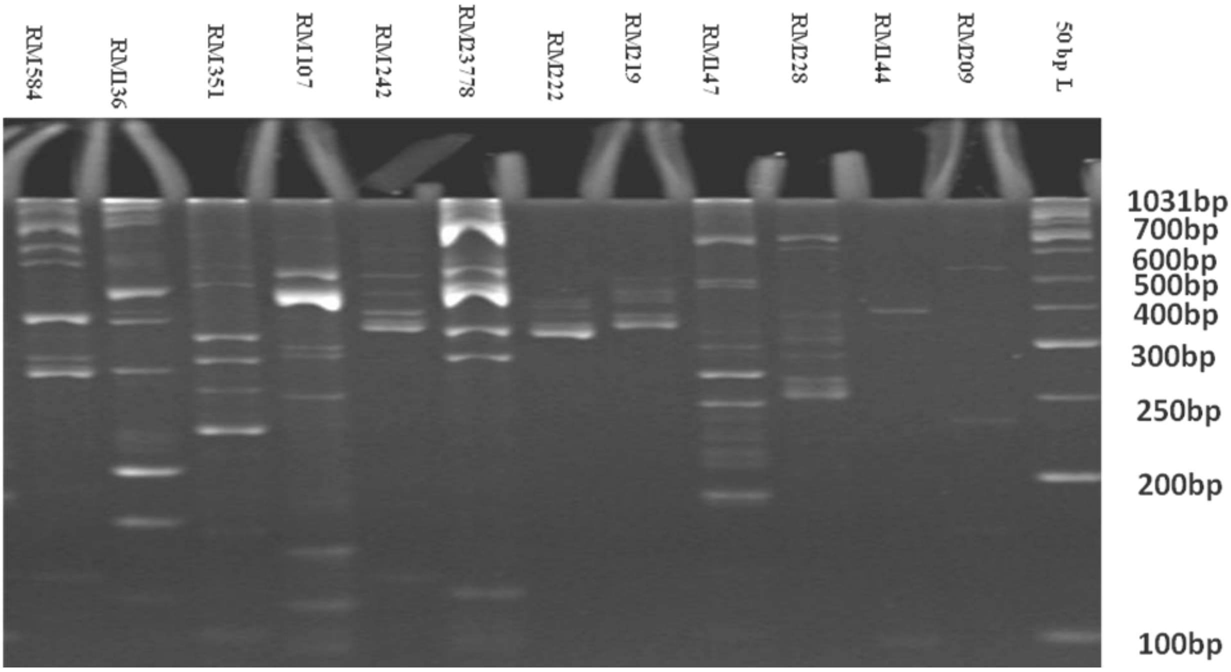


Figure 37: DNA fingerprint of MV-20

MV40

Shape of the ligule of penultimate leaf was split. Flag leaf of the variety was semi erect, stem length 61-80 cm and panicle length was 19 cm. Number of the effective tillers per plant was 18, maturity period was 135 days, grain weight of 1000 fully developed grains is 20 gm and decorticated grain shape 4.4. To characterize this variety twelve primers were used. Primers were RM584, RM136, RM351, RM107, RM242, RM 23778, RM 222, RM 219, RM147, RM228, RM144 and RM209. Among the primers RM136 produced the highest number of bands (18) was from the chromosome 6 ranging from 1031bp to 120bp and RM209 produced lowest number of brands(3) in chromosome number 11 ranges from 400bp to 100bp .

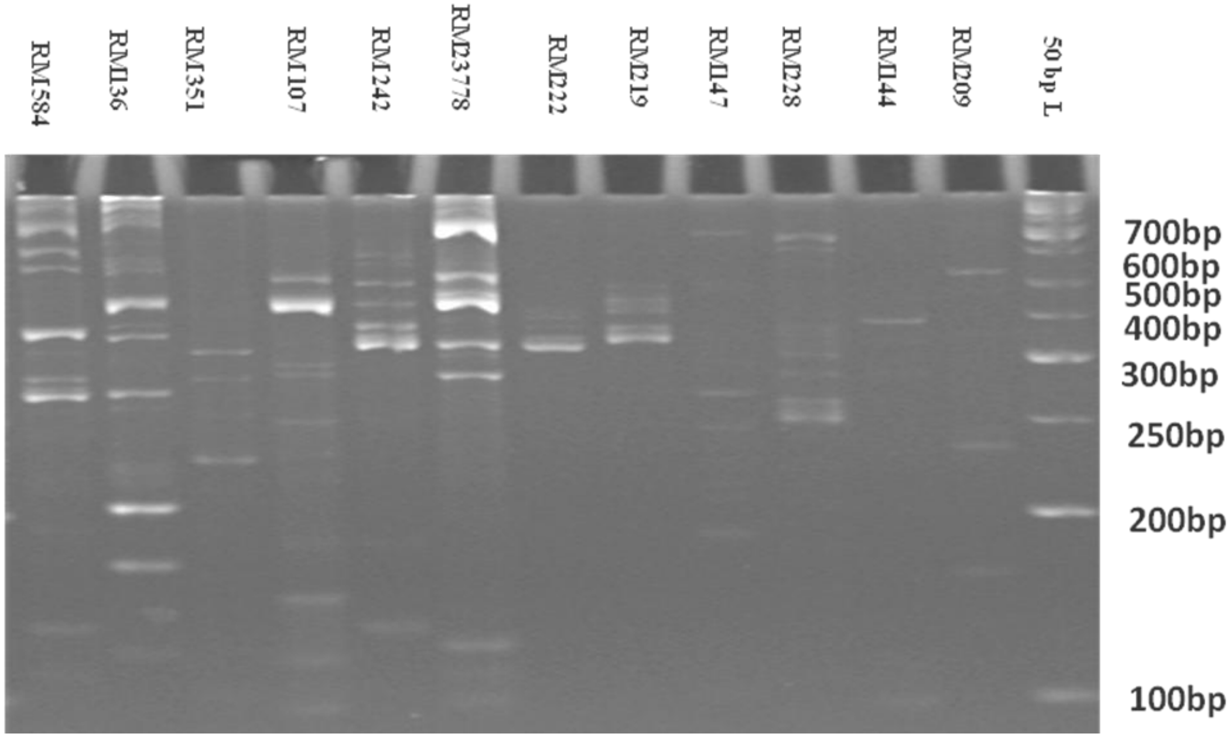


Figure 38: DNA fingerprint of MV-40

THDB

Shape of the ligule of penultimate leaf was acute. Flag leaf of the variety was erect, stem length 81-110 cm and panicle length was 21 cm. Number of the effective tillers per plant 19, maturity period was 140 days, grain weight of 1000 fully developed grains was 26.5 gm and decorticated grain shape 3.4. The maximum grain yield is 6.9 t/ha in Boro season. To characterize this variety twelve primers were used. Primers were RM584, RM136, RM351, RM107, RM242, RM 23778, RM 222, RM 219, RM147, RM228, RM144 and RM209. Among the primers RM147 produced the highest number of bands (19) from the chromosome 10 ranging from 1500bp to 100bp and RM228 produced the lowest number of bands (4) was in chromosome number 10 ranges from 700bp to 100bp .

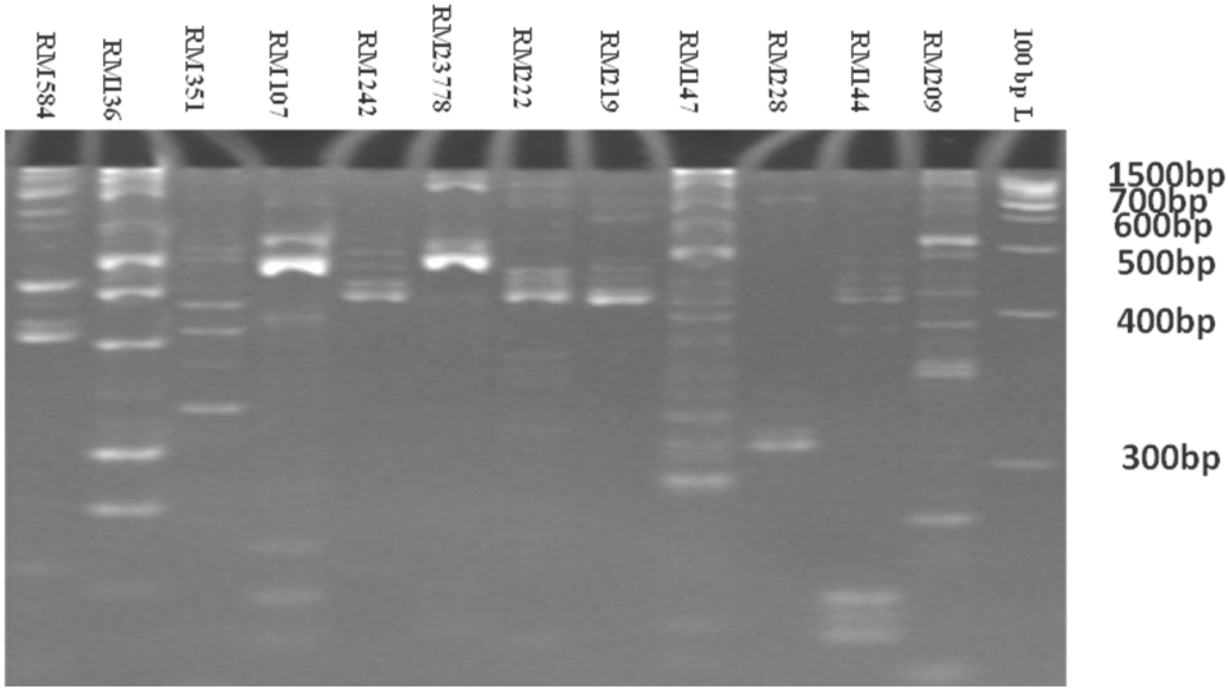


Figure 39: DNA fingerprint of THDB

E02

Shape of the ligule of penultimate leaf was split. Flag leaf of the variety was semi erect, stem length 81-110 cm and panicle length was 26 cm. Number of the effective tillers per plant 24, time of maturity 130 days, grain weight of 1000 fully developed grains is 18.8 gm and decorticated grain shape 3.4.

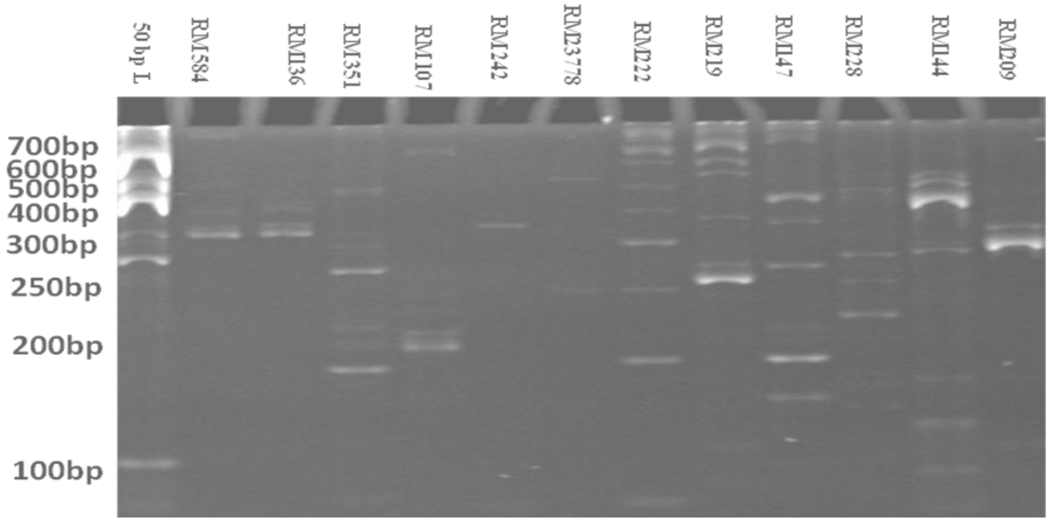


Figure 40: DNA fingerprint of E02

To characterize this variety twelve primers were used. Primers were RM584, RM136, RM351, RM107, RM242, RM 23778, RM 222, RM 219, RM147, RM228, RM144 and RM209. Among the primers RM147 produced the highest number of bands (19) from the chromosome 10 ranging from 900bp to 100bp and RM222 produced lowest number of bands (4) in chromosome number 10 ranges from 400bp to 300.

Dumai

Shape of the ligule of penultimate leaf was split. Flag leaf of the variety was semi erect, stem length 61-80 cm and panicle length was 25 cm. Number of the effective tillers per plant 1, maturity period was 135 days, grain weight of 1000 fully developed grains is 19 gm and decorticated grain shape 2.5.

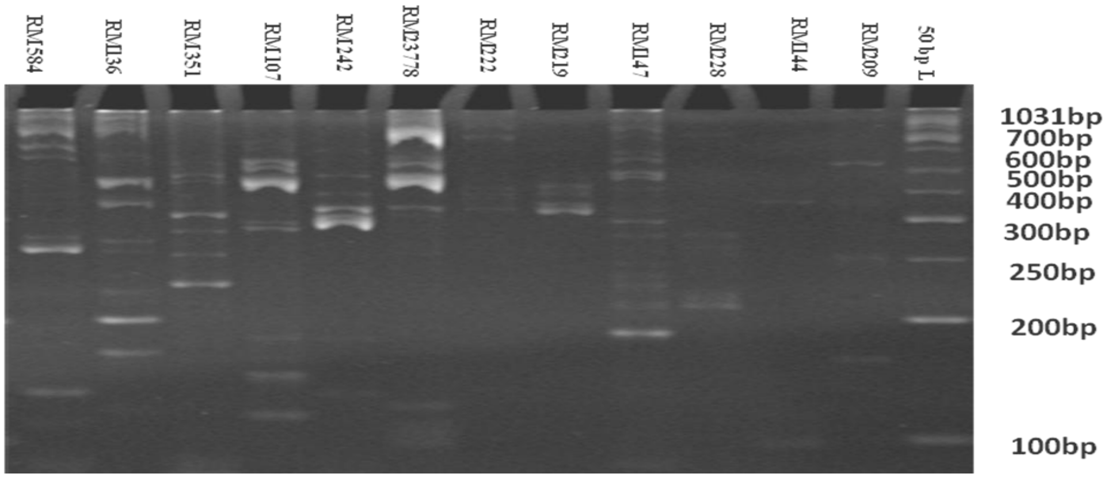


Figure 41: DNA fingerprint of Dhumi

To characterize this variety twelve primers were used. Primers were RM584, RM136, RM351, RM107, RM242, RM 23778, RM 222, RM 219, RM147, RM228, RM144 and RM209. Among the primers RM228 produced the highest number of bands (15) from the chromosome 10 ranging from 700bp to 50bp and RM242 produced lowest number of bands (2) in chromosome number 9 ranges from 400bp to 100.

Laxmidigha

Shape of the ligule of penultimate leaf was split. Flag leaf of the variety was semi erect, stem length 81-110 cm and panicle length was 24 cm. Number of the effective tillers per plant 28, maturity period was 175 days, grain weight of 1000 fully developed grains is 20.8 gm and decorticated grain shape **3**. The maximum grain yield is 2.6 t/ha in Aman season.

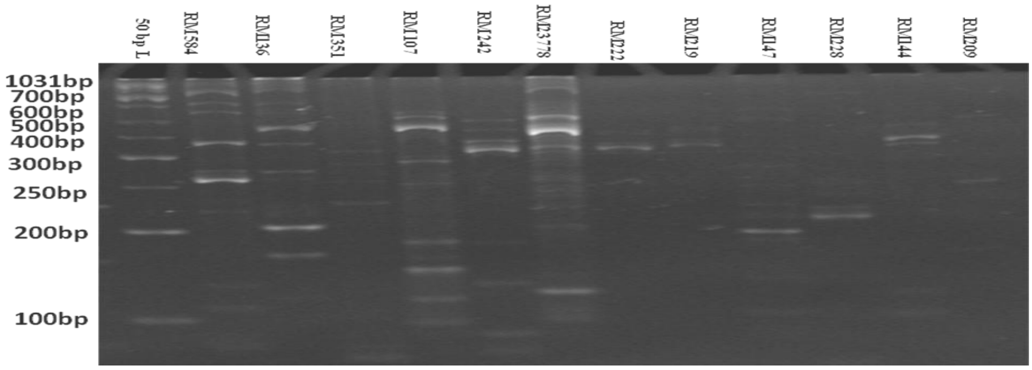


Figure 42: DNA fingerprint of Laxmidiga

To characterize this variety twelve primers were used. Primers were RM584, RM136, RM351, RM107, RM242, RM 23778, RM 222, RM 219, RM147, RM228, RM144 and RM209. Among the primers RM147 produced the highest number of bands (18) from the chromosome 10 ranging from 1031bp to 75bp and RM144 produced lowest number of bands (2) in chromosome number 11 ranges from 350bp to 100bp.

Kataktara

Shape of the ligule of penultimate leaf was split. Flag leaf of the variety was semi erect, stem length 81-110 cm and panicle length was 17.9 cm. Number of the effective tillers per plant 14, maturity period was 148 days, grain weight of 1000 fully developed grains is 15.6 gm and decorticated grain shape 2.9.

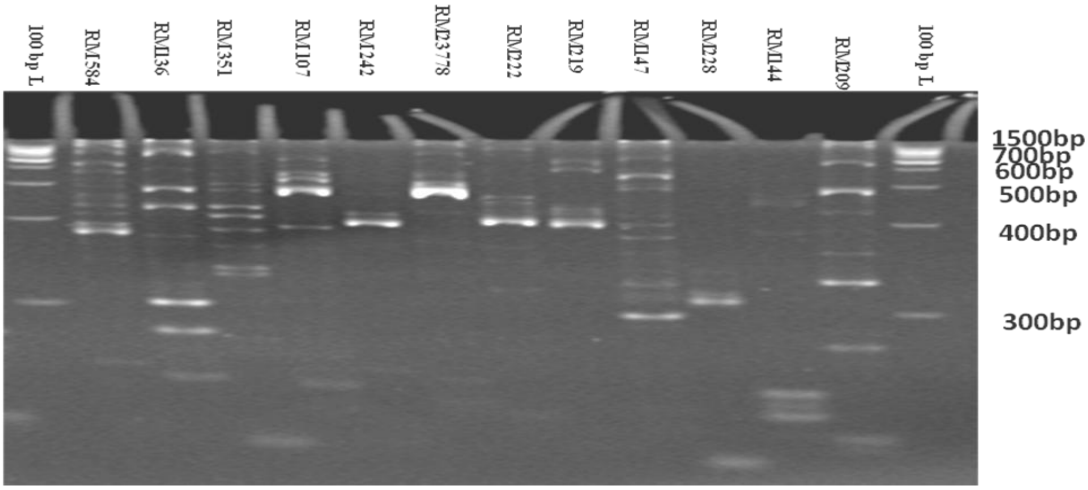


Figure 43: DNA fingerprint of Kataktara

To characterize this variety twelve primers are used. Primers are RM584, RM136, RM351, RM107, RM242, RM 23778, RM 222, RM 219, RM147, RM228, RM144 and RM209. Among the primers RM147 produced the highest number of bands (14) from the chromosome 10 ranging from 1031bp to 100bp and RM209 produced lowest number of brands (3) in chromosome number 11 ranges from 250bp to 150.

Hutra

Shape of the ligule of penultimate leaf was split. Flag leaf of the variety was semi erect, stem length 61-80 cm and panicle length 19 cm. Number of the effective tillers per plant 12, maturity period was 130 days, grain weight of 1000 fully developed grains is 18.3 gm and decorticated grain shape 2.8.

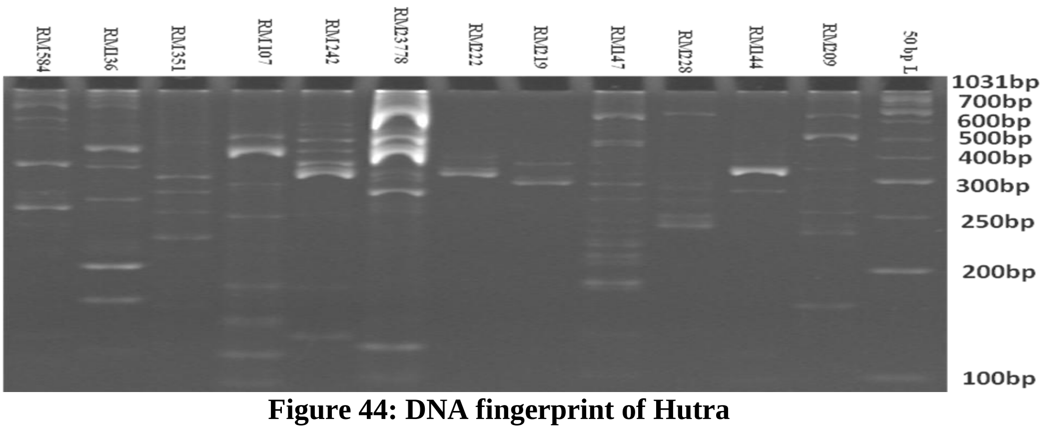


Figure 44: DNA fingerprint of Hutra

To characterize this variety twelve primers were used. Primers were RM584, RM136, RM351, RM107, RM242, RM 23778, RM 222, RM 219, RM147, RM228, RM144 and RM209. Among the primers RM584 produced the highest number of bands (12) from the chromosome 6 ranging from 1031bp to 100bp and RM144 produced lowest number of bands (3) in chromosome number 11 ranges from 110bp to 50.

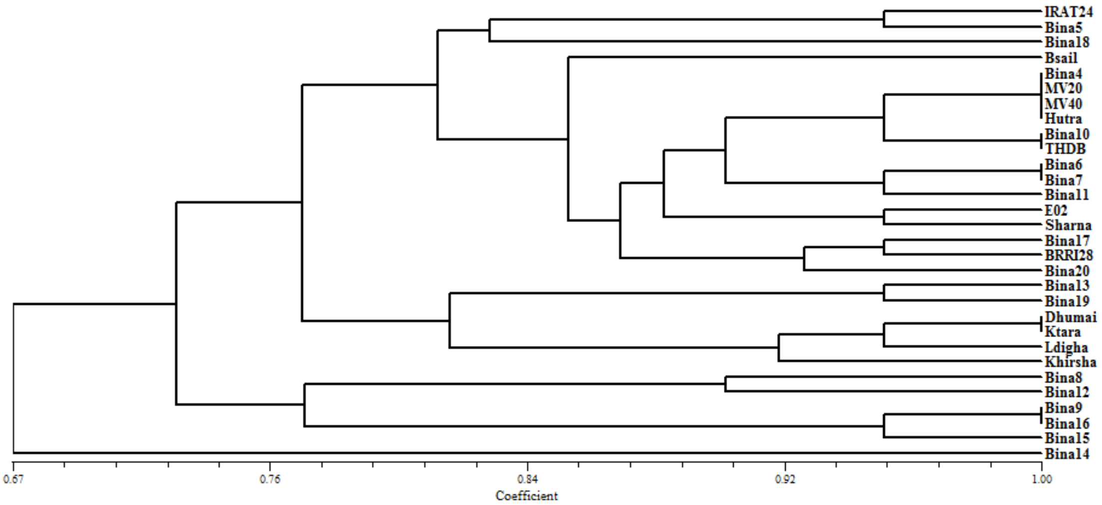


Figure 45: A dendogram based single gene (RM136) amplification of different rice genotypes

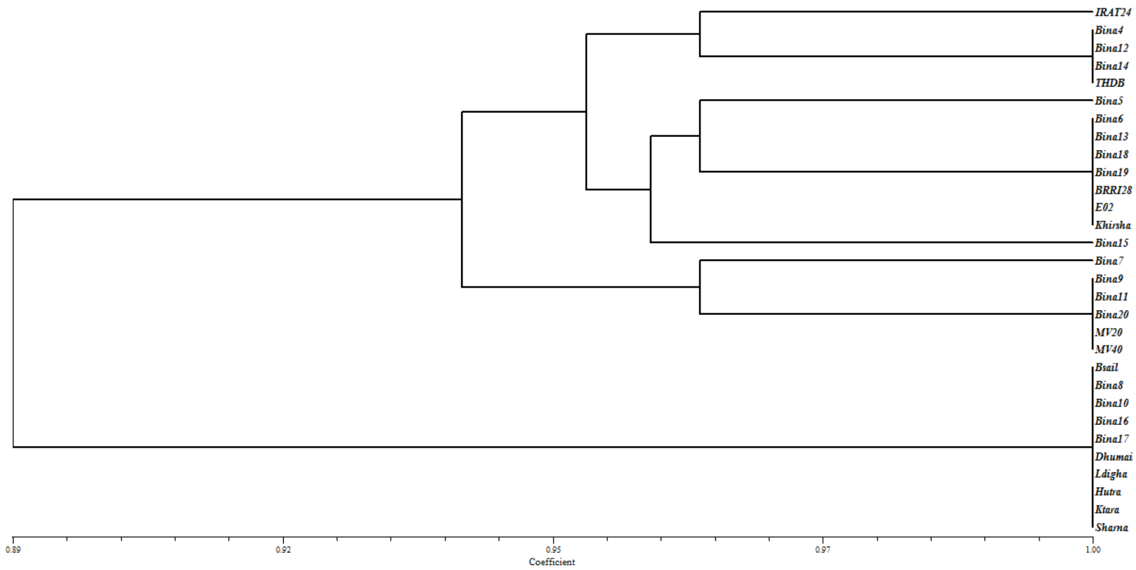


Figure 46: A dendogram based combined DNA fingerprint data from twelve selected primers of different rice genotypes

Experiment 6. Morpho-physiological diversity of root nodule rhizobia from mimosa (*Mimisa pudica* L.) and water mimosa (*Neptunia oleracea* L.)

Objectives:

- To assess the morpho-physiological diversity of mimosa and water mimosa root nodulating rhizobia
- To assess the genetic diversity of mimosa and water mimosa root nodulating rhizobia
- To identify potential strains for agricultural and industrial use

Nodule collection

The dry land mimosa root nodules were collected from naturally grown mimosa plants from fallow-lands and road sides of four different districts of Bangladesh (Khulna, Magura, Mymensingh and Satkhira). Water mimosa root nodules were collected from naturally grown water mimosa on pond at 'Sherpur' districts of Bangladesh. Two strains were isolated from Bangi, Malaysia. Nodules from five plants from each site were collected and preserved in silica gel for further use. Well developed, uninjured, round shape and pink colored healthy nodules were chosen for bacterial isolation purposes.

Surface sterilization of nodules

Collected nodules from silica gel were soaked in sterile water for 5hours at room temperature before processing for rhizobial isolation purpose. Then nodules were washed with 70% ethanol for 1 minute followed by 3 min washing with 2% NaOCl. Then, nodules were washed 7 times with sterile distilled water (dH_2O) to remove extra surface disinfectant.

Isolation of rhizobia from nodules

After surface sterilizing, nodules were crushed individually in eppendorf tubes containing 50 µL sterile dH_2O by sterile micro homogenizer. Subsequently, one full loop of suspension was picked from crashed nodule containing bacteria, and spread smoothly on Congo red yeast extract mannitol agar (CRYEMA) media in Petri-dish. Then inoculated plates were incubated at 28^0C for 72 hours. Cultures were purified by repeated streaking on CRYEMA plates to get pure single colony.

Preservation of isolated rhizobial strains

Single colony was preserved in agar slant at 4^0C for working sample. For long term preservation of the isolates, 5 mL of fresh liquid culture of bacteria was taken into the equal volume of 50% glycerin and stored at -80^0C in 2mL eppendorf tube.

Colony size measurements of isolated strains

Colony size of the strains was measured using millimeter graph paper. A single loop of bacterial culture was streaked on a CRYEMA containing plate sequentially like cord of circle from one edge to another and incubated at 28^0 C. After 3 days, using millimeter graph paper on plates keeping just opposite site of colonies, the diameters of them were measured. Mean value was taken from each strain of five colonies.

Nodulation and cross inoculation test

Mimosa, water mimosa and giant mimosa seeds were collected from field grown plant for nodulation and cross inoculation tests. Collected seeds were taken in 15 mL Falcon tubes and washed with flooded sulfuric acids (H_2SO4, 98%) for 3 minutes and then the seeds were washed with sterile water. Afterward, 2% NaOCl were added to the seeds and shaking for 10 minutes. Later, the seeds were washed for seven times with dH_2O via vortex to remove excess surface disinfectant. Finally, these seeds were immersed overnight in sterilized dH_2O in that tube. Overnight water-immersed sterilized seeds were transferred to water-Agar medium in a Petridis for germination in dark for three days at 37^0 C. Germinated seedlings were then transferred to 150 mL conical flasks/test tubes containing Fahraeus-nitrogen free medium. After two weeks of plant transfer at plant growth room, three types of mimosa (dry land mimosa, water mimosa and giant mimosa) plants were inoculated with 2 mL of each overnight growth bacterial culture. To know the host range, each strain was used to inoculate three types of mimosa (dry land, water and giant). Three replications for each strain were maintained and every flask was labeled according to strain name and date of inoculation. Nodulations were observed after four to five weeks of inoculation. A 16/8 hrs light/dark photoperiods were maintained at growth chamber and plants were irrigated with 0.5X Fahraeus N-free nutrients medium at 7 days intervals for five weeks.

Morpho-physiological characterization of isolated rhizobial strains

In case of bromo-thymol blue **(**BTB) test, YEMA medium were prepared containing 10 mL/L BTB solution in YEMA. For salt tolerance test, media were prepared with 0.5%, 1.0%, 1.5%, 2.0%, 2.5% and 3.0% (w/v) NaCl containing YEMA, in conical flax. For pH tolerance test, four different levels of pH (pH4.0, pH5.0, pH9.0 and pH10.0) were made where the pH was controlled either by adding 1M acetic acid or 1M sodium hydroxide to make YEMA media acidic or basic. For temperature tolerance test, only YEMA media were used but inoculated plates were incubated at different temperature. One µL of each overnight grown rhizobial culture was dropped on labeled squares in petri-plates by micropipette. Three replications were maintained for accurate result. Until the drops were absorbed by the solid media, the petri-dishes wrapped with paraflim. Finally, plates were incubated at 28^0 C for 3 days except culture plates for temperature tolerance test were incubated at 1^0 C, 4^0 C, 31^0 C, 34^0 C, 37^0 C, 40^0 C, 43^0 C and 46^0 C.

Collection and preservation of mimosa seeds for plant infection and symbiotic affectivity test

Mature, healthy and fresh seeds of mimosa and water mimosa were collected from naturally grown plants during October to December in 2015 to conduct plant infection and pot experiment. The collected seeds were dried under sun-light, and then stored in screw caped glass bottle in room temperature for further use.

Symbiotic effectiveness of isolated rhizobia on host plant growth

Each pot contained 2.00 Kg soil, mixed with some chemical fertilizer, with TSP (12.38 gm), MoP (9.52 gm), ZYP (7.73 gm), $ZnSO_4$ (0.42 gm), H_3BO_3 (0.45 gm). Mimosa seeds were prepared by 10 minutes acidic treatment (98% H_2SO_4), then 7 times washing with water. Followed by overnight soaked in water; moisture containing viable seeds (4 seeds per pot) were sowed in pots and cultivated as usual. After 2 weeks of sowing, plants were inoculated with bacterial cultures (3 mL^{-1}). Beside bacterial treatment a treatment of urea and a control were kept in the study. Each treatment implemented with 5 replications.

Plant harvesting, dry weight measurement and data analysis

After six weeks of inoculation, the plants were harvested, washed and nodules were separated from the roots. The nodules were separated from plants, counted and data were recorded. Then nodules were preserved in paper packets and plants were kept in brown paper packets and both plants and nodules were dried at 65 ^{0}C for 72 hours in hot air oven, slightly modified from. After drying properly the weight of dry mass was measured by electric balance. The data were analyzed using MSTAT-Program and the means were compared using ANOVA at 1% level of statistical significance. The compared effectiveness of each treatment was evaluated through Duncan's, Multiple Range Test (DMRT) by comparing the mean values of different characters and the results are shown in (Table 12, 13).

Results

Nodulation and cross inoculation test

In vitro nodulation test was performed on respective hosts (dry land mimosa and water mimosa) to confirm the nodulation nature of our collected strains. We evaluated 24 strains of which 21 strains produced nodule *in vitro* in their respective hosts (Fig.49). All strains were availed to form nodules with their respective host at laboratory conditions except the strain MB-22 and MB-59 (Table 12). These are possible for opportunistic bacteria which enter insides the nodules with the help of other nodule forming bacteria at field conditions. Thus, the strains MB-22 and MB-59 might be opportunistic bacteria entered into the nodules of mimosa at field conditions with nodule forming rhizobia. Thus, they were unable to form nodules at laboratory conditions. Interestingly, two strains MB-64 and MB-65 were availed to form nodules with dry land and giant mimosa in additions to their respective host suggesting that they had broad host range for nodulation and might have different nodulation genes then other strains from water mimosa.

Colony morphology of the isolated strains

Most of the strains on the CRYEMA medium were milky white to creamy colored, where some of them were transparent. Most of the mimosa root symbionts appeared milky white (MB-08, MB-32, MB-33, MB-43, MB-47, MB-48, MB-49 and MB-56), but few of them produced transparent colonies (i. e. MB-17, MB-22, MB-26, MB-46 and MM-54). All water mimosa root symbionts (MB-57, MB-58, MB-59, MB-60, MB-61, MB-62, MB-63, MB-64, MB-65, MB-66 and MB-67) produced milky white colonies (Table 12) which are similar to other studies. The study found colon size ranged from 2.2 to 3.5 mm in case of mimosa root symbionts; where the smallest was MB-56 and the largest was MM-54. The water mimosa nodulating rhizibial colonies were ranges from 1.8 mm (MB-64) to 2.8 mm (MB-58 and MB-60). We found bigger colony size from our strains (maximum 3.5 mm) then the other studies who have found the maximum colony size of 2 mm. We found diversified colony characters; transparent to milky white in color, round shaped, convex and moderately mucoid with smooth edge. Similar to our study a diverse colony characters like circular, convex and domed shape with entire margins; and mucous producers were also found by others.

Characterization of isolated root nodulating strains based on acid-alkali production

In our present investigation, strains showed green to light blue colors (Fig50), after 3 days of incubation at 28 ^{0}C on YEMA-BTB plates. We found that, 8 mimosa strains (MB-17, MB-32, MB-33, MB-43, MB-47, MB-48, MB-49 and MB-56) form green color; which represents acidic reaction. The remaining 4 strains viz. MB-08, MB-22, MB-26 and MM-54 form light blue color, which indicates alkaline reaction producer. On the other hand, all tested water mimosa root symbionts (MB-57, MB-58, MB-59, MB-60, MB-61, MB-62, MB-63, MB-64, MB-65, MB-66 and MB-67) produce deep blue color (Fig.50) on YEMA-BTB plates; formation of deep blue indicates these strains exhibit alkaline reaction. Suggesting that rhizobial strains found from dry land mimosa were both first and slow grower while rhizobial strains from water mimosa were slow grower because, the colonies of fast growers produced acid reactions, whereas the colonies of the slow growers produced alkaline reactions in YEMA-BTB medium.

Survival capacity of mimosa root nodulating rhizobia at acid-alkaline conditions

Soil acidity or alkalinity (extreme low or high pH) is another abiotic stress that affects legume and rhizobia growth and inhibits root nodule formation. Though liming on acid soils has been followed as a common practice to raise the soil pH for creating a favorable conditions for the growth and survival of root nodule bacteria, it bears cost and farmers are not interested to use it . Thus, best way to solve it is to identify acid insensitive strains for acidic soil and base insensitive strains for basic soils.

Recent evidence suggested high abundance of *Burkholderia* in acidic soils and different rhizobia could survive at pH 4.5–7.0. In our study, we categorized both acid and base tolerable strains via pH tolerance test. All isolated mimosa root symbionts/rhizobia were grew at pH 5.0 (Table 13) except the strain MB-08. Out of 13 mimosa strains, 5 strains (MB-43, MB-47, MB-48, MB-49, and MB-56) grew weakly at pH 4 while 3 strains grew (MB-17, MB-32 and MB-33) moderately at highly acidic pH 4.0 (Table 13). At basic pH 9.0, 4 mimosa nodulating strains (MB-08, MB-26, MM-46 and MM-54) grew well; 5 strains viz. MB-17, MB-22, MB-33, MB-43 and MB-49 grew moderately; other 3 strains (MB-32, MB-47 and MB-48) grew slightly (Table 13). On the other hand, out of 13 mimosa strains, 6 strains viz. MB-08, MB-22, MB-26, MB-43, MM-46 and MM-54 grew moderately; 6 strains (MB-17, MB-32,MB-33, MB-47 and MB-49) grew slightly at pH 10.0 (Table 13). Though rhizobia from *Neptunia (L. portucalens)* is able to grow at pH range 4.0 but not able to survive at pH-10. All water mimosa root nodulating strains viz. MB-57, MB-58, MB-59, MB-60, MB-61, MB-62, MB-63, MB-64, MB-65, MB-66 and MB-67 grew slightly at pH 5.0 (Figure 49) but none of them were availed to survive at pH-4; where all strains grew well at basic pH up to 10.0 (Table 13). Almost similar results also observed by authors who reported that water mimosa root symbionts, *A. undicola* grew well at pH of 4.0-10.0 though optimal growth was at pH 7.0–8.0. In general, water mimosa nodulating rhizobial strains grew well at more alkaline condition whereas most of the mimosa strains preferred moderate to high acidic condition. Some mimosa strains (MB-17, MB-32, MB-33, MB-43, MB-47, MB-48 and MB-49) survived at a wide range of pH (≤4.0 to ≥10.0). We found few acid tolerant strains (MB-17, MB-32 and MB-33) which could be used in acidic soil and moderately base tolerant strains, MB-08, MB-22, MB-26, MB-43 and MM-54 could be used in basic soil with respective legume hosts for better growth. In comparison between mimosa and water mimosa, it is clear that strains of water mimosa are less acid tolerant than that of mimosa.

Characterization of isolated root nodulating rhizobia based on salt tolerance test

Salinity is a major constrains for crop production in the southern region of Bangladesh. It decreases the nutrition uptake of plants, particularly Phosphorus, due to their binding with Calcium ions in salt-stressed soils. Salinity inhibits bacterial growth and nodulation process in the legumes. But salt tolerant growth promoting rhizo-bacteria (PGPR) has promising effect to overcome this limitation. In this study, we found that all strains grown on 1% NaCl; but 14 strains were unable to survive at 1.5-2.0% NaCl (Table 13). While six strains such as MB-17, MB-22, MB-26, MB-32, MB-33 and MM-54 were grown up to 2.5% NaCl (Figure 51). The minimum salt tolerance capacity of all isolates was 1% but few strains were able to survive with 2.5% NaCl (Table 14). Different studies reported different level (0.5-3%) of salt tolerance by root nodulating rhizobacteria. From our study, we found few strains tolerant to high NaCl-stress, such as MB-17, MB-22, MB-26, MB-32, MB-33 and MM-54 those could be used as growth promoting rhizobia for mimosa and water mimosa inoculation grown in salt stress areas of Bangladesh. In comparison between mimosa and water mimosa, it is important to note that strains of water mimosa are less salt tolerant than that of dry land mimosa.

Temperature tolerance of isolated root nodulating rhizobia

Global climates change results in land degradation, salinity, desertification etc. which lead to reduction in nodule number, rhizobial growth, rate of colonization and infectious events, and can lead to delay in nodulation or restrict the nodule to the subsurface region. But it has been reported that temperature tolerant soybean rhizobia can improve nitrogen fixation in areas where temperature is the major factor limiting production. Isolates tolerant to temperature stress and with a high symbiotic effective were identified in the present work. Studies reported the temperature tolerance of root nodulating rhizobia up to 42^0C. In our study, the isolated strains grew well at 31-34^0C. But in higher temperature they did not survive except four strains, MB-17, MB-32, MB-33 and MM-54 were survived up to 43^0C (Table 15). In another study reported water mimosa root symbionts *A. undicola* grew well at temperatures ranging 25-35^0 C and optimal growth were at 28–30 ^{0}C. Neptunia symbiont *L. portucalensis,* able to grow at temperature ranges 16-37 ^{0}C, where the optimum growth ranges 28–32 ^{0}C. In line with previous study, we found that water mimosa root symbionts grew up to 34^0C, but could not survive at 43^0C on YEMA plate up to 72 hours. For having high temperature tolerance potentialities of the strains, MB-17, MB-32, MB-33 and MM-54 could be used as growth promoting root nodules rhizobia of mimosa in the hot areas and could be important sources for temperature tolerant genes for biotechnological applications.

Nodulation and growth of mimosa influenced by the inoculation with isolated rhizobial strains

Rhizobia stimulate the growth of host plants through N_2 fixation. Studied strains were used for inoculation in pot experiment. We observed that, both number and weight of nodules influence the plant weight. Increased root nodule number and weight parallel increase the plant weight. After inoculation of selected mimosa nodulating strains (MB-08, MB-17, MB-26, MB-32, MB-33, MB-43, MB-48, MB-49 and MM-54) to mimosa plants, the mean dry weights of the plants varied from 1690.00 mg to 422.00 mg. The MB-49 exhibited the highest plant weight and nodule number. Where the lower growth was observed by plants inoculated with MB-32; even though it exhibited better plant growth compared to control and urea treated groups. The nodule weight were also enhanced significantly ($p<0.01$) and ranged from 68.80 mg to 15.40 mg. Higher nodule weight was noticed by the strain MB-43, where MB-49 exhibits statistically similar effect on nodule weight; where lowest nodule weight was showed by plants inoculated with MB-26; but it exhibited better growth compared to control and urea treated groups (Table 15).

Similarly, after inoculation of 10 randomly selected water mimosa nodulating strains to its respective hosts, the highest nodulation was exhibited by the plant inoculated with MB-61; and the lowest inoculation was shown by urea treated groups. After inoculation of isolated strains, nodule numbers were significantly ($p<0.01$) enhanced and ranged from 57.60 to 12.80. On the other hand, the highest nodule weight was noticed by MB-58, the effect of MB-66 on nodule weight was statistically similar to MB-58; where the lowest nodule weight was observed by plants inoculated with MB-61 (Table 16). The mean plant weight differed from 1360 to 589 mg. MB-66 exhibited the highest plant dry weight and the highest nodule number; where the lowest plant growth was exhibited by plants inoculated with MB-64; and it also exhibits lower growth compared to control and urea treated groups. The nodule number, nodule dry weight and plant dry weights were significantly increased after rhizobial inoculation. Similar to this result, other study reported *Thiobacillus* sp. significantly enhanced the groundnut root, root length and plant biomass in pot and field experiments by 5-10%.

In comparison between mimosa and water mimosa, mimosa has lesser and smaller root nodule than that of water mimosa (Table 15 and Table 16). Likely, nodules produced by water mimosa strains are bigger than that of mimosa. But we can conclude that, the MB-49 strain is responsible for the highest plant dry weight and the height nodule number in mimosa (Table 15) and MB-66 strain in water mimosa showed statistically similar effect to highest nodule weight producing strains (Table 16). These two strains may be used as bio-fertilizer in future.

Conclusion

Mimosa and water mimosa play a significant role in sustainability of agricultural and environmental control systems and heavy metals accumulation; these plants also used as good sources of novel phytochemicals which are also influenced by their symbiotic rhizobia. So far, this is the first study of root nodulating rhizobia from mimosa and water mimosa from Bangladesh. Isolated rhizobial strains showed high diversity with different tests and also showed important characteristics such as capacity to tolerate at high concentration of salt, high temperature and highly acidic pH. It was found that plant dry weight, nodule number and nodule weight were increased when plants inoculated with isolated strains. We found some strains (MB-43 and MB-49) influences better growth and development for mimosa; where some other strains (MB-58, MB-60 and MB-66) exhibits better growth and development of water mimosa. Thus, the strains MB-49 and MB-58 could be used as bio-fertilizer for mimosa and water mimosa, respectively. Present study found that rhizobia from mimosa are very specific for nodule formation with their original host but two strains from water mimosa were availed to form nodules with three different type of mimosa. Present study on isolation and characterization of rhizobia from mimosa and water mimosa will extend their application in their production, biotechnological application, and agriculture practices and alleviation of salt stress affected soils.

Fig. 47: *in vitro* growing plants from sterilized seeds for nodulation test. Abbreviations: A= germination efficiency test of collected seed; B= sterilized mimosa seed germinated after 3-4 days incubation at 37^{0}C; C= germinated giant mimosa plant; D= rhizobia inoculated mimosa plant at growth chamber; E= inoculated water mimosa; F= rhizobia inoculated water mimosa

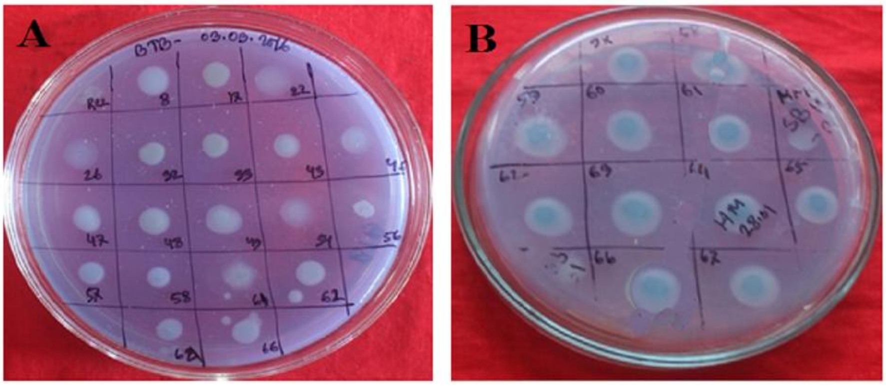


Fig. 48: Isolated root nodulatingrhizobial response to BTB test. A= isolated mimosa root nodulating strains, with some water mimosa nodulating strains; B= isolated water mimosa root nodulating strains

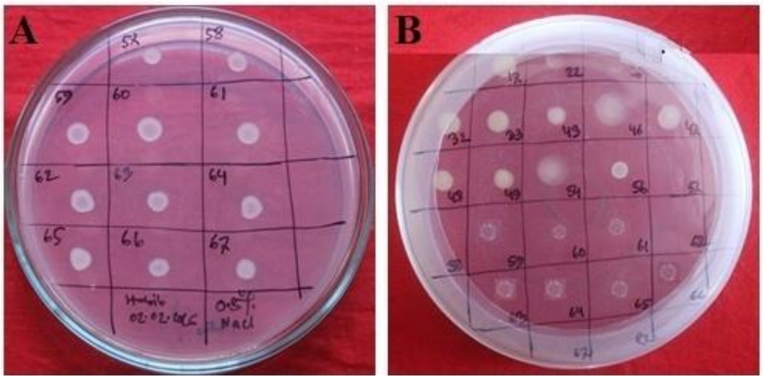


Fig. 49: Isolated root nodulating rhizobial tolerance to different salt stress. A= growth of water mimosa nodulating strains at 0.5% NaCl; B=mimosa and water mimosa nodulating rhizobial growth at 1.0% NaCl.

Table -12: *in vitro* nodulation test and host range recognition of collected isolates

Isolates/ strain name	Host plants					
	Dry land mimosa		Water mimosa		Giant mimosa	
	Nodulation capability	Numbers of nodules	Nodulation capability	Numbers of nodules	Nodulation capability	Numbers of nodules
MB-08	+	12	-	0	-	0
MB-17	+	13	-	0	-	0
MB-22	-	0	-	0	-	0
MB-26	+	8	-	0	-	0
MB-32	+	4	-	0	-	0
MB-33	+	3	-	0	-	0
MB-43	+	8	-	0	-	0
MM-46	+	4	-	0	-	0
MB-47	+	11	-	0	-	0
MB-48	+	10	-	0	-	0
MB-49	+	7	-	0	-	0
MM-54	+	5	-	0	-	0
MB-56	+	3	-	0	-	0
MB-57	-	0	+	7	+	6
MB-58	-	0	+	12	+	2

MB-59	-	0	-	0	-	0
MB-60	-	0	+	9	+	6
MB-61	-	0	+	3	+	2
MB-62	-	0	+	4	+	2
MB-63	-	0	+	6	+	2
MB-64	+	4	+	9	+	6
MB-65	+	3	+	8	+	4
MB-66	-	0	+	5	-	0
MB-67	-	0	+	8	+	2
Control	-	0	-	0	-	0

Table 13: Colony morphology of the isolated mimosa root symbionts and their response to BTB test

Isolate/strain no.	Avg. colony size (mm)	Colony shape	Colony color	BTB test	
				Colony Color	Growth
MB-08	3.2	R, C, S, M	M	Light blue	+++
MB-17	3.1	R, C, S, M	T	Green	++
MB-22	3.2	R, C, S, M	T	Light blue	+++
MB-26	3.3	R, C, S, M	T	Light blue	+++
MB-32	2.5	R, C, S, M	M	Green	++
MB-33	2.8	R, C, S, M	M	Green	++
MB-43	3.2	R, C, S, M	Mw	Green	++
MB-46	3.4	R, C, S, M	T	Light blue	++
MB-47	3.0	R, C, S, M	Mw	Green	++
MB-48	3.2	R, C, S, M	Mw	Green	++
MB-49	3.2	R, C, S, M	Mw	Green	++
MM-54	3.5	R, C, S, M	T	Light blue	+++
MB-56	2.2	R, C, S, M	Mw	Green	++
MB-57	2.6	R, C, S, M	Mw	Deep blue	+++
MB-58	2.8	R, C, S, M	Mw	Deep blue	+++
MB-59	2.7	R, C, S, M	Mw	Deep blue	+++
MB-60	2.3	R, C, S, M	Mw	Deep blue	+++
MB-61	2.9	R, C, S, M	Mw	Deep blue	+++
MB-62	2.3	R, C, S, M	Mw	Deep blue	+++
MB-63	2.8	R, C, S, M	Mw	Deep blue	+++
MB-64	1.8	R, C, S, M	Mw	Deep blue	+++
MB-65	1.9	R, C, S, M	Mw	Deep blue	+++
MB-66	1.9	R, C, S, M	Mw	Deep blue	+++
MB-67	2.5	R, C, S, M	Mw	Deep blue	+++

Abbreviations: C= convex; M= moderately mucoid; Mw=milky white in color; R= round shaped; S=smooth edge; T= transparent, ++ = moderate growth; +++ = vigorous growth

Table- 14: Isolated root nodulating rhizobial tolerance to different salt, pH and temperature stress

Isolate/strain no.	NaCl (%)				pH			
	0.5-1.0	1.5-2.0	2.5	3.0	pH4	pH5	pH9	pH10
MB-08	++	-	-	-	-	-	+++	++
MB-17	+++	++	+	-	++	+++	++	+
MB-22	+++	++	+	-	-	+	++	++
MB-26	+++	++	+	-	-	+	+++	++

MB-32	+++	++	+	-	++	+++	+	+
MB-33	+++	++	+	-	++	+++	++	+
MB-43	++	+	-	-	+	+++	++	+
MB-47	++	+	-	-	+	+++	+	+
MB-48	++	+	-	-	+	++	+	++
MB-49	++	+	-	-	+	+++	++	+
MM-54	+++	-	+	-	-	+	+++	++
MB-56	+	-	-	-	+	+	-	-
MB-57	++	-	-	-	-	+	+++	+++
MB-58	++	-	-	-	-	+	+++	+++
MB-59	++	-	-	-	-	+	+++	+++
MB-60	++	-	-	-	-	+	+++	+++
MB-61	++	-	-	-	-	+	+++	+++
MB-62	++	-	-	-	-	+	+++	+++
MB-63	++	-	-	-	-	+	+++	+++
MB-64	++	-	-	-	-	+	+++	+++
MB-65	++	-	-	-	-	+	+++	+++
MB-66	++	-	-	-	-	+	+++	+++
MB-67	++	+	-	-	-	+	+++	+++

Abbreviations: +++ = well grown, + + = moderately grown, + = slightly grown, **-** = could not survived.

Table- 15: Isolated root nodulating rhizobial tolerance to different temperatures

Isolate/strain no.	**Temperature**							
	1^0C	**4^0C**	**31^0C**	**34^0C**	**37^0C**	**40^0C**	**43^0C**	**46^0C**
MB-08	±	±	+++	+++	++	-	-	-
MB-17	±	±	+++	+++	+++	+++	+	-
MB-22	±	±	+++	+++	+++	+	-	-
MB-26	±	±	+++	+++	+++	+	-	-
MB-32	±	±	+++	+++	+++	+++	+	-
MB-33	±	±	+++	+++	+++	+++	+	-
MB-43	±	±	+++	+++	+++	+	-	-
MM-46	±	±	+++	+++	+++	++	-	-
MB-47	±	±	+++	+++	+++	+	-	-
MB-48	±	±	+++	+++	+++	+	-	-
MB-49	±	±	+++	+++	+++	+	-	-
MM-54	±	±	+++	+++	+++	++	+	-
MB-56	±	±	+++	+++	++	-	-	-
MB-57	±	±	+++	+++	++	-	-	-
MB-58	±	±	+++	+++	++	-	-	-
MB-59	±	±	+++	+++	++	-	-	-
MB-60	±	±	+++	+++	++	-	-	-
MB-61	±	±	+++	+++	++	-	-	-
MB-62	±	±	+++	+++	++	-	-	-
MB-63	±	±	+++	+++	++	-	-	-
MB-64	±	±	+++	+++	++	-	-	-
MB-65	±	±	+++	+++	++	-	-	-
MB-66	±	±	+++	+++	++	-	-	-
MB-67	±	±	+++	+++	++	-	-	-

Abbreviations: +++ = well grown, + + = moderately grown, + = slightly grown, ±= growth not clear, **-** = could not grow

Table- 16: Effect of isolated rhizobial strains on mimosa growth

Isolate/ strains no.	Plant weight (mg.)	Nodule nos.	Nodule weight (mg.)
MB-08	662f	34.0d	46.0a
MB-17	981.0c	38.0c	36.0c
MB-26	665.0f	17.0g	19.0e
MB-32	488.0g	26.0f	28.0d
MB-33	645.0f	13.0i	20.0e
MB-43	893.0d	35.0d	68.0a
MB-48	888.0d	31.0e	28.0d
MB-49	1690.0a	101.0a	67.0a
MM-54	1542.0b	72.0b	47.0b
Urea	475.0g	13.2h	15.4f
Control	422.0h	14.0h	18.0e
CV (%)	**1.86**	**3.39**	**4.24**

*Any two means having a common letter are not significantly different at 1% level of significance;
** indicates significant at 1% level of proximity.

Table- 17: Effect of isolated rhizobial strains on water mimosa growth

Isolate/ strain no.	Plant weight (mg.)	Nodule nos.	Nodule weight (mg.)
MB-57	829.0e	24.0f	87.0d
MB-58	825.0e	23.0f	146.0a
MB-59	835.0e	24.0f	129.0b
MB-60	1325.0ab	45.0c	140.0a
MB-61	819.0e	57.6a	65.0f
MB-62	890.0d	27.8e	106.0c
MB-63	1098.0c	29.2e	125.0b
MB-64	589.0g	23.8f	130.0b
MB-65	1297.0b	32.4d	107.0c
MB-66	1360.0a	52.8b	105.0c
Urea	784.0f	12.8h	72.0ef
Control	742.0f	15.4g	79.0e
CV (%)	2.12	4.56	4.02

*Any two means having a common letter are not significantly different at 1% level of significance;
** indicates significant at 1% level of proximity.

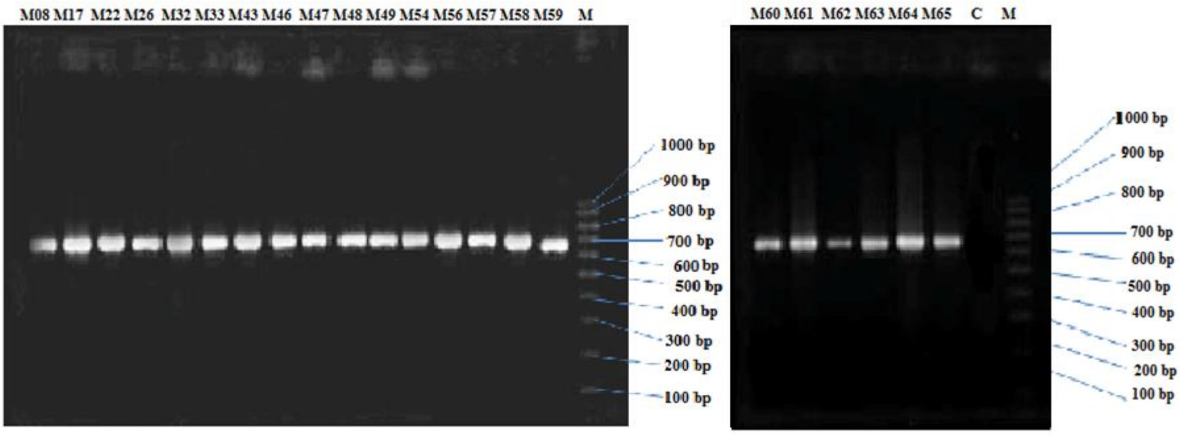


Figure 50. Amplification of 16S rRNA and glnII genes for sequencing

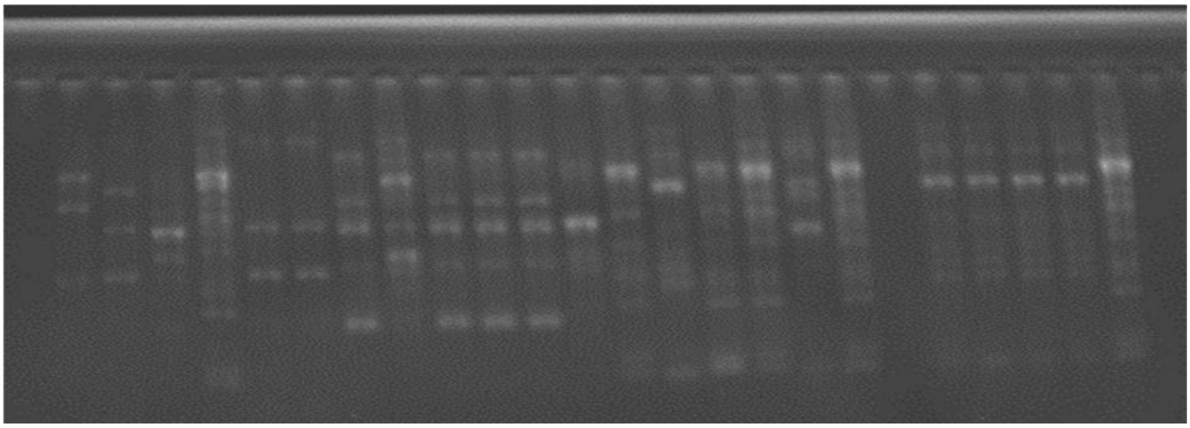


Fig. 51. Fingerprinting with ERIC primer

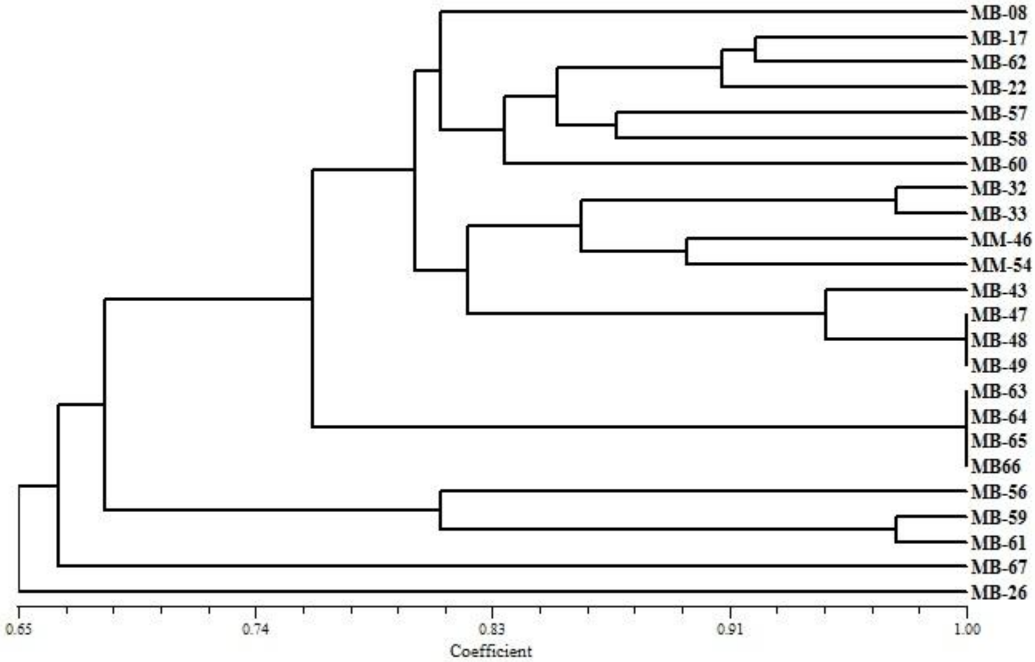


Fig 52. A dendogram based on DNA fingerprint data

Development of laboratory facilities

One essential laboratory facility like gene gun facility for gene transformation have recently installed at Biotechnology Division of BINA.

Fig. 53. PDS 1000He System (Gene Gun).

Horticulture Division

Research Highlights

Tomato

The field experiment was conducted at BINA farm, Mymensingh during the kharif season of 2017-18 to develop new summer varieties with high yield potential. All the M_1 population was harvested to grow M_2 progeny for next generation screening.The experiments on seed production were conducted with Binatomato-10, Binatomato-11 and Binatomato-12 at Mymensingh during rabi season 2017-2018. Total production of seeds of Binatomato-10, Binatomato-11 and Binatomato-12 were 500g, 950g and 800g respectively.

Okra

An experiment was conducted for growing M1 generation at BINA HQ farm, Mymensingh to develop desirable mutants for high yield and tolerance to fruit borer and YMV. All the M_1 population was harvested to grow M_2 progeny for next generation screening.

Brinjal (M_5)

The experiment was conducted at BINA farm, Mymensingh and Ishurdi substation to observe the performance of M_5 mutants of brinjal. The mutant line $IndM_5D_{75}P_{29}$ showed the highest fruit yield (Mymensingh = 103.87tha^{-1} & Ishurdi = 102.56 tha^{-1}) followed by $IndM_4D_{75}P_{38}$ (mymensingh= 90.80 t/ha & ishurdi= 91.42 t/ha) as compared to control (mymensingh = 48.0 t/ha & ishurdi= 46.03 t/ha).

Chili (M_7)

Two experiments were conducted at BINA HQ farm and Sutiakhali farmer’s field, Mymensingh to see the pungency of M_7 mutant of chilli. Among the three mutant lines the mutant $CM_7D_{300}P_8$ produced high yield (43.32tha^{-1}) with more pungency that that of control which was almost similar to $CM_7D_{300}P_{93}$ (41.38 tha^{-1}) and $CM_7D_{300}P_{49}$ (41.09 tha^{-1}).

Bottle gourd (M_5)

The experiment was conducted at Sutiakhali, Mymensingh during rabi season 2017-18 to select desirable mutants of bottle gourd for high yield potential and also desirable size, shape, color and cooking performances. Among the selected 15 mutants lines BL-$4M_5D_{300}P_{4-2}$ produced the highest number of fruits (28 fruits/plant). The selection procedure will be continuing in next season.

Cucumber (M_4)

The experiment was conducted at BINA farm, Mymensingh to screen the M_4 population from local cucumber variety of Norsingdi for yield potential and desirable size, shape, color, taste and quality attributes. Among the 12 mutants lines $CM_4D_{100}P_{2,}$ and $CM_4D_{100}P_5$ produced the highest number of fruits/ plant (18 fruits/plant) as compared to parent, Norsingdi local (control; 10 fruits/plant). Among the 12 mutants, eight mutants are promising for next year.

Garlic

The experiment was conducted to observe the performance of the M_3 populations and screen the high yield potential of Garlic. Maximum M_2 populations produced higher yield compared to non-irradiated mother plants of $B_1D_{0.}$

Onion (M_3)

Seed yield potential was assessed of 7 onion mutant lines (M_3) along with the parents at BINA HQ farm, Mymensingh. The M_3 population $TD_{50}P_1$ = 3.60 g, $TD_{75}P_1$ = 3.40 g, $TD_{100}P_1$ = 4.50 g, $O_3D_0P_3$ = 3.50 g, $O_3D_{100}P_{11}$ = 3.50 g, ID_{50} P_2= 10.0 g, $ID_{75}P_4$ = 1.84 g and $ID_{100}P_5$ = 1.58g produced higher seed yield compared to their mother. The selection procedure will be continued in next season.

Ginger (M_3)

The experiment was conducted to observe the performance of M_2 populations of ginger. Among the eight mutants of ginger, most of all M_2 population produced higher yield at 2 Gy compared to their mother. The mutant population of 2 Gy irradiation would be evaluated for rhizome yield and other characters in the next year.

Carrot (M_3)

The experiment was conducted with two varieties (*Brasilia agroflora* and *Prima agroflora*) and three doses of gamma radiation viz. 50 Gy, 75 Gy and 100Gy at BINA HQ farm. The 75 Gy treated plants produced the highest seed yield.

i) In case of *Brasilia agroflora* variety the highest seed yield (1395.20 kg/ha) was recorded from $V_1D_{75}P_{14}$ population while the lowest yield (836.80 kg/ha) was recorded from $V_1D_oP_4$ population.

ii) In case of *Prima agroflora* variety, the highest seed yield (1440.00 kg/ha) was recorded from $V_2D_{100}P_{22}$ population while the lowest yield (840.00 kg/ha) was recorded from $V_2D_oP_2$ population.

Malta

The experiment was conducted with 16 M_1 populations of Malta and five check varieties at the BINA farm, Mymensingh to create genetic variability. In case of number of fruits per plant, $WNMD_{40}P_2$ produced the highest no. of fruits (48) and the lowest number of fruits per plant (12) was found in $TMD_0P_{1.}$ Accumulated higher TSS (13.9%) in$WNMD_{40}P_2$ than the other population.

Lime

The experiment was carried out with M_1 population and two cheek varieties at BINA HQ farm, Mymensingh. The M_1 (LBD40P1) plant produced the highest number of fruit yield (270/plant) whereas the lowest was found in LBD20P3 (255/plant). The non irradiated plants produced 185-201 furits/plant.

Pomegranate

The experiment was conducted with seven pomegranate genotypes at BINA head quarter farm. The tallest plant (301cm) was recorded in P2 genotype followed by P1 genotype (280cm) and P3 genotype (255cm) whereas the shortest plant was recorded in B1 genotype (172cm).

The cultilvar P_2 produced the maximum number of fruits (59/plant) along with length of fruit (5.5cm), breadth of fruit (5.4cm) and weight of fruit (260g) whereas the minimum number of fruits (5/plant), length of fruit (4.8cm), breadth of fruit (4.3cm) and weight of fruit (200g) were recorded in A1. P2 genotype accumulated the highest TSS (18.6%) where the lowest (16.3%) was recorded in B_1.

Growing of M_1 generation of tomato in summer season

Dry seeds of BARI tomato-2, BARI tomato 19, Durga, BINA tomato-12 were irradiated with 100, 200 and 300 Gy doses of gamma rays using the ^{60}Co source to create genetic variability for yield improvement in summer season. One hundred fifty seeds per dose were sown on 10 March 2018 in seedbed. The seedlings were transplanted in the main field on 15 April 2018 at BINA HQ farm, Mymensingh. Irradiated treated seedlings and variety were planted in row planting. Seedlings were transplanted at 60 cm distance within rows of 45 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. Cultural and intercultural practices were followed as and when it is necessary. Finally, M_1 plants were harvested from the survived plants and kept separately dose and variety wise to screen the M_2 generation in next season.

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

The seed production experiments of Binatomato-10, Binatomato-11, Binatomato-12, were conducted at BINA HQ farm and Sutiakhali, Boyra, Mymensingh during rabi season 2017-2018. Seed production of these released varieties was 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 harvests. Total seed production of Binatomato-10, Binatomato-11, Binatomato-12, Binarashun-1 and Binamorich-1 were 500 g, 950 g, 800 g, 90 kg and 3 kg respectively (Table-1). The production of seeds was low due to unfavorable environmental conditions such as early blight of tomato.

Table 1. Performance of Seed production of Binatomato-10, Binatomato-11, Binatomato-12, Binarashun-1 and Binamorich-1 varieties on seed yield grown under field condition at Mymensingh during rabi season 2017-18

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

Screening of M_1 generation of Okra (Lady's finger)

This experiment was carried out at BINA HQ farm, Mymensingh to create desirable mutants with high yield potential and softness of okra and tolerance to fruit borer and YMV. The seeds of Chamak, Green Chamak, Durga, Anamica were irradiated 300, 400and 500Gy using ^{60}Co source. Seeds were sown on 15 April 2018 at 60 cm distances within rows of 50 cm apart following non replicated plant progeny-rows. Recommended doses of fertilizers were applied together with recommended cultural and intercultural practices. Data on plant height, days to first and last harvest (harvesting duration), number of fruits/plant, fruit yield (t/ha), %fruit borer infestation and YMV tolerant plants and softness of fruits were recorded.

Performances of promising mutant (M_5) of brinjal

Mymensingh

The experiment was conducted with 7 mutants with their parents at Sutiakhali farmers field, Mymensingh and BINA sub-station farm at Ishwardi to observe the performance of M_5 mutants of brinjal. Seeds were sown on 12th October 2018 and transplanted on 15th November 2018. The experiment was laid out in 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 2. Results showed that the mutants differed for yield and yield attributes (Table 2). The mutant line $IndM_5D_{75}P_{29}$ showed the highest fruit yield **(14.87** kg plant^{-1}**)** which was statistically similar to $IndM_5D_{75}P_{38}$ **(12.16** kg plant^{-1}**).** The rest mutants showed the fruit yield ranged from 7.96 to 4.29 kg/plant. It could be concluded that the mutants $IndM_5D_{75}P_{29}$ contributed the highest yield (103.87 t/ha) followed by $IndM_5D_{75}P_{38}$ (90.80 t/ha) as compared to control (48.0 t/ha).

Table 2. Yield attributes of M_5 mutants of brinjal

Mutant/Variety	Plant height (cm)	Branch plant^{-1} (no.)	Fruit plant^{-1} (no.)	Total fruit wt. plant^{-1} (kg)	Yield. (tha^{-1})
$IndM_5D_{75}P_{29}$	105	9	10	14.87	103.87
$IndM_5D_{75}P_{30}$	97	10	6	6.06	60.60
$IndM_5D_{75}P_{38}$	87	9	8	12.16	90.80
$IndM_5D_{75}P_{42}$	64	8	8	6.75	65.25
$IndM_5D_{75}P_{43}$	90	8	8	7.96	76.12
$IndM_5D_{75}P_{45}$	88	10	6	5.58	65.25
$IndM_5D_{75}P_{49}$	75	9	4	4.29	60.10
Control (Parent)	88	7	5	3.92	48.0
S D (±)	12.58	1.04	1.95	3.87	18.20

BINA Sub-station, Ishurdi

The experiment was conducted at Ishwardi substation farm to observe the performance of M_5 mutants of brinjal. Seedlings of the mutants were transplanted during 1st week of November, 2018. The experiment was laid out with eight mutants using suggested spacing 70 cm × 60 cm. 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 taken from each mutant. Results showed that the mutants differed for yield and yield attributes (Table 3). The mutant line $IndM_5D_{75}P_{29}$ showed the highest fruit yield (13.62 kg plant^{-1}) which was statistically similar to $IndM_5D_{75}P_{38}$ (10.06 kg plant^{-1}) and $IndM_5D_{75}P_{42}$ mutant (7.45 kg plant^{-1}). The rest mutants showed the fruit yield ranged from 3.78-6.86 kg/plant. It could be concluded that the mutant $IndM_5D_{75}P_{29}$ contributed the highest fruit yield (102.56t/ha) followed by $IndM_5D_{75}P_{38}$ and $IndM_5D_{75}P_{42}$ as compared to control (46.03 t/ha).

Table 3. Yield attributes of M_5 population of brinjal at Ishwardi substation farm

Mutant/Variety	Plant height (cm)	Branch plant^{-1} (no.)	Fruit plant^{-1}(no.)	Total fruit wt. plant^{-1}(kg)	Yield. (tha^{-1})
Ind$M_5D_{75}P_{29}$	92	8	9	13.62	102.56
Ind$M_5D_{75}P_{30}$	96	12	6	6.49	54.51
Ind$M_5D_{75}P_{38}$	82	10	5	10.06	91.42
Ind$M_5D_{75}P_{42}$	72	9	8	7.45	64.69
Ind$M_5D_{75}P_{43}$	89	12	7	3.78	60.96
Ind$M_5D_{75}P_{45}$	93	10	5	6.86	65.24
Ind$M_5D_{75}P_{49}$	108	12	4	4.10	61.57
Control (Parent)	89	12	4	3.78	46.03
SD (±)	10.44	1.60	1.85	3.43	18.85

Performance of selected pungent mutants (M_7) of Chili

On farm trial

The experiment was conducted to observe the performance of the selected pungent mutants (M_7) of chilli. Farmer's yield trial with desirable mutants had been done at Sutiakhali farmer's field, Mymensingh during rabi season, 2017-18. Seedlings of the mutant were transplanted during 1st week of November, 2017. The experiment was laid out in RCBD with 3 replications using suggested spacing 50 cm × 40 cm. recommended production packages were followed to ensure normal plant growth and development. Data on various characters, such as plant height, fruit length, fruit diameter, number of fruit/plant, fruit yield and average fruit weight were taken from each mutants. Results showed that the desirable mutant $CM_7D_{75}P_8$ produced the highest yield (43.32 tha^{-1}) for contributing fruit yield plant. Although this mutant showed lower fruit number per plant but fruit size was bigger. The rest mutants produced fruit yield ranged from 26.67 to 41.38 t/ha.

Table 5. Yield and Yield attributes of selected pungent mutants (M7) of Chili at Sutiakhali, Mymensingh

Mutant/ Variety	Plant height (cm)	Branch plant^{-1}(no.)	Fruits plant^{-1}(no.)	Fruit length (cm)	Fruit diameter (cm)	Yield plant^{-1}(kg)	Yield (tha^{-1})
$CM_7D_{300}P_{93}$	19	7	99	14	6	1.10	41.38
$CM_7D_{150}P_{46}$	17	8	63	13	6	0.72	27.28
$CM_7D_{150}P_{39}$	18	7	87	12	5	1.07	40.96
$CM_7D_{75}P_8$ (Pungent)	25	7	76	13	6	1.20	43.32
$CM_7D_{150}P_{49}$	23	6	93	12	5	1.08	41.09
$CM_7D_{150}P_{77}$	25	7	82	12	6	1.06	38.60
$CM_7D_{150}P_{81}$	24	8	77	13	6	0.90	35.11
Mother	23	7	65	12	6	0.70	26.67
SD(±)	**3.24**	**0.64**	**12.65**	**0.74**	**0.46**	**0.18**	**6.53**

Evaluation of promising mutants (M_5) of bottle gourd

The experiment was conducted at Sutiakhali, Mymensingh during rabi season 2017-18 to evaluate the performance of promising mutants (M5) of bottle gourd. The experiment was laid out in row planting method using recommended spacing (3 plants per pit), Recommended production packages were followed to ensure normal plant growth and development. Data on various characters, such fruit length, fruit diameter, number of fruit/plant, fruit yield and average fruit weight were taken from each mutant (Table 6).

Results showed that BL-4M_5D_{300}P4-2 produced the highest number of fruits (28 fruits/plant) in all the mutants population. Rest of the mutants showed the number of fruit 18-26 fruits/plant. The control plant produced 18 fruits/plant.

Table 7. Yield attributes of elite M_5 mutants of Bottle gourd

Mutant/Variety	No. of fruits plant^{-1}(no.)	Length of fruit (cm)	Diameter of fruit (cm)	Colour
BL-4(control)	**18**	43	35.66	Dark green with whitish spot
BL-4$M_5D_{300}P_{4-1}$	**25**	47	39	Light green
BL-4$M_5D_{300}P_{4-2}$	**28**	50	38	Light green
BL-4$M_5D_{300}P_{5-1}$	22	45	36	Light green
BL-4$M_5D_{300}P_{5-2}$	25	47	39	Light green
BL-4$M_5D_{300}P_{5-3}$	21	62	34	Light green
BL-4$M_5D_{300}P_{6-1}$	22	53	42	Light green with whitish spot
BL-4$M_5D_{300}P_{6-2}$	22	45	38	Light green with whitish spot
BL-4$M_5D_{300}P_{6-3}$	25	42	36	Light green with whitish spot
BL-4$M_5D_{300}P_{7-1}$	23	49	39	Light green with whitish spot
BL-4$M_5D_{300}P_{7-2}$	22	61	35	Light green with whitish spot
BL-4$M_5D_{300}P_{7-3}$	23	43	34	Light green with whitish spot
BL-4$M_5D_{150}P_{3-1}$	22	50	42	Dark green
BL-4$M_5D_{150}P_{3-2}$	23	48	38	Dark green
BL-4$M_5D_{150}P_{3-3}$	26	53	40	Dark green
BL-4$M_5D_{150}P_{4-1}$	25	51	38	Whitish green
SD(±)	1.12	2.90	1.86	-

Screening of M_4 mutants of cucumber

The experiment was conducted at BINA HQ farm, Mymensingh to screen the M_4 mutants from local cucumber variety of Norsingdi. The experiment was laid out in row planting method using recommended spacing. Recommended production packages were followed to ensure normal plant growth and development. Data on various characters, such as fruit length, fruit diameter, number of fruit/plant, fruit yield and average fruit weight were taken from each mutants (Table 7). Results showed that the number of fruit ranged from 10 to 18 fruit plant^{-1}. Some mutants $CM_4D_{100}P_2$, $CM_4D_{100}P_5$ and $CM_4D_{300}P_3$ produced the highest number of fruits/ plant (18 fruit/plant) as compared to parent, Norsingdi local (10 fruit/plant). Some mutants are different in colour, shape and size. The highest yield (18.37 kg/plant) was found in $CM_4D_{100}P_2$ mutant and the lowest yield (5.53 kg/plant) was in the local plant.

Table 7. Yield attributes of M_4 mutant of cucumber at BINA farm, Mymensingh

Mutant/Variety	First flowering	First fruiting	Average length of fruit (cm)	Average diameter of fruit (cm)	No. of fruits/ plant	Yield/ plant (kg)
CM_4 $D_{100}P_1$	07.05.2018	15.05.2018	25.57	6.98	16	14.51
$CM_4D_{100}P_2$	05.05.2018	14.05.2018	26.50	8.25	**18**	**18.37**
$CM_4D_{100}P_3$	09.05.2018	17.05.2018	23.30	6.46	13	11.25
$CM_4D_{100}P_4$	10.05.2018	18.05.2018	24.42	7.08	16	9.34
$CM_4D_{100}P_5$	12.05.2018	20.05.2018	23.17	7.03	**18**	10.34
$CM_4D_{100}P_6$	06.05.2018	15.05.2018	23.00	7.32	15	9.09

$CM_4D_{100}P_8$	01.05.2018	10.05.2018	27.14	6.34	15	6.63
$CM_4D_{200}P_3$	09.05.2018	18.05.2018	21.60	8.26	13	8.36
$CM_4D_{200}P_4$	10.05.2018	19.05.2018	23.70	6.34	13	5.83
$CM_4D_{300}P_1$	05.05.2018	12.05.2018	22.35	6.05	16	6.63
$CM_4D_{300}P_3$	03.05.2018	12.05.2018	29.12	7.02	**18**	11.41
$CM_4D_{300}P_4$	05.05.2018	14.05.2018	29.10	5.85	16	6.58
Parent (Norsingdi local)	12.05.2018	20.05.2018	24.00	5.12	10	**5.53**
SD(±)	**-**	**-**	**1.15**	**0.82**	**0.55**	**1.11**

Screening of M_1 generation of cucumber

With view to develop high yielding cucumber mutants, dry seeds of cv. baromasi, baropatha were irradiated with 100,150 & 200 Gy doses of gamma rays using the ^{60}Co source to create genetic variability for yield improvement in summer season. One hundred seeds per dose were sown on 10 March 2018 in seedbed. The germinated seedlings were transplanted in the main field on 15 April 2018 at BINA HQ farm, Mymensingh in separate plots dose and variety wise along with a plot for un-irradiated control of each variety. Seedlings were transplanted using recommended spacing 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. Cultural and intercultural practices were followed as and when necessitated. Finally, M1 plants were harvested from the survived plants and kept separately dose and variety wise to screen in the M2 generation in next season.

Evaluation of M_3 mutants of Garlic

The experiment was conducted to observe the performance of the M_3 mutants developed from Garlic BAURasun-1, BAURasun-2, BAURasun-3, BAURasun-4 and AC-5. Seeds (Cloves) of the garlic were planted during 2nd week of November, 2017. 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_3 population differed with the check (Mother) variety for yield and yield attributes (Table 8-12). M_3 population produced the higher yield compared to non-irradiated mother plants of $B_1D_{0.}$

In case of BAURasun 1, yield of the M_3 populations were observed ranged from 7.81 t/ha to 11.06 t/ha whereas the highest yield (11.06 t/ha) was produced by the $B1M_3D_{1.5}P_2$ mutant plants. The lowest yield was produced by $B_1M_3D_{2.0}P_2$ (7.81 t/ha) (Table. 8).

In case of BAURasun 2, yield of M_3 populations were ranged from 8.54 to 5.04 t/ha. The $B_2M_3D_{1.5}P_3$ produced the highest yield (8.54 t/ha) .The lowest yield was produced by $B_2M_3D_{0.75}P_{12}$ (Table. 9).

In case of BAURasun 3, yield of M_3 populations were observed ranged from 6.02 to 10.2 t/ha. The $B_3M_3D_{0.75}P_1$ mutant plant produced the highest yield (10.20 t/ha) and the lowest yield was produced by $B_3M_3D_{2.0}P_1$ (6.02 t/ha) (Table. 10).

In case of BAURasun 4, yield of M_3 populations were observed ranged from 6.54 to 9.58 t/ha. The $B_4M_3D_{1.5}P_2$ plant produced the highest yield (9.58 t/ha) and the lowest yield was produced by B_4D_0 (6.54 t/ha).

The genotype AC-5 **(Binarasun-1)** of garlic responded well to the gamma irradiation. In case of AC-5 population, yield of M_3 populations were observed ranged from 10.11 to 8.45 t/ha. The AC-5$M_3D_{0.75}P_1$ plant produced the highest yield (10.11 t/ha) which was followed by AC-5$M_3D_{0.75}P_9$ (9.66 t/ha) and AC-5M_3D1P_5 (9.42t/ha). The lowest yield was produced by AC-5M_3 $D_{0.75}P_8$ (8.45 t/ha) and the non irradiated mother (8.95 t/ha) (Table. 12).

Table 8. Screening of M_3 populations derived from irradiated BAURasun-1

M_3 population	Plant height (cm)	Leaf/ plant (no.)	Fresh weight of Bulb/plant (g)	Clove/ bulb (no.)	Clove yield/ Plot (kg)	Bulb yield (t ha^{-1})
$B_1M_3D_{0.75}P_1$	69.4	10.14	24.1	18.3	0.84	8.61
$B_1M_3D_{0.75}P_2$	68.3	11.20	24.3	16.3	0.86	8.80
$B_1M_3D_{1.0}P_1$	59.4	7.50	20.3	28.5	0.99	9.92
$B_1M_3D_{1.0}P_2$	57.1	6.40	19.4	26.2	0.92	9.17
$B_1M_3D_{1.0}P_3$	59.6	6.50	17.3	30.1	1.05	10.70
$B_1M_3D_{1.0}P_5$	55.3	5.30	20.4	25.3	0.89	8.85
$B_1M_3D_{1.0}P_6$	50.3	5.55	19.6	26.1	0.91	9.14
$B_1M_3D_{1.0}P_7$	60.4	4.10	21.5	26.8	0.94	9.38
$B_1M_3D_{1.5}P_1$	60.5	6.60	19.3	26.9	0.94	9.42
$B_1M_3D_{1.5}P_2$	**58.2**	**5.50**	**18.6**	**31.6**	**1.12**	**11.06**
$B_1M_3D_{1.5}P_3$	52.3	5.60	18.7	22.4	0.78	7.84
$B_1M_3D_{1.5}P_5$	52.4	6.60	19.9	22.3	0.78	7.82
$B_1M_3D_{2.0}P_1$	50.6	4.20	18.8	24.3	0.87	8.77
$B_1M_3D_{2.0}P_2$	50.3	4.40	19.8	22.6	0.78	7.81
$B_1M_3D_{2.0}P_4$	52.2	6.20	17.5	25.1	0.89	8.96
$B_1M_3D_{2.0}P_5$	50.1	5.80	20.8	25.6	0.89	8.94
B_1D_0 (Mother)	67.7	10.89	19.7	26.7	0.93	9.35
SD (±)	**1.69**	**5.12**	**1.92**	**1.87**	**0.74**	**1.21**

Table 9. Screening of M_3 populations derived from irradiated BAURasun-2

M_2 population	Plant height (cm)	Leaf/ plant (no.)	Fresh weight of bulb/plant (g)	Clove/ bulb (no.)	Bulb yield/ plant (kg)	Clove yield (t ha^{-1})
$B_2M_3D_{0.75}P_2$	62	10.9	16.6	25.5	0.581	5.81
$B_2M_3D_{0.75}P_3$	60	11.8	16.8	26.6	0.588	5.88
$B_2M_3D_{0.75}P_4$	57.5	11.1	15.4	27.5	0.539	5.39
$B_2M_3D_{0.75}P_{11}$	54.6	10.5	16.3	22.6	0.571	5.73
$B_2M_3D_{0.75}P_{12}$	60.6	12.2	14.4	22.9	0.504	5.04
$B_2M_3D_{1.0}P_2$	51.5	10.5	15.7	28.9	0.549	5.49
$B_2M_3D_{1.0}P_3$	52.5	7.80	17.8	25.5	0.623	6.23
$B_2M_3D_{1.0}P_5$	50.5	10.5	23.5	28.9	0.822	8.23
$B_2M_3D_{1.0}P_7$	48.5	10.8	15.6	30.5	0.546	5.46
$B_2M_3D_{1.5}P_1$	46.6	10.5	23.7	24.5	0.822	8.22
$B_2M_3D_{1.5}P_3$	46.6	9.80	24.4	23.6	0.854	8.54
$B_2M_3D_{1.5}P_4$	47.1	9.90	15.6	24.5	0.546	5.46
$B_2M_3D_{1.5}P_6$	45.6	10.5	15.9	22.5	0.555	5.51
$B_2M_3D_{2.0}P_1$	48.5	11.6	23.6	23.9	0.819	8.19
$B_2M_3D_{2.0}P_3$	44.4	11.5	21.5	25.8	0.751	7.51
$B_2M_3D_{2.0}P_4$	46.5	9.50	21.7	23.6	0.760	7.60
B_2D_0 (Mother)	40.54	8.50	15.9	25.5	0.557	5.57
SD (±)	**5.16**	**1.50**	**1.75**	**2.16**	**0.22**	**1.10**

Table 10. Screening of M_3 populations derived from irradiated BAURasun-3

M_2 population	Plant height (cm)	Leaf/plant (no.)	Fresh weight of bulb/plant (g)	Clove/ bulb (no.)	Bulb yield/ plant	Bulb yield t/ha
$B_3M_3D_{0.75}P_1$	69.8	9.2	22.5	29	1.02	**10.2**
$B_3M_3D_{0.75}P_2$	72.2	8.2	21.1	26	0.738	**7.38**
$B_3M_3D_{0.75}P_3$	64.1	8.7	19.5	19.2	0.683	**6.83**
$B_3M_3D_{0.75}P_4$	62.3	7.7	22.1	20.5	0.772	**7.72**
$B_3M_3D_{0.75}P_{10}$	64.2	7.5	18.8	23.4	0.658	6.58
$B_3M_3D_{1.0}P_2$	63.4	8.8	193.5	16.6	0.682	**6.82**
$B_3M_3D_{1.0}P_3$	60.6	8.4	20.2	23.8	0.707	**7.07**
$B_3M_3D_{1.5}P_1$	57.4	9.6	19.7	28.8	0.696	**6.76**
$B_3M_3D_{1.5}P_2$	48.3	6.9	20.7	23.6	0.703	7.03
$B_3M_3D_{1.5}P_3$	51.2	7.8	22.1	25.5	0.773	**7.73**
$B_3M_3D_{1.5}P_5$	49.2	7.9	21.0	26.7	0.753	7.53
$B_3M_3D_{2.0}P_1$	51.2	7.9	17.2	24.4	0.602	6.02
$B_3M_3D_{2.0}P_2$	48.8	8.1	18.3	20	0.640	6.40
B_3D_0(Mother)	64.4	8.8	13.2	23.4	0.562	6.62
SD (±)	**5.16**	**1.25**	**1.62**	**1.13**	**0.167**	**1.10**

Table 11. Screening of M_3 populations derived from irradiated BAURasun-4

M_2 population	Plant height (cm)	Leaf/plant (no.)	Fresh weight of bulb/plant (g)	Clove/ bulb (no.)	Bulb yield/ plant	Bulb yield t/ha
$B_4M_3D_{0.75}P_1$	77.1	8.1	24.2	27.1	0.847	**8.47**
$B_4M_3D_{0.75}P_3$	75.2	8.2	25.1	22.3	0.878	8.78
$B_4M_3D_{0.75}P_4$	76.1	11.2	22.2	24.5	0.777	**7.77**
$B_4M_3D_{0.75}P_5$	75.2	12.3	22.4	23.3	0.784	7.84
$B_4M_3D_{0.75}P_6$	76.1	13.3	24.4	28.5	0.854	8.54
$B_4M_3D_{0.75}P_7$	74.3	12.4	26.2	20.5	0.917	9.17
$B_4M_3D_{0.75}P_8$	72.2	13.3	26.4	21.3	0.924	9.24
$B_4M_3D_{0.75}P_{10}$	71.2	12.6	27.0	21.4	0.945	9.45
$B_4M_3D_{0.75}P_{11}$	70.2	10.5	22.6	23.4	0.791	7.91
$B_4M_3D_{0.75}P_{12}$	72.2	11.8	26.5	25.6	0.957	9.27
$B_4M_3D_{0.75}P_{13}$	73.2	10.6	23.4	26.6	0.819	8.19
$B_4M_3D_{1.0}P_1$	70.2	9.0	25.4	23.6	0.891	**8.91**
$B_4M_3D_{1.0}P_2$	66.6	9.5	23.3	28.8	0.815	**8.18**
$B_4M_3D_{1.5}P_2$	61.4	7.9	18.8	26.6	0.658	9.58
B_4D_0(Mother)	86.2	5.62	13.58	20.2	0.564	6.54
SD (±)	**5.82**	**1.26**	**1.72**	**1.19**	**0.27**	**1.37**

Table 12. Screening of M_3 populations derived from irradiated AC-5(Binarasun-1)

M_2 population	Plant height (cm)	Leaf/ plant (no.)	Fresh weight of bulb/plant (g)	Clove/ bulb (no.)	Bulb yield/ plant	Bulb yield t/ha
AC-5$M_3D_{0.75}P_1$	85.3	11.3	28.6	26.2	1.0	**10.11**
AC-5$M_3D_{0.75}P_2$	80.1	11.5	25.3	24.4	0.885	**8.85**
AC-5$M_3D_{0.75}P_4$	78.7	12.4	26.4	24.7	0.924	**9.24**
AC-5$M_3D_{0.75}P_6$	77.5	11.4	26.6	22.6	0.680	**8.62**
AC-5$M_3D_{0.75}P_7$	79.6	10.4	25.6	20.4	0.878	**8.78**
AC-5$M_3D_{0.75}P_8$	77.5	10.3	25.7	24.5	0.890	8.45
AC-5$M_3D_{0.75}P_9$	80.6	10.4	27.7	22.5	0.960	**9.66**
AC-5$M_3D_{0.75}P_{10}$	75.3	11.3	26.7	22.4	0.930	9.32
AC-5$M_3D_{0.75}P_{12}$	78.6	12.3	25.8	22.4	0.900	9.02
AC-5$M_3D_{0.75}P_{13}$	79.9	10.8	26.6	20.1	0.930	9.30
AC-5$M_3D_{1.0}P_1$	73.3	9.9	26.8	25.2	0.920	**9.21**
AC-5$M_3D_{1.0}P_2$	72.4	9.2	24.3	20.6	0.850	8.52
AC-5$M_3D_{1.0}P_4$	73.5	8.3	24.4	20.5	0.850	8.51
AC-5$M_3D_{1.0}P_5$	72.3	6.6	26.9	22.5	0.940	**9.42**
AC-5D_0(Mother)	88.2	9.9	22.6	19.9	0.790	8.95
SD (±)	**6.71**	**1.25**	**1.67**	**1.19**	**0.26**	**1.15**

Evaluation of M_3 populations of Onion

The experiment was conducted to observe the performance of the mutant population (M_3) derived from 7 onion accessions (Taherpuri, Faridpuri, Onion-2, Onion-3, Onion-4, Spring and Indian Piaz). 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 mutants differed for yield and yield attributes in respect of cheek variety (Table. 13). In case of seven genotypes of onion, the M_3 populations $TD_{50}P_{1,}$, $TD_{75}P_1$, $TD_{100}P_1$, $O_3D_0P_3$, $O_3D_{100}P_{11}$, $ID_{50}P_2$, $ID_{75}P_4$, $ID_{100}P_5$ produced higher seed yield ($TD_{50}P_1$ = 3.60 g, $TD_{75}P_1$ = 3.40 g, $TD_{100}P_1$ = 3.50 g, $O_3D_0P_3$ = 3.50 g, $O_3D_{100}P_{11}$=3.50 g, compared to their mother (Table 13).

Table 13. Screening of M_3 populations of nine onion genotypes

Treatment	Emergence (%)	Plant height (cm)	No. of leaves/ plant	No. of flowering stalks/plant	Length of stalks (cm)	No. of umbels/ plant	No. of seeded fruits/ umbel	Seed wt./ umbel (g)	Seed yield/plant (g)	Bulb yield t/ha
TD_0P_1	86.5	51.2	5.77	2.87	48.5	3.42	96.6	0.88	3.01	1.65
$TD_{50}P_1$	86.4	52.5	5.66	2.90	51.2	3.95	99.9	0.91	**3.60**	1.98
$TD_{75}P_1$	85.2	50.1	5.16	3.06	48.3	3.69	101.1	0.92	**3.40**	1.71
$TD_{100}P_1$	86.9	55.5	5.39	3.13	51.7	2.30	106.6	1.50	**3.50**	1.92
FD_0P_1	67.1	48.8	5.16	3.40	47.3	2.23	77.8	1.06	2.40	1.32
$FD_{50}P_3$	62.6	51.3	5.55	3.00	47.6	2.68	79.6	0.82	2.20	1.21
$FD_{75}P_5$	60.2	48.7	5.62	2.67	47.9	2.96	56.6	0.72	2.10	1.15
$O_2D_0P_2$	72.3	49.9	5.66	2.56	44.3	2.35	75.4	0.72	1.67	0.92
$O_2D_{50}P_4$	68.6	51.3	5.19	2.87	50.5	2.71	82.8	0.74	2.01	1.10
$O_2D_{100}P_8$	60.1	49.3	6.30	3.0	48.6	2.70	88.8	0.99	2.01	1.15
$O_3D_0P_3$	88.4	48.3	6.89	2.87	45.6	3.57	102.4	0.73	**3.50**	1.92
$O_3D_{50}P_9$	83.1	48.2	5.98	2.66	45.5	2.53	88.8	0.98	2.10	1.15
$O_3D_{75}P_{10}$	83.2	48.8	5.18	2.455	40.5	2.61	91.9	0.86	2.20	1.21
$O_3D_{100}P_{11}$	87.7	50.5	6.90	2.71	48.7	3.68	94.4	0.84	**3.50**	1.92
$O_4D_0P_2$	85.2	48.3	6.45	2.88	47.3	4.18	49.3	0.55	2.30	1.27
SD_0P_1	64.5	46.6	5.7	3.00	44.5	3.10	88.8	0.55	1.82	1.01
$SD_{100}P_{13}$	74.5	46.6	4.6	3.00	44.1	3.00	88.8	0.49	1.91	1.05
ID_0P_1	77.6	48.8	4.7	3.00	45.5	3.30	90.9	0.66	**1.17**	1.19
$ID_{50}P_2$	66.6	47.6	5.5	2.00	43.3	2.00	82.8	0.67	**1.34**	0.73
$ID_{75}P_4$	74.4	45.5	4.8	3.00	41.2	3.10	77.7	0.61	**1.84**	1.04
$ID_{100}P_5$	68.8	43.3	5.2	3.00	40.2	3.10	67.8	0.51	**1.58**	0.87
SD (±)	**5.65**	**2.47**	**1.35**	**0.587**	**2.65**	**0.35**	**6.58**	**0.085**	**0.245**	**0.142**

Note: T-Taherpuri, F-Faridpuri, O_2 –Onion-2, O_3-Onion-3, O_4-Onion-4, O_9- Onion-9, S-Spring, I-Indian, O_{10}-Onion-10

Fig. Vigorous and healthy growth of Onion at BINA HQ

Evaluation of M_3 populations of Ginger

The experiment was conducted to observe the performance of the mutant populations (M_3) derived from 8 ginger accessions viz. Rangpur local (Taragonj), Dinajpur local (Rajbari, khanshama), Thanchy local, Shilkhali local, Mirzapur lama, Bandarban local (Whykong,Lama), Dinajpur local (Aamgonj, Khanshama), Bandarban local (Ruma). Eight mutants including parents were planted during 2nd week of November, 2017. The experiment was laid out in row planting method 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 eight genotypes of ginger, the M_3 populations produced higher yield at 2 Gy compare to their parents (Table 14). The mutant population under 2 Gy irradiation would be further evaluated for rhizome yield and other characters in the next year.

Table 14. Growing of M_2 populations of different genotypes of Ginger

Treatment	Plant height (cm)	No. of leaves/ plant	No. of tillers /clump	Wt. of old mother rhizome/ Plant (g)	Wt. of primary rhizome/ Clump (g)	Wt. of secondary rhizome/ Clump (g)	Yield /plant	Yield (t/ha)
Taragonj, Rangpur (2Gy)	31.75	22.82	13.19	9.95	322.67	103.49	109.62	**18.79**
Taragonj, Rangpur(0Gy)	33.53	26.06	15.43	10.18	336.40	127.46	111.56	14.56
Rajbari, khanshama, Dinajpur(2GY)	29.50	19.90	11.03	8.08	126.67	96.085	93.19	**14.17**
Rajbari, khanshama, Dinajpur(0GY)	34.75	23.17	12.48	9.46	253.33	97.07	103.22	12.41
Thanchy (2Gy)	35.36	24.47	15.94	10.73	312.89	84.37	115.26	**19.63**
Thanchy (0Gy)	37.64	26.47	14.50	11.77	471.70	95.12	135.14	16.48
Shilkhali (2Gy)	33.97	28.99	10.25	11.68	118.00	147.70	125.76	**20.78**
Shilkhali (0 Gy)	38.83	28.54	11.25	10.73	452.20	80.14	127.30	16.84
Mirzapur, Lama, Bandarban (2Gy)	30.43	21.09	8.92	9.21	280.00	106.56	95.40	**16.12**
Mirzapur, Lama, Bandarban (0Gy)	35.21	23.91	10.17	11.12	333.34	115.62	111.84	14.16
Whykong, Lama, Bandarban (2Gy)	35.21	23.91	10.62	10.17	333.34	115.62	101.84	**14.16**
Whykong, Lama, Bandarban (0Gy)	39.92	26.62	9.21	7.86	324.00	134.32	119.58	12.60
Aamgonj, Khanshama, Dinajpur (2Gy)	33.97	28.99	10.25	11.68	118.00	147.70	110.76	**13.84**
Aamgonj, Khanshama, Dinajpur (3Gy)	30.88	22.18	10.65	8.16	225.12	127.52	108.70	12.66
Aamgonj, Khanshama, Dinajpur (0Gy)	38.83	28.54	11.25	10.73	452.20	80.14	119.30	10.78
Ruma, Bandarban (2Gy)	33.20	21.91	8.17	7.89	320.00	113.62	109.84	**16.56**
Ruma, Bandarban (0Gy)	35.62	25.62	9.58	11.65	320.00	132.30	117.59	15.62
SD (±)	**3.65**	**1.47**	**1.45**	**0.150**	**2.89**	**6.98**	**9.65**	**1.25**

Fig. Irradiated Rhizome of Ginger collected from different regions of Bangladesh (Doses: 0Gy, 2Gy & 3 Gy)

Screening of M_3 populations of Carrot (Seed to seed method)

The experiment was conducted with 20 mutants and two check varieties (*Brasilias agroflora* and *Prima agroflora*). The experiment 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 was 1.0 m. All the parameters on plant growth, yield components and quality seed of carrot were significantly influenced by mutants. The mutants $V_1D_{75}P_{15}$ produced the tallest plant (179.91 cm), maximum no. of primary umbel/plant (11.99), no. of secondary umbel/plant (136.62), seed yield per plant(6.01 g), seed yield per plot (216.36 g) as well as yield (1081.80 kg/ha) than parents. The non irradiated plants took the minimum time to 50% flowering, days required from flower to fruit set whereas irradiated plants also took the maximum time in both of *Brasilia agroflora* (Table 17 & 18) and *Prima agroflora* varieties (Table 19 & 20). The highest seed yield (1081.80kg/ha) was recorded from $V_1D_{75}P_{15}$ populations (Table 18) while the lowest yield (692.66kg/ha) was recorded from $V_2D_oP_5$ populations (Table 20)

Table 17: Screening of M_3 population 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
$V_1D_oP_1$	154.44	55.12	8.11	8.77	10.11
$V_1D_oP_2$	152.46	55.13	8.29	8.56	10.69
$V_1D_oP_3$	153.98	55.62	8.92	7.36	10.80
$V_1D_oP_4$	151.66	55.51	8.87	7.86	10.92
$V_1D_oP_5$	148.89	56.61	9.72	7.56	11.86
$V_1D_{50}P_6$	160.61	57.33	9.82	7.23	11.76
$V_1D_{50}P_7$	158.73	60.19	11.23	9.86	12.12
$V_1D_{50}P_8$	161.11	56.32	9.99	9.77	12.63
$V_1D_{50}P_9$	156.64	60.61	10.13	10.12	12.39
$V_1D_{50}P_{10}$	158.64	58.80	11.89	9.66	12.65
$V_1D_{50}P_{11}$	161.54	58.02	10.85	9.86	12.39
$V_1D_{50}P_{12}$	164.44	59.11	10.75	10.12	12.58
$V_1D_{75}P_{13}$	165.55	60.54	10.38	10.32	11.39
$V_1D_{75}P_{14}$	167.73	58.40	11.89	10.46	11.87
$V_1D_{75}P_{15}$	179.91	57.39	10.31	11.99	13.62
$V_1D_{75}P_{16}$	170.74	56.31	9.99	10.13	13.19
$V_1D_{75}P_{17}$	172.20	58.50	10.54	10.14	12.42
$V_1D_{75}P_{18}$	167.66	57.51	11.30	9.67	13.62
$V_1D_{100}P_{19}$	137.60	60.61	11.28	9.79	12.44
$V_1D_{100}P_{20}$	136.66	60.32	9.78	9.66	11.42
$V_1D_{100}P_{21}$	135.22	60.87	12.411	9.36	11.56
$V_1D_{100}P_{22}$	140.40	58.39	11.44	9.31	11.93
$V_1D_{100}P_{23}$	141.33	56.64	11.58	9.32	12.66
$V_1D_{100}P_{24}$	139.99	61.32	10.32	9.55	11.22

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

Table 18: Screening of M_3population of Carrot (Var. *Brasilia agroflora*) (Cont'd)

Mutants	Seed yield/ plant (g)	Seed yield/ plot (g)	Yield (Kg/ha)
$V_1D_oP_1$	4.32	155.52	777.61
$V_1D_oP_2$	4.42	148.32	741.60
$V_1D_oP_3$	4.25	145.56	702.66
$V_1D_oP_4$	4.49	158.84	**801.20**
$V_1D_oP_5$	4.44	159.84	789.20
$V_1D_{50}P_6$	4.29	154.44	772.20
$V_1D_{50}P_7$	5.23	192.24	961.20
$V_1D_{50}P_8$	4.02	144.72	723.60
$V_1D_{50}P_9$	4.19	150.84	754.20
$V_1D_{50}P_{10}$	4.47	169.92	849.60
$V_1D_{50}P_{11}$	5.01	180.36	821.12
$V_1D_{50}P_{12}$	5.22	187.92	939.60
$V_1D_{75}P_{13}$	5.62	202.32	1011.61
$V_1D_{75}P_{14}$	5.15	185.41	927.00
$V_1D_{75}P_{15}$	6.01	216.36	1081.80
$V_1D_{75}P_{16}$	5.52	198.72	993.60
$V_1D_{75}P_{17}$	5.62	202.32	1011.63
$V_1D_{75}P_{18}$	5.01	183.60	918.00
$V_1D_{100}P_{19}$	4.10	144.36	721.80
$V_1D_{100}P_{20}$	3.92	141.12	705.50
$V_1D_{100}P_{21}$	3.34	141.84	709.70
$V_1D_{100}P_{22}$	4.42	158.76	793.80
$V_1D_{100}P_{23}$	4.11	149.97	739.80
$V_1D_{100}P_{24}$	5.02	180.72	903.60

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

Table 19: Growing of M_3 population of Carrot (Var. *Prima agroflora*)

Mutants/ Germplasm	Plant height	Days to 50% flowering	Days required flower to fruit set	No. of primary umbels/ plant	No. of secondary umbels/ plant
$V_2D_oP_1$	92.12	49.29	10.23	7.99	7.21
$V_2D_oP_2$	94.42	49.12	10.57	8.11	8.82
$V_2D_oP_3$	95.21	48.23	10.55	8.22	8.91
$V_2D_oP_4$	97.14	47.65	10.46	8.11	8.78
$V_2D_oP_5$	97.33	50.23	10.54	8.12	8.88
$V_2D_{50}P_6$	97.36	51.32	11.09	8.95	9.72
$V_2D_{50}P_7$	124.12	51.11	11.47	8.96	10.11
$V_2D_{50}P_8$	119.21	50.39	12.21	9.98	9.21
$V_2D_{50}P_9$	131.33	52.12	12.01	9.77	9.12
$V_2D_{50}P_{10}$	133.49	53.44	12.12	9.87	6.12
$V_2D_{50}P_{11}$	129.99	54.29	12.11	9.92	9.32
$V_2D_{50}P_{12}$	131.31	55.12	12.34	9.80	11.12
$V_2D_{75}P_{13}$	132.54	53.34	12.46	9.21	10.26
$V_2D_{75}P_{14}$	131.11	53.23	12.23	10.51	11.13
$V_2D_{75}P_{15}$	128.72	54.44	12.44	9.64	10.44
$V_2D_{75}P_{16}$	127.11	55.19	12.66	8.88	10.54
$V_2D_{75}P_{17}$	122.42	53.44	11.11	8.78	10.36
$V_2D_{75}P_{18}$	140.42	56.62	12.34	8.64	9.87
$V_2D_{100}P_{19}$	132.20	51.29	12.56	8.82	9.46
$V_2D_{100}P_{20}$	136.40	52.17	12.36	9.77	9.66
$V_2D_{100}P_{21}$	142.31	51.77	12.64	9.64	9.01
$V_2D_{100}P_{22}$	144.12	53.32	12.64	9.50	8.81

$V_2D_{100}P_{23}$	121.56	51.48	12.91	8.77	9.12
$V_2D_{100}P_{24}$	119.91		12.11	9.01	9.12

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

Table 20. Growing of M_3 population of carrot (Var. *Prima agroflora*) (Cont'd)

Mutants	Seed yield/ plant (g)	Seed yield/ plot (g)	Yield(t/ha)
$V_2D_oP_1$	4.41	158.76	793.80
$V_2D_oP_2$	4.21	151.56	757.80
$V_2D_oP_3$	4.66	167.76	838.80
$V_2D_oP_4$	4.11	169.92	849.60
$V_2D_oP_5$	4.01	135.56	692.66
$V_2D_{50}P_6$	4.02	144.72	723.60
$V_2D_{50}P_7$	4.43	159.48	797.40
$V_2D_{50}P_8$	4.42	159.62	795.60
$V_2D_{50}P_9$	4.59	165.24	826.20
$V_2D_{50}P_{10}$	4.19	150.64	754.20
$V_2D_{50}P_{11}$	4.77	169.92	849.60
$V_2D_{50}P_{12}$	4.44	159.84	799.20
$V_2D_{75}P_{13}$	5.19	186.84	934.20
$V_2D_{75}P_{14}$	5.55	199.80	999.00
$V_2D_{75}P_{15}$	5.54	199.44	997.20
$V_2D_{75}P_{16}$	6.01	212.36	1061.80
$V_2D_{75}P_{17}$	5.77	207.72	1038.60
$V_2D_{75}P_{18}$	5.87	210.32	1053.61
$V_2D_{100}P_{19}$	5.91	210.76	1053.80
$V_2D_{100}P_{20}$	5.66	203.76	1018.80
$V_2D_{100}P_{21}$	5.70	205.20	1026.00
$V_2D_{100}P_{22}$	5.28	190.08	**950.40**
$V_2D_{100}P_{23}$	5.66	203.76	1018.80
$V_2D_{100}P_{24}$	6.00	216.00	1080.00

Legend: V_2-Carrot variety *Prima agroflora*

Growing of M_1 population of Malta and lime

Malta

The experiment was conducted with 16 $\mathbf{M_1}$ population of malta and five check varieties at the BINA farm, Mymensingh to create genetic variability. The experiment was laid out in row planting. The $WNMD_{40}P_2$ populatin showed the tallest plant (260 cm) along with maximum number of fruits (48), length of fruit (6.7 cm), breadth of fruit (6.9 cm) and minimum number of seed/fruit (5) whereas the shortest plant (205 cm) ,the minimum number of fruits (12), length of fruit(5.0 cm), breadth of fruit (5.1 cm) and maximum number of seed/fruit (11) were recorded in TMD_0P_1 (Table 21) . Accumulated higher TSS (%) 13.90 was observed in $WNMD_{40}P_2$ than the other population.

Lime

The experiment was carried out with M1 population and two cheek varieties at BINA HQ farm, Mymensingh. The experiment was laid out in row planting. The M_1 (LBD40P1) plant produced the highest number of fruit yield (270/plant) whereas the lowest was found in LBD20P3 (255/plant). The non irradiated plants showed the fruits number ranged from 185-201.

Table 21. M_1 population of Malta and Lime

Sl No.	Crop species	Planting Date	Plant hight (cm)	No. of fruits/ plant	Weight of fruit/ plant (g)	Length of fruit (cm)	Breadth of fruit (cm)	No. of seed/ fruit	% TSS
	Malta								
1.	TMD_0P_1	08.05.16	205	12	104	5.0	5.1	11	10.5
2.	$TMD_{20}P_2$	08.05.16	207	18	94	5.6	5.7	9	10.9
3.	$TMD_{20}P_3$	08.05.16	245	14	95	5.4	5.4	8	10.6
4.	$TMD_{40}P_1$	08.05.16	215	13	99	5.3	5.5	5	11.2
5.	$TMD_{40}P_2$	08.05.16	210	17	98	5.0	5.6	6	11.0
6.	$TMD_{40}P_3$	08.05.16	217	15	102	4.8	5.7	7	11.0
7.	$TMD_{40}P_4$	08.05.16	247	15	125	4.6	5.6	6	10.8
8.	$TMD_{40}P_5$	08.05.16	217	14	126	4.5	5.5	8	11.5
9.	$WNMD_0 P_1$	08.05.16	178	21	**203**	6.8	5.5	10	13.4
10.	$WNMD_{20}P_1$	08.05.16	241	31	198	6.5	6.9	9	13.4
11.	$WNMD_{20}P_2$	08.05.16	221	32	201	6.7	6.8	9	13.6
12.	$WNMD_{20}P_3$	08.05.16	252	39	205	6.8	6.7	9	13.7
13.	$WNMD_{40}P_1$	08.05.16	211	42	204	6.4	6.8	9	13.5
14.	$\mathbf{WNMD_{40}P_2}$	**8.5.16**	**260**	**48**	**207**	**6.7**	**6.9**	**5**	**13.9**
15.	$WNMD_{60}P_1$	08.05.16	240	25	200	6.4	6.5	7	13.6
16.	$MMD_0 P_1$	08.05.16	225	25	195	5.7	5.0	7	13.4
17.	$MMD_{20} P_1$	08.05.16	235	42	181	5.6	5.2	6	13.3
18.	BARI malta-1	08.05.16	221	28	122	5.7	5.9	10	13.3
19.	BARI malta-1	08.05.16	234	32	125	5.6	5.8	10	13.2
20.	MMD_{40}	08.05.16	**305**	28	188	5.3	5.2	5	13.4
21.	NMD_{20}	08.05.16	285	33	184	5.4	5.4	6	13.7
	Lime								
22.	LBD_0P_1	08.05.16	**305**	185	28	4.4	4.5	5	9.3
23.	LBD_0P_2	08.05.16	301	**201**	**32**	5.4	5.1	2	9.5
24.	$LBD_{20}P_3$	08.05.16	307	255	38	5.5	5.2	1	9.6
25.	$LBD_{20}P_4$	08.05.16	257	265	39	5.6	5.5	0	9.7
26.	$LBD_{40}P_1$	08.05.16	271	270	41	6.2	5.6	0	9.5

Screening of pomegranate germplasm on growth and yield quality attributes

The experiment was conducted with seven pomegranate genotypes at BINA head quarter farm. The tallest plant (301 cm) was recorded in P2 followed by P1 (280 cm) and P3 (255 cm) whereas the shortest plant was recorded in B1 (172 cm).

The cultivar P2 showed the maximum number of fruits (59/plant), length and breadth of fruit whereas the minimum number of fruits (5/plant), length of fruit and breadth of fruit were recorded in A1 .P2 genotype accumulated the highest TSS (18.6%) where as the lowest (16.3%) was recorded in B1.

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

Sl No.	Crop species	Planting Date	Plant hight (cm)	No. of fruits/ plant	Weight of fruit/ plant (g)	Length of fruit (cm)	Breath of fruit (cm)	% TSS
	Pomegranate							
1.	Pomegranate (India)P1	28.11.16	280	54	255	5.8	5.5	17.5
2.	Pomegranate (India)P2	09.10.16	301	59	260	5.5	5.4	18.6
3.	Pomegranate (India)P3	09.10.16	255	22	260	5.6	4.5	17.2
4.	Anar (India)A1	28.11.16	240	5	200	4.8	4.3	17.1
5.	Anar (India)A2	28.11.16	248	6	239	4.9	5.4	16.5
6.	Bedana (India)B1	28.11.16	172	6	225	4.6	5.2	16.3
7.	Bedana (India) B2	28.11.16	230	13	230	4.9	5.1	17.3

Agricultural Economics Division

Research Highlights

The profitability of BINA released sesame variety Binatil-3 was undertaken in five major sesame growing areas of Bangladesh. The highest production cost was for human labour (42.62%); followed by fertilizer use (16.03%), power tiller (11.65%), and irrigation (10.11%).The average yield of Binatil-3 was 1.4 ton per hectare. The average net return per hectare was Tk. 23232.57. The net return was highest in Kushtia (Tk. 33149.58 ha^{-1}) followed by Magura (Tk. 25318.01 ha^{-1}), Jhenaidah (Tk. 23824.76 ha^{-1}), Faridpur (Tk. 19362.44 ha^{-1}) and Madaripur (Tk. 14511.05 ha^{-1}), respectively. The average Benefit cost ratio was estimated at 1.48 and 2.16 on full cost and cash cost basis implying that the Binatil-3 cultivation at farm level was highly profitable. The highest BCR was found in Kushtia (1.66) followed by Magura (1.52), Jhenaidah (1.49), Faridpur (1.41) and Madaripur (1.32), respectively.

The Yield gap of potential Aman rice variety Binadhan-7 was conducted in five major Binadhan-7 growing areas in Bangladesh namely Mymensingh, Magura, Rangpur, Dinajpur and Jhenaidah. In the study, the concept of yield gap as suggested by Zandstra *et al.* (1981) was used. The highest yield was obtained from Magura (4.70 t ha^{-1}) followed by Rangpur (4.51 t ha^{-1}), Jhenaidah (4.48 t ha^{-1}), Dinajpur (4.20 t ha^{-1}) and Mymensingh (4.15 t ha^{-1}) district. The average yield of Binadhan-7 was 4.41 t ha^{-1}. The estimated yield gap I was 0.46 t ha^{-1} (8.51 %.) and yield gap II was 0.54 t ha-1 (10.80 %.). The lowest gap was 0.72 t $ha-^{1}$ (14%) observed in Rangpur district and it was the highest 1.24 t $ha-^{1}$ (24.20 %) in case of Jhenaidah district. Considering all, the average yield gap was 1 t ha^{-1} (19.38%) in Aman season for Binadhan-7. The average seed rate was 33.65 Kg ha^{-1}, Urea 105.58 Kg ha^{-1}, TSP 86.70 Kg ha^{-1}, MoP 57.70 Kg ha^{-1} and seedling age 27.10 days respectively, indicating that they are either below or above the recommendation. It can be seen that 21 % farmer were in no yield gap, 31.5 % farmer were in low yield gap (1-15% i. e less than 0.70 t ha^{-1}) category, 22 % farmer were in medium yield gap (16-30 % i. e greater than 0 .70 and less than 2.00 t ha^{-1}), 25% farmer were in high gap (>30% i. e greater than 2.00 t ha^{-1}) category among the study areas. The contribution of specified factors affecting production of Binadhan-7 was seen from the estimation of regression equation. The coefficients for power tiller, seed, Urea, TSP, MoP, weeding, irrigation, farm size & experience were found to be positively significant at 1%, 5% and 10% level.

The yield gap of stress tolerant varieties Binadhan-10 & Binadhan-11 were conducted in eight districts in Bangladesh namely Satkhira, Khulna, Barishal, and Cox's Bazar for Binadhan-10 and Mymensingh, Jamalpur, Sherpur and Sunamgonj for Binadhan-11. The concept of yield gap as suggested by Zandstra *et al.* (1981) was used. The average yield of Binadhan-10 was 4.96 t ha^{-1}.The highest yield was obtained from Barishal (5.98 t ha^{-1}) followed by Khulna (5.23 t ha^{-1}), Satkhira (4.45 t ha^{-1}), Cox's Bazar (4.16 t ha^{-1}) district. The estimated yield gap I was 0.69 t ha^{-1} (10.33 %.) and yield gap II was 0.99 t ha^{-1} (16.58 %.). The lowest gap was 1.02 t ha^{-1} (16.83%) found in Khulna district and it was the highest 2.34 t ha^{-1} (39.53%) in case of Cox's Bazar district. Considering all, the average yield gap of Binadhan-10 was 1.67 t ha^{-1} (26.92%). The average yield of Binadhan-11 was 4.00 t ha^{-1}.The highest yield was obtained from Sherpur (4.08 t ha^{-1}) followed by Sunamgonj (4.03 t ha^{-1}), Jamalpur (3.99 t ha^{-1}) and Mymensingh (3.87 t ha^{-1}) district. The estimated yield gap I was 0.69 t ha^{-1} (12.57 %) and yield gap II was 0.83 t ha^{-1} (17.18%). The lowest gap was 1.42 t ha^{-1} (27.74%) observed in Sherpur district and it was the highest 1.73 t ha^{-1} (33.64 %) in case of Mymensingh district. Considering all, the average yield gap of Binadhan-11was 1.52 t ha^{-1} (29.76 %). The responded were classified as affected and not affected by salinity in case of Binadhan-10 producing farmers and not affected, affected and highly affected by flood in case of Binadhan-11 producing farmers to identify the factors responsible for yield gap of the varieties. In case of non-saline areas 26.67% farmer's average yield was 6.30 t ha^{-1} by using 41.62 kg ha^{-1} seed rate which was greater than the recommended dose and other major inputs such as

Urea 187.46 kg ha^{-1}, TSP 103 kg ha^{-1}, MoP 53.49 kg ha^{-1}, Gypsum 22.74 kg ha^{-1} were also below the required level. In case of saline areas farmer's average yield was 4.7 t ha^{-1} and using 39.59 kg ha^{-1} seed rate which was greater than the recommended dose and other major inputs for Binadhan-10 cultivation such as Urea 155.56 kg ha^{-1}, TSP 99.47kg ha^{-1}, MoP 69.24 kg ha^{-1}, Gypsum 27.85 kg ha^{-1} were also below the required level. In case of submergence tolerant rice variety and not affected by flood, 16.66 % Binadhan-11 producing farmer getting yield 4.1 t ha^{-1} by using 40.30 kg ha^{-1} seed rate which was higher than the recommended dose and other major inputs such as Urea 107.83 kg ha^{-1}, TSP 86.49kg ha^{-1}, mop 81.50 kg ha^{-1}, gypsum 11.51 kg ha^{-1} were either below or above the required level. In case of medium flood affected area (affected 1-10 days) 68.33% Binadhan-11 farmer also getting yield 4.1 t ha^{-1} using 45.00 kg ha^{-1} seed rate which was higher than the recommended dose and other major inputs such as Urea 142.23kg ha^{-1}, TSP 80.59 kg ha^{-1}, MoP 57.40kg ha^{-1}, gypsum 4.87 kg ha^{-1} were also below the required level except Mop. In case of highly flood affected area (affected 11-20 days) 15 % Binadhan-11 producing farmer getting yield 3.7 t ha^{-1} by using 42.32 kg ha^{-1} seed rate which was higher than the recommended dose and other major inputs such as Urea 104.30 kg ha^{-1}, TSP 57.57 kg ha^{-1}, MoP 48.70 kg ha^{-1}, Gypsum 18.03kg ha^{-1} were below the required level. Correlation between yield and factors of Binadhan-10 and Binadhan-11 were significant and positive respectively.

Economic study of Binadhan-14 cultivation in some selected areas of Bangladesh was undertaken in four major rice growing areas of Bangladesh namely Mymensingh, Rangpur, Cumilla and Magura district. The average yield of Binadhan-14 was 5.6 t ha-^{1}. The highest production was in Magura (6.3 t h^{-1}) and it was lowest in Rangpur (4.7 t ha^{-1}). The average cost of production of Binadhan-14 was Tk. 80824 ha-^{1} . The highest cost was found in human labour (50.09 %); followed by irrigation (10.08 %), power tiller (7.8%), and land use (7.7 %). The average net return per hectare was Tk. 36666. The net return was highest in Magura (Tk. 46781 ha-^{1}) followed by cumilla (Tk. 35928 ha-^{1}), Rangpur (Tk. 33316 ha^{-1}), and Mymensingh (Tk. 30637 ha^{-1}), respectively. The average Benefit cost ratio was estimated at 1.45 and 2.02 on full cost and cash cost basis implying that the Binadhan-14 cultivation at farm level was highly profitable. By using Cobb-Douglas production function it was seen that maximum input cost such as human labor, power tiller, seed, irrigation, fertilizer, insecticide were significant at 1 %, 5 % & 10 % level. Return to scale was greater than 1 which means more production is possible by using all inputs efficiently.

Profitability of BINA Released Sesame Variety Binatil-3 in Some Selected Areas of Bangladesh

The study was conducted in four major Binatil-3 growing areas of Bangladesh, namely Magura, Kushtia, Jhenaidah, Madaripur and Faridpur district. The objectives were (i) to estimate the cost and return of Binatil-3; (ii) to identify the major constraints of Binatil-3; and (iii) to suggest some policy guidelines. Simple random sampling technique was followed for this study. A total of 200 farmers were randomly selected in the study areas, 40 from each district. Data were collected from Binatil-3 growers through interview schedule. Collected data were edited, summarized, tabulated and analyzed to fulfill the objectives. Some descriptive statistics were used for analyzing the collected data. In the study, costs and return analysis were done on both cash cost and full cost basis.

Results and Discussion

Estimation of the Cost and Return of Binatil-3 of Production

The cost and return are the major criteria for determination of profitability of a crop. The cost of Binatil-3 production, gross return, gross margin, net return and the benefit cost ratio (BCR) for Binatil-3 cultivation are being discussed in the following sections.

Cost of Binatil-3 cultivation

The cost of human labour, land preparation, seed, fertilizers, pesticides, and irrigation were taken into consideration, while calculating cost of Binatil-3 production. Beside this, interest on operating capital was also considered as the cost of Binatil-3 production. Total cost consists of variable cost and fixed cost that covered 91.53% and 8.47% of total cost for Binatil-3 production.

The average costs of Binatil-3 cultivation were Tk. 48604.49 and Tk. 33218.48 per hectare on full cost and cash cost basis, respectively (Table 1). The highest production cost was for human labour (42.62%), followed by fertilizer use (16.03%), power tiller (11.65%) and irrigation (10.11%). The cost of Binatil-3 cultivation was found highest in Kushtia (Tk. 49915.54 ha^{-1}) followed by that in Magura (Tk. 48632.58 ha^{-1}), Jhenaidah (Tk. 48554.63 ha^{-1}), Madaripur (Tk. 47663.23 ha^{-1}) and Faridpur (Tk. 47356.46 ha^{-1}), respectively.

Table 1. Per hectare cost of Binatil-3 production in different locations

Cost Component	Location-wise cost in Taka					Average
	Magura	Madaripur	Jhenaidah	Faridpur	Kushtia	
Labor (man-days)	20578.56	20639.47	21008.88	19899.47	21068.54	20638.98 (42.62)
Family	5210.23	6626.72	5467.20	5607.28	4548.04	5491.89
Hired	15368.33	14012.75	15541.68	14292.19	16520.50	15147.09
Power tiller	5602.69	6025.47	4990.23	5826.31	5754.04	5639.75 (11.65)
Owned	1867.56	2008.49	1663.41	1942.10	1918.01	1879.92
Hired	3735.13	4016.98	3326.82	3884.21	3836.03	3759.83
Seed	594.23	613.94	611.26	664.94	720.37	640.95
Owned	198.08	204.65	203.75	221.65	240.12	213.65
Purchased	396.15	409.29	407.51	443.29	480.25	427.30
Fertilizer	7300.92	7694.18	7964.92	7437.74	8407.81	7761.11

						(16.03)
Organic manure	1645.61	1674.09	2352.05	1800.20	1969.58	1888.31 (3.90)
Pesticide	720.95	959.67	841.60	951.99	825.87	860.02
Insecticide	598.98	642.42	563.38	664.94	637.36	621.42
Irrigation	6152.65	4390.94	4641.65	4524.82	4776.01	4897.21 (10.11)
Owned	2050.88	1463.65	1547.22	1508.27	1592.00	1632.40
Hired	4101.77	2927.29	3094.43	3016.55	3184.01	3264.81
Interest on operating capital	1379.24	1433.55	1255.61	1365.25	1450.85	1376.90
Total variable cost	44573.83	44073.73	44229.58	43135.66	45610.43	44324.65 (91.53)
Total Fixed cost	4058.75	3589.50	4325.05	4220.80	4305.11	4099.84 (8.47)
Total cash cost	33601.47	32096.14	32995.95	32056.16	35342.67	33218.48 (68.60)
Total Cost	48632.58	47663.23	48554.63	47356.46	49915.54	48424.49 (100.00)

Note: Bracketed figures indicate the percentage of total cost

Return from Binatil-3 production

The average return from Binatil-3 production in different locations is shown in Table 2. The average yield of Binatil-3 was 1386.90 kg ha^{-1}. The yield was highest at Kushtia 1540.16 kg ha^{-1} followed by Magura (1422.81 kg ha^{-1}), Jhenaidah (11394.58 kg ha^{-1}), Faridpur (1312.04 kg ha^{-1}) and Madaripur (1264.91 kg ha^{-1}). Most of the farmers in the study areas sold their product just after harvest. The price of Binatil-3 was found the highest in Kushtia (Tk. 51.00 kg^{-1}) and the lowest in Madaripur (Tk. 47.00 kg^{-1}). The total return from Binatil-3 production consists of the values of yield of grain and straw.

The average gross margin was found Tk. 27512.41 ha^{-1} on variable cost basis. Gross margin was highest in Kushtia (Tk. 37451.69 ha^{-1}) followed by Magura (Tk. 29376.76 ha^{-1}), Jhenaidah (Tk. 28149.81 ha^{-1}), Faridpur (Tk. 23583.24 ha^{-1}) and Madaripur (Tk. 19000.55 ha^{-1}), respectively. The average net return per hectare was Tk. 23232.57. The net return was highest in Kushtia (Tk. 33149.58 ha^{-1}) followed by Magura (Tk. 25318.01 ha^{-1}), Jhenaidah (Tk. 23824.76 ha^{-1}), Faridpur (Tk. 19362.44 ha^{-1}) and Madaripur (Tk. 14511.05 ha^{-1}), respectively.

Table 2. Profitability of Binatil-3 cultivation in different location

Type	Cost and Return in Taka					Average
	Magura	Madaripur	Jhenaidah	Faridpur	Kushtia	
Yield (kg/ha)	1422.81	1264.91	1394.58	1312.04	1540.16	1386.90
Yield (Tk/ha)	69717.69	59450.77	68334.42	62977.92	78548.16	67805.79
By product (Tk/ha)	4232.90	3623.51	4044.97	3740.98	4513.96	4031.26
Gross Return (Tk/ha)	73950.59	63074.28	72379.39	66718.90	83062.12	71837.06
Total variable cost (Tk/ha)	44573.83	44073.73	44229.58	43135.66	45610.43	44324.65
Total cash cost (Tk/ha)	33601.47	32096.14	32995.95	32056.16	35342.67	33218.48
Total Cost (Tk/ha)	48632.58	47663.23	48554.63	47356.46	49915.54	48424.49
Gross Margin (Tk/ha)	29376.76	19000.55	28149.81	23583.24	37451.69	27512.41
Net Return (Tk/ha)	25318.01	15411.05	23824.76	19362.44	33146.58	23412.57
Benefit Cost Ratio (BCR)						
Full cost basis	1.52	1.32	1.49	1.41	1.66	1.48

Cash cost basis	2.20	1.97	2.19	2.08	2.35	2.16

The average Benefit cost ratio was estimated at 1.48 and 2.16 on full cost and cash cost basis implying that the Binatil-3 cultivation at farm level was highly profitable. The highest BCR was found in Kushtia (1.66) followed by Magura (1.52), Jhenaidah (1.49), Faridpur (1.41) and Madaripur (1.32), respectively.

Major constraints to Binatil-3 cultivation

Binatil-3 is a profitable crop in the study areas. But Farmers faced various constraints to Binatil-3 cultivation. In table 3, about 81% farmers opined inadequate supply of quality seeds at proper time as a top ranked problem of Binatil-3 cultivation. Other constraints were infestation of root rot disease (70%), lack of technical know-how (60%), natural calamities (46%), higher price of fertilizers and insecticides (19%).

Table 3. Major constraints to Binatil-3 cultivation in the study areas

SL. No.	Constraints	% of farmers responded					Average
		Magura	Madaripur	Jhenaidah	Faridpur	Kushtia	
1.	Inadequate supply of quality seeds at proper time	76	90	80	87	70	81
2.	Infestation of root rot disease	66	80	75	68	61	70
3.	Lack of technical know-how	56	69	58	61	55	60
4.	Natural calamities	44	57	50	48	30	46
5.	Higher price of fertilizers and insecticides	15	35	18	9	-	19

Recommendations for policy guidelines

To solve the major farmers problem following recommendations may be suggested as: i) it should be ensured quality seed timely; ii) drainage system should be developed, more research are needed to recover root rot disease or release disease resistant variety; iii) most of the farmers did not follow the recommended doses of inputs in the production process. So the field workers of the Department of Agricultural Extension (DAE) should be more careful about the proper dissemination of the scientific technology, more extension and training services must be enhanced and lastly; and iv) Government should take appropriate action through law enforcement team to stop the use of adulterated fertilizers and insecticides throughout the country.

Conclusion

Binatil-3 production in the study areas was profitable. Binatil-3 farmers received high return on its investment and cultivation of this variety increasing in the study areas day by day due to its higher yield potential and shorter duration.

Yield gap of potential Aman rice variety Binadhan-7 in some selected areas of Bangladesh

The study was conducted in five major Binadhan-7 growing areas in Bangladesh namely Mymensingh, Magura, Rangpur, Dinajpur and Jhenaidah. The objectives of the study were i) to estimate the yield gap of Binadhan-7 growers among the study areas ii) to identify the factors affecting the yield of this 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 the 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:

Yield Gap I= $[(Y_R - Y_D)/Y_R] \times 100$
Yield Gap II= $[(Y_D-Y_F)/Y_D] \times 100$

Where,
Y_R is the yield of research stations,
Y_D is the yield of demonstration plots, and
Y_F is the yield of actual farm.

The production of Binadhan-7 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:

$Y= AX_1^{b1} X_2 b^2 \ldots\ldots\ldots\ldots\ldots\ldots X_n^{bn} e^{ui}$

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:

$\text{Log}Y= \text{Log}a + b_1 \text{Log}X_1 + b_2 \text{Log}X_2 +b_3 \text{Log}X_3 +b_4 \text{Log}X_4 +b_5 \text{Log}X_5 +b_6 \text{Log}X_6 + b_7 \text{Log}X_7 +b_8 \text{Log}X_8 +$
$b_9 \text{Log}X_9 +b_{10} \text{Log}X_{10} +b_{11} \text{Log}X_{11} + b_{12} \text{Log}X_{12+} Ui$

Where,
Y= Yield (kg/ha)
X_1 = No. of power tiller
X_2 = Amount of Seed (kg/ha)
X_3= Amount of Urea (kg/ha)
X_4= Amount of TSP (kg/ha)
X_5= Amount of MoP (kg/ha)
X_6= Amount of Gypsum (kg/ha)
X_7= Amount of Zn (kg/ha)
X_8= No. of Irrigation
X_9= No. of Wedding
X_{10}= Soil fertility
X_{11}=Farm size
X_{12}=Experience

a= constant value
$b_1 b_2 \ldots\ldots\ldots\ldots b_6$ = Co-efficient of the respective variables and
U_i = Error term.

Result and Discussion

The results showed that the highest yield was obtained from Magura (4.70 t ha^{-1}) followed by Rangpur (4.51 t ha^{-1}), Jhenaidah (4.48 t ha^{-1}), Dinajpur (4.20 t ha^{-1}) and Mymensingh (4.15 t ha^{-1}) district. The average yield of Binadhan-7 was 4.41 t ha^{-1} (Table 4).

Table 4. Estimated yield gap of Binadhan-7 in different locations

Particular	Magura	Rangpur	Dinajpur	Jhenaidah	Mymensingh	Average
Average yield of research station ($Y_{R)}$, t ha^{-1}	5.80	5.23	5.23*	5.80*	5.00	5.42
Average yield of demonstration plots (Y_D), t ha^{-1}	5.38	4.87	4.75	5.17	4.58	4.94
Average yield of actual farm (Y_F), t ha^{-1}	4.70	4.51	4.20	4.48	4.15	4.41
Yield gap I (%)	0.42 (7.24)	0.36 (6.88)	0.48 (9.17)	0.63 (10.86)	0.42 (8.4)	0.46 (8.51)
Yield gap II (%)	0.68 (12.63)	0.36 (7.39)	0.55 (11.57)	0.69 (13.35)	0.43 (9.38)	0.54 (10.80)
Total yield gap (%)	1.1 (19.88)	0.72 (14.27)	1.03 (20.75)	1.24 (24.20)	0.85 (17.78)	1.00 (19.38)

*Indicates the value of nearest sub-stations

As seen from Table 4, the estimated yield gap I was 0.46 t ha^{-1} (8.51 %.) and yield gap II was 0.54 t ha^{-1} (10.80 %.). The lowest gap was 0.72 t ha^{-1} (14%) observed in Rangpur district and it was the highest 1.24 t ha^{-1} (24.20 %) in case of Jhenaidah district. Considering all, the average yield gap was 1 t ha^{-1} (19.38%) and much scope for yield enhancement in the variety.

Major factors that influencing the yield of Binadhan-7 were described in Table 5. Though in 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 33.65 Kg ha^{-1}, Urea 105.58 Kg ha^{-1}, TSP 86.70 Kg h^{-1}, MoP 57.70 Kg ha^{-1} and seedling age 27.10 days respectively, indicating that they are either below or above the recommendation.

Table 5. Input–use pattern of Binadhan-7 growing farmers

Factors	Seed Kg ha^{-1}	Urea Kg ha^{-1}	MoP Kg ha^{-1}	TSP Kg ha^{-1}	seedling age (days)
Recommendation	25-30	150-180	60-80	100-120	20-25
Magura	36.00	102.48	68.44	100.52	24.55
Rangpur	31.29	112.94	70.31	91.08	27.00
Dinajpur	33.11	100.89	51.54	79.65	27.87
Jhenaidah	34.16	121.68	59.53	92.1	25.47
Mymensingh	33.69	85.95	39.23	53.18	30.62
Average	**33.65**	**104.78**	**57.81**	**86.70**	**27.10**

Other factors which were also responsible in the yield of Binadhan-7 are described in Table 5.1. In average 77% responded maintained line to line and plant to plant distance, 49 % used power tiller more than two times, 40% irrigated their lands 1-5 times and 57 % weeded their lands and 63 % spray pesticide and insecticide to control disease and insect.

Table 6. Input–use pattern of Binadhan-7 growing area (cont.)

Factors	Magura	Rangpur	Dinajpur	Jhenaidah	Mymensingh	Average
Line to line & plant to plant distance (%)	82	84	65	74	78	77
Power Tiller (%)						
One times	10	22	15	17	8	14
Two times	25	37	43	50	27	16
More than 2	65	40	42	33	65	49
Irrigation (%)						
No irrigation	5	15	17.5	-	-	13
Irrigation (1-5)	80	85	27.5	8	10	40
Irrigation (>5)	15	-	55	-	2	24
Weeding (%)						
No Weeding	10.52	12.50	15.00	17.50	-	13
Weeding (1)	17.50	37.50	47.50	25.00	27.5	31
Weeding (2-3)	72.50	50.00	37.50	53.00	72.5	57
Pesticide and insecticide (%)	23	68	72	72	80	63

The practice gap was ascertained in table 7. It can be seen that 21 % farmer were in no yield gap, 31.5 % farmer were in low yield gap (1-15% i. e less than 0.70 t ha^{-1}) category, 22 % farmer were in medium yield gap (16-30 % i. e. greater than 0 .70 and less than 2.00 t ha^{-1}), 25% farmer were in high gap (>30% i. e greater than 2.00 t ha^{-1}) category among the study areas.

Table 7. Farmers' practice gaps in Binadhan-7 cultivation in the study areas

Gap in Practices	Categories (gap in %)	Farmer no (%)	Mean	Standard deviation
1. Seed rate	No gap (0%)	43 (21.5%)	26.10	7.30
2. Power tiller			3.84	0.84
3. Irrigation			3.25	3.17
4. Fertilizer				
• Urea			112.79	50.79
• TSP			99.76	40.77
• MoP			90.07	49.46
• Gypsum			14.66	27.96
• Zn			4.167	5.10
• Sulphur			0.71	1.81
5.Weeding			1.28	0.97
Gap in Practices	**Categories**	**Farmer no (%)**	**Mean**	**Standard deviation**
1. Seed rate	Low gap (1-15 %)	63 (31.5%)	23.98	3.58
2. Power tiller			3.42	1.02
3. Irrigation			5.56	6.09
4. Fertilizer				
• Urea			117.90	50.79
• TSP			93.48	49.10
• MoP			77.78	40.12
• Gypsum			19.89	36.30
• Zn			2.83	4.51
• Sulphur			1.26	2.47
5.Weeding			1.03	0.78
Gap in Practices	**Categories**	**Farmer no. (%)**	**Mean**	**Standard deviation**
1. Seed rate	Medium Gap	44 (22%)	26.10	10.66

2. Power tiller	(16-30 %)		3.84	0.83
3. Irrigation			4.03	5.68
4. Fertilizer				
• Urea			122.75	51.34
• TSP			93.44	42.63
• MoP			79.20	40.26
• Gypsum			29.72	51.00
• Zn			4.33	5.34
• Sulphur			0.70	2.36
5.Weeding			1.20	0.97
Gap in Practices	**Categories**	**Farmer no. (%)**	**Mean**	**Standard deviation**
1. Seed rate	High Gap (>30 %)	50 (25%)	23.72	9.55
2. Power tiller			3.56	0.62
3. Irrigation			4.40	4.89
4. Fertilizer				
• Urea			82.32	46.42
• TSP			65.45	43.97
• MoP			54.24	44.84
• Gypsum			12.02	22.97
• Zn			3.49	7.01
• Sulphur			0.76	2.14
5.Weeding			1.28	0.73

The contribution of specified factors affecting production of Binadhan-7 could be seen from the estimation of regression equation (Table 8). Very few farmers used Sulphur and manure, so this was not including in the equation. The result showed that few coefficients do not have the expected sign. However, the coefficients for power tiller, seed, Urea, TSP, MoP, weeding, irrigation, farm size 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 Binadhan-7 production could increase the yield to some extent. The negative sign of soil fertility indicate that yield was not achieved according to the fertility.

Table 8. Estimating coefficient in the cobb-Douglas production for Binadhan-7 cultivation in the study areas

Item	Co-efficient	t-value	P>t-value
Intercept	7.048***	15.28	0.000
Power tiller (X_1)	0.133*	1.77	0.077
Seed (X_2)	0.145**	2.03	0.044
Urea (X_3)	0.129***	2.91	0.000
TSP (X_4)	0.087**	2.69	0.007
MoP (X_5)	0.071**	2.44	0.015
Gypsum (X_6)	0.001	0.13	0.894
Zn (X_7)	-0.035	1.27	0.203
Irrigation (X_8)	0.054*	1.66	0.098
Weeding (X_9)	0.106 *	1.56	0.078
Soil fertility (X_{10})	-0.275 * *	2.79	0.005
Farm size (X_{11})	0.054*	1.34	0.102
Experience (X_{12})	0.124***	2.89	0.000

Note: '*' '**' and '***' indicate significant at 10%, 5% and 1% level.

Constraints

Farmers of Binadhan-7 growing areas are facing some problem in cultivating this variety. Major constraints that mentioned by the farmers and limit the yields of Binadhan-7 below the potential yield are described in Table 9.

Table 9. Major Constraints of Binadhan-7 cultivation

Sl. No	Particulars	Magura	Rangpur	Dinajpur	Jhenaidah	Mymensingh	Average
1.	Infestation of pest and disease	12.5	45.71	20	45	65	37.64
2.	Rice become soft	10	22.88	20	17.14	20	18.00
3.	Attack rat	5	7	12	8	15	9.4
4.	Rainfall	85	62.5	92	82.5	60	76.4
5.	Unfilled grain	85	14.28	45	22.86	-	41.78
6.	Lack of credit facilities	8.57	28.57	30	5	2.5	14.92

Some policy guidelines to reduce the Yield Gap

Policies to reduce the yield gap are: i) Farmers among the study areas did not follow the recommended doses of inputs in the production process. So awareness and motivation is required to reduce the yield gap ii) Farmers noticed about high price of labour, reluctant in adopting technology and adulterated fertilizer and insecticide. Thus it is necessary to provide adequate labour facilities during sowing and harvesting time; and Government should take appropriate action through law enforcement team to stop the use of adulterated fertilizer and insecticide throughout the country.

In conclusion, in average we are losing one t ha^{-1} yield of Binadhan-7 during Aman period. Besides, out of 200 farmers, 50 (25%) farmers were in category high yield gap and loosing greater than two t ha^{-1} yield in Aman season. If we could reduce this gap by building awareness and motivation, our Aman production will be increased and farmer as well as the country will be benefitted.

Yield gap of potential stress tolerant varieties Binadhan-10 & Binadhan-11 in some selected areas of Bangladesh

The study was conducted in eight Binadhan-10 & Binadhan-11 growing areas in Bangladesh. Four districts namely Satkhira, Khulna, Barishal, and Cox's Bazar were used for Binadhan-10 and Mymensingh, Jamalpur, Sherpur and Sunamgonj were taken for Binadhan-11. The objectives of the study were i) to estimate the yield gap of Binadhan-10 and Binadhan-11 growers among the study areas ii) to identify the factors affecting the yield of these variety; and iii) to suggest some policy guidelines to minimize the yield gap. A total of 240 farmers were randomly selected (30 from each location) to collect the data with a pre-designed questionnaire. Tabular and statistical technique was used to analyze the data.

In the 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, was the difference between yield obtained at the nearest demonstration plot and actual yield obtained on farmers' fields. The yield gaps were estimated as follows:

Yield Gap I= [(Y_R - Y_D)/Y_R] × 100
Yield Gap II= [(Y_D-Y_F)/Y_D] × 100

Where,
Y_R is the yield of research stations,
Y_D is the yield of demonstration plots, and
Y_F is the yield of actual farm.

Result and Discussion

The results presented in Table 10 showed that the highest yield was obtained from Barishal (5.98 t h^{-1}) followed by Khulna (5.23 t ha^{-1}), Satkhira (4.45 t ha^{-1}), Cox's Bazar (4.16 t h a^{-1}) district. The average yield of Binadhan-10 was 4.96 t ha^{-1}.

Table 10. Estimated yield gap of Binadhan-10 in different locations

Particular	Barishal	Khulna	Satkhira	Cox's Bazar	Average
Average yield of research stations ($Y_{R)}$, t ha^{-1}	7.50	6.25*	6.25	6.50	6.63
Average yield of demonstration plots (Y_D), t ha^{-1}	7.00	6.0	5.15	5.61	5.94
Average yield of actual farm ($Y_{F)}$, t ha^{-1}	5.98	5.23	4.45	4.16	4.96
Yield gap I (%)	0.50 (6.66)	0.25 (4.00)	1.10 (17.6)	0.89 (13.59)	0.69 (10.33)
Yield gap II (%)	1.02 (14.57)	0.77 (12.83)	0.70 (13.59)	1.45 (25.84)	0.99 (16.58)
Total yield gap (%)	1.52 (21.23)	1.02 (16.83)	1.80 (31.19)	2.34 (39.53)	1.67 (26.92)

*Indicates the value of nearest sub-stations

As seen from Table 7, the estimated yield gap I was 0.69 t ha^{-1} (10.33 %.) and yield gap II was 0.99 t ha^{-1} (16.58 %.). The lowest gap was 1.02 t ha^{-1} (16.83%) found in Khulna district and it was the highest 2.34 t ha^{-1} (39.53%) in case of Cox's Bazar district. Considering all, the average yield gap was 1.67 t ha^{-1} (26.92%) and much scope for yield enhancement in the variety.

The results presented in Table 11 showed that the highest yield was obtained from Sherpur (4.08 t ha^{-1}) followed by Sunamgonj (4.03 t ha^{-1}), Jamalpur (3.99 t ha^{-1}) and Mymensingh (3.87 t ha^{-1}) district. The average yield of Binadhan-11 was 4.00 t ha^{-1}.

Table 11. Estimated yield gap of Binadhan-11 in different locations

Particular	Jamalpur	Mymensingh	Sunamgonj	Sherpur	Average
Average yield of research station ($Y_{R)}$, t ha^{-1}	5.5	5.60	5.50	5.50	5.52
Average yield of demonstration plots (Y_D), t ha^{-1}	4.90	4.50	5.20	4.73	4.83
Average yield of actual farm ($Y_{F)}$, t ha^{-1}	3.99	3.87	4.03	4.08	4.00
Yield gap I (%)	0.6 (10.90)	1.1 (19.64)	0.30 (5.45)	0.77 (14)	0.69 (12.57)
Yield gap II (%)	0.91 (18.57)	0.63 (14)	1.17 (22.50)	0.65 (13.74)	0.83 (17.18)
Total yield gap (%)	1.51 (29.48)	1.73 (33.64)	1.44 (27.95)	(1.42) 27.74	1.52 (29.76)

As seen from Table 7.1, the estimated yield gap I was 0.69 t ha^{-1} (12.57 %) and yield gap II was 0.83 t ha^{-1} (17.18%). The lowest gap was 1.42 t ha^{-1} (27.74%) observed in Sherpur district and it was the highest 1.73 t ha^{-1} (33.64 %) in case of Mymensingh district. Considering all, the average yield gap was 1.52 t ha^{-1} (29.76 %) and much scope for yield enhancement in the variety.

Major factors that were responsible for the yield gap of Binadhan-10 were described in Table 8. It was seen from the Table 10, most of the farmers did not consider the recommended doses of seed rate, fertilizer and seedling age. The average seed rate was 40. 60 Kg ha^{-1}, Urea 162.07 Kg ha^{-1}, TSP 99.62 Kg ha^{-1}, MoP 62.07 Kg ha^{-1} and seedling age 29.45 days respectively, was indicating that they are either below or above the recommendation.

Table 12: Input–use pattern of Binadhan-10 growing farmers

Factors	Seed Kg ha^{-1}	Urea Kg h^{-1}	MoP Kg ha^{-1}	TSP Kg ha^{-1}	Seedling age (days)
Recommendation	25-30	210-220	85-100	110-115	30-35
Khulna	42	172.12	56.64	91.21	29.33
Satkhira	38	170.619	82.48	121.8703	29.12
Barishal	40.23	171.66	53.46	102.76	31.05
Cox’s Bazar	42.16	133.9	55.71	82.64	28.30
Average	**40.60**	**162.02**	**62.07**	**99.62**	**29.45**

In case of Binadhan-11 average seed rate was 42.54 Kg ha^{-1}, Urea 126.43 Kg ha^{-1}, TSP 72.40 Kg ha^{-1}, MoP 56.80 Kg ha^{-1} and seedling age 28.27 days respectively, indicating except seedling age , they are either below or above the recommendation (Table 12).

Table 13. Input–use pattern of Binadhan-11 growing farmers

Factors	Seed Kg ha^{-1}	Urea Kg ha^{-1}	MoP Kg ha^{-1}	Tsp Kg ha^{-1}	seedling age (days)
Recommendation	25-30	150-180	50-70	110-120	25-30
Jamalpur	40.37	169.28	58.60	76.80	27.73
Mymensingh	44.04	144.04	59.79	64.69	28.46
Sunamgonj	42.45	89.88	38.43	61.57	28.16
Sherpur	43.31	102.52	70.38	86.57	28.73
Average	**42.54**	**126.43**	**56.80**	**72.40**	**28.27**

The responded were classified as affected and not affected by salinity in case of Binadhan-10 producing farmers and not affected, affected and highly affected by flood in case of Binadhan-11 producing farmers to identify the factors responsible for yield gap of the varieties. In case of non-saline areas 26.67% farmer’s average yield was 6.3 t ha^{-1} by using 41.62 kg ha^{-1} seed rate which was greater than the recommended dose and other major inputs such as Urea 187.46 kg ha^{-1}, TSP. 103 kg ha^{-1}, MoP 53.49 kg ha^{-1}, Gypsum 22.74 kg ha^{-1} were also below the required level.

The seedling age of the Binadhan-10 was 32.03 days was in the recommended range, land cultivated by power tiller, weeding, pesticide and insecticide spray were 3.23, 1.57, 0.38 and 1.12 times, respectively,. The average farmers yield gap was 2.02 t ha^{-1} (Table 13).

Table 14. Factors responsible for yield gap of Binadhan-10 cultivation in the study areas

Item	recommended	Farmer (no) (%)	Mean	Standard deviation
1. Yield (kg h^{-1})	7500	Not affected (32) (26.67%)	6322.41	2319.50
1.1. Yield gap	-		2023.69	1605.65
2. Seed rate (kg h^{-1})	25-30		41.62	17.21
3. Power tiller (no.)	-		3.23	0.82
4. Fertilizer (kg h^{-1})				
• Urea	210-220		187.46	260.91
• TSP	110-115		103.48	69.56
• MoP	85-100		53.49	52.18
• Gypsum	50-60		22.74	30.13
5.Seedling age (days)	30-35		32.03	5.84
6.Weeding (no.)	-		1.57	0.89
7. Pesticide	-		0.38	0.90
8. Insecticide	-		1.12	1.16
9. Soil fertility			1.90	0.40
Item	**recommended**	**Farmer (no) (%)**	**Mean**	**Standard deviation**
1. Yield (kg h^{-1})	5500	Affected (88) (73.33%)	4692.58	1225.66
1.1. Yield gap	-		1191.39	852.01
2. Seed rate (kg h^{-1})	25-30		39.59	23.48
3. Power tiller (no.)	-		3.36	0.76
4. Fertilizer (kg h^{-1})				
• Urea	210-220		155.56	55.04
• TSP	110-115		99.47	39.99
• MoP	85-100		69.24	35.74
• Gypsum	50-60		27.85	49.92
5.Seedling age (days)	30-35		27.90	3.52
6.Weeding (no.)	-		1.74	0.73
7. Pesticide	-		0.16	0.58
8. Insecticide	-		2.16	0.92
9. Soil fertility			1.65	0.75

In case of saline areas farmer's average yield was 4.7 t ha^{-1} and using 39.59 kg ha^{-1} seed rate which was greater than the recommended dose and other major inputs for Binadhan-10 cultivation such as Urea 155.56 kg ha^{-1}, TSP 99.47 kg ha^{-1}, Mop 69.24 kg ha^{-1}, Gypsum 27.85 kg ha^{-1} were also below the required level. The seedling age of the Binadhan-10 was 27.90 days, land cultivated by power tiller, weeding, pesticide and insecticide spray were 3.36, 1.74, 0.16 and 2.16 times, respectively. The average farmers yield gap was 1.2 t ha^{-1}. It can be seen that soil fertility was important factor for both of the variety. The overall soil fertility was the highest in case of not affected farmer as well as their yield was also the highest 6.32 t ha^{-1}.

In case of submergence tolerant rice variety and not affected by flood, 16.66 % Binadhan-11 producing farmer getting yield 4.1 t ha^{-1} by using 40.30 kg ha^{-1} seed rate which was higher than the recommended dose and other major inputs such as Urea 107.83 kg ha^{-1}, TSP 86.49kg ha^{-1}, MoP 81.50 kg ha^{-1}, Gypsum 11.51 kg ha^{-1} were either below or above the required level. The seedling age of the Binadhan-11 was 28.72 days, land cultivated by power tiller, weeding, pesticide and insecticide spray were 3.63, 1.63, 0.67 and 1.11 times, respectively,. The average farmers yield gap was 1.42 t ha^{-1} (Table 14).

In case of medium flood affected area (affected 1-10 days) 68.33% Binadhan-11 farmer also getting yield 4.1 t ha^{-1} using 45.00 kg ha^{-1} seed rate which was higher than the recommended dose and other major inputs such as Urea 142.23 kg ha^{-1}, TSP 80.59 kg ha^{-1}, MoP 57.40 kg ha^{-1}, Gypsum 4.87 kg ha^{-1} were also below the required level except MoP. The seedling age of the Binadhan-11 was 28.04 days, land cultivated by power tiller, weeding, pesticide and insecticide spray were 3.33, 1.58, 0.24 and 1.04 times, respectively. The average farmers yield gap was 0.38 t ha^{-1}.

Table 15. Factors responsible for yield gap of Binadhan-11 cultivation in the study areas

Gap in Practices	Recommended	Farmer (no) (%)	Mean	Standard deviation
1. Yield (kg ha^{-1})	5500	Not affected (20) (16.66 %)	4075.82	809.44
1.1. Yield gap	-		1427.17	809.44
2. Seed rate (kg ha^{-1})	25-30		40.30	10.87
3. Power tiller (no.)	-		3.63	0.49
4. Fertilizer (kg ha^{-1})				
• Urea	150-180		107.83	54.47
• TSP	110-120		86.49	49.09
• MoP	50-70		81.50	50.22
• Gypsum	20-30		11.51	27.68
5. Seedling age (days)	25-30		28.72	2.29
6.Weeding (no.)	-		1.63	0.49
7. Pesticide	-		0.67	0.84
8. Insecticide	-		1.11	0.82
9. Soil fertility	-		1.63	0.59
Gap in Practices	**Recommended**	**Farmer (no) (%)**	**Mean**	**Standard deviation**
1. Yield (kg ha^{-1})	4500	Affected (1-10 days) (82) (68.33%)	4111.89	1094.36
1.1. Yield gap	-		388.10	1094.36
2. Seed rate (kg ha^{-1})	25-30		45.00	16.45
3. Power tiller (no.)	-		3.33	0.88
4. Fertilizer (kg ha^{-1})				
• Urea	150-180		142.23	70.20
• TSP	110-120		80.59	45.31
• MoP	50-70		57.40	37.93
• Gypsum	20-30		4.87	13.96
5. Seedling age (days)	25-30		28.04	2.59
6. Weeding (no.)	-		1.58	0.66
7. Pesticide	-		0.24	0.64
8. Insecticide	-		1.04	1.01
9. Soil fertility	-		1.85	0.38
Gap in Practices	**Recommended**	**Farmer (no) (%)**	**Mean**	**Standard deviation**
1. Yield (kg ha^{-1})	4500	Highly affected (11-20 days) (18) (15%)	3690.63	934.55
1.1. Yield gap	-		809.36	934.55
2. Seed rate (kg ha^{-1})	25-30		42.32	15.22
3. Power tiller (no.)	-		3.05	0.80
4. Fertilizer (kg ha^{-1})				
• Urea	150-180		104.30	52.38
• TSP	110-120		57.57	44.69

• MoP	50-70	48.70	48.75
• Gypsum	20-30	18.03	28.60
5. Seedling age (days)	25-30	27.33	2.54
6. Weeding (no.)	-	1. 16	0.78
7. Pesticide	-	0.61	0.84
8. Insecticide	-	0.50	0.78
9. Soil fertility	-	1.22	0.73

In case of highly flood affected area (affected 11-20 days) 15 % Binadhan-11 producing farmer getting yield 3.7 tha^{-1} by using 42.32 kg ha^{-1} seed rate which was higher than the recommended dose and other major inputs such as Urea 104.30 kg ha^{-1}, TSP 57.57 kg ha^{-1}, MoP 48.70 kg ha^{-1}, Gypsum 18.03 kg ha^{-1} were below the required level. The seedling age of the Binadhan-11 was 27.33 days, land cultivated by power tiller, weeding, pesticide and insecticide spray were 3.05, 1.16, 0.61 and 0.50 times, respectively. The average farmers yield gap was 0.80 t ha^{-1}. It can be seen that soil fertility was important factor for both of the variety. The overall soil fertility was the highest in case of medium flood affected farmer as well as their yield was also the highest 4.1 t ha^{-1}.

Correlation between different factors in rice cultivation and yield in the study areas

Correlation co-efficient were computed to ascertain the relationships between different factors in rice cultivation and yield in these varieties. The findings presented in Table 10 showed that all the inputs in case of Binadhan-10 cultivation had significant positive relationships with the yield. This meant that yield of rice increased with the increase level of inputs.

Table 16. Correlation between yield and factors used by the farmers among the study areas for Binadhan-10

Sl. No.	Factors	Correlation co-efficient(r)
1.	Seed rate	0.606***
2.	Power tiller	0.210**
3.	Urea	0.550***
4.	TSP	0.551***
5.	MoP	0.420***
6.	Gypsum	0.251**
7.	Quantity of irrigation	0.168*
8.	farm size	0.727***

Note: '*' '**' and '***' indicate significant at 10%, 5% and 1% level.

The results showed that all the inputs in Binadhan-11 cultivation had significant positive relationships with the yield (Table 10). This meant that yield of rice increased with the increase level of inputs.

Table 17. Correlation between yield and factors used by the farmers among the study areas for Binadhan-11

Sl. No.	Factors	Correlation co-efficient(r)
1.	Seed rate	0.739***
2.	Power tiller	0.184**
3.	Urea	0.674***
4.	TSP	0.578***
5.	MoP	0.484***
6.	Gypsum	0.289**
7.	farm size	0.912***

Note: '**' and '***' indicate significant at 5% and 1% level.

Constraints

Farmers of Binadhan-10 and Binadhan-11 growing areas were facing some problem in cultivating this variety. Major constraints that mentioned by the farmers and limit the yields of Binadhan-10 and Binadhan-11 below the potential yield were described in Table 18 and 19, respectively. The highest constrain for Binadhan-10 was infestation of pest and diseases (84 %), found in Cox's Bazar among the study areas, followed by Barishal (33.33%), Satkhira (30%) and Khulna (20%). In the study area 41.83 % farmer was facing this problem. The other constraint were rainfall (75.49), followed by high transportation cost (41.33%), lack of credit facility (22.91%), lack of quality seed (16.55%), market distance (11%), attack animal and bird (3.75%) and appropriate market price (3.33%) (Table 18).

Table 18. Major Constraints of Binadhan-10 cultivation in the study areas

Sl. No.	Particulars	% of farmers responded				
		Khulna	Satkhira	Barishal	Cox's Bazar	Average
1.	Infestation of pest and disease	20	30	33.33	84	41.83
2.	Lack of quality seed	36.66	22.88	6.66	-	16.55
3.	Lack of appropriate market price	10	3.33	-	-	3.33
4.	Distance of Market	-	16	-	28	11
5.	High Transportation cost	-	80	13.33	72	41.33
6.	Attack animal & bird	-	-	10	5	3.75
7.	Rainfall	93.33	93.33	23.33	92	75.50
8.	Lack of credit facilities	40	26.66	20	5	22.92

The highest constrain for Binadhan-11 was infestation of pest and diseases (93%), found in Sherpur among the study areas, followed by Mymensingh (83.33%), Jamalpur (56.66 %) and Sunamgonj (40%). In the study area 68.24 % farmer was facing this problem. The other constraint were natural calamities (65.83%), followed by high transportation cost (56.66%), lack of credit facility (18.33%), attack animal and bird (9.99%) and lack of quality seed (1.67%) (Table 19.).

Table 19. Major Constraints of Binadhan-11 cultivation in the study areas

Sl. No	Particulars	% of farmers responded				
		Jamalpur	Mymensingh	Sunamgonj	Sherpur	Average
1.	Infestation of pest and disease	56.66	83.33	40	93.00	68.25
2.	Inadequate supply of quality seed	-	-	6.66	-	1.67
3.	High Transportation cost	26.66	93.33	66.66	40	56.66
4.	Attack animal & bird	13.33	6.66	6.66	13.33	9.99
5.	Natural calamities	40	90	40	93.33	65.83
6.	Lack of credit facilities	13.33	16.66	23.33	20.00	18.33

Some policy guidelines to reduce the Yield Gap

At fast, Farmers should follow the recommended doses of inputs in the production process. Besides quality seed must be ensured in timely and awareness, motivation as well as extension programme also be increased. Secondly some farmers noticed about high price of labour in sowing and harvesting time, reluctant in adopting new technology and adulterated fertilizer & insecticide also responsible for achieving targeted yield. Thus it is necessary to provide adequate labour facilities during sowing and harvesting time and government should take appropriate action through law enforcement team to stop the use of adulterated fertilizer and insecticide throughout the country.

In conclusion, we were losing 1.67 t ha^{-1} (26.92%) yield of Binadhan-10 in Boro season and 1.52 t ha^{-1} (29.76 %) of Binadhan-11 in Aman season. If we could reduce these gaps, our total production per year will be increased by 3.19 t ha^{-1} which will support in achieving food security as well as Sustainable Development Goals (SDGs).

Economic study of Binadhan-14 cultivation in some selected areas of Bangladesh

The study was conducted in four Binadhan-14 growing areas of Bangladesh, namely Mymensingh, Rangpur, Cumilla and Magura district. The objectives were **(i)** to determine the profitability of Binadhan-14 growers; **(ii)** to assess the factors affecting production of Binadhan-14; and **(iii)** to identify the major constraints to Binadhan-14 production. Simple random sampling technique was followed for this study. A total of 160 farmers were randomly selected as sample size in the study areas, 40 from each District. Data were collected from Binadhan-14 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

Economic profitability of Binadhan-14 production

Profitability is one of the major criteria for determination of acceptance of a variety. The cost of Binadhan-14 production, gross return, gross margin, net return and the benefit cost ratio (BCR) for Binadhan-14 cultivation are being discussed in the following sections.

Cost of Binadhan-14 cultivation

The cost of human labour, land preparation, power tiller, seed, fertilizers, pesticides and irrigation were taken into consideration, while calculating cost of Binadhan-14 production. Beside this, interest on operating capital was also considered as the cost of Binadhan-14 production. Total cost consists of variable cost and fixed cost that covered 72% and 28% of total cost for Binadhan-14 production.

From Table 20, the average costs of Binadhan-14 cultivation were Tk. 80824 and Tk. 58158 per hectare on full cost and cash cost basis, respectively. The highest production cost was for human labour (50.9%), followed by irrigation (10.8%), power tiller (7.8%), and land use (7.7%). The cost of Binadhan-14 cultivation was found highest in Cumilla (Tk. 85764/ha) followed by that in Magura (Tk. 83344/ha), Mymensingh (Tk. 80874/ha) and Rangpur (Tk. 73314/ha), respectively.

Table 20. Per hectare cost of Binadhan-14 production in different locations

Cost Component	Cost of production (Tk/hectare)				All area	% of total cost
	Mymensingh	Rangpur	Cumilla	Magura		
Variable Cost	**58654**	**52918**	**60613**	**60445**	**58158**	**72.0**
Hired labour (Man days)	24676	23342	26065	24945	24757	**30.6**
Power tiller	6669	5558	7040	5928	6299	**7.8**
Seed	2408	2223	2149	2594	2344	**2.9**
Fertilizers						
Urea	2371	2223	2594	2668	2464	**3.0**
TSP	2445	2668	2490	2816	2605	**3.2**
MoP	1667	1853	1890	2038	1862	**2.3**
Cow dung	5669	5299	5328	5817	5528	**6.8**
Pesticides	2297	1853	2223	2075	2112	**2.6**
Irrigation	8892	6669	9114	10374	8762	**10.8**
Int. on operating capital	1560	1230	1720	1190	1425	**1.8**
Fixed Cost	**22220**	**20396**	**25151**	**22899**	**22667**	**28.0**
Family labour	15784	14895	18323	16724	16432	**20.3**
Land use cost	6436	5501	6828	6175	6235	**7.7**
Total Cost (A+B)	**80874**	**73314**	**85764**	**83344**	**80824**	**100**

Return from Binadhan-14 production

The average return from Binadhan-14 production in different locations is shown in Table 21. The average yield of Binadhan-14 was 5631 kg/ha. The yield was highest at Magura (6378 kg/ha) followed by Cumilla (5962 kg/ha), Mymensingh (5442 kg/ha) and Rangpur (4741 kg/ha). The total return from Binadhan-14 production consists of the values of Binadhan-14 and straw.

The average gross margin was found Tk. 59332 on variable cost basis. Gross margin was highest in Magura (Tk. 69680/ha) followed by Cumilla (Tk. 61079/ha), Rangpur (Tk. 53712/ha) and Mymensingh (Tk. 52857/ha) respectively. The average net return per hectare was Tk. 36666. The net return was highest in Magura (Tk. 46781/ha) followed by Cumilla (Tk. 35928/ha), Rangpur (Tk. 33316/ha) and Mymensingh (Tk. 30637/ha) respectively. Benefit cost ratio was estimated at 1.45 and 2.02 on full cost and variable cost basis implying that the Binadhan-14 cultivation at farm level was profitable.

Table 21: Profitability of Binadhan-14 cultivation in different location

Type	Study areas				All area
	Mymensingh	Rangpur	Cumilla	Magura	
Yield from Binadhan-14 (Kg/ha.)	**5442**	**4741**	**5962**	**6378**	**5631**
Return from Binadhan-14 (Tk./ha)	109112	103780	119538	127560	114998
Return from straw (Tk./ha)	2399	2850	2154	2565	2492
Total return (Tk./ha)	**111511**	**106630**	**121692**	**130125**	**117490**
Total variable cost (Tk./ha)	58654	52918	60613	60445	58158
Total Cost (Tk./ha)	80874	73314	85764	83344	80824
Gross margin (Tk./ha)	52857	53712	61079	69680	59332
Net return (Tk./ha)	**30637**	**33316**	**35928**	**46781**	**36666**
Rate of return (BCR)					
BCR on full cost	**1.38**	**1.45**	**1.42**	**1.56**	**1.45**
BCR on variable cost	**1.90**	**2.02**	**2.01**	**2.15**	**2.02**

Contribution of different inputs to Binadhan–14 production

To determine the effects of the explanatory variables, linear and Cobb-Douglas model were initially estimated for Binadhan-14 rice production. Some of the key variables are explained below.

Human labour cost (X_I)

In Table 22 most of the parameters are statistically significant and positive. The regression coefficients for Binadhan-14 under Mymensingh, Rangpur, Cumilla and Magura districts were positive and significant. The coefficient of Mymensingh, Rangpur and Cumilla districts were significant at 5% level implying that the 1 percent increases in the labour use cost increase the gross return from rice by 0.080, 0.302 and 0.399 percent, respectively. The coefficient of Magura districts was significant at 1 percent level and it was 0.225 percent. This indicated that 1 percent increase in human labour cost keeping other factors constant, would increase the gross returns by 0.225 percent (Table 22).

Power tiller (X_2)

In Table 22 showed that the coefficient of power tiller cost in Mymensingh and Magura districts was 0.020 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 0.020 and 0.010 percent, respectively. The coefficient of power tiller cost under Rangpur and Cumilla district was positive but not significant.

Seed cost (X_3)

The coefficient of seedling cost of the Binadhan-14 production was statistically significant at 1 percent level of significance for Magura district. The result implies that 1 percent increase in the seedling cost for Magura district, keeping other factors constant, would result in an increase in gross return from rice by 0.702 percent.

The coefficient of seedling cost of the rice production was statistically significant at 10 percent level of significance for Mymensingh, Rangpur and Cumilla districts were 0.690, 0.150 and 0.230. The result implies that 1 percent increase in the seedling cost for Mymensingh, Rangpur and Cumilla districts farming systems, keeping other factors constant, would result increase in gross return from rice by 0.690, 0.150 and 0.230 percent, respectively

Fertilizer cost (X_4)

The coefficient of fertilizer cost was statistically significant at 10 percent level of significance for Cumilla district. The result implies that 1 percent increase in the fertilizer cost for Cumilla district, keeping other factors constant, would result in an increase in gross return from rice by 0.780 percent. The coefficient of fertilizer cost under Mymensingh, Rangpur and Magura districts were positive but not significant.

Irrigation cost (X_5)

In Table 3 showed that the coefficient of irrigation cost in Mymensingh and Rangpur districts was 0.020 and 0.050, 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 0.020 and 0.050 percent, respectively. The coefficient of irrigation cost under Cumilla and Magura districts were positive but not significant.

Insecticides cost (X_6)

The coefficient of insecticides cost in Mymensingh and Magura districts were 0.257 and 0.580, which was found to be significant at 5 percent level. It indicated that an 1 percent increase in insecticides cost keeping other factors constant would be able increase the gross returns by 0.257 and 0.580 percent, respectively.

The coefficient of insecticides cost was statistically significant at 10 percent level of significance for Rangpur and Cumilla districts was 0.186 and 0.221. The result implies that 1 percent increase in the insecticides cost for Rangpur and Cumilla districts, keeping other factors constant, would result increase in gross return from rice by 0.186 and 0.221 percent, respectively (Table 22).

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 3 that the values of R^2 were 0.746, 0.778, 0.820 and 0.845 for Mymensingh, Rangpur, Cumilla and Magura districts, respectively. This means that around 75, 79, 82 and 84 percent of the variations in gross return for Binadhan–14 rice, respectively were explained by the independent variables included in the model.

Return to Scale

The summation of all the production coefficient indicates return to scale. The sum of elasticity coefficients were 1.020, 1.056, 1.078 and 1.088 in case of Binadhan–14 meaning increasing returns to scale. This means that, 1 percent increase in all inputs simultaneously would result on average 1.020, 1.056, 1.078 and 1.088 percent increase in gross return of Binadhan–14. This value being greater than 1 means that the farmers are operating at the region of increasing return to scale.

Table 22: Estimated values of regression co-efficient and related statistics of Cobb-Douglas revenue type production function for Binadhan–14 production

Explanatory variables	Study areas							
	Mymensingh		Rangpur		Cumilla		Magura	
	Estimated Co-efficient	T-values	Estimated Co-efficient	T-values	Estimated Co-efficient	T-values	Estimated Co-efficient	T-values
Intercept	2.558* (0.651)	4.070	2.528* (0.851)	4.010	4.950* (0.510)	9.78	4.170* (0.850)	4.890
Human labour cost (X_I)	0.080** (0.040)	1.710	0.302** (0.119)	2.995	0.399** (0.186)	3.861	0.225*** (0.086)	4.713
Power tiller cost (X_2)	0.020** (0.010)	2.550	0.312 (0.084)	2.845	0.059 (0.626)	2.192	0.010** (0.010)	1.980
Seed cost (X_3)	0.690* (0.050)	8.410	0.150* (0.080)	2.010	0.230* (0.160)	2.139	0.702*** (0.248)	4.379
Fertilizer cost (X_4)	0.287 (0.061)	4.713	0.250 (0.080)	2.930	0.780* (0.130)	5.820	0.054 (0.120)	2.182
Irrigation cost (X_5)	0.020* (0.300)	0.530	0.050* (0.040)	1.130	0.079 (0.122)	2.355	0.430 (0.198)	3.415
Insecticides cost (X_6)	0.257** (0.109)	3.139	0.186* (0.156)	1.456	0.221* (0.147)	2.889	0.580** (0.161)	4.879

Coefficient of multiple determination (R^2)	0.746	0.778	0.820	0.845
F-value	8.436	9.336	10.114	11.238
Returns to scale	1.020	1.056	1.078	1.088

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-14 cultivation

Binadhan-14 is a profitable rice variety in the study area. Farmers faced various constraints to Binadhan-14 cultivation. In Table 23, about 87% farmers opined seed sowing time problem as a top ranked problem of Binadhan-14 cultivation. Other constraints were shattering problem (67%), natural calamities (37%), lack of technical know-how (31%), lack of capital (26%) and low education level of farmers (15%).

Table 23. Major constraints to Binadhan-14 cultivation in the study areas

Constraints	% of farmers responded					Rank
	Mymensingh	Rangpur	Cumilla	Magura	All area	
1. Seed sowing time problem	88	94	89	76	87	1
2. Shattering problem	60	65	70	74	67	2
3. Natural calamities	30	82	8	28	37	3
4. Lack of technical know-how	30	25	53	15	31	4
5. Lack of capital	17	50	12	25	26	5
6. low education level of farmers	10	15	18	20	15	6

Conclusion

Binadhan-14 production is profitable in the study area. All of the factors namely, human labour cost, power tiller cost, seed cost, fertilizer cost, irrigation cost and insecticides cost are very important for Binadhan-14 cultivation. Binadhan-14 farmers received high return on its investment. Major constraints faced by rice farmers in the study area are seed sowing time and shattering problem. There is a need of proper guide to farmers about Binadhan-14 rice production in the study areas.

BINA Sub-stations

BINA Sub-station, Rangpur

Research Highlights

A total of 5 demonstrations were conducted with Binadhan-17.Binadhan-17produced higher yield (31.93%yield increased) than check variety, BRRI dhan56.

A total of 3 demonstrations with Binasarisha-9 were conducted. Binasarish-9 produced higher yield (59.03% increased) than check variety, Tori 7.

Up scaling of Binadhan-17 in Rangpur region

During Kharif-2 of 2017-18, 5 demonstrations were conducted with Binadhan-17in Rangpur region. The check variety was BRRI dhan56.The main objectives were to demonstrate the performance of Binadhan-17and widening their adoption by the farmers. Area of demonstration plots was 100 decimals (1acre). Seeds were sown during Julyto mid August 2017. All fertilizers were applied as per recommendation in the demonstration plots. Pesticides were sprayed as andwhen 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-17 in Rangpur regionduring 2017-18

Upazila	No. of demo.	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binadhan-17	BRRI dhan56 (check)	Binadhan-17	BRRI dhan56 (check)	
Rangpur Sadar	4	116	108	6.30	4.80	31.25
Sadullapur, Gaibandha	1	118	110	6.10	4.60	32.60
Total	**5**					
Mean		**117**	**109**	**6.20**	**4.70**	**31.93**

Results reveal that Binadhan-17produced average seed yields of 6.20t ha^{-1}which higher 31.93percent compared to check varietyBRRI dhan56. Average maturity period of Binadhan-17 was 117days. The check variety BRRI dhan56 produced average gain yield of 4.80 t ha^{-1} with average maturity period of 109 days. Therefore the variety of BINA, Binadhan-17 increased crop production as well as farmer's income. Farmers were found interested to cultivate Binadhan-17in Rangpur region.

Up scaling of Binasarisha-9in Rangpur region

During the Rabi season of 2017-18, 3 demonstrations were conducted with Binasarisha-9in Rangpur region. The check variety wasTori 7.The objectives were to demonstrate the performance of Binasarisha-9 and widening their adoption by the farmers. Area of demonstration plots was 100decimals. Seeds were sown during October to November 2017 at the rate of 7.5 kg ha^{-1}. 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 ofBinasarisha-9Rangpur regionduring 2017-18

Upazila	No. of demo.	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binasarisha-9	Tori 7 (check)	Binasarisha-9	Tori 7 (check)	
Rangpur Metro	1	78	74	1.40	0.9	55.55
Sadullahpur, Gaibandha	2	80	72	1.30	0.8	62.50
Total	**3**					
Mean		**79**	**73**	**1.35**	**0.85**	**59.03**

Results reveal that Binasarisha-9 produced average seed yields of 1.35 tha^{-1}, which higher 59.03 percent compared to check variety Tori 7. Average maturity period of Binasarisha-9 was 79 days. The check variety Tori 7 produced average gain yield of 0.85t ha^{-1} with average maturity period of 73 days. Therefore the variety of BINABinasarisha-9increased crop production as well as farmer'sincome. Farmers were found interested to cultivate these variety in Rangpur region during Rabi season.

Establishment of BINA Technology village in surrounding area of BINA Sub-station, Rangpur

In order to establish BINA-Technology village demonstrations and other extensionwork 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 Chandan pat Union are presented below in table 3

Table 3: Performance of BINA developed varieties atChandanpatUnionduring 2017-18

Sl. No	Crops	Varity Name	No of Demonstration	Average Duration	Average Yield (t/ha)
1	Rice	Binadhan-7	5	118	4.8
		Binadhan-10	5	142	6.5
		Binadhan-11	5	116	5.0
		Binadhan-14	5	105	5.0
		Binadhan-17	5	118	6.0
2	Wheat	Binagom-1	3	130	3.0
3	Mustard	Binasarisha-4	5	87	1.6
		Binasarisha-9	5	80	1.5
		Binasarisha-10	5	78	1.3
4	Sesame	Binatil-2	1	98	1.3

Chandanpatin Rangpur district is very suitable areafor growing rice, oilseeds and vegetables. Transplanted varieties Binadhan-17, Binadhan-11, Binadhan-7 & Binadhan-16 produced higher grain yield than check. Farmers had beeninterested to cultivate BINA developed aman rice varieties in aman season for their high yield, short crop duration and getting varietals diversification. Mustard variety, Binasarisha-4, Binasarisha-9 & Binasarisha-10 showed immense potentials in terms of yield and duration for cultivation in between aman and boro rice.Binatil-2 also produced higher grain yield than check. BINA technology village establishment in Chandanpat union is in progress.

Production of quality seed of BINA released crop varieties in Rangpur

Seeds of BINA released crop varieties 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 2017-18. Seed production activities, locations, crop varieties and areas during the reporting period were shown in (Table 4).In case of farmer's fields, partial inputs subsidies and free seeds or only free seeds were provided. During the reporting period a total of 31.85 tons seeds of different crop varieties of BINA were produced and procured.

Table 4. Seeds produced/purchased, distributed/sold and stored at BINA Substation, Rangpur during 2017-18

Sl. No.	Crops	Varieties	Total seed produced/ purchased (ton)	Total seed distributed /sold (ton)
1	Rice	Binadhan -7	3.00	3.00
		Binadhan -11	5.00	5.00
		Binadhan -17	4.00	4.00
		Binadhan -8	0.25	0.25
		Binadhan -10	2.00	2.00
		Binadhan -14	3.50	3.50
		Binadhan -19	1.50	1.50
		Sub-total	**19.25**	**19.25**
2	Wheat	Binagom-1	0.30	0.30
3	Mustard	Binasarisha-4	1.50	1.50
		Binasarisha-9	1.20	1.20
		Binasarisha-10	0.40	0.40
		Sub-total	**3.10**	**3.10**
3	Groundnut	Binachinabadam-4	3.00	3.00
		Binachinabadam-8	4.00	4.00
		Binachinabadam-6	2.00	2.00
		Sub-total	**9.00**	**9.00**
4	Sesame	Binatil-2	0.20	0.20
		Total	**31.85**	**31.85**

Training on the use of BINA developed technologies

In order to transfer BINA developed technologies several training workshop of one day was arranged at BINA Substation, Rangpur. The participants were farmers (both male and female) and Sub-assistant Agriculture Officer. Details of the training are presented in Table 5.

Table 5. Farmers Training on the use of BINA developed technologies during 2017-18

S.L No	Topic of training	Place of Training	No. of participants	Source of fund
1	Workshop for the DAE officers	Rangpur	55	Nutrition security project
2	Workshop for the DAE officers	Dinajpur	50	Nutrition security project
3	Production technology of BINA developed crop varieties around the season and suitability of cropping pattern	Rangpur	75	Nutrition security project
4	Use of Biofertilizer in Oil seed crops	Rangpur	55	Mutation Project
5	Production technology of late Rangpur boro rice Binadhan-14	Rangpur	75	Revenue

Field Day

In order to motivate the farmers to adopt BINA developed varieties/technologies, 9 field days on different crop varieties were organized in Rangpur region. Details of the field day activities are presented in Table 6.

Table 6. Field days arranged at the farmers fields on different crop varieties during 2017-18

Sl. No.	Crops	Varieties	Locations	Participants
1	Rice	Binadhan -17	Birganj, Dinajpur	150
		Binadhan -17	Sadullapur, Gaibandha	180
2	Mustard	Binasarisha-4	Pirgacha, Rangpur	150
		Binasarisha-9 and Binasarisha-10	Shreerampur, Rangpur Sadar	150
		Binasarisha-4, Binasarisha-9 and Binasarisha-10	Fokiran, Rangpur Sadar	150
3	Groundnut	Binachinabadam-6 and Biofertilizer	Bhoda, Panchagarh	150
		Binachinabadam-6 and Biofertilizer	Hatibandha, Lalmonirhat	150
		Binachinabadam-6 and Biofertilizer	Fulchori, Gaibandha	150
4	Sesame	Binatil-2	Tetulia, Panchagarh	150

BINA Sub-station, Ishurdi

Research Highlights

Binamoog-8 produced highest yield (1.41 t ha^{-1}) followed by BARI mung 6 and Binamoog-5 at Ishurdi. Irrespective of varieties seeds quality and seedling vigor of 1st picking seeds were better when seeds of 2nd picking.Binadhan-7 (25 no.) produced average yield 4.30 t ha^{-1}, Binadhan-11(20 no.) produced average yield 4.85 t ha^{-1}, Binadhan-12 (10 no.) produced average yield 4.35 t ha^{-1}, Binadhan-13 (2 no.) produced average yield 2.85 t ha^{-1}, Binadhan-17 (30 no.) produced average yield 5.50 t ha^{-1}, number of demonstration of lentil was 69, mustard was 65, mungbean was 74, sesame and grass pea was 5. A total of 389 demonstrations were conducted. Some 1281 kg breeder seeds of different crops and 1025 kg of TLS seeds were produced on the farm of Ishurdi sub-station in 2017-2018 growing season

Seed Quality and Yield Performance of Different Flashes of Mungbean Flower

The field experiment was conducted in the farms of BINA sub-stations at Ishurdi, during Kharif-I, 2018, where four mungbean varieties (Binamoog-5, Binamoog-8, BARI Mung 5 and BARI mung 6) were used as experimental materials. The experiment was laid out in a randomized complete block design with three replications. Unit plot size was 6m^2 (3m × 2m) keeping 30 cm spacing between two rows and 8-10 cm among the plants in rows. Seeds were sown on 15 March 2018. Recommended production packages like application of recommended doses of fertilizers, weeding, thinning, irrigation, application of pesticide etc. were followed to ensure normal plant growth and development. Data were taken from 10 randomly selected plants from each plotfor plant height (cm), no of pods plant^{-1}, pod length (cm), seeds pod^{-1}, 1000- seed weight (g), for seed yield of each picking and total yield, mature pods were harvested from entire plot and converted into t ha^{-1}. For Seed quality test: the performance of seeds collected from different picking of different varieties was examined by using a laboratory germination test. Four replications of 100 seeds of each treatment were placed in petridish containing filter paper soaked with distilled water. The Petri dishes were placed in an incubator at 27^{0}C and germination was counted daily for 14 days (according to ISTA rules). A seed was considered to be germinated as seed coat ruptured, plumule and radicle came out up to 2 mm in length. Germination (%), mean germination time (MGT) and germination index (GI) were measured.

Germination index (GI) was calculated from a daily count of germinated seeds until it reached a constant value, using the following formula given by Zhang *et al*. (2007).

$$GI = \sum \left(\frac{Gt}{Tt} \right)$$

Where, Gt is the number of germinated seeds on day t and Tt is time corresponding to Gt in days.

Mean germination time (MGT) was calculated according to the equation of Kaya *et al*. (2008).

$$MGT = \frac{\sum (Gt \times Tt)}{\sum Gt}$$

Where, Gt is the number of germinated seeds on day t and Tt is time corresponding to Gt in days.

Data were then analyzed by analysis of variance (ANOVA) using MSTAT package and the means were compared according to Least Significant Different Test at 5% significance.

The results showed significant variations for plant height, branch plant^{-1}, pods plant^{-1}, seeds pod^{-1} and yield among the varieties (Table-1). Among the four varieties Binamoog-5 produced the tallest plant (65.60 cm) compare to other three varieties but more branching behavior (1.96) were observed in Binamoog-8. Highest number of pod (13.33) and seeds per pod (11.37) was observed in Binamoog-8 which was statistically similar to BARI mung 6 and lowest seeds per pod was observed in Binamoog-5 (10.13). Number of branches, pods per plant and seeds per pod significantly influenced the seed yield of mungbean. During the 1st harvest it was observed that Binamoog-8 and BARI mung 6 produced the statistically higher yield but incase of 2nd harvest Binamoog-5 produced the highest seed yield. But the sum of different harvested seeds were showed the different results, the statistically total height yield (1.41 t ha^{-1}) was observed in Binamoog-8 followed by BARI mung 6 and Binamoog-5 and lowest (1.13 t ha^{-1}) was in BARI mung-5.

Table.1. Growth and yield of different Mungbean varieties at Ishurdi

Variety	Plant height (cm)	Branch $plant^{-1}$	Pods $plant^{-1}$	Pod length $(cm)^{NS}$	Seeds pod^{-1}	1000 seed weight (g) ^{NS}	Yield (t ha^{-1}) 1st picking	2nd picking	Total
Binamoog-5	65.60 a	1.53 b	11.27 b	7.33	10.13 b	4.18	0.78 b	0.50 a	1.28 b
Binamoog-8	47.93 c	1.96 a	13.33 a	7.63	11.37 a	3.67	1.30 a	0.11 d	1.41 a
BARI mung-5	52.27 c	1.19 c	9.33 c	8.90	10.40b	4.42	0.71 b	0.42 b	1.13 c
BARI mung-6	58.93 b	1.83 a	11.07 b	7.60	11.67a	4.68	1.12 a	0.22 c	1.32 b
CV%	**10.55**	**5.56**	**10.11**	**4.55**	**4.13**	**6.34**	**6.67**	**7.44**	**7.54**

Means with common letter in a column are not differ significantly at 5% level of significance by LSD.

Germination capacity of mungbean was varied with the variation of picking. Irrespective of variety seeds of 1st picking were showed more germination percent compare to 2nd picking (Table 2). Highest germination (%) was observed in the seeds of 1st picking of Binamoog-5 (83.25) which was statistically similar to BARI mung5 of same picking and lowest (70.00) germination capacity was observed in Binamoog-8 in case of 2nd picking which was statistically similar to BARI mung 5 of same picking. Presence of hard seeds decreases the germination percentage in mungbean seeds. More hard seeds were observed in small seeded varieties compare to bold seeded varieties. Irrespective to varieties hard seededness were increased in advance of picking times. Measuring the mean germination time and germination index it was observed that 1st picking seeds germinated faster than 2nd picking also showed better germination index.

Table. 2. Seed quality of mungbean varied with variation of picking

Variety	Germination (%)		Hard seeds (%)		Mean germination time (day)		Germination index	
	1st picking	2nd picking	1st picking	2nd picking	1st picking	2nd picking	1st picking	2nd picking
Binamoog-5	83.25 a	79.75ab	16.75de	20.25c	2.33 b	3.08 a	48.25 a	41.21 b
Binamoog-8	76.00 b	70.00 c	24.00b	30.00a	2.35 b	3.33 a	47.55 a	39.34 b
BARI mung 5	80.50 a	73.25 c	19.50cd	26.75ab	2.35 b	3.21 a	47.70 a	40.21 b
BARI mung 6	76.00 b	83.25 a	14.00e	16.75de	2.25 b	3.10 a	48.67 a	39.60 b
CV%	**4.25**		**6.55**		**5.68**		**5.21**	

Means with common letter in a column are not differ significantly at 5% level of significance by LSD.

Production of quality seed of BINA released crop varieties at BINA Sub-station, Ishurdi

Seeds of BINA released crop varieties popular in Pabna, Natore and Sirajgonj region were produced at the sub-station farms during 2017-18. During the reporting period a total 1.28 tons of breeder seeds and 1.03 tons of TLS seeds of different crops were produced (Table 3).

Table 3. Seeds production (on station) during 2017-18

SL. No	Variety	Seed production (kg)	
		Breeder seed (kg)	TLS seed (kg)
1	Binadhan-7	-	125
2	Binadhan-11	-	82
3	Binadhan-12	300	62
4	Binadhan-13	-	80
5	Binadhan-14	-	200
6	Binadhan-16	-	50
7	Binadhan-17	500	121
8	Binasoybean-4	68	-
9	Binamoog-5	-	100
10	Binamoog-7	5	-
11	Binamoog-8	-	80
12	Binamoog-9	20	-
13	Binamasur -3	45	-
14	Binamasur -4	36	-
15	Binamasur-7	-	10
16	Binamasur-8	-	6
17	Binamasur-9	-	9
18	Binapatshakh-1	40	
19	Binasorisha-7	48	-
20	Binasorisha-9	50	-
21	Binatil-2	35	
22	Binasoybean-4	134	
23	Binakhesari-1	-	100
	Total	**1,281 kg**	**1,025 kg**

Field demonstration

In order to disseminate the BINA developed varieties in Pabna, Natore and Sirajgonj regions several demonstrations (389 no. demonstrations of 23 varieties) and other extension work were done during 2017-18. Achievements and results of demonstration are presented in Table 4.

Table 4. Details of demonstration in three seasons during 2017-18

Sl. No.	Crops	Variety	No. of Demonstration	Average yield (t ha^{-1})
Kharif-II, 2017-18				
1	Rice	Binadhan-7	20	4.30
2		Binadhan-11	20	4.85
3		Binadhan-12	10	4.35
4		Binadhan-13	2	2.85
5		Binadhan-17	30	5.50
Rabi, 2017-2018				
6	Lentil	Binamoshur-4	2	1.10
7		Binamoshur-5	35	1.70
8		Binamoshur-6	5	1.45
9		Binamoshur -7	3	1.50
10		Binamoshur -8	20	1.75
11		Binamoshur -9	4	1.70
12	Mustard	Binasorisha-4	30	1.50
13		Binasorisha-7	1	1.60
14		Binasorisha-9	23	1.60
15		Binasorisha-10	11	0.90
16	Rice	Binadhan-14	50	5.75
17	Groundnut	Binachinabadam-4	8	2.4
Kharif-I-2017-2018				
18	Rice	Binadhan-19	14	4.75
19	Mungbean	Binamoog-5	06	1.00
20		Binamoog-8	54	1.2
21	Sesame	Binatil-2	19	0.75
22		Binatil-3	7	0.80
23	Grass pea	Binakhesari-1	5	1.6
Total			**389 no.**	

Training

In order to transfer BINA developed technologies 02 trainings (each for one day) were arranged at BINA Substation, Ishurdi. The participants were farmers (both male and female) and Sub Assistant Agriculture Officer. Another training for all employees and labour of BINA Sub-station related to national integrity strategy. Details of the training are presented in Table 5.

Table 5. Farmers Training on the use of BINA developed technologies during 2017-18

S.L No	Topic of training	Place of Training	No. of participants	Source of fund
1.	Introduction of extension able of BINA developed crop varieties (rice, mungbean, sesame and groundnut) and their production technology, seed processing & preservation	BINA substation, Ishurdi	80	SRSD
2.	Introduction of extension able of BINA developed crop varieties, production technology & development of cropping pattern	BINA substation, Ishurdi	90	Poribotita Awbhawa project
3.	National integrity strategy	BINA substation, Ishurdi	21	Poribotita Awbhawa project

Field Day

In order to motivate the farmers to adopt BINA developed varieties/technologies, 5 field days on different crop varieties were organized in Pabna region by BINA Sub-station, Ishurdi. Details of the field day activities are presented in Table 6.

Table 6. Field days arranged at the farmers fields on different crop varieties during 2017-18

Sl. No.	Crops	Varieties	Locations	Participants	Average yield (t ha^{-1})
1.	Rice	Binadhan-17	Ishta, Ishurdi, Pabna	200	6.5
		Binadhan-17	Aronkhola, Ishurdi, Pabna	150	7.1
2.	Mustard	Binasarisha-4	Dadpur, dashuria, Ishurdi, Pabna	140	1.9
		Binasarisha-9	Sathia, pabna	140	1.8
		Binasarisha-9	Sathia, pabna	140	2.1

BINA Sub-station, Cumilla

Research Highlights

Twenty advanced lines from T.Aman were selected from Preliminary Yield Trial (PYT) for uniformity in desirable characters and high yield potential with diverse genetic background having earliness, good grain type, compact panicle, lodging resistance. Another 14 advanced lines from T.Aman were selected from Preliminary Yield Trial for Fe and Zn rich rice with high yield potential.

Considering the yield performance (5-5.5t/ha) and premium quality and earliness 20 lines of T.Aman were selected for further evaluation in Advanced Yield Trial during next T.Aman season. For biofortified rice i.e. Fe and Zn rich rice12 lines were selected from Observation Trial for giving satisfactory yield (5-5.5 t/ha) and growth duration (120-130 days) as compared with all the standard checks for further evaluation.

VARIETAL DEVELOPMENT

Preliminary Yield Trial at Bina sub-substation, cumilla during T.Aman, 2017-18

Two preliminary Yield Trial (PYT) containing 35 genotypes were grown along with standard checks viz Binadhan-7, BRRIdhan62 for selection of genetically fixed lines with uniform plant height, short duration, heading, plant type and grain type along with high yield potential. Each genotype was grown in a 5.4mx4 rows plot with a spacing of 20x15 cm using single seedling per hill for transplanting. Twenty five days old seedlings were used for transplanting. Fertilizer was applied at the time of final land preparation. N was applied in three splits at 15, 30 and 45 days after transplanting. Gypsum and Zinc Sulphate @ 100 and 10 kg/ha respectively were applied during land preparation. Other cultural operations were done as and when necessary. Twenty genotypes were selected from Preliminary Yield Trial considering field duration ranged from 120-125 and good phenotyping acceptability. Fourteen genotypes were selected from Preliminary Yield Trial for biofortified rice i.e. Fe and Zn rich rice. (Table1).

Table 1. List of selected materials grown in Preliminary Yield Trial (PYT) for biofortified rice during T.Aman 2017-18

SL no	Genotype	Days to maturity	Plant height (cm)	Effective tiller	Panicle length (cm)	Grains/ panicle	Yield (t/ha)
1	ZI-02	109.0	103.1	11.0	21.3	148.0	5.15
2	ZI-03	109.0	90.0	15.3	24.9	188.5	5.77
3	ZI-20	109.0	96.7	11.4	22.3	169.5	5.14
4	ZI-28	118.5	99.2	11.3	23.7	179.0	5.59
5	ZI-32	114.5	100.6	11.0	23.3	171.0	5.37
6	ZI-35	106.0	98.2	10.4	22.3	163.5	5.22
7	ZI-39	112.0	97.9	9.3	22.4	159.5	5.06
8	ZI-40	110.0	97.2	12.1	24.1	184.5	5.69
9	ZI-51	114.5	101.3	11.4	22.6	180.0	5.57
10	ZI-56	109.0	97.9	12.7	23.6	186.0	5.55
11	ZI-58	116.0	98.7	8.6	21.2	164.0	4.37
12	ZI-59	106.5	100.9	10.4	23.0	192.5	5.33
13	ZI-66	116.5	98.2	11.1	21.8	191.5	5.15
14	ZI-181	117.0	98.8	11.3	21.0	167.0	5.34
15	BRRIdhan6	102.5	93.3	20.1	21.7	147.0	4.63

SL no	Genotype	Days to maturity	Plant height (cm)	Effective tiller	Panicle length (cm)	Grains/ panicle	Yield (t/ha)
	2 (check)						
LSD $_{(0.05)}$		**6.8**	**9.7**	**3.6**	**3.7**	**36.0**	**0.49**
CV%		**2.9**	**4.6**	**14.2**	**7.7**	**9.8**	**4.4**

Growing of M_1 generation of sweet gourd in summer season

With a view to improve yield potential and resistant to disease particularly fruit flies, dry seed of BARI Misti kumra-1was irradiated with 70, 100 and 150Gy doses of gamma rays from the ^{60} Co source of BINA. For each dose 100 g seeds of BARI Misti kumra-1 were used. Immediately after irradiation, the seeds were sown in pit on first week of March at BINA sub-station, Cumilla following non replicated design at 2.5 m distance from pit to pit. 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 when necessary. Data were recorded on seedling mortality and plant length. Seeds were collected and stored to screen and evaluate in the next generation.

Development of three crops based cropping pattern (Rabi-Boro-T.aman) against two crops based cropping pattern (Fallow+Boro+T.Aman)

The experiment was conducted at Rampur, Dayarampur and Abdarpur village under Brurichong upazilla of Cumilla district and at Alampur, Mondabag and Shahpur village under Kasbaupazilla of Brahmanbaria district during Rabi, Boro and Aman season of 2017-2018 with a view to evaluate the performance of Rabi (Mustard)-Boro-T.Aman cropping pattern in rice based dominant cropping pattern instead of Fallow-Boro-T.aman rice cropping pattern. Data were recorded on crop duration and yield (Table 2).

Table 2. Crop duration and yield of existing and proposed cropping pattern at six different location of Cumilla and Brahminbaria district during Rabi, Boro and Aman season of 2017-2018

Locations	Duration and yield (t ha^{-1}) of Existing cropping pattern					Proposed cropping pattern					
	Fallow	Boro (Binadhan-10)		T.aman (Binadhan-7)		Rabi (Binasarisha-4)		Boro (Binadhan-14)		T.aman (Binadhan-17)	
		Duration (Days)	Yield (t ha^{-1})	Duration (Days)	Yield (t ha^{-1})	Duration (Days)	Yield (t ha^{-1})	Duration (Days)	Yield (t ha^{-1})	Duration (Days)	Yield (t ha^{-1})
Rampur	-	139	6.10	112	4.20	85	1.80	132	4.65	119	5.70
Dayarampur	-	135	5.54	104	3.90	87	1.84	127	4.70	116	4.87
Abdarpur	-	140	6.50	118	3.89	75	1.45	124	4.16	117	4.56
Alampur	-	129	6.98	121	4.87	79	1.37	130	4.98	112	5.87
Mondabag	-	137	5.48	109	4.12	82	1.98	128	4.10	127	5.98
Shahpur	-	128	5.87	113	4.5	87	2.00	125	4.74	124	5.89

				0						
Mean	134.6 6	6.07	112.8	4.2 4	82.5	1.74	127. 6	4.55	119	5.47

Performance of Binachenabadam-4 in Cumilla region

In season of Kharif-1, 2017-18 some demonstrations were conducted in Cumilla region to know performance of Binachenabadam-4. Dhaka-1 used as check variety. 134 kg seed was sown per hectare in March, 2018. The size of per demonstration plot was 33 decimal. 7 kg urea, 23 kg TSP, 19 kg MP, 16 kg Gypsum, 100 ml nitro as insecticide and 50 gm truper as fungicide were applied per demonstration plot. Data were recorded on crop duration and yield. Recorded data presented in (Table 3).

Table 3. Duration and Yield of Binachinabadam-4 in Cumilla region during 2017-18

Locations	No. of demonstration	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binachinabadam-4	Dhaka-1 (check)	Binachinabadam-4	Dhaka-1 (check)	
Sadar Brahmanbaria	3	103	124	1.98	1.18	40.40
Ashuganj, Brahmanbaria	2	109	128	2.00	1.29	35.50
Muradnagar, Cumilla	3	105	126	2.10	1.30	38.09
Titas, Cumilla	3	115	129	2.04	1.26	38.23
Homna, Cumilla	3	113	125	2.07	1.31	36.71
Meghna, Cumilla	2	110	124	2.10	1.32	37.14
Sadardakshin, Cumilla	2	115	125	2.12	1.20	43.39
Mean		**110**	**125**	**2.11**	**1.26**	**38.49**

From this table we found that Binachenabadam-4 produced 2.11 t/ha yield in 110 days where Dhaka-1 takes 125 days to produce 1.26 t/ha yield. It means Binachenabadam-4 was 15 days earlier and had 38.49% higher yields than Dhaka-1. As a result farmers were highly interested to cultivate Binachenabadam-4 instead of Dhaka-1.

Performance of Binadhan-11 in Chauddagram, Burichong, Sadar Dakshin and Brahmanpara upazilla of Cumilla and Bijoynagar upazilla of Brahmanbaria.

In Aman season of 2017-2018 10 demonstrations were conducted in Cumilla and Brahmanbaria to find out the recover potentiality after submerged and farmers response to Binadhan-11. Seeds were sown in different time in different locations. 25 days aged Seedling was transplanted in 20 cm row to row and 15 cm plant to plant distance. The area of each demonstration was 33 decimal. 24 kg urea, 16 TSP, 9 kg MOP, 7 kg Gypsum and 0.5 kg Zinc sulphate were applied per each demonstration plot. Imitap and Truper were applied to control insects and fungi respectively. Weeding and irrigation were done when necessary. Data was collected on crop duration, days under submerged condition and yield (t/ha). Recorded data presented in table 4.

Table 4. Days under submerged condition, Crop duration and Yield of Binachenadhan-11 in some upazilla of Cumilla and Bijoynagarupazilla of Brahmanbariaduring 2017-18

Locations	No. of the demonstration	Days under submerge condition	Crop duration (days)	Yield (t/ha)
Bijoynagar Brahmanbaria	2	15	128	3.98
Chauddagram, Cumilla	2	19	132	4.00
Sadardakshin, Cumilla	2	-	114	4.87
Burichong, Cumilla	2	18	124	4.10
Brahmanpara, Cumilla	2	20	135	3.89
Total	**10**			
Mean		**18**	**126.6**	**4.16**

25 percent Farmers of Chauddagram, Sadadakshin, Burichong and Brahmanpara upazilla of Cumilla and 70 percent farmers of Bijoynagar upazilla of Brahmanbaria are suffered by flash flood. Therefore Binadhan-11 is highly demandable for this region. This variety can tolerate up to 20 days under submerged and gave moderate yield 4.16 t/ha. Famers of this region are not highly interested to this variety due to moderate coarse rice.

Performance of Binadhan-17 in Cumilla region

20 demonstrations were conducted during Aman season of 2017-2018 in Cumilla region to find out the yield potential compare with check variety BRRI Dhan-49. Size of the each demonstration was 33 decimal. Seeds were sown during mid June to 1st week of July. 25 days aged seedling was transplanted maintaining optimum spacing (20 cm × 15 cm). 20 kg urea, 13 kg TSP, 6 kg MP, 6 Gypsum and 0.5 kg zinc sulphate was applied each demonstration plot for Binadhan-17. On the other hand 20 kg urea, 13 kg TSP, 9 kg MP, 8 kg Gypsum and 1 kg zinc sulphate for BRRI Dhan-49. Others intercultural operation done when necessary. Data on crop duration and yield were which are presented in following table 5.

Table 5. Duration and yield of Binadhan-17 in Cumilla region during 2017-18

Upazila	No. of demonstration	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binadhan-17	BRRI dhan49 (check)	Binadhan-17	BRRI dhan49 (check)	
Kasba, Brahmanbaria	2	120	138	5.80	4.40	24.13
Chandina, Cumilla	10	117	140	5.88	4.78	18.70
Sadardakshin, Cumilla	5	125	137	5.74	4.81	16.20
Burichong, Cumilla	1	124	134	6.01	4.96	17.47
Debidwar, Cumilla	1	119	133	5.94	5.00	15.82
Sadar, Cumilla	1	114	138	6.00	4.90	18.33
Total	**20**					
Mean		**119.83**	**136.66**	**5.89**	**4.80**	**18.44**

Binadhan-17 has earlier and had higher yield than BRRI dhan-49. Farmers are highly interested to cultivate Binadhan-17 due to its high yield, short duration. As they can cultivate Rabi crops after the harvesting Binadhan-17.

Table 6. Establishment of BINA Technology village, in Burichong, Sadardakshin and Brahmanpara upazilla of Cumilla and KasbaUpazilla of Brahmanbaria

Sl. No	Crops	Variety Name	Demonstration No.	Av. Duration in days	Av.Yield (t ha^{-1})
	Rice	Binadhan-10	15	138	6.00
		Binadhan-14	25	131	4.70
		Binadhan-11	20	118	4.21
		Binadhan-12	5	130	3.98
		Binadhan-13	5	138	2.19
		Binadhan-16	5	98	4.14
		Binadhan-17	20	112	5.98
		Binadhan-18	5	142	5.31
2.	Mustard	Binasarisha-4	8	85	1.87
		Binasarisha-9	7	72	1.51
3.	Groundnut	Binachinabadam-4	10	113	1.89
4.	Mungbean	Binamoog-7	9	60	1.86
5.	Till	Binatill-2	15	100	1.13

Seed Production, Purchase, Distribution and sell of popular BINA released variety in Cumilla region

There are 5 acre land under Cumilla sub-station for seed production and research. Among this 2 acre land can be cultivated in Boro season. Three acre land is used for seed production and research. Due to land of this sub-station is low; some of the crops can grow in here. Produced seed in this sub-station research field is not sufficient for extension activities. This sub-station has produced seed in farmer field and purchased from them. For more and effective extension seeds are distributed to farmers by this sub-station. Some farmers and DAE purchase seed from this sub-station.

Table 7. Seeds production, purchase, distribution and sell of popular BINA released variety in Cumilla during 2017-18

Crop	Varieties	Total seeds produced /purchased (ton)	Totaldistributed/sold (ton)	Seeds stored (ton)	Remarks
Rice	**Aman**				
	Binadhan-7	-	0.34	-	
	Binadhan-11	0.78	0.50	0.78	
	Binadha-12	0.40	0.23	0.40	
	Binadhan-13	0.07	0.19	0.07	
	Binadhan-15	-	0.59	-	
	Binadhan-16	0.20	0.39	0.20	
	Binadhan-17	1.50	0.96	1.50	
	Boro				
	Binadhan-10	1.60	1.00	1.60	
	Binadhan-18	0.42	0.20	-0.42	
	Sub-total	**4.97**	**4.40**	**4.97**	
Mustard	Binasarisa-4	0.80	0.81	0.80	
	Binasarisa-9	0.10	0.05	0.10	
	Sub-total	**0.9**	**0.86**	**0.9**	
Groundnut	Binachinabadam-	-	0.20	-	

	4			
Till	Binatil-1	-	0.05	-
	Binatil-2	-	0.25	-
	Sub-total	-	-0.30	-
	Total	**5.87**	**5.56**	**5.87**

Training on BINA developed technologies

In order to transfer BINA developed technologies some farmer's and one UAO's training were arranged by BINA Substation, Cumilla. The participants were farmers (both male and female) and Sub-assistant Agriculture Officer and UAOs. Details of the training are presented in Table 8.

Table 8. Farmers Training on BINA developed technologies during 2017-18

S.L No	Topic of training	Place of Training	No. of participants	Source of fund
4.	Introduction of extensionable of BINA developed crop varieties, production technology & development of cropping pattern	BINA substation, Cumilla	85	Nutrition project
5.	Introduction, characteristic, production technology, seed processing and storage technology of Bina developed varieties.	BINA substation, Cumilla	85	Nutrition project
6.	Introduction, characteristics and production technology of Binadhan-19	BINA substation, Cumilla	85	SRSD
7.	Introduction, characteristics, production technology, seed production and storage technology of BINA released Aman varieties.	BINA substation, Cumilla	85	SRSD

Field Day

In order to motivate the farmers and evaluate the yield of varieties developed by BINA at farmer's field, 8 field days on different crop varieties were organized in Cumilla region. Details of the field day activities are presented in Table 9.

Table 9. Field days arranged at the farmers fields on different crop varieties during 2017-18

Sl. No.	Crops	Varieties	Locations	Participants
3.	Rice	Binadhan-14	Burichong and Kasba	110
		Binadhan-17	Chandina and Burichong	110
4.	Groundnut	Binachinabadam-4	Muradnagar and Ashuganj	130
5.	Mustard	Binasarisha-4	Burichong and Kasba	130

BINA Sub-station, Magura

Research Highlights

A total of 06 demonstrations with Binachinabadam-4 showed that Binachinabadam-4 produced better yield (32.43% yield increased) with less maturity period than check varieties of Dacca-1.

Nine observation trials of Binadhan-7, Binadhan-16, Binadhan-17 and BRRI dhan39 revealed that Binadhan-17 was better than all ther varieties. Average yield increase was observed 22.06% over chek. Binadhan-16 was found early maturing variety (102.3 days) over chek.

Validation trials with HYV mustard varieties Binasarisha-4, Binasarisha-10 with BARI Sarisha-15 and Tori-7 showed that, Binasarisha-4 and BARI Sarisha-15 had almost same yield. Average yield of Binasarisha-4 (1.59 t ha^{-1}) was 4.89% more over the yield of BARI Sarisha-15 (1.52 t ha^{-1}). Maturity period was also similar for both the varieties. In case of Binasarisha-10 and Tori-7; Binasarisha-10 produced 19.22% higher yield than Tori-7.

Observation trials of Binamasur-5, Binamasur-8, Binamasur-9 with BARI Masur-6 exhibited that, highest yield increase (36.88%) was found in Binamasur-9 (1.96 t ha^{-1}) at 104.6 days maturity followed by Binamasur-8 (1.85 t ha^{-1} yield at 103.6 days). The check variety BARI Masur-6 produced 1.43 t ha^{-1} at 110.6 days maturity.

Trials with Binamoog-7, Binamoog-8 and BARI Mug-6 showed the superior performance of Binamoog-8. It produced 1.54 t ha^{-1} seed yield at 68.66 days maturity followed by Binamoog-7; which was produced 1.42 t ha^{-1} seed yield at 79 days maturity period. BARI Mug-6 (Check variety) produced 1.29 t ha^{-1} yield at 79 days maturity. Average yield increase was highest in Binamoog-8 (20.08%) compared to all the varieties.

Up-scaling of BINA developed Binachinabadam-4

During Rabi season of 2017-18, 06 demonstrations were conducted with Binachinabadam-4 in Magura region to demonstrate the performance of Binachinabadam-4 and widening their adoption by the farmers. The check variety was Dacca-1Area of demonstration plots was 33 decimals. Seeds were sown during mid-January 2018 at the rate of 150 kg ha^{-1}. Recommendated fertilizerswere applied in the demonstration plots. Pesticides were sprayed as and when necessary to control pests. Data were recorded on crop duration and grain yield. The results are presented in Table 1

Table 1: Performance of Binachinabadam-4 in Sunamganj region during 2017-18

Upazila	No. of demon.	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binachinabadam-4	Dacca-1 (check)	Binachinabadam-4	Dacca-1 (check)	
Jhamarchar, Md.pur	2	140	162	1.80	1.50	+20.00
CharSelamotpur, Md.pur	2	145	160	1.66	1.45	+14.48
Binodpur, Md.pur	2	144	155	1.97	1.21	+62.80
Total / Mean	06	143	159	1.81	1.39	+32.43

Data in Table 1 reveal that Binachinabadam-4 produced average seed yields of 1.81 t ha^{-1} which was 32.43% higher compared to check variety Dacca-1. Average maturity period of Binachinabadam-4 was 143 days. The check variety Dhaka-1 produced average gain yield of 1.39 t ha^{-1} with average maturity period of 159 days. The variety Binachinabadam-4 increased crop production as well as farmer's income. Therefore Farmers were found interested to cultivate Binachinabadam-4 in Mohammadpur Upazila of Magura district.

Observation trial of Binadhan-7, 16, 17 and BRRI dhan39

During aman season of 2017-18, total 9 demonstration trial with Binadhan-7, Binadhan-16, Binadhan-17 and BRRi dhan39 were conducted at the farmer's fields in Magura region BRRI dhan49 was used as check. The main objective was to find out the field performances of Binadhan-7, Binadhan-16, Binadhan-17 and adoption of suitable variety by the farmers. Area of demonstration plot was 33 decimals. Seeds were sown during mid June 2017 at the rate of 10 kg ha^{-1} and 25 days old seedlings were transplanted in the main field. All fertilizers were applied as per recommendation in the 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 2.1: Comparison of Growth duration and yield of Binadhan-7 with BRRI dhan39 during 2017-18

Location (Magura Sadar)	No.s Number of validation trials	Duration (days)		Yield (t ha^{-1})		(%) Yield (+/-) over check
		Binadhan - 7	BRRI dhan39 check	Binadhan - 7	BRRI dhan39 check	
Alomkhali Magura Sadar	3	113	120	4.95	4.70	+5.32
Moghi Magura Sadar	3	109	122	5.15	4.63	+11.23
Ramnagar Magura Sadar	3	110	123	5.07	4.87	+4.11
Total/Mean	**09**	**110.6**	**121.6**	**5.06**	**4.73**	**+6.89**

Table 2.2: Comparison of Growth duration and yield of Binadhan-16 with BRRI dhan39 during 2017-18

Location (Magura Sadar)	No.s Number of validation trials	Duration (days)		Yield (t ha^{-1})		(%) Yield (+/-) over check
		Binadhan - 16	BRRI dhan39 check	Binadhan - 16	BRRI dhan39 check	
Alomkhali Magura Sadar	3	100	120	4.55	4.70	-3.19
Moghi Magura Sadar	3	105	122	4.77	4.63	+3.02
Ramnagar Magura Sadar	3	102	123	4.89	4.87	+0.41
Total/Mean	**09**	**102.3**	**121.6**	**4.74**	**4.73**	**+0.08**

Table 2.3: Comparison of Growth duration and yield of Binadhan-17 with BRRI dhan39 during 2017-18

Location (Magura Sadar)	No.s Number of validation trials	Duration (days)		Yield (t ha^{-1})		(%) Yield (+/-) over check
		Binadhan -17	BRRI dhan39 check	Binadhan -17	BRRI dhan39 check	
Alomkhali Magura Sadar	3	115	120	5.45	4.70	+15.96
Moghi Magura Sadar	3	121	122	5.90	4.63	+27.43
Ramnagar Magura Sadar	3	117	123	5.98	4.87	+22.79
Total/Mean	**09**	**117.6**	**121.6**	**5.78**	**4.73**	**+22.06**

Data in Table 2.1 indicates that Binadhan-7 produced average grain yield of 5.06 t ha^{-1} which was 6.89% higher than to check variety BRRI dhan39. Average maturity period of Binadhan-7 was 110.6 days and the check variety was 121.6 days. On other trials of Binadhan-16 grain yield was found 4.74 t ha^{-1} which was similar to the yield of check variety BRRI dhan39 (4.73 t ha^{-1}); But Binadhan-16 matured very early (102.3 days) than BRRI dhan39 (121.6 days) (Table 2.2). Another trials of Binadhan-17 gave a seed yield of 5.78 t ha^{-1}; Which was 22.06% more yield than the check variety BRRI dhan39 (4.73 t ha^{-1}). Maturity days were closer in case of both the varieties (Table 2.3). Binadhan-17 increased crop production as well as farmer’s income. Therefore Farmers were interested to cultivate Binadhan-17 for high yield and less input requirement in the next season.

Validation trial of Binasarisha-4, 10 with BARI Sarisha-15 and Tori-7

During the rabi season of 2017-18, 09 observation trials of Binasarisha-4 with Bari sarisha-15 and Binasarisha-10 with Tori-7 were conducted. To know the relative performances of mustard varieties in field so that farmers can choose their desired variety in terms of yield and quality. Area of the trial plots were 33 decimal for each variety and there were 3 (three) locations. Seeds were sown in the 2^{nd} week of November. Broadcasting method was followed for seed sowing @ 7.4 kg ha^{-1}. All types of fertilizers were applied as per recommendation in the trial plots. Pesticides were applied as and when necessary to control pests. Data were collected on duration and grain yield. The results are presented in Table 3.

Table 3.1: Performance of Binasarisha-4 with BARI Sarisha-15 during 2017-18

Location	Number of validation trials	Duration (days)		Yield (t ha^{-1})		(%) Yield (+/-) over check
		Binasarisha-4	BARI Sarisha-15 check-1	Binasarisha-4	BARI Sarisha-15 check-1	
Moghi, Magura Sadar	3	82	86	1.54	1.65	-6.67
Rautara, Magura Sadar	3	85	83	1.65	1.44	+14.58
Nandalalpur, Magura Sadar	3	81	88	1.58	1.48	+6.76
Total/Mean	**09**	**82.6**	**85.6**	**1.59**	**1.52**	**+4.89**

Table 3.1: Performance of Binasarisha-10 with Tori-7 during 2017-18

Location	Number of validation trials	Duration (days)		Yield (t ha^{-1})		(%) Yield (+/-) over check
		Binasarisha-10	Tori-7 check-2	Binasarisha-10	Tori-7 check-2	
Moghi, Magura Sadar	3	80	77	1.40	1.11	+26.13
Rautara, Magura Sadar	3	83	74	1.35	1.06	+27.35
Nandalalpur, Magura Sadar	3	78	79	1.25	1.20	+4.17
Total/Mean	**09**	**80.3**	**76.6**	**1.33**	**1.12**	**+19.22**

Table 3.1 showed that, yield of Binasarisha-4 (1.59 t ha^{-1}) was almost similar to BARI Sarisha-15 (1.52 t ha-1); and the maturity days was also close to both of the varieties. Seed yield was just 4.89% more over the check-1; BARI Sarisha-15. Binasarisha-10; seed yield was 1.33 t ha^{-1} whereas the check variety Tor-7 produced a yield of 1.12 t ha^{-1}. Binasarisha-10 gave 19.22% more yield than the check-2 variety Tor-7 (Table 3.2). Days to maturity were more or less close for both of the varieties. Farmers of Moghi, Rautara and Nandalalpur of Magura sadar were interested to cultivate both Binasarisha-4 and BARI Sarisha-15 for their high yielding capability. So, they preserved seeds for mustard production in next Rabi season.

Observation trials with Binamasur-5, 8, 9 with BARI Masur-6

During Rabi season of 2017-18, 09 observation trials of Binamasur-5, Binamasur-8 and Binamasur-9 were done with BARI Masur-6 (check). Goal was to demonstrate the relative performances of different lentil so that farmers can choose their desired variety for better yield and quality. Area of the trial plots were 33 decimal or one bigha for each variety and there were 3 (three) locations. Seeds were sown in the 2nd week of November. Broadcasting method was followed at the rate of 25 kg ha^{-1}. All types of fertilizers were applied as per recommendation in the trial plots. Pesticides were applied as and when necessary to control pests. Data were taken on maturity and yield. The results are presented in Table 4.

Table 4.1: Performance of Binamasur-5 with BARI Masur-6 during Rabi season 2017-18

Location	Number of validation trials.	Duration (days)		Yield (t ha^{-1})		(%) Yield (+/-) over check
		Binamasur-5	BARI Masur-6 check	Binamasur-5	BARI Masur-6 check	
Ramnagar, Magura Sadar	3	109	111	1.62	1.33	+21.80
EchaKhata, Magura Sadar	3	104	108	1.55	1.45	+6.90
Shiv Rampur, Magura Sadar	3	102	113	1.41	1.52	-7.24
Total/Mean	**09**	**105**	**110.6**	**1.53**	**1.43**	**+7.15**

Table 4.2: Performance of Binamasur-8 with BARI Masur-6 during Rabi season 2017-18

Location	Number of validation trials.	Duration (days)		Yield (t ha^{-1})		(%) Yield (+/-) over check
		Binamasur-8	BARI Masur-6 check	Binamasur-8	BARI Masur-6 check	
Ramnagar, Magura Sadar	3	107	111	1.97	1.33	+48.12
EchaKhata, Magura Sadar	3	101	108	1.75	1.45	+20.68
Shiv Rampur, Magura Sadar	3	103	113	1.83	1.52	+20.39
Total/Mean	**09**	**103.6**	**110.6**	**1.85**	**1.43**	**+29.73**

Table 4.3: Performance of Binamasur-8 with BARI Masur-6 during Rabi season 2017-18

Location	Number of validation trials.	Duration (days)		Yield (t ha^{-1})		(%) Yield (+/-) over check
		Binamasur-9	BARI Masur-6 check	Binamasur-9	BARI Masur-6 check	
Ramnagar, Magura Sadar	3	108	111	1.97	1.33	+48.12
EchaKhata, Magura Sadar	3	102	108	1.88	1.45	+29.65
Shiv Rampur, Magura Sadar	3	104	113	2.02	1.52	+32.89
Total/Mean	**09**	**104.6**	**110.6**	**1.96**	**1.43**	**+36.88**

From the data of Table 4.1, Binamasur-5 seems to have a closer yield compared to the check variety BARI Masur-6. Binamasur-5 produced a yield of 1.53 t ha^{-1} at 105 days which was 7.15% more than BARI Masur-6. On the other trials of Binamasur-8 showed that yield (1.85 t ha^{-1}) was 29.73% higher compared to check variety BARI Masur-6 (1.43 t ha^{-1}) and it matured 7 days later (110.6 days) than Binamasur-8 (103.6 days) (Table 4.2). Trials of Binamasur-9 with BARI Masur-6showed that Binamasur-9 gave a superior yield (1.96 t ha^{-1}) over BARI Masur-6 (1.43 t ha^{-1}); which was 36.88% greater yield than BARI Masur-6. Average maturity period was 104.6 days for Binamasur-9 and 110.6 days for BARI Masur-6 (Table 4.2). Lentil growers of Ramnagar, Echa Khata and Shiv Rampur of Magura sadar were keen to cultivate Binamasur-9 for it's high yielding capability and higher market price. So, they preserved seeds for cultivating in the next Rabi season.

Observation trials with Binamoog-7, 8 with BARI Mug-6

During Kharif season of 2017-18, total 9 observation trials of Binamoog-7, Binamoog-8 and BARI Mug-6 were conducted in Magura region. To know the relative performances of Mung bean varieties in field so that farmers can choose their desired variety in terms of yield and quality. BARI Mug-6 was used as check. Area of the trial plots were 33 decimal for each variety and there were 3 (three) locations. Seeds were sown between mid-february to 1st week of November.

Broadcasting method was followed for planting and seed rate was 25 kg ha^{-1}. All types of fertilizers were applied as per recommendation in the trial plots. Pesticides were applied as and when necessary to control pests. Data were recorded on crop duration and grain yield. The results are presented in Table 5.

Table 5.1: Performance of Binamoog-7 with BARI Mug-6 during Kharif season 2017-18

Location	Number of validation trials	Duration (days)		Yield (t ha^{-1})		(%) Yield (+/-) over check
		Binamoog-7	BARI Mug-6 check	Binamoog-7	BARI Mug-6 check	
Ramnagar, Magura Sadar	2	78	80	1.47	1.25	+17.60
Sachani, Magura sadar	2	75	83	1.42	1.32	+7.57
Moghi, Magura sadar	2	84	79	1.38	1.29	+6.97
Total/Mean	**6**	**79**	**80.66**	**1.42**	**1.29**	**+10.71**

Table 5.2: Performance of Binamoog-8 with BARI Mug-6 during Kharif season 2017-18

Location	Number of validation trials	Duration (days)		Yield (t ha^{-1})		(%) Yield (+/-) over check
		Binamoog-8	BARI Mug-6 check	Binamoog-8	BARI Mug-6 check	
Ramnagar, Magura Sadar	2	65	80	1.56	1.25	+24.80
Sachani, Magura sadar	2	68	83	1.45	1.32	+9.85
Moghi, Magura sadar	2	73	79	1.62	1.29	+25.58
Total/Mean	**6**	**68.66**	**80.66**	**1.54**	**1.29**	**+20.08**

Table 5.1 showed that Binamoog-7 produced a yield of 1.42 t ha^{-1} which was 10.71% more than BARI Mug-6 (1.29 t ha^{-1}). Maturity days were almost same for both the varieties. In the trials of Binamoog-8; maximum yield was obtained compared to all other varieties. It gave 1.54 t ha^{-1} yield against the check (1.29 t ha^{-1}). Increased yield of Binamoog-8 was 20.08% over BARI Mug-6. Average maturity of Binamoog-8 was 68.66 days; whereas the check variety took 12 days more i.e., 80.66 days for maturity (Table 5.2). Mung bean growers of Ramnagar, Sachani and Moghi of Magura sadar upazila preferred Binamoog-8 for its synchronized plucking period, higher yield and good market price; thus they were interested to cultivate Binamoog-8 in the next kharif season.

Establishment of BINA Technology village in surrounding area of BINA Sub-station, Magura

In order to establish BINA-Technology village demonstrations and other extension work were done in surrounding area of BINA-substation, Magura at the farmer's fields. Results of overall promotional activities related to BINA-Technology village establishment at Alomkhali Union are presented below-

Table 6: Average duration and yield of BINA developed varieties at Magura during 2017-18

Sl. No	Crops	Variety Name	Demonstration No.	Duration in days	Yield (t ha^{-1})
1.	Rice	Binadhan-7	9	109	5.10
		Binadhan-14	10	125	6.0
		Binadhan-16	02	104	4.90
		Binadhan-17	09	117	5.9
2.	Lentil	Binamasur-5	10	106	1.50
		Binamasur-7	01	92	1.40
		Binamasur-8	50	104	1.80
		Binamasur-9	02	107	2.00
3.	Mustard	Binasarisha-4	03	83	1.60
		Binasarisha-10	05	80	1.30
4.	Sesame	Binatil-1	05	88	0.68
		Binatil-2	12	93	1.10
		Binatil-3	05	91	0.75
5.	Groundnut	Binachinabadam-4	04	144	1.40
6.	Mungbean	Binamoog-7	06	79	1.40
		Binamoog-8	34	70	1.50

Alomkhali of Magura Sadar Upazila is very suitable for growing pulse crops specially lentil. They also grow rice, oilseeds, pulse and vegetables. Results indicated that Binadhan-7 & Binadhan-17 produced higher grain yield than check. Farmers had been interested to cultivate BINA developed aman rice varieties in aman season for their higher yield, short duration and getting varietals diversification. Mustard variety, Binasarisha-4 & Binasarisha-10 Binatil-1 and Binatil-2 were found to have good scope for extension for their demand as preparation cake, *Khaja* etc. food items. Binachinabadam-4, Binamoog-7 and. Binamoog-8 also produced higher yield than check. Therefore, Binamoog-8 may be a suitable variety for this region and mass extension is possible with this variety for its qualitative characteristics. BINA technology village establishment in Alomkhali of Magura Sadar upazila is under progress.

Production of quality seed of BINA released crop varieties popular in Magura region

Seeds of BINA released crop varieties popular in Magura 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 2017-18. Seed production activities are described in Table 7. In case of farmer's fields, partial inputs subsidies and free seeds or only free seeds were provided. During the reporting period a total of 12.861 tons seeds of different crop varieties of BINA were produced and procured. Among them 1.87 tons were distributed. Rest of the stored seeds (10.991 ton) will be distributed in 2018-19.

Table 7. Seeds produced/purchased, distributed/sold & stored during 2017-18

Crop	Season	Variety	Total seeds produced /purchased (ton)	Total distributed/sold (Kg)	Seeds stored (ton)	Remarks
Rice	Aus	Binadhan-19	0.10	0	0.1	
	Aman	Binadhan-7	1	1	0	Breeder seed
		Binadhan-8	0.10	0	0.10	
		Binadhan-10	0.40	0	0.40	
		Binadhan-11	0.20	0.2	0	Breeder seed 120 Kg
		Binadhan-13	0.150	0.15	0	
		Binadhan-16	0.020	0.020	0	
		Binadhan-17	0.50	0.50	0	
	Boro	Binadhan-14	0.150	0	0.150	
		Binadhan-18	0.10	0	0.10	
Mustard	Rabi	Binasarisa-4	0.280	0	0.280	
		Binasarisa-9	0.140	0	0.140	
		Binasarisa-10	0.710	0	0.710	
Lentil	Rabi	Binamasur-5	0.875	0	0.875	
		Binamasur-8	2.625	0	2.625	
Sesame	Kharif-1	Binatil-1	0.039	0	0.039	
		Binatil-2	0.104	0	0.104	
		Binatil-3	0.046	0	0.046	
Mungbean	Kharif-1	Binamoog-7	0.922	0	0.922	
		Binamoog-8	4.40	0	4.40	
		Total	**12.861**	**1.87**	**10.991**	

Training on the use of BINA developed technologies

In order to transfer BINA developed technologies a training of one day was arranged at BINA Substation, Magura. The participants were farmers (both male and female) and Sub-assistant Agriculture Officer. Details of the training are presented in Table 5.

Table 8. Farmers Training on the use of BINA developed technologies during 2017-18

S. L No	Topic of training	Place of Training	No. of participants	Source of fund
8.	Introduction of extensionable of BINA developed crop varieties, production technology & development of cropping pattern	BINA sub-station, Magura	85	Nutrition project
9.	Insect disease management of pulse crops	BINA sub-station, Magura	100	Poribortito Abohoa
10.	Seed processing of rice, sesame and groundnut.	BINA sub-station, Magura	75	Poribortito Abohoa

Field Day

In order to motivate the farmers to adopt BINA developed varieties/technologies, 8 field days on 6 different crop varieties were organized in Magua region. Details of the field day activities are presented in Table 9.

Table 9. Field days arranged at the farmers fields on different crop varieties during 2017-18

Sl. No.	Crops	Varieties	Locations	Participants
6.	Rice	Binadhan-14	Moghi, Sadar, Magura	108
7.	Lentil	Binamasur-8	Moghi, Sadar, Magura	111
			Ramnagar, Sadar, Magura	119
8.	Mungbean	Binamoog-8	Batikadanga, Sadar, Magura	107
			JibonNagar, Chuadanga	125
9.	Sesame	Binatil-2	Batikadanga, Sadar, Magura	96
10.	Mustard	Binasarisha-10	Moghi, Sadar, Magura	134
11.		Binasarisha-4 and 10	Jagla, Sadar, Magura	126

BINA Sub-station, Satkhira

Research Highlights

A total of 25 demonstrations with short durated T. aman rice BINAdhan-7, Binadhan-16 and Binadhan-17 produced average grain yields of 5.2, 5.53 t ha^{-1} and 6.35 t ha^{-1} respectively. Average maturity period of Binadahn-7 was 116 days, Binadhan-16 was 104 days and Binadhan-17 was 114 days. One popular cultivars was used as check, BRRI dhan49. Check variety BRRI dhan49 produced average gain yield of 5.17 with average maturity period of 133 days. Farmers were interested to cultivate Binadhan-7, Binadhan-16 and Binadhan-17 because of their higher yield and increased income.A total of 103 demonstrations with short durative high yielding Binasarisha-4, Binasarisha-9 and Binasarisha-10 which produced better yield with less maturity period in most cases than check variety of BARI sarisha-14 A total of 120 demonstrations with salt tolerant Boro rice Binadhan-10 which produced better yield with less maturity period than check variety of BRRI dhan61. A total of 8 demonstrations with high yielding late Boro rice Binadhan-14 which produced better yield with less maturity period than check variety of BRRI dhan28.

A total of 10 demonstrations with high yielding moog variety Binamoog-8 which produced better yield than check variety of BARI Mug-6.Up-scaling BINA developed high yielding and short durative T.Aman rice variety in Satkhira region

During aman season of 2017-18, 25 demonstrations with Binadhan-7, Binadhan-16 and Binadhan-17 were conducted at the farmer's fields in Satkhira 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 and 15 cm. All fertilizers were applied as per recommendation. Transplanting dates ranged from 31 July to 8 August 2017, and age of seedlings was 20 to 25 days. The farmers managed all the production practices as per recommendation. Based on the available reports, data of demonstration plots are presented in Table 1-3.

Table 1: Performance of Binadhan-7 in Satkhira region during 2017-18

Upazila	No.of demonstration	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binadhan-7	BRRI dhan49 (check)	Binadhan-7	BRRI dhan49 (check)	
Sadar	3	117	132	5.1	4.90	4.08
Tala	3	115	136	5.3	5.0	6.0
Total	**6**					
Mean		**116**	**134**	**5.2**	**4.95**	**5.04**

Data in Table 1 reveal that Binadhan-7 produced average grain yield of 5.2 t ha^{-1}, which was 5.04 percent higher compared to check variety. Average maturity period of Binadhan-7 was 116 days. The mean yield of Binadhan-7 was 5.22 tha^{-1} which differs statistically from BRRI dhan49 (4.95 tha^{-1}). Therefore Binadhan-7 increased crop production as well as farmer's income. Farmers were found interested to cultivate Binadhan-7 as a Aman variety in Satkhira region.

Table 2: Performance of Binadhan-16 in Satkhira region during 2017-18

Upazila	No. of	Duration (days)	Yield (t ha^{-1})	Yield increased

	demonstration	Binadhan-16	BRRI dhan49 (check)	Binadhan-16	BRRI dhan49 (check)	over check (%)
Sakhira Sadar	2	103	132	5.50	5.0	10.0
Tala	3	105	134	5.55	5.1	8.82
Total	5					
Mean		104	133	5.53	5.05	9.41

Data in Table 2 reveal that Binadhan-16 produced average grain yield of 5.53 t ha^{-1}, which was 9.41 percent higher compared to check variety. Average maturity period of Binadhan-16 was 104 days. The mean yield of Binadhan-16 was 5.53 tha^{-1} which differs statistically from BRRI dhan49 (5.05 tha^{-1}). Therefore Binadhan-16 increased crop production as well as farmer's income. Farmers were found interested to cultivate Binadhan-16 as a Aman variety in Satkhira region.

Table 3: Performance of Binadhan-17 in Satkhira region during 2017-18

Upazila	No. of demonstration	Date of transplanting	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
			Binadhan-17	BRRI dhan49 (check)	Binadhan-17	BRRI dhan49 (check)	
Satkhira sadar	3	31/07/17	115	132	6.50	5.10	27.45
Tala	11	5/08/17	113	133	6.20	5.05	22.77
Total	14						
Mean			114	134	6.35	5.08	25.11

Data in Table 3 reveal that Binadhan-17 produced average grain yield of 6.35 t ha^{-1}, which was 25.11 percent higher compared to check variety. Average maturity period of Binadhan-17 was 114 days. The mean yield of Binadhan-17 was 6.35 tha^{-1} which differs statistically from BRRI dhan49 (5.08 tha^{-1}). Therefore Binadhan-17 increased crop production as well as farmer's income. Farmers were found interested to cultivate Binadhan-17 as a Aman variety in Satkhira region.

Up-scaling BINA developed high yielding and short durative mustard variety in Satkhira region

During the Rabi season of 2017-18, total 103 demonstrations were conducted with Binasarisha-4, Binasarisha-9 and Binasarisha-10 in Satkhira region. The main objectives were to demonstrate the performance of Binasarisha-4, Binasarisha-9 and Binasarisha-10 as well as widening their adoption by the farmers. Area of demonstration plots was 33 decimals. Seeds were sown during October to November 2017 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 Table 4-6.

Table 4: Performance of Binasarisha-4 compared to popular cultivar in Satkhira region during 2017-18

Upazila	No. of demo	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binasarisha-4	BARI sarisha-14 (Check)	Binasarisha-4	BARI sarisha-14 (Check)	

Satkhira Sadar	04	86	80	1.9	1.60	18.75
Tala	09	84	80	1.7	1.45	17.24
Total	**13**					**18**
Mean		**85**	**80**	**1.8**	**1.53**	**15.00**

Data in Table 4 reveal that Binasarisha-4 produced average seed yield of 1.8 t ha^{-1}, which was 18.00 percent higher than the cheek variety BARI sarisha-14. Average maturity period of Binasarisha-4 was 85 days. BARI sarisha-14 produced average gain yield of 1.53 t ha^{-1} with average maturity period of 80 days. Farmers were interested to cultivate Binasarisha-4 because of its higher yield and increased income.

Table 5: Performance of Binasarisha-9 compared to popular cultivar in Satkhira region during 2017-18

Upazila	**No. of demo**	**Duration (days)**		**Yield (t ha^{-1})**		**Yield increased over check (%)**
		Binasarisha-9	**BARI sarisha-14 (Check)**	**Binasarisha-9**	**BARI sarisha-14 (Check)**	
Satkhira sodor	10	80	78	1.8	1.5	20.0
Tala	10	79	78	1.68	1.52	10.53
Kolaroya	10	81	78	1.70	1.5	13.33
Total	**30**					
Mean		**80**	**78**	**1.73**	**1.51**	**14.62**

Data in Table 5 reveal that Binasarisha-9 produced average seed yield of 1.73 t ha^{-1} which was 14.62 percent higher than the check variety BARI sarisha-14. Average maturity period of Binasarisha-9 was 80 days. BARI sarisha-14 produced average yield of 1.51 t ha^{-1} with average maturity period of 78 days. Farmers were found interested to cultivate Binasarisha-9 because of its higher yield and increased income.

Table 6: Performance of Binasarisha-10 compared to popular cultivar in Satkhira region during 2017-18

Upazila	**No. of demo**	**Duration (days)**		**Yield (t ha^{-1})**		**Yield increased over check (%)**
		Binasarisha-10	**BARI sarisha-14 (Check)**	**Binasarisha-10**	**BARI sarisha-14 (Check)**	
Satkhira sodor	30	78	78	1.5	1.45	3.49
Tala	15	79	77	1.5	1.48	1.35
Kolaroya	15	80	79	1.6	1.5	6.67
Total	**60**					
Mean		**79**	**78**	**1.53**	**1.48**	**3.84**

Data in Table 6 reveal that Binasarisha-10 produced average seed yield of 1.53 t ha^{-1} which was 3.84 percent higher than the check variety BARI sarisha-14. Average maturity period of Binasarisha-9 was 79 days. BARI sarisha-14 produced average gain yield of 1.48 t ha^{-1} with average maturity period of 78 days. There for its increase crop production as well as income of farmer's. Farmers were interested to cultivate Binasarisha-10.

Up-scaling BINA developed salt tolerant variety Binadhan-10 in Satkhira region

During Boro season of 2017-18, 120 demonstration with Binadhan-10 were conducted at the farmer's fields in Satkhira and Khulna region. The main objectives were to demonstrate the yield performance of the variety and widening it's adoption by the farmers. Area of demonstration plots was 33 decimals. Spacing between line-to-line and plant-to-plant was 20 cm and 15 cm. All fertilizers were applied as per recommendation. Transplanting dates ranged from 19 January to 29 January 2018, and age of seedlings was 35 to 40 days. The farmers managed all the production practices as per recommendation. Data of demonstration plots are presented in Table 7.

Table 7: Performance of Binadhan-10 in Satkhira region during 2017-18

Upazila	No. of demonstration	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binadhan-10	BRRI dhan-61 (check)	Binadhan-10	BRRI dhan-61(check)	
Satkhira Sadar	44	128	141	5.6	5.2	7.69
Shyamnogor	49	127	141	5.5	5.3	3.77
Koyra	20	127	140	6.0	5.1	17.65
Asasuni	04	128	143	5.8	5.3	9.43
Tala	03	130	145	6.0	5.5	9.09
Total	**120**		**143**			
Mean		**128**	**142**	**5.78**	**5.28**	**9.53**

Data in Table 7 reveal that Binadhan-10 produced average yields of 5.78 t ha^{-1} which was 9.5 percent higher compared to check variety BRRI dhan-61. Average maturity period of Binadhan-10 was 128 days. The check variety BRRI dhan-61 produced average grain yield of 5.28 t ha^{-1} with average maturity period of 142 days. Therefore, the variety of BINA, Binadhan-10. Farmers were found interested to cultivate Binadhan-10 in Satkhira and Khulna region because of its higher yield and increased income.

Up-scaling BINA developed high yielding late Boro variety Binadhan-14 in Satkhira region

During Boro season of 2017-18, 08 demonstrations with Binadhan-14 were conducted at the farmer's fields in Satkhira region. The main objectives were to demonstrate the yield performance of the variety and widening it's adoption by the farmers. Area of demonstration plots was 33 decimals. Spacing between line-to-line and plant to plant was 20 cm and 15 cm. All fertilizers were applied as per recommendation. Transplanting dates ranged from 19 February to 29 February 2018, and age of seedlings was 35 to 40 days. The farmers managed all the production practices as per recommendation. Data of demonstration plots are presented in Table 8

Table 8: Performance of Binadhan-14 in Satkhira region during 2017-18

Upazila	No. of dem.	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binadhan-14	BRRI dhan-28 (check)	Binadhan-14	BRRI dhan-28 (check)	
Kolaroa	4	128	136	6.60	6.0	10
Sadar	4	130	138	6.40	5.9	8.47
Total	**8**					
Mean		**129**	**137**	**6.50**	**6.15**	**9.24**

Data in Table 8 reveal that Binadhan-14 produced average grain yield of 6.50 t ha^{-1}, which was 9.24 percent higher compared to check variety. Average maturity period of Binadhan-14 was 129 days). Farmers were found interested to cultivate Binadhan-14 as a late Boro variety in Satkhira region.

Up-scaling BINA developed high yielding and short durative mungbean variety in Satkhira region

During the Rabi season of 2017-18, total 10 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 2018 at the rate of 30 kg ha^{-1}. The check variety was BARI mug-6. All fertilizers were applied as per recommendation in the demonstration plots. Pesticides were sprayed as and when necessary to control insects and pests. Data were recorded on crop duration and seed yield. The results are presented in Table 9.

Table 9: Performance of Binamoog-8 compared to popular cultivar in Satkhira region during 2017-18

Upazila	No. of demo	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binamoog-8	BARI mung-6	Binamoog-8	BARI mug-6	
Satkhira sadar	06	67	60	1.6	1.5	6.67
Tala	03	68	62	1.5	1.45	3.45
Kolaroya	01	66	61	1.5	1.45	3.45
Total	**10**					
Mean		**67**	**61**	**1.53**	**1.47**	**4.52**

Data in Table 9 reveal that BINAmoog-8 produced average grain yield of 1.53 t ha^{-1}, which was 4.52 percent higher compared to check variety. Average maturity period of Binamoog-8 was 67 days. Farmers were found interested to cultivate BINAmoog-8 as a summer moog variety 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 sub-station, Satkhira. Results of overall promotional activities related to BINA-Technology village establishment at Nogorghata Union are presented below.

Table 10: Performance of BINA developed varieties at Nogorghata union during 2017-18

Sl. No	Crops	Variety Name	Demonstration No.	Duration in days	Yield (t ha^{-1})
1.	Rice	Binadhan-10	5	131	5.50
		Binadhan-14	3	125	6.50
		Binadhan-7	3	115	4.60
		Binadhan-16	3	100	4.79
		Binadhan-17	5	113	6.20
2.	Mustard	Binasarisha-4	3	83	1.65
		Binasarisha-9	5	79	1.62
		Binasarisha-10	4	76	1.5
3.	Mungbean	Binamoog-8	3	66	1.53

Nogorghata Union in satkhira district is very suitable area for growing rice, oilseeds, pulse and vegetables. Results indicated that Binadhan-14 produced higher grain yield with moderate crop duration (Table 10).Transplanted aman varieties Binadhan-17, Binadhan-11, Binadhan-7 & Binadhan-16 produced higher grain yield than check. Farmers had been interested to cultivate BINA developed aman rice varieties in aman season for their high yield, short crop duration and getting varietals diversification. Mustard variety, Binasarisha-4, Binasarisha-9 and Binasarisha-10 showed immense potentials in terms of yield and duration for cultivation in between aman and boro rice. Binamoog-8 also produced higher grain yield than check. BINA technology village Establishment in Nogorghata union is in progress.

Production of quality seed of BINA released crop varieties popular in Satkhira region

Seeds of BINA released crop varieties popular in Satkhira 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 2017-18. Seed production activities, locations, crop varieties and areas during the reporting period were shown in (Table 4). In case of farmer's fields, partial inputs 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. Among them rice were about 6.92 tons, mustard 0.95 ton.

Table 11. Seeds produced/purchased, distributed/sold & stored during 2017-18

Crop	Varieties	Total seeds produced /purchased (ton)	Total distributed/sold (ton)
Rice	**Aman**		
	Binadhan-17	0.42	0.42
	Boro		
	Binadhan-10	6.5	6.5
	Sub-total	**6.92**	**6.92**
Mustard	Binasarisa-4	0.733	0.30
	Binasarisa-9	0.045	0.20
	Binasarisha-10	0.172	
	Sub-total	**0.95**	**0.95**

Training on the use of BINA developed technologies

In order to transfer BINA developed technologies a training of one day was arranged at BINA sub-station, Satkhira. The participants were farmers (both male and female) and Sub-assistant Agriculture Officer. Details of the training are presented in Table 12.

Table 12. Farmers Training on the use of BINA developed technologies during 2017-18

S.L No	Topic of training	Place of Training	No. of participants	Source of fund
11.	Introduction of BINA developed crop varieties and production technology in saline prone areas	BINA sub-station, Satkhira	50	SRSD
12.	Processing and storage techniques of rice, mustard, mung and chinabadam.	BINA sub-station, Satkhira	70	SRSD
13.	Effects of chemicals used in food on human health and preventive measures	BINA sub-station, Satkhira	50	Poribotita Awbhawa project

Field Day

In order to motivate the farmers to adopt BINA developed varieties/technologies, five field days on different crop varieties were organized in Satkhira region. Details of the field day activities are presented in Table 13.

Table 13. Field days arranged at the farmers fields on different crop varieties during 2016-17

Sl. No.	Crops	Varieties	Locations	Participants
12.	Rice	Binadhan-10	Komorpur, sadar, Satkhira	160
			Ashasuni, Satkhira	140
			Kalmegha, shyamnogor, Satkhira	150
			Botulpur, koyra, Khulna	140

BINA Sub-station, Nalitabari

Research Highlights

Rice

Three hundred and fifty M_3 mutant lines have been selected from M_2 bulk population of irradiated indigenous local aromatic rice Tulsimala for higher yield, short duration and disease tolerant. Again M_1 populations were recurrent irradiated for better yield, short duration and disease tolerance. Binadhan-14 was crossed for free from shattering problem in Boro season.
Papaya

Fifteen local and hermaphorodite papaya germplasm were collected for evaluation of field performance in relation to yield, early fruit bearing, pest and disease tolerance and postharvest quality.

Technology Transfer

A total no of 85 demonstrations were conducted of Binadhan-11, Binadhan-16, Binadhan-17 and check with BRRI dhan 49 in T. Amon season. Result showed than higher yield (5.75 t ha^{-1}) of Binadhan-17 and short duration (105 days) of Binadhan-16 than the check variety BRRI dhan 49 (5.10 t ha^{-1} with 135 days) respectively. A total of 35 demonstration were conducted of Binasarisha-4, Binasarisha-9 and Binasarisha-10 and check with BARI sarisha-14 in winter season and result showed that produced higher yield (1.90 t ha^{-1}) of Binasarisha-9 and short duration (78 days) of Binasarisha-10 than the check BARI sarisha-14 (1.60 tha^{-1} with 82 days) respectively. A total of 6 demonstration were conducted of Binadhan-10 with check variety BR-26 and result showed that highest yield and short duration (6.5 tha^{-1} and 127 days) of Binadhan-10 than the check BR26 (5.7 tha^{-1} and 135 days) respectively. Seven demonstrations were conducted of Binachinabadam-4 and produced average yield (2.2 tha^{-1}) compared to check variety Dhaka-1. A total of 75 demonstrations were conducted of Binadhan-19 with check variety BR26 in Aus season. A profitable three crop based cropping pattern (Aman-Sarisha-Boro) where developed by BINA released varieties in Nalitabari, Sherpur.

Screening of mutant (M_2 population) of local rice Tulsimala

A large number of M_3 mutant were developed from from M_2 bulk population of irradiated (150, 200, 250, 300 and 350 Gy) indigenous local aromatic rice Tulsimala. The M_2 bulk populations were grown in plant-progeny-rows for selecting desirable mutants at BINA substation, Nalitabari farm on 30, July, 2017. Recommended doses fertilizer (less urea), cultural and intercultural operations were followed. A total of 350 desired M_3 mutants were selected on the basis of duration, yield and disease tolerant during the period.

Recurrent irradiation to M_1 seeds of Tulsimala for developing M_1R_1 population

With a view to create variability for maturity period, yield, disease and insect reaction recurrent irradiation of M_1 bulk seeds were irradiated with different doses of Gamma ray (150+150, 200+200, 250+250, 300+300 and 350+350 Gy). The irradiated seeds were sown at BINA substation, Nalitabari farm on 01 August, 2017 following non replicated design. Germination percentages were found to be the best (with varieties received irradiation) in higher doses line 300+300 and 350 +350 Gy (Table 1). 2018. Recommended doses fertilizer (less urea), cultural and intercultural operations were followed where necessary. At maturity, the panicle of the survive plants were collected and kept separately. These doses also exerted variation in terms of seed colour, plant height, unfilled grain and duration. Finally, M_1 seeds were harvested and kept separately to grow M_2 generation in next Aman season (2018).

Table 1: Effect of different recurrent doses of Co^{60} on germination and plant survival in i Tushimala rice cultivars.

Doses of radiation (Gy)	Germination (%)	Plant Survival (%)
0	90	85.5
150 +150	85	80.7
200+200	80	72.0
250 +250	75	71.3
300 +300	88	82.0
350 +350	86	80.9

Development of short duration high yielding Boro rice through hybridization techniques

A hybridization program was initiated with view to transfer non shattering, short duration high yielding fine grain rice from Binadhan-7, BRRI Dhan28 and BRRI Dhan29 with Binadhan-14. A total number of F_1 seeds were harvested from the cross combination Binadhan-14×BRRI Dhan28, Binadhan-14×BRRI Dhan29, Binadhan-14×Binadhan-7 and Binadhan-07×BRRI Dhan28, Binadhan-7×BRRI Dhan29. The collected seeds were gave the No of F_1-seeds back crosses for production of BC_1F_1 next year.

Evaluation of papaya germplasm and Varietal Improvement of Papaya using Induced mutation techniques

To select best papaya germplasm based on yield, early fruit bearing, pest and disease tolerance and postharvest quality 15 local and hermaphorodite papaya germplasms were collected from the differint districts of Mymensingh, Rajshahi and Sylhet division during the period (September 2017 to March 2018). The seed will sown in month of September 2018.

Technology Transfer

Block demonstration with different BINA released crop varieties in Sherpur Districts

In order to establish BINA Technology village demonstrations and other extension work were done at the farmer's fields in surrounding area of BINA-substation, Nalitabari. Results of overall promotional activities related to BINA-Technology village establishment at Kakorkandi, Noyabil, Rajnagor, Poragau and Rupnarayonkura Union in Nalitabari Upazilla in Sherpur district are given below.

Rice

Aman

During T.aman season of 2017-18, 85 demonstrations with Binadhan-11, Binadhan-16 and Binadhan-17 were conducted at the farmer's fields in Sherpur region. The main objectives were to demonstrate the yield performance of these varieties and widening their adoption by the farmers. The plots size was 33 decimals. 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 2017 and age of seedlings was 20 to 24 days. The farmers managed all the production practices as per recommendation. Based on the available information, data of demonstration plots are presented in Table 2.

Table 2: Performance of Binadhan-11, Binadhan-16 and Binadhan-17 in Sherpur region during 2017-18

Name of the Upazila	Name of the Variety	No. of Demons tration	Date of transplant Ting	Duration (days)		Yield (t ha^{-1})	
				Different varieties	BRRI dhan49 (check)	Treatment	BRRI dhan49 (check)
Nalitabari	Binadhan-11	35	31/07/17	118	135	5.22	5.09
	Binadhan-16	04	25/07/17	105	133	4.25	5.10
	Binadhan-17	15	31/07/17	122	136	5.75	5.11
Nakla	Binadhan-11	20	27/07/17	118	135	5.21	5.10
	Binadhan-16	02	22/07/17	104	134	4.25	5.09
	Binadhan-17	09	31/07/17	123	135	5.65	5.11
Total		**85**					

Data in Table 2 revealed that the total of 85 demonstrations with short duration T. aman rice Binadhan-11, Binadhan-16 and Binadhan-17 produced average grain yields of 5.2 t ha^{-1}, 4.25t ha^{-1} and 5.75 t ha^{-1} respectively. Average maturity period of Binadahn-11 was 118 days, Binadhan-16 was 105 days and Binadhan-17 was 122 days. One of the mostly popular cultivars was used as a check, BRRI dhan49. BRRI dhan49 was produced average gain yield of 5.10 with maturity period of 135 days. Result showed that BINA released variety increased crop productions, income of farmer's and cropping intensity and farmers are interested to cultivate BINA released variety like Binadhan-11, Binadhan-16 and Binadhan-17.

Boro

During Boro season of 2017-18, six demonstrations with Binadhan-10 were conducted at the farmer's fields in Sherpur district. The main objectives were to demonstrate the yield performance of the variety and widening its adoption by the farmers. Area of demonstration plots was 33 decimals. Spacing between line to line and plant to plant was 20 cm × 15 cm. All fertilizers were applied as per recommendation. Transplanting dates ranged from 22 January 2017, and age of seedlings was 30 to 35 days. The farmers managed all the production practices as per recommendation. Based on the available reports, data of demonstration plots are presented in Table 3.

Table 3: Performance of Binadhan-10 in Sherpur region during 2017-18

Name of the Upazila	Name of the Variety	No. of demons tration	Date of transplant Ting	Duration (days)		Yield (t ha^{-1})	
				Treatment	BR-26 (check)	Check	BR-6 (check)
Nalitabari (Rupnarayonkura Union)	Binadhan-10	06	22/01/18	127	135	6.5	5.7
Total		**06**					

Data reveal that, a total of six demonstrations with salt tolerant Boro rice Binadhan-10 which produced higher yield 6.5 tha^{-1} with less maturity 127 days than check varieties of BR26 with yield 5.7 tha^{-1} and maturity period 135 days respectively .Therefore the variety of Binadhan-10 increased crop production as well as farmer's income. Farmers were found interested to cultivate Binadhan-10 in Sherpur district.

Aus

During Aus season of 2017-18, seventy demonstrations with Binadhan-19 were conducted at the farmer's fields in Sherpur district. The main objectives were to demonstrate the yield performance of the variety and widening its adoption by the farmers. Area of demonstration plots was 33 decimals. Spacing between line to line and plant to plant was 20 cm × 15 cm. All fertilizers were applied as per recommendation. Transplanting dates ranged from 22 January 2018, and age of seedlings was 30 to 35 days. The farmers managed all the production practices as per recommendation. Based on the available reports, data of demonstration plots are presented in Table 4

Table 4: Performance of Binadhan-19, in Sherpur region during 2017-18

Name of the Upazila	Name of the Variety	No. of Demons tration	Date of transplant ting	Duration (days)		Yield (t ha^{-1})	
				check	BR26	check	BR-26
Nalitabari(Nalitabari, Kakorkandi, Noyabil, Rajnagor, Poragau, Pourosava, Rupnarayonkura Union)	Binadhan-19	37	16/04/18 To 30/04/18	98	108	5.0	4.4
Sadar (Ghinapara, Chorvabna, Daripara, Lochompur)	Binadhan-19	18	18/04/18 To 30/04/18	104	112	4.5	4.0
Nakla(Kursha, Talki, Baneshordi, Gourdar, Paisha,Ufra Union)	Binadhan-19	15	01/05/18 To 15/05/18	-	-	-	-
Total				**101**	**110**	**4.75**	**4.2**

Data in Table 4 showed that a total of 70 demonstrations with Binadhan-19 produced average grain yields of 4.75 t ha^{-1} and average maturity period of Binadahn-19 was 101 days. Check variety BR26 produced average gain yield of 4.2 t ha^{-1} with average maturity period of 110 days. Farmers` easily can grow four crops in their field. Therefore the variety of BINA, Binadhan-19 increased crop production as well as farmer's income. Farmers were found interested to cultivate Binadhan-19 in Sherpur district.

Mustard

During the Rabi season of 2017-18, a total of 35 demonstrations were conducted with Binasarisha-4, Binasarisha-9 and Binasarisha-10 in Sherpur district. The main objectives were to demonstrate the performance of Binasarisha-4, Binasarisha-9 and Binasarisha-10 as well as widening their adoption by the farmers. Area of demonstration plots was 100 decimals or one acres. Seeds were sown during October to November 2017 at the rate of 7.5 kg ha^{-1}. The check variety was BARI sarisha-14. Fertilizers were applied as per recommendation and 1-2 irrigation was applied in the demonstration plots. Pesticides were sprayed when necessary to control insects and pests. Data were recorded on crop duration and seed yield. The results are presented in Table 5.

Table 5: Performance of Binasarisha-4, Binasarisha-9 and Binasarisha-10 compared to popular cultivar in Sherpur region during 2017-18

Name of the Upazila	Name of the Variety	No. of Demons tration	Date of seed sowing	Duration (days)		Yield (t ha^{-1})	
				Tested variety	BARI Sarisha-14 (Check)	Tested variety	BARI Sarisha-14 (Check)
Nalitabari	Binasarisha-4	03	25/10/17	87	82	1.9	1.7
	Binasarisha-9	12	27/10/17	82	83	1.7	1.5
	Binasarisha-10	08	25/10/17	78	81	1.5	1.6
Nakla	Binasarisha-4	01	01/11/17	90	85	1.9	1.5
	Binasarisha-9	06	27/10/17	85	84	1.7	1.7
	Binasarisha-10	07	25/10/17	76	83	1.5	1.6
Total		**85**					

Data in Table 5 reveal that a total 35 demonstrations with short duration high yielding Binasarisha-4, Binasarisha-9 and Binasarisha-10 which produced average yields 1.90 tha^{-1}, 1.7 t ha^{-1} and 1.5 t ha^{-1} respectively whereas the check variety of BARI Sarisha-14 given 1.60 tha^{-1} . Average maturity period of Binasarisha-10 was 78 days, Binasarisha-09 was 82 days and Binasarisha-4 was 87 days with less maturity period in most of the time Binasarisha-10 and Binasarisha-09 than check variety of BARI sarisha-14 with average maturity period of 82 days. Therefore farmers were interested to cultivate Binasarisha-9.

Groundnut

During Rabi of 2017-18, seven demonstrations were conducted with Binachinabadam-4 in Sherpur region. The check variety was Dhaka-1.The main objectives were to demonstrate the performance of Binachinabadam-4 and widening their adoption by the farmers. Area of demonstration plots was 33 decimals or one bigha. Seeds were sown during 01 February to 09 February 2018 at the rate of seed 120 kg ha^{-1}. Fertilizers were applied as per recommendation and pesticides were sprayed as when necessary to control pests. Data were recorded on crop duration and grain yield. The results are presented in Table 6

Table 6: Performance of Binachinabadam-4 in Sherpur district during 2017-18

Name of the Upazila	Name of the Variety	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binachina badam-4	Dacca-1 (check)	Binachina badam-4	Dakcca-1 (check)	
Nalitabari (Uttar nakshi, Koloshpar)	5	130	135	2.20	1.6	46.67
Nokla (Chorvabna, Chondokona)	2	128	132	2.20	1.5	44.83
Total	**10**					
Mean		**129**	**133.5**	**2.20**	**1.55**	**46.59**

Data in Table 6 reveal, that Binachinabadam-4 produced average seed yields of 2.2 t ha^{-1} which higher 46.59 percent compared to check variety Dacca-1. Average maturity period of Binachinabadam-4 was 129 days and check variety Dacca-1 produced average gain yield of 1.55 t ha^{-1} with average maturity period of 133.5 days. Therefore the variety of BINA, Binachinabadam-4 increased crop production as well as farmer's income. Farmers were found interested to cultivate Binachinabadam-4 in Sherpur district.

Profitable cropping pattern by BINA released varieties in Sherpur district.

Rice based pattern are in Sherpur district mostly Indigenous rice (75% local rice like as Tulsimala, chinishail and paijam)- Fallow- Boro rice (mainly Hybrid) (75 % land Covered). To increase the cropping intensity and change the cropping pattern for improvement the socio-economic condition of the Sherpur farmers' BINA substation Nalitabari worked specific advantages of crop varieties to the farmers adaptation at large scale and include BINA technologies in the existing cropping pattern as T aman (Binadhan-11) --Rabi (Bina sarisha 9) –Boro (BRRI Dhan28) during 2017-18 at Ratkuchi, Noyabil Union, Naliatabari, Sherpur. This experiment continued for last year. It has been observed that this cropping pattern is being rapidly disseminated among the local growers. Profit can be shown in the table 6 in the last two year.

Table-7: **Yield of different rice based cropping system in Ratkuchi, Noyabil Union, Naliatabari, Sherpur in 2016-2017**

Cropping patterns	Yield of crops (kg/ha)		
	T. Aman	Rabi	Boro
		2016-17	
T. aman (Tulsimala)-Fallow-Boro	2900	-	6600
T. aman (Binadhan-11)- Rabi (Binasharisha-9) – Boro (BRRI Dhan28)	5000	1500	6600
		2017-18	
T. aman (Tulsimala)-Fallow-Boro	3000	-	6500
T. aman (Binadhan-11)- Rabi (Binasharisha-9) – Boro (BRRI Dhan28)	5200	1600	6400

Data in Table7 reveal, that T. aman (Tulsimala)-Fallow-Boro in 2016-2017 aman season 2.9 t ha^{-1} and boro rice 6.5 t ha^{-1} again the profitable pattern T. aman (Binadhan-11)- Rabi (Binasharisha-9) – Boro (BRRI Dhan28) in T.aman season given 5 tha^{-1} rabi sharisha 1.5 tha^{-1} and boro rice 6.6 tha^{-1}. Again 2017-18 T. aman season 3.0 t ha^{-1} and boro rice 6.5 t ha^{-1} again the profitable pattern T. aman (Binadhan-11)- Rabi (Binasharisha-9) – Boro (BRRI Dhan28) in aman season given 5.20 tha^{-1} , rabi sharisha 1.6 tha^{-1} and boro rice 6.4 tha^{-1}. For the above result farmers has been observed that this cropping pattern is being rapidly disseminated among the local growers.

Production of quality seed of BINA released crop varieties popular in Sherpur district

Seeds of BINA released crop varieties popular in Sherpur district 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 2017-18. Seed production activities, locations, crop varieties and areas during the reporting period were shown in (Table 7). In case of farmer's fields, partial inputs subsidies and free seeds or only free seeds were provided. The results are presented in Table 8

Table 8. Seeds produced/purchased, distributed/sold & stored during 2017-18

Crop	Varieties	Total seeds purchased (ton)	Total production /sold (ton)	Seeds stored (ton)	Remarks
Rice	**T .aman**				
	Binadhan-7		0.50 + 0.50	-	
	Binadhan-11	0.35	0.25+0.25		
	Binadhan-12		0.10		
	Binadhan-15		0.10		
	Binadhan-16		0.15+0.15	-	
	Binadhan-17	0.75	0.25+0.25	-	
	Boro				
	Binadhan-8		0..25+0.15		
	Binadhan-10		0.30+0.30	-	
	Aus				
	Binadhan-19	-	-		
	Sub-total	**1.0**	**3.50**	**-**	
Mustard	Binasarisa-4	0.6	0.20	-	
	Binasarisa-9	0.7	0.30	-	
	Binasarisa-10	0.7	0.15		
	Sub-total	**2.0**	**0..65**	**-**	
Groundnut	Binachinabadam-4	0.5	-	-	
	Total	**3.5**	**4.15**		

Training on the use of BINA developed technologies

In order to transfer BINA developed technologies a one training programme was arranged at BINA Substation, Sherpur. The participants were farmers (both male and female) and Sub-assistant Agriculture Officer (SAAO). Details of the training are presented in Table 9.

Table 9. Farmers Training on the use of BINA developed technologies during 2017-18

S.L No	Topic of training	Place of Training	No. of participants	Source of fund
1.	Introduction of extension able of BINA developed crop varieties, production technology & development of cropping pattern	BINA substation, Nalitabari, Sherpur	75	Nutrition project
2.	Production of BINA developed crop varieties around the season & suitability of cropping pattern development.	BINA substation, Nalitabari, Sherpur	50	SRSD
3.	Insecticidal effect and intregated vegetable production	BINA substation, Nalitabari, Sherpur	100	Poribotita Awbhawa project
4.	Insecticidal effect and intregated vegetable production	DD office, Sherpur	100	Poribotita Awbhawa project
5.	Introduction & Production of BINA developed high yielding aman rice varieties	BINA substation, Sunamganj	90	Poribotita Awbhawa project

Field Day

In order to motivate the farmers to adopt BINA developed varieties/technologies, Five field days on different crop varieties were organized in Sherpur district. Details of the field day activities are presented in Table 6.

Table 10 . Field days arranged at the farmers fields on different crop varieties during 2016-17

Sl. No.	Crops	Varieties	Locations and fund	Participants
1.	Rice	Binadhan-11	Rosaitola, Kakorkandi, Nalitabari, Sherpur. **CCTF**	150
		Binadhan-11	Poshchim chatgau, Rajnagor, Nalitabari, Sherpur. **CCTF**	150
2.	Mustard	Binasarisha-9	Kodomtoli Bazar, Rupnarayonkura, Nalitabari, Sherpur. **Revenue fund**	200
		Binasarisha-10	Koshpar, Nalitabari, Sherpur. **Pusti…..kormosuchi**	150
		Binasarisha-10	Balugata bazar, Nalitabari, Sherpur. **Pusti…..kormosuchi**	150

BINA Sub-station, Sunamganj

Research Highlights

A total of 10 demonstrations with Binachinabadam-4 showed that Binachinabadam-4 produced better yield (46.59% yield increased) with less maturity period than check varieties of Dacca-1.

Transplanting time of Binadhan-17 showed that yield of July 31 transplanting gave the highest yield (6.50 t ha^{-1}) and August10 gave second highest yield (6.30 t ha^{-1}). The mean yield of Binadhan-17 was 6.33 *t ha^{-1}* which differs statistically from BRRI dhan49 (4.63 t ha^{-1}).

Up-scaling BINA developed Binachinabadam-4 in Sunamganj region

During Kharif-1 of 2017-18, 10 demonstrations were conducted with Binachinabadam-4 in Sunamganj region. The check variety was Dacca-1.The main objectives were to demonstrate the performance of Binachinabadam-4 and widening their adoption by the farmers. Area of demonstration plots was 33 decimals. Seeds were sown during mid January to February 2017 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: Performance of Binachinabadam-4 in Sunamganj region during 2017-18

Upazila	No. of demonstration	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binachinabadam-4	Dacca-1 (check)	Binachinabadam-4	Dacca-1 (check)	
Sunamganj Sadar	4	118	121	2.20	1.50	46.67
Bishsambarpur	3	117	120	2.10	1.45	44.83
Tahirpur	3	119	122	2.15	1.45	48.28
Total	**10**					
Mean		**118**	**121**	**2.15**	**1.47**	**46.59**

Results in Table 1 revealed that Binachinabadam-4 produced average seed yields of 2.15 t ha^{-1} which 46.59 percent higher as compared to check variety Dacca-1. Average maturity period of Binachinabadam-4 was 118 days. The check variety Dacca-1 produced average grain yield of 1.47 t ha^{-1} with average maturity period of 121 days. Therefore the variety of BINA, Binachinabadam-4 increased crop production as well as farmer’s income. Farmers were interested to cultivate Binachinabadam-4 in Sunamganj region.

Effect of different time of transplanting on performance of T. Aman rice Binadhan-17 in Sunamganj region

During aman season of 2017-18, 9 demonstrations with Binadhan-17 were conducted at the farmer’s field in Sunamganj region. A popular cultivar BRRI dhan49 was used as the check. The main objective was to observe how the yield performance of Binadhan-17 was affected by different transplanting time. Three different transplanting time were July 31, August 10 and August 20 and age of seedlings ware 22 to 25 days. Area of demonstration plots was 33 decimals. Spacing between line to line and plant to plant was 20 cm and 15 cm. All fertilizers were applied as per recommendation. The farmers managed all the production practices as per recommendation. Data of demonstration plots are presented in Table 2.

Table 2: Performance of Binadhan-17 in Sunamganj region during 2017-18

Upazila	No. of demonstration	Date of transplanting	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
			Binadhan-17	BRRI dhan49 (check)	Binadhan-17	BRRI dhan49 (check)	
Sunamganj Sadar Bishsambarpur Tahirpur	3	31/07/17	110	132	6.50	4.80	35.42
Sunamganj Sadar Bishsambarpur Tahirpur	3	10/08/17	112	133	6.30	4.70	34.04
Sunamganj Sadar Bishsambarpur Tahirpur	3	20/08/17	114	136	6.20	4.40	40.91
Total	**9**						
Mean			**112**	**134**	**6.33**	**4.63**	**36.79**

Data in Table 2 revealed that Binadhan-17 produced average grain yield of 6.33t ha^{-1}, which was 36.79 percent higher compared to check variety. Average maturity period of Binadhan-17 was 116 days. Transplanting time of Binadhan-17 showed that yield of July 31 transplanting gave the highest yield (6.50 tha^{-1}) and August10 gave second highest yield (6.30 t ha^{-1}). The mean yield of Binadhan-17 was 6.33 t ha^{-1} which differs statistically from that of BRRI dhan49 (4.63 t ha^{-1}). Therefore Binadhan-17 increased crop production as well as farmer's income. Farmers were interested to cultivate Binadhan-17 as a late aman variety in Sunamganj region.

Establishment of BINA Technology village in surrounding area of BINA Sub-station, Sunamganj

In order to establish BINA-Technology village, demonstrations and other extension work were done in surrounding area of BINA sub-station, Sunamganj. Results of overall promotional activities related to BINA-Technology village establishment at Surma Union are presented below.

Table 3: Performance of BINA developed varieties at Surma Union during 2017-18

Sl. No	Crops	Variety Name	Demonstration No.	Duration in days	Yield (t ha^{-1})
1.	Rice	Binadhan-5	5	152	5.60
		Binadhan-10	5	141	5.50
		Binadhan-14	5	125	5.00
		Binadhan-7	5	116	4.60
		Binadhan-11	10	117	5.00
		Binadhan-16	5	100	4.50
		Binadhan-17	10	112	6.50
2.	Mustard	Binasarisha-4	10	83	1.70
		Binasarisha-9	10	76	1.60

3.	Groundnut	Binachinabadam-4	5	118	2.10
4.	Mungbean	Binamoog-8	5	64	1.90

Surma Union in Sunamganj district is very suitable area for growing rice, oilseeds, pulse and vegetables. Results indicated that Binadhan-5 produced higher grain yield with moderate crop duration (Table 3).Transplanted aman varieties Binadhan-17, Binadhan-11, Binadhan-7 & Binadhan-16 produced higher grain yield than check. Farmers had been interested to cultivate BINA developed aman rice varieties in aman season for their high yield, short duration and getting varietal diversification. Binasarisha-4 & Binasarisha-9 showed immense potentials in terms of yield and duration for cultivation in between aman and boro rice. Binachinabadam-4 and Binamoog-8 also produced higher grain yield than check. BINA technology village establishment in Surma Union is in progress.

Production of quality seed of BINA released crop varieties popular in Sunamganj region

Seeds of BINA released crop varieties popular in Sunamganj 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 2017-18. Seed production activities, locations, crop varieties and areas during the reporting period were shown in (Table 4). In case of farmer's fields, partial inputs subsidies and free seeds or only free seeds were provided. During the reporting period a total of 3.25 tons seeds of different crop varieties of BINA were produced and procured. Among them rice were about 2.50 tons, mustard 0.5 ton, Groundnut 0.25 ton.

Table 4. Seeds produced/purchased, distributed/sold & stored during 2017-18

Crop	Varieties	Total seeds produced /purchased (ton)	Totaldistributed/sold (ton)
Rice	**Aman**		
	Binadhan-11	0.50	0.50
	Binadhan-16	0.50	0.50
	Binadhan-17	0.50	0.50
	Boro		
	Binadhan-5	0.80	0.80
	Binadhan-10	0.20	8.00
	Sub-total	**2.50**	**2.50**
Mustard	Binasarisa-4	0.30	0.30
	Binasarisa-9	0.20	0.20
	Sub-total	**0.50**	**0.50**
Groundnut	Binachinabadam-4	0.25	0.25
	Total	**3.25**	**3.25**

Training on the use of BINA developed technologies

In order to transfer BINA developed technologies, a training day-long was arranged at BINA Sub-station, Sunamganj. The participants were farmers (both male and female) and Sub-assistant Agriculture Officer. Details of the training are presented in Table 5.

Table 5. Farmers Training on the use of BINA developed technologies during 2017-18

S.L No	Topic of training	Place of Training	No. of participants	Source of fund
14.	Introduction of extensionable of BINA developed crop varieties, production technology & development of cropping pattern	BINA sub-station, Sunamganj	60	Nutrition project
15.	Production of BINA developed crop varieties around the season & suitability of cropping pattern development.	BINA sub-station, Sunamganj	50	SRSD
16.	Production & extension of BINA developed crop varieties in haor area.	BINA sub-station, Sunamganj	50	SRSD
17.	Introduction & production of BINA developed high yielding aman rice varieties	BINA sub-station, Sunamganj	75	CCTF
18.	Introduction & production of BINA developed high yielding aman rice varieties	BINA sub-station, Sunamganj	75	Poribotita Awbhaw a project

Field Day

In order to motivate the farmers to adopt BINA developed varieties/technologies, 5 field days on different crop varieties were organized in Sunamganj region. Details of the field day activities are presented in Table 6.

Table 6. Field days arranged at the farmers fields on different crop varieties during 2017-18

Sl. No.	Crops	Varieties	Locations	Participants
13.	Rice	Binadhan-17	Noabon, Dhormopasha, Sunamganj	140
		Binadhan-17	Berigaw, Surma, Sunamganj	140
14.	Groundnut	Binachinabadam-4	Palash, Bisshomvorpur, Sunamganj	140
15.	Mustard	Binasarisha-4	Fenarbak, Jamalganj, Sunamganj	140
		Binasarisha-9	Fenarbak, Jamalganj, Sunamganj	140

BINA Sub-station, Jamalpur

Research Highlights

A pot experiment was conducted to investigate the effects of single and combined application of compost and compost tea on yield and quality of tomato. It was observed that combination of compost tea (100% conc) and compost (5 t/ha) gave highest fruit yield (1.03 kg pot^{-1}) of tomato.

A field experiment was carried out to reveal the effects of different soil amendments, nitrogen level and irrigation on the growth, N uptake and yield of Wheat.It was found that grain yield of wheat was increased with increasing application of N, irrigation water and soil amendments. The combined application of irrigation 3 times at 21, 55 and 80 days and soil amendments potassium@90kg/ha + Gypsum@ 100 kg/ha + FYM@ 5 t/ha may be considered as the best among the treatments to grow wheat.

An experiment was conducted at Jamalpur during 2017-18 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 and gave the highest profitability by giving highest gross margin and BCR.

A total of 135 demonstrations (33 decimal/demonstration) were conducted in Jamalpur during the year 2017-18.

A total number of 11,973 kg seed including breeder and truthfully labeled seed (TLS) was produced during 2017-18.

During the year 2017-18 seven training and 5 field day programs were organized whereas 460 farmers and 57 Sub Assistant Agriculture Officers (SAAO) were trained.

Effects of single and combined application of compost and compost tea on yield and quality of tomato

Use of organic amendments is an effective tool to enhance soil fertility and increase crop yields. Composting has been recognized as a low cost and environmentally sound process for treatment of many organic wastes. Compost tea is a concentrated organic liquid fertilizer that is made from steeping biologically active compost in aerated water. Compost tea is nutritionally rich and can help to provide plants with beneficial soil bacteria.The present study was carried out to evaluate the effect of single and combined application of compost and compost tea on yield and quality of tomato.

The pot experiment was conducted at BINA Substation farm, Jamalpur during the period from November 2017 to April 2018. Pots were filled with soil and compost was added to the pot according to treatment. Tomato seedlings were hand-transplanted to the irrigated pot on 14 December 2017. Three seedlings were planted in each pot. After seedling establishment 1 seedling was uprooted to keep 2 plant in eachpot. Intercultural operations were done as necessity. Seven treatments were considered in this experiment which are T_1: Control, T_2: Fungicide (Ridomil gold), T_3: Compost (5 t/ha), T_4: Compost tea (50% concentration), T_5: Compost (5 t/ha) + Compost tea (50% concentration), T_6: Compost tea (100% concentration) and T_7: Compost (5t/ha) + Compost tea (100% concentration). The experiment was laid out in a Randomized Complete Block

Design (RCBD) with three replications.Data on plant height (cm), number of fruits per plant (no./plant) and yield per plant (g/plant) were recorded after harvesting of the fruits.The collected data on various parameters were statistically analyzed using Statistix10 and the significance was tested by ANOVA.

Fruits per plant is one of the most important yield contributing characters in all fruits and as well as tomato. The treatments differed for fruit per plant. Statistically significant differences were found among all the treatment than control. Though no significant differences were observed among the treatment from T_2 to T_7, but all the treatments showed significantly higher yield than control. Fruits number was found higher in T_7: Compost (5t/ha) + Compost tea (100% conc.) following T_2: Fungicide (Ridomil gold), T_6: Compost tea (100% conc.) and T_5: Compost (5 t/ha) + Compost tea (50% conc.) (Table 1).

Table 1: Effects of single and combined application of compost and compost tea on yield of tomato

Treatment	Plant height (cm)	Fruits (no./pot)	Fruit weight (g/pot)
T_1: Control	69.00 c	15.67 b	733.67 d
T_2: Fungicide (Ridomil gold)	67.33 c	21.00 a	906.00 bc
T_3: Compost (5 t/ha)	81.67 ab	19.67 a	938.33 ab
T_4: Compost tea (50% conc.)	79.67 ab	19.00 a	799.67 cd
T_5: Compost (5 t/ha) + Compost tea (50% conc.)	75.33 bc	20.00 a	961.33 ab
T_6: Compost tea (100% conc.)	81.67 ab	20.33 a	816.33 cd
T_7: Compost (5t/ha) + Compost tea (100% conc.)	87.33 a	21.67 a	1027.67 a
CV (%)	**6.7**	**9.24**	**7.6**
Level of significance	**	*	**

Values having same letters in a column do not differ significantly at 5% level by DMRT.
*= Significant at 5% level and **= Significant at 1% level. CV = Coefficient of variation

Fruit yield per plant was significantly differed in different level of compost treatments. Among the treatments, T_7: Compost (5t/ha) + Compost tea (100% conc.) produced the highest fruit yield of 1027.67 g/pot and the lowest yield of 733.67 g/pot was obtained from the treatment T_1: Control. Fruit yield was found higher in treatment containing compost alone and combined with compost tea rather than control and also only fungicide. Among the compost treatment combination of compost with the application of compost tea increased fruit yield than only application of compost or compost tea. So, it could be concluded that combining compost tea (100% conc) with compost (5 t/ha) have better nutrient providers than the use of every single application method.

Effects of different Soil amendments, Nitrogen level and Irrigation on the growth, N uptake and yield of Wheat

A field experiment was conducted from November, 2017 to April, 2018 following a split-split plot design of randomized complete block with I_1= Irrigation at 55 days and I_2= Irrigation at 21, 55 and 80 days practices as main plot; T_1= Control (No amendment added), T_2= Application of potassium@90kg/ha + Gypsum@ 100 kg/ha, T_3= Application of potassium @90kg/ha + FYM@ 5 t/ha and T_4= Application of potassium @90kg/ha + Gypsum@ 100 kg/ha + FYM@ 5 t/ha as a subplot and N_1=Application of N @100kg/ha & N_2=Application of N @120kg/ha as a sub-sub plot with three replications. The experiment comprises 16 treatments ($I_1T_1N_1$,

$I_1T_1N_2, I_1T_2N_1, I_1T_2N_2, I_1T_3N_1, I_1T_3N_2, I_1T_4N_1, I_1T_4N_2, I_2T_1N_1, I_2T_1N_2, I_2T_2N_1, I_2T_2N_2, I_2T_3N_1, I_2T_3N_2, I_2T_4N_1$ $, I_2T_4N_2$).

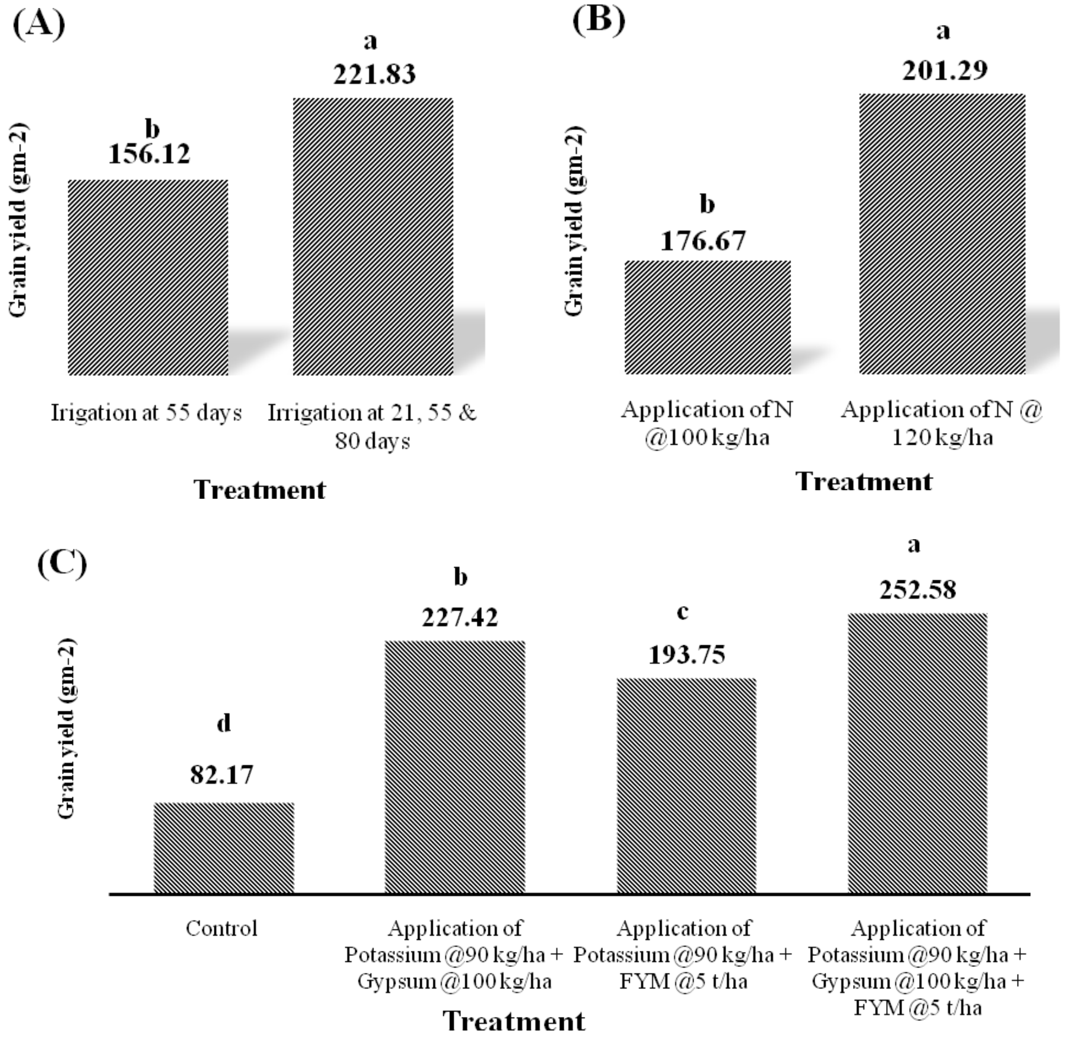


Figure 1: Effects of (A) irrigation, (B) nitrogen level and (C) soil amendments on grain yield of wheat

Each treatment had three replications. Wheat was directly seeded in December and grains were harvested at the end of March of the following year. All data were analyzed with Statistix10 program. The objectives of the study were to reveal the effects of different soil amendments, nitrogen level and irrigation on the growth, N uptake and yield of Wheat.

Grain yield of wheat per square meter was measured. The treatments of irrigation, N level and soil amendments significantly differed for grain yield per plot (Figure 1). Between the treatments of irrigation higher grain yield was observed in I_2= Irrigation at 21, 55 and 80 days (221.83 gm^{-2}) than I_1= Irrigation at 55 days treatment (156.12 gm^{-2}).On the other hand, N_2=Application of N @120kg/ha showed higher grain yield of 201.29 gm^{-2}compared to grain yield of 176.67 $gm^{-2}$of N_1=Application of N @100kg/ha treatment . Grainyield was also significantly differed in different level of soil amendment treatments. Among the treatmentsT_4= Application of potassium @90kg/ha + Gypsum@ 100 kg/ha + FYM@ 5 t/ha produced the highest grain yield of 252.58 gm-^{2} and the lowest yield of 82.17 $gm^{-2}$was obtained from treatment T_1= Control (No amendment added).

In all-pairwise comparisons of grain for main plot and sub plot, significant differences were observed among the pairs. Among the pairs of main and sub plot highest yield was recorded in the combination of I_2= Irrigation at 21, 55 and 80 days treatment and T_4= Application of potassium @90kg/ha + Gypsum@ 100 kg/ha + FYM@ 5 t/ha treatment (Figure 2).

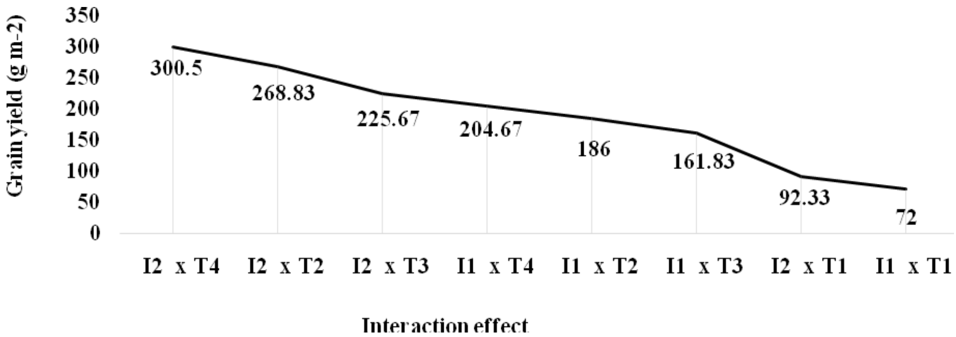


Figure 2: Interaction effects of irrigation and soil amendments on grain yield of wheat

It could be concluded that grain yield of wheat was increased with increasing application N, irrigation water and soil amendments. The combined application of irrigation 3 times at 21, 55 and 80 days and soil amendments potassium @90kg/ha + Gypsum@ 100 kg/ha + FYM@ 5 t/ha may be considered as the best among the treatments to grow wheat.

Determination of profitable cropping pattern with BINA developed crop varieties for Jamalpur

Bangladesh is predominantly rice growing country and rice is the staple food. Rice based cropping pattern are mostly following all over the country. In Jamalpur more than 50% followed cropping pattern is Rice-Fallow-Rice. To increase overall productivity there is need to increase number of crops in the cropping pattern. On the other hand for sustainable production and food security there is also need to cultivate oil and pulse crop. Choosing good variety of different crops is also needed to consider importantly for getting higher yield within short time. For this reason, the experiment was conducted to study the suitability and profitability of 4 crops and 3 crops cropping pattern with BINA developed rice, oilseed and pulse crops varieties against commonly used 2 crops cropping pattern in Jamalpur.

The experiment was conducted at three location of Sadar, Jamalpur during 2017-18. Three treatments of cropping sequences were taken to conduct the study which is as follows:
T_1: Mustard - Mungbean – Aus – T. Aman
T_2: Mustard – Jute – T. Aman
T_3: Boro – Fallow – T. Aman

Varieties developed by BINA were chosen to cultivate in cropping sequences except Jute and Boro rice.The details of crop management of different crops under two proposed and 1 existing cropping pattern are shown in the Table2. Recommended fertilizer dose was applied in each crop. Intercultural operations were done as necessary. In the 4 crops cropping pattern short duration rice variety Binadhan-7 and mustard variety Binasarisha-10 were introduced. Total field duration of four crops cropping pattern Mustard - Mungbean – Aus – T. Aman will needed 323 days (excluding seedling age of rice) to complete the cycle. The experiment was started from the robiseason (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.

Table2: Spacing, sowing & harvesting time and crop duration of the varieties of crops in the cropping pattern

Crop	Variety	Spacing	Sowing/ transplanting time	Harvesting time	Crop duration (days)
Boro	BRRIdhan 28	20cm × 15cm	24/12/16 (sowing) 30/01/16 (transplanting)	12/05/2016	138
Mustard	Binasarisha-10	30cm × 5cm	06/11/2016	25/01/2017	79
Mungbean	Binamoog-8	30cm × 5cm	25/02/2017	01/05/2017	64
Aus	Binadhan-19	20cm × 15cm	05/05/2017	10/08/2017	95
Jute	CVL-1	30cm × 5cm	01/04/2017	20/07/2017	109
T. Aman	Binadhan-7	20cm × 15cm	20/07/17 (sowing) 15/08/17 (transplanting)	10/11/2017	110

Yield

Mustard (Binasarisha-10) was grown both in 4 crops and 3 crops cropping pattern and found same yield (1.5 t/ha) in both cases (Table 3). The yield of mungbean (Binamoog-8) and Aus (Binadhan-19) was recorded 0.82 t/ha and 3 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 2.4 t/ha. T. Aman (Binadhan-7) was also grown both in 4 crops and 3 crops cropping pattern and found same yield (4.5 t/ha) in 4 crops and exiting cropping pattern and 4.6 t/ha in 3 crops cropping pattern.

Table3: Yield crops grown in different cropping pattern

Cropping pattern	Yield (t/ha)					
	Boro (local)	Mustard (Binasarisha-10)	Mungbean (Binamoog-8)	Aus	Jute (CVL-1)	T. Aman (Binadhan-7
Mustard - Mungbean– Aus– T. Aman	-	1.5	0.82	3.0	-	4.5
Mustard – Jute – T. Aman	-	1.5	-	-	2.4	4.6
Boro – Fallow – T. Aman	5.5	-	-	-	-	4.5

Rice equivalent yield

Total productivity of different cropping sequence was determined by rice equivalent yield (REY) through calculating from yield of component crops (Table 4). Rice equivalent yield was found different under different cropping sequences. The highest REY (12,960 kg/ha) was recorded from the cropping sequence ofMustard – Mungbean – Aus-T.Aman followed by the cropping sequence of Mustard-Jute-T.Aman (11,440 kg/ha). The lowest REY (10,000 kg/ha) was recorded from the existing cropping sequence Boro – Fallow-T.Aman.

Table 4: Rice equivalent yield (REY) in rice based cropping system

Treatment	REY (kg/ha)						
	Mustard	Mungbean	Aus	Jute	T.Aman	Boro	Total
Mustard-Mungbean-Aus-T.Aman	3000	2460	3000	-	4500	-	12960
Mustard-Jute-T.Aman	3000	-	-	3840	4600	-	11440
Boro-Fallow-T.Aman	-	-	-	-	4500	5500	10000

Economic analysis

Gross return, variable cost, gross margin and benefit-cost ratio was calculated for economic analysis (Table 5). Gross margin was found highest in Mustard – Mungbean – Aus-T.Aman cropping sequence followed by Mustard – Jute-T.Aman and lowest in existing cropping sequence of Boro – Fallow-T.Aman.But benefit cost ratio was observed highest in Mustard – Mungbean – Aus-T.Aman cropping sequence followed by Boro – Fallow - T.Aman. Due to higher variable cost, BCR was found lower in Mustard – Jute-T.Aman cropping sequence than Boro – Fallow - T.Aman.

Table 5: Gross margin and BCR in rice based cropping system

Cropping pattern	Gross return (Tk/ha)	Total variablecost (Tk/ha)	Gross margin (Tk/ha)	BCR (Tk/Tk)
Mustard–Mungbean–Aus–T. Aman (CP 1)	268200	124760	143440	2.2
Mustard-Jute-T. Aman (CP 2)	238000	119687	118313	1.9
Boro-Fallow–T. Aman (CP 3)	198000	93379	104621	2.1

So, it could be concluded that Mustard–Mungbean–Aus–T. Aman cropping sequences produced the highest yield and gave the highest profitability by giving highest gross margin and BCR.

Demonstration with different aman rice (Kharif II), mustard (Robi) and groundnut varieties developed by BINA

The different varieties of rice, mustard and groundnut 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 district. Four varieties of rice (Binadhan-7, Binadhan-11, Binadhan-17 & Binadhan-14), 3 varieties of mustard (Binasarisha-4, Binasarisha-9 & Binasarisha-10) and 1 variety of groundnut (Binachinabadam-4) were considered to disseminate. For the demonstration program 100 decimal, 33 decimal and 33 decimal areas were taken for each demonstration of rice, mustard and groundnut varieties, respectively. The lands were fertilized with recommended dose of fertilizers and other intercultural operations were done as necessary. Partial fertilize cost per demonstration was given to the farmers to produce the crop. The yield data was recorded plot wise and means data were calculated.

Table6: Yield of different varieties of different crops (rice, mustard and groundnut) in demonstration plots in Jamalpur

Sl. No.	Crop	Variety	Location	No. of farmers	Area (decimal)	Av. Yield (t/ha)
1	Rice	Binadhan-7	Sadar	2	100	4.8
		Binadhan-11	Sadar	2	100	4.5
			Melandah	6		4.8
			Madargonj	1		5.5
			Sharishabari	3		4.3
		Binadhan-17	Sadar	1	100	5.0
		Binadhan-14	Sadar	8	33	5.8
			Melandah	6		5.5
			Sharishabari	2		5.9
2	Mustard	Binasarisha-4	Sadar	2	33	1.1
		Binasarisha-9	Melandah	1	33	1.4
		Binasarisha-10	Sadar	17	33	0.9
			Melandah	10		0.8
3	Groundnut	Binachinabadam-4	Sadar	14	33	2.5
			Islampur	30		2.4

The yield of rice, mustard and groundnut were presented in Table 6. The highest grain average yield of rice was recorded at Sadar (4.8 t/ha), Madargonj (5.5 t/ha), Sadar (5.0 t/ha)and sharishabari (5.9 t/ha) of the variety Binadhan-7, Binadhan-11, Binadhan-17 and Binadhan-14, respectively. In case of mustard variety, the average yield of Binasarisha-9 was found 1.4 t/ha at Melandah and Binasarisha-10 was found 0.9 t/ha at Sadar and 0.8 at Melandah. The groundnut average yield was found highest (2.5 t/ha) atSadar.

Farmers of different upazila of Jamalpur preferred Binadhan-7 due to its earliness as they can grow robi crops easily and yield is also good. Farmers of low land area who are experienced with the flash flood shown interest to grow Binadhan-11 due to its submergence tolerance characters. At Melandah, Madargonj and Sharishabari, farmers got 4.8 t/ha, 5.5 t/ha and 4.3 t/haaverage yield respectively after submergence of 10 days after transplanting.Demonstartion of Binadhan-17 and Binadhan-14 were conducted at Sadar, Melandah and Sharishabariupazilla whereas farmers are also preferred these varieties and shown interest to grow in the next year. In case of mustard variety, farmer of Melandah preferred Binasarisha-9 than Binasarisha-10 due to get comparatively higher yield.

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 quarter. The substation also produced few amount of seed on basis of land availability after producing demanding seed by the divisions of head quarter. 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 2017-18.A total number of11,973 kg seedof 3,918 kg breeder seed and 8,055 TLS was produced at BINA Substation, Jamalpur during the year 2017-18 (Table 7).

Table 7: Amount of breeder and truthfully labeled seed production during 2017-18

Sl. No.	Seed	Division/Substation	Varieties	Total production (kg)
1	Breeder seed	Plant Breeding	Binadhan-7	900
			Binadhan-11	800
			Binadhan-17	1,100
			Binadhan-8	900
			Binadhan-10	150
			Binasarisha-5	18
			Binasarisha-9	50
			Total (Breeder seed)	**3,918**
2	Truthfully Labeled Seed	BINA Substation, Jamalpur	Binadhan-7	385
			Binadhan-11	4,640
			Binadhan-13	10
			Binadhan-15	75
			Binadhan-16	70
			Binasail	40
			Binadhan-5	900
			Binadhan-8	900
			Binadhan-10	150
			Binadhan-14	300
			Binasarisha-4	252
			Binasarisha-9	50
			Binasarisha-10	45
			Binachinabadam-4	238
			Total (TLS)	**8,055**
	Total (Breeder seed + Truthfully labeled seed)			**11,973**

Training organized by BINA Substation, Jamalpur

Training programs were organized at the training room of BINA Substation, Jamalpur.

Table 8: Number of trained farmers and extension personnel of Jamalpur district

Sl. No	Training and Field day	Date of training	No. of farmers	No. of SAAO	Source of fund
1	Training on production techniques of BINA developed crop varieties to cope with flood and for post flood agricultural rehabilitation	26.10.2017	86	14	"Changeable climate….varietal improvement" kormosuchi
2	Training on production techniques of BINA developed boro rice and oilseed crop varieties	29.11.2017	50	0	"SRSD" project
3	Training on production techniques of BINA developed late boro rice and pulse crop varieties to increase cropping intensity through extending the varieties to the farmers of Jamalpur	30.01.2018	86	14	Revenue
4	Training on improvement of farm productivity through intervention of improved agricultural technologies in char land ecosystem	03.06.2018	20	02	"Improvement of farm ………char land ecosystem" project
5	Training on introduction and production of BINA developed aman rice varieties	10.06.2018	58	02	Revenue
6	Training on introduction of BINA	27.06.2018	70	05	"Nutritional

	developed technologies and cultivation procedure of Binadhan-11 at Melandah, Jamalpur.				security....variety development" project
7	Training on introduction of BINA developed technologies and cultivation procedure of Binadhan-11 at Madargonj, Jamalpur	27.06.2018	90	20	"Changeable climate….varietal improvement" kormosuchi
8	Field day on Binadhan-11,	07/11/2017 09/11/2017	240	2	"SRSD" project and "Nutritional security....variety development" project
	Field day on Binasarisha-9 & Binasarisha-10	30.01.2018 30.01.2018	250	2	Revenue
	and Field day on Binadhan-14	10.06.2018	60	1	Revenue

Farmers and SAAO were selected from 7 different upazila of Jamalpur district. A total number of 460 farmers and 57 SAAO were trained in these training program (Table 8). A total of 5 field day programs were also organized on different crop varieties developed by BINA to motivate the farmers of Jamalpur to adopt BINA developed varieties/technologies. Experienced and efficient trainer from HQ, BINA and other institute gave speech in these programs. The response of trainee was also very good during the training session.

Publication during the year 2017-18

1. **Ashrafi R.**, Mian M.H., Rahman M.M., Jahiruddin M. **(2017)**. Reuse of Spent Mushroom Substrate as Casing Material for the Production of Milky White Mushroom.*Journal of the Bangladesh Agricultural University*,15(2): 239-247.

BINA Sub-station, Barishal

Research Highlights

About 137 demonstration of Binadhan-10 exhibited that remarkably higher (5.50t/ha) than locally cultivated BRRIdhan 29 (4.80t/ha). Among Binasarisha-4 and Binasarisha-10, Binasarisha 10 produced prodigious yield & Binamoog 7 and Binamoog 8 also gave remarkable yield.

Block demonstration of Binadhan-10, Binasarisha-4 & Binasarisha-10

During 2017-18, around 200 demonstrations were carried out with BINA released varieties in some selected areas of Barisal Sadar, Babuganj, Gouronodi, Wajirpur and Bakerganj upzillas of Barisal district and Jhalokathi sadar, Nolchiti, Rajapur and Kathalia upazilla of Jhalokathi district. Results of the demonstrations are presented in Table 1.

Yield of Binadhan 10 was remarkably higher than locally cultivated BRRIdhan 29 (4.80t/ha). Farmers preferred BINA released variety Binadhan 10 for its higher yield and coarse grain. Among Binasarisha-4 and Binasarisha-10, Binasarisha 10 produced prodigious yield and farmer showed positive response to this variety. Binamoog 7 and Binamoog 8 also gave remarkable yield but Binamoog 8 was mostly affected by YMV. It was expected that this varieties would be extended rapidly in this areas.

Table 1: Performance of different BINA released varieties in Barisal region during 2017-18

Variety	No of Demonstration	Duration (Days)	Yield (t/ha)
Rice			
Binadhan 10	137	139	5.50
Oilseeds			
Binasarisha-4	07	85	0.8
Binasarisha-10	06	78	1.0
Pulse			
Binamoog 7	10	62	1.4
Binamoog 8	40	68	1.3
Grand total	**200**		

Establishment of BINA Technology village in surrounding area of BINA Sub-station, Barisal

In order to establish BINA-Technology village, demonstrations and other extension work were done in surrounding area of BINA-substation, Barisal at the farmer's fields of Babuganj. Results of overall promotional activities related to BINA-Technology village establishment are presented in table 2.

Table 2: Performance of BINA developed varieties at Babuganj during 2017-18

Sl. No	Crops	Variety Name	Demonstration No.	Duration (days)	Yield (t ha^{-1})
	Rice	Binadhan-10	10	139	5.70
2.	Mustard	Binasarisha-4	7	85	1.30
		Binasarisha-10	6	78	1.0
3.	Mungbean	Binamoog 8	10	64	1.30

Most of the region of Barisal is suitable for growing rice, oilseeds and pulse. Results indicated that Binadhan-10 produced higher grain yield with moderate crop duration. Farmers had been interested to cultivate BINA developed boro rice variety Binadhan-10 for its higher yield, short crop duration and coarse grain. Mustard variety, Binasarisha-4 & Binasarisha-10 showed moderate potentials in terms of yield and duration for cultivation. Binamoog-8 also produced higher grain yield than check but effect of mosaic was notable in the field.

Production of quality seed of BINA released crop varieties popular in Barisal region

Seeds of BINA released crop varieties popular in Barisal 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 2017-18. Seed production activities, locations, crop varieties are shown in (Table 3). In case of farmer's fields, partial inputs subsidies and free seeds or only free seeds were provided. During the reporting period a total of 7.2 tons seeds of different crop varieties of BINA were purchased. Among them rice were about 5.0 tons and mungbean was 2.2 tons.

Table 3. Seeds produced/purchased, distributed/sold & stored during 2017-18

Crop	Varieties	Total distributed/sold seed (ton)	Total seeds produced /purchased (ton)	Remarks
Rice	Binadhan-10	3.50	5.00	
Mung bean	Binamoog 7	0.8	2.2	
	Total	3.58	7.2	

Training on the use of BINA developed technologies

In order to transfer BINA developed technologies single day training was arranged by BINA Substation, Barisal. The participants were farmers (both male and female), Sub-assistant Agriculture Officer, Upazilla Agriculture Officers and other agriculture related personnel. Details of the trainings are presented in Table 4.

Table 4. Farmers Training on the use of BINA developed technologies during 2017-18

S. L No	Topic of training	Place of Training	No. of participants	Source of fund
1.	Introduction of extension able BINA developed crop varieties, production technology & development of cropping pattern	DD Office, Barisal	60	Nutrition project
2.	Introduction of extension able of BINA released oil seed and pulse crop varieties and their production technology	BINA substation, Barisal	75	Nutrition project
3.	Introduction of extension able BINA developed crop varieties, production technology & development of cropping pattern.	DD Office, Barisal	50	SRSD

Field Day

In order to motivate the farmers to adopt BINA developed varieties/technologies, 1 field days on Binamoog 7 was organized in Chatrakanda of Jahlokathi Sadar Upazilla. About 170 farmers were present in the field day program. As per farmers consent, yiled of Binamoog 7 was outstanding in their field.

BINA Sub-station, Chapai Nawabganj

Research Highlights

A total of 15 demonstrations with short duration T. aman rice varieties BINAdhan-7, Binadhan-16 and Binadhan-17 were conducted which produced average grain yields of 5.7, 4.85 t ha^{-1} and 6.21 t ha^{-1} respectively. Average maturity period of Binadhan-7 was 117 days, Binadhan-16 was 104 days and Binadhan-17 was 125 days. BRRI dhan-49 were used as check, BRRI dhan49. Check variety BRRI dhan-49 produced average gain yield of 5.21 with average maturity period of 135 days. Farmers were found interested to cultivate Binadhan-7, Binadhan-16 and Binadhan-17.

A total of 5 demonstrations with short duration 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 10 demonstrations with short duration high yielding Binamasur-5 and Binamasur-8 which produced better yield with less maturity period in most of the time than check variety of local cultivar.

A total of 1 demonstrations with short duration high yielding Binakhesari-1 which produced better yield with less maturity period than check variety of local cultivar.

A total of 10 demonstrations with high yielding moog variety Binamoog-8 which produced better yield than check varieties of BARI Mung-6.

A total of 35 demonstrations with high yielding sesame variety Binatil-3 which produced better yield than check varieties of local cultivars.

Up-scaling BINA developed high yielding and short duration T.Aman rice variety in Chapai Nawabganj region

During aman season of 2017-18, 15 demonstrations with Binadhan-7, Binadhan-16 and Binadhan-17 were conducted at the farmer's fields in Chapai Nawabganj 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 2017, and age of seedlings was 20 to 25 days. The farmers managed all the production practices as per recommendation. Based on the available reports, data of demonstration plots are presented in Table 1-3.

Table 1: Performance of Binadhan-7 in Chapai Nawabganj region during 2017-18

Upazila	No.of demonstration	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binadhan-7	BRRI dhan49 (check)	Binadhan-7	BRRI dhan49 (check)	
Sadar	3	116	134	5.6	5.2	7.69
Nachol	3	118	136	5.8	5.22	11.11
Total	**6**					
Mean		**117**	**135**	**5.7**	**5.21**	**9.2**

Results reveal that Binadhan-7 produced average grain yield of 5.7 t ha^{-1}, which was 9.2 percent higher compared to check variety. Average maturity period of Binadhan-7 was 117 days. The mean yield of Binadhan-7 was 5.7 t/ha which differs statistically from BRRI dhan49 (5.21 t/ha). Therefore Binadhan-7 increased crop production as well as farmer's income. Farmers were found interested to cultivate Binadhan-7 as an Aman variety in Chapai Nawabganj region.

Table 2: Performance of Binadhan-16 in Chapai Nawabganj region during 2017-18

Upazila	No. of demonstration	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binadhan-16	BRRI dhan49 (check)	Binadhan-16	BRRI dhan49 (check)	
Sadar	2	101	133	4.8	5.21	-7.89
Nachol	2	107	138	4.9	5.25	-6.67
Total	**4**					
Mean		**104**	**135.5**	**4.85**	**5.23**	**-7.28**

Results reveal that Binadhan-16 produced average grain yield of 4.85 t ha^{-1}, which was 7.28 percent lower compared to check variety (Table-2). Average maturity period of Binadhan-16 was 104 days. Therefore farmers were found interested to cultivate Binadhan-16 as an Aman variety in Chapai Nawabganj region.

Table 3: Performance of Binadhan-17 in Chapai Nawabganj region during 2017-18

Upazila	No. of demonstration	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binadhan-17	BRRI dhan49 (check)	Binadhan-17	BRRI dhan49 (check)	
Sadar	3	121	133	6.15	5.21	18.04
Nachol	2	128	138	6.27	5.25	19.43
Total	**5**					
Mean		**125**	**135.5**	**6.21**	**5.23**	**18.74**

Results reveal that Binadhan-17 produced average grain yield of 6.21 t ha^{-1}, which was 18.74 percent higher compared to check variety (Table-3). Average maturity period of Binadhan-17 was 125 days. The mean yield of Binadhan-17 was 6.21 t ha^{-1} which differs statistically from BRRI dhan49 (5.23 t ha^{-1}). Therefore Binadhan-17 increased crop production as well as farmer's income. Farmers were found interested to cultivate Binadhan-17 as an Aman variety in Chapai Nawabganj region.

Up-scaling BINA developed high yielding and short duration mustard variety in Chapai Nawabganj region

During the Rabi season of 2017-18, total 5 demonstrations were conducted with Binasarisha-4 and Binasarisha-9 in Chapai Nawabganj 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 2017 at the rate of 7.5 kg ha^{-1}. The check variety was BARI sarisha-14. All fertilizers were applied as per recommendation and 1-2 irrigation was applied in the demonstration plots. Pesticides were sprayed as and when necessary to control insects and pests. Data were recorded on crop duration and seed yield.

Table 4: Performance of Binasarisha-4 compared to popular cultivar in Chapai Nawabganj region during 2017-18

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 (Bidirpur)	1	86	80	1.70	1.45	17.24
Sadar (Milky)	1	84	80	1.90	1.60	18.75
Total	**2**					
Mean		**85**	**80**	**1.80**	**1.53**	**18.00**

Results reveal that Binasarisha-4 produced average seed yield of 1.8 t ha^{-1}, which was 18.00 percent higher than the cheek variety BARI sarisha-14 (Table-4). Average maturity period of Binasarisha-4 was 85 days. BARI sarisha-14 produced average gain yield of 1.53 t ha^{-1} with average maturity period of 80 days. Farmers were found interested to cultivate Binasarisha-4.

Table 5: Performance of Binasarisha-9 compared to popular cultivar in Chapai Nawabganj region during 2017-18

Upazila	No. of demo	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binasarisha-9	BARI sarisha-14 (Check)	Binasarisha-9	BARI sarisha-14 (Check)	
Nachol (Chowpukuria)	1	80	79	1.72	1.50	14.67
Nachol (Nezampur)	1	79	81	1.77	1.52	16.45
Nachol (Mallikpur)	1	81	81	1.66	1.50	10.67
Total	**3**					
Mean		**80**	**81**	**1.72**	**1.51**	**13.93**

Results reveal that Binasarisha-9 produced average seed yield of 1.72 t ha^{-1} which was 13.93 percent higher than the check variety BARI sarisha-14 (Table-5). Average maturity period of Binasarisha-9 was 80 days. BARI sarisha-14 produced average gain yield of 1.51 t ha^{-1} with average maturity period of 81 days. Farmers were found interested to cultivate Binasarisha-9.

Up-scaling BINA developed high yielding and short duration lentil variety in Chapai Nawabganj region

During the Rabi season of 2017-18, total 10 demonstrations were conducted with Binamasur-5 and Binamasur-8 in Chapai Nawabganj 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 2017. The check variety was local cultivar. All fertilizers were applied as per recommendation and 1-2 irrigation was applied in the demonstration plots. Pesticides were sprayed as and when necessary to control insects and pests. Data were recorded on crop duration and seed yield.

Table 6: Performance of Binamasur-5 compared to popular cultivar in Chapai Nawabganj region during 2017-18

Upazila	No. of demo	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binamasur-5	Local cultivar (Check)	Binamasur-5	Local cultivar (Check)	
Sadar	5	103	117	1.9	1.45	31.03
Total	**5**					
Mean		**103**	**117**	**1.9**	**1.45**	**31.03**

Results reveal that Binamasur-5 produced average seed yield of 1.9 t ha^{-1}, which was 31.03 percent higher than the check variety (Table-6). Average maturity period of Binamasur-5 was 103 days. Local variety produced average gain yield of 1.45 t ha^{-1} with average maturity period of 117 days. Farmers were found interested to cultivate Binamasur-5.

Table 7: Performance of Binamasur-8 compared to popular cultivar in Chapai Nawabganj region during 2017-18

Upazila	No. of demo	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binamasur-5	Local cultivar (Check)	Binamasur-5	Local cultivar (Check)	
Nachol	5	98	115	2.1	1.41	48.94
Total	**5**					
Mean		**98**	**115**	**2.1**	**1.41**	**48.94**

Results reveal that Binamasur-8 produced average seed yield of 2.1 t ha^{-1}, which was 48.94 percent higher than the check variety (Table-7). Average maturity period of Binamasur-8 was 98 days. Local variety produced average gain yield of 1.45 t ha^{-1} with average maturity period of 117 days. Farmers were found interested to cultivate Binamasur-8.

Up-scaling BINA developed high yielding and short duration Mungbean variety in Chapai Nawabganj region

During the Kharif-1 season of 2017-18, total 10 demonstrations were conducted with Binamug-8 in Chapai Nawabganj region. The main objectives were to demonstrate the performance of Binamug-8 as well as widening their adoption by the farmers. Area of demonstration plots was 33 decimals. Seeds were sown during mid February to mid March 2018 at the rate of 30 kg ha^{-1}. The check variety was BARI mug-6. All fertilizers were applied as per recommendation in the demonstration plots. Pesticides were sprayed as and when necessary to control insects and pests. Data were recorded on crop duration and seed yield.

Table 8: Performance of Binamug-8 compared to popular cultivar in Chapai Nawabganj region during 2017-18

Upazila	No. of demo	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binamug-8	BARI mung-6	Binamug-8	BARI mug-6	
Sadar	10	68	62	1.5	1.45	3.45
Total	**10**					
Mean		**68**	**62**	**1.5**	**1.45**	**3.45**

Results reveal that Binamug-8 produced average grain yield of 1.5 t ha^{-1}, which was 3.45 percent higher compared to check variety (Table-8). Average maturity period of Binamug-8 was 68 days.

Farmers were found interested to cultivate Binamug-8 as a summer mug variety in Chapai Nawabganj region.

Up-scaling BINA developed high yielding and short duration Sesame variety in Chapai Nawabganj region

During the Kharif-1 season of 2017-18, total 35 demonstrations were conducted with Binatil-3 in Chapai Nawabganj region. The main objectives were to demonstrate the performance of Binatil-3 as well as widening their adoption by the farmers. Area of demonstration plots was 33 decimals. Seeds were sown during mid February to mid March 2018 at the rate of 7.5 kg ha^{-1}. The check variety was local cultivar. All fertilizers were applied as per recommendation in the demonstration plots. Pesticides were sprayed as and when necessary to control insects and pests. Data were recorded on crop duration and seed yield.

Table 9: Performance of Binatil-3 compared to popular cultivar in Chapai Nawabganj region during 2017-18

Upazila	No. of demo	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binatil-3	Local cultivar	Binatil-3	Local cultivar	
Gomostapur	35	92	103	1.2	1.15	4.35
Total	35					
Mean		92	103	1.2	1.15	4.35

Results reveal that Binatil-3 produced average grain yield of 1.2 t ha^{-1}, which was 4.35 percent higher compared to check variety (Table-9). Average maturity period of Binatil-3 was 92 days. Farmers were found interested to cultivate Binatil-3 as a summer mug variety in Chapai Nawabganj region.

Establishment of BINA Technology village, in surrounding area of BINA Sub-station, Chapai Nawabganj

In order to establish BINA-Technology village demonstrations and other extension work were done in surrounding area of BINA-substation, Chapai Nawabganj at the farmer's fields. Results of overall promotional activities related to BINA-Technology village establishment at Nachol Union are presented below.

Table 10: Performance of BINA developed varieties at Nachol union during 2017-18

Sl. No	Crops	Variety Name	Demonstration No.	Av. Duration in days	Av.Yield (t ha^{-1})
1.	Rice	Binadhan-14	3	125	6.50
		Binadhan-7	3	115	4.60
		Binadhan-16	3	100	4.79
		Binadhan-17	5	113	6.20
2.	Mustard	Binasarisha-4	3	83	1.65
		Binasarisha-9	5	79	1.62
3.	Mungbean	Binamug-8	3	66	1.53

Production of quality seed of BINA released crop varieties popular in Chapai Nawabganj region.

Seeds of BINA released crop varieties popular in Chapai Nawabganj 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 2017-18. Seed production activities, locations, crop varieties and areas during the reporting period were shown in (Table 4). In case of farmer's fields, partial inputs 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. Among them rice were about 6.92 tons, mustard 0.95 ton.

Table 11. Seeds produced/purchased, distributed/sold & stored during 2017-18

Crop	Varieties	Total seeds produced /purchased (ton)	Total distributed/sold (ton)	Seeds stored (ton)	Remarks
Rice	**Aman**				
	Binadhan-16	0.1	0.1		
	Binadhan-17	0.4	0.4		
	Boro				
	Binadhan-14	1.0	-	1.0	
	Sub-total	**1.5**	**0.5**	**1.0**	
Mustard	Binasarisa-4	0.5	-	0.5	
	Binasarisa-9	0.5	-	0.5	
	Sub-total	**1.0**	**-**	**1.0**	

Training on the use of BINA developed technologies

In order to transfer BINA developed technologies a training of one day was arranged at BINA Substation, Chapai Nawabganj. The participants were farmers (both male and female) and Sub-assistant Agriculture Officer. Details of the training are presented in Table 12.

Table 12: Farmers Training on the use of BINA developed technologies during 2017-18

S.L No	Topic of training	Place of Training	No. of participants	Source of fund
1.	Introduction of BINA developed crop varieties and production technology in Drought prone areas	BINA substation, Chapai Nawabganj	50	SRSD
2.	Cultivation techniques of Transplanted Aman Rice in Drought prone areas	BINA substation, Chapai Nawabganj	70	SRSD
3.	Cultivation techniques of Rabi crops in Drought prone areas	BINA substation, Chapai Nawabganj	70	SRSD

Field Day

In order to motivate the farmers to adopt BINA developed varieties/technologies, 2 field days on different crop varieties were organized in Chapai Nawabganj region. Details of the field day activities are presented in Table 13.

Table 13. Field days arranged at the farmers fields on different crop varieties during 2016-17

Sl. No.	Crops	Varieties	Locations	Participants
1.	Mustard	Binasarisha-9	Lakkhipur, Nachol, Chapai Nawabganj	160
		Binadhan-10	Badalgachi, Nagaon	140

BINA Sub-station, Khagrachari

Research Highlights

A total of 08 validation trials during the aus season with Binadhan-14, Binadhan-19, BRRI dhan43 and BRRI dhan48 showed that Binadhan-14 produced 7.32% more yield than BRRI dhan43 and 12.01% less than BRRI dhan48. Duration of Binadhan-14 was lesser (101.5 days) compared to BRRI dhan43 (104.5 days) and BRRI dhan48 (118.5 days). Binadhan-19 was found to be promising among all the tested varieties which gave 4.53 t ha^{-1} yield within 100 days maturity. Farmers found to prefer this variety for its high yielding capacity, slender fine grain, short duration and dwarf in height.

Among the 12 observation trials with five HYV (Binasarisha-4, Binasarisha-9, Binasarisha-10, Tori-7 and BARI Sarisha-14) and one local mustard cultivar (*Doli*) revealed that, Binasarisha-9 and Binasarisha-10 were superior in terms of grain yield. Average yield of Binasarisha-9 and Binasarisha-10 was 1.68 t ha^{-1} and 1.80 t ha^{-1}. The check varieties and cultivar, Tori-7, BARI Sarisha-14 and *Doli* produced a yield of 0.775 t ha^{-1}, 1.255 t ha^{-1} and 1.395 t ha^{-1} respectively. Crop duration was lowest in Tori-7 (82 days) followed by Bari sarisha-14 (83 days), *Doli* (85.5 days), Binasarisha-10 (90 days) and Binasarisha-9 (92.5 days).

Validation of Binadhan-14, Binadhan-19, BRRI dhan43 and BRRI dhan48

Adaptive trials at Khagrachari during Aus season of 2017-18, a total of 08 validation trials were conducted with Binadhan-14, Binadhan-19, BRRI dhan43 and BRRI dhan48. The main objective was to demonstrate the relative performance of Binadhan-14, Binadhan-19, BRRI dhan43 and BRRI dhan48 and find out the advantages and disadvantages of these varieties, so that farmers may choose the right suitable variety for them. Area of the trial plots were 33 decimals and there were 2 (two) locations for each variety. Seeds were sown during mid May at the rate of 10 kg ha^{-1} and 25 days old seedlings were transplanted in the main field. All fertilizers were applied as per recommendation in the trial plots. Pesticides were sprayed as and when necessary to control pests. Data were recorded on crop duration and grain yield. The results are presented in Table 1.

Table 1a. Performance of Binadhan-14 with BRRI dhan43 and BRRI dhan48 at Khagrachari Sadar Upazila during Aus season 2017-18

Location	No. of trials	Duration (days)	Yield (t ha^{-1})	Duration (days)	Yield (t ha^{-1})	(%) Yield (+/-)	Duration (days)	Yield (t ha^{-1})	(%) Yield (+/-)
		Binadhan-14		**BRRI dhan43**			**BRRI dhan48**		
Charpara, Sadar, Khagrachari	3	102	4.05	104	3.51	+ 15.38	122	4.83	-16.15
Satvaiyapara, Sadar, Khagrachari	3	101	3.98	105	4.01	-0.75	115	4.32	-7.87
Total/Mean	**06**	**101.5**	**4.02**	**104.5**	**3.76**	**+7.315**	**118.5**	**4.575**	**-12.01**

Table 2. Performance of Binadhan-19 with BRRI dhan43 and BRRI dhan48 at Khagrachari Sadar Upazila during 2017-18

Location	No. of trials	Duration (days)	Yield (t ha^{-1})	Duration (days)	Yield (t ha^{-1})	(%) Yield (+/-)	Duration (days)	Yield (t ha^{-1})	(%) Yield (+/-)
		Binadhan-19		BRRI dhan43			BRRI dhan48		
Charpara, Sadar, Khagrachari	1	102	4.82	104	3.51	+ 37.32	122	4.83	-0.21
Satvaiyapara, Sadar, Khagrachari	1	98	4.24	105	4.01	+5.74	115	4.32	+1.85
Total/Mean	**02**	**100**	**4.53**	**104.5**	**3.76**	**+21.515**	**118.5**	**4.575**	**+1.64**

Binadhan-14 produced average seed yield of 4.02 t ha^{-1} in 101.5 DAS and Binadhan-19 gave an average seed yield of 4.53 t ha^{-1} in 100 DAS (Table 1 and Table 2). One check variety BRRI dhan43 gave lower yield (3.76 t ha^{-1}) than those of the tested BINA rice varieties and it took 3- 4.5 days more to mature. On the other hand widely cultivated variety BRRI dhan48 yielded 4.575 t ha^{-1} and took more duration (118.5 days) for maturity than Binadhan-14 and Binadhan-19. Farmers were very interested for cultivation of Binadhan-19 due its slender fine grain, short duration and dwarf in height but they had to take additional control measures from bird attack during the maturity period. Overall, the farmers of Khagrachari were motivated to cultivate Binadhan-19 in next season.

Block farming of Binasarisha-4, Binasarisha-9 and Binasarisha-10

During Rabi season of 2017-18, 12 observation trials of Binasarisha-4, Binasarisha-9 and Binasarisha-10 were conducted at two locations of Khagrachari. Tori-7, Bari sarisha-14 and *Doli* were used as check. Objective was to demonstrate the relative performances of different mustard variety and cultivar so that farmers can choose their desired variety in terms of yield and quality. Area of the trial plots were 33 decimals for each variety and there were 2 (two) locations. Due to late arrival of winter season in Khagrachari, seeds were sown in the 2nd week of November. Farmer's practices were followed for sowing mustard seeds which was broadcasting method @ 7.4 kg ha^{-1}. All types of fertilizers were applied as per recommendation in the trial plots. Pesticides were applied as and when necessary to control pests. Data were recorded on crop duration and grain yield. The results are presented in Table 3, Table 4 and Table 5.

Table 3: Performance of Binasarisha-4 with Tori-7, Bari sarisha-14 and *Doli* (local cultivar) during 2017-18

Location	No. of trials	Duration (days)	Yield (t ha^{-1})	Duration (days)	Yield (t ha^{-1})	(%) Yield (+/-)	Duration (days)	Yield (t ha^{-1})	(%) Yield (+/-)	Duration (days)	Yield (t ha^{-1})	(%) Yield (+/-)
		Binasarisha-4		Tori-7			BARI Sarisha-14			Doli		
Vaibonchara, Khagrachari	4	88	1.02	80	0.74	+37.84	84	1.31	-22.14	88	1.49	-31.54
Komolchari, Khagrachari	4	89	1.15	84	0.81	+41.98	85	1.20	-4.17	83	1.30	-11.54
Total/	**08**	**88.5**	**1.08**	**82**	**0.77**	**+39.9**	**83**	**1.25**	**-**	**85.5**	**1.39**	**-**

Mean	**5**	**5**	**1**	**5**	**13.15**	**5**	**21.54**

Results exhibited that Binasarisha-4 yielded 1.085 t ha^{-1} at 88.5 DAS whereas Tori-7 yielded 0.775 t ha^{-1} at 82 DAS (Table 3). Average increase in yield of Binasarisha-4 is 39.91% over check-1 variety (Tori-7). But the 2nd check variety BARI Sarisha-14 gave more grain yield (1.255 t ha^{-1}) at 83 DAS compared to Binasarisha-4 (1.085 t ha^{-1}) at 88.5 DAS. Average yield reduction was 13.15% in Binasarisha-4. The local cultivar Doli as check-3 produced 1.395 t ha^{-1} grain yield at 85.5 DAS which was higher than Binasarisha-4 (1.085 t ha^{-1}) at 88.5 DAS and decrease in yield was 21.54%.

Table 4: Performance of Binasarisha-9 with Tori-7, Bari sarisha-14 and *Doli* (local cultivar) during 2017-18

Location	No. of trials	Duration (days)	Yield (t ha^{-1})	Duration (days)	Yield (t ha^{-1})	(%) Yield (+/-)	Duration (days)	Yield (t ha^{-1})	(%) Yield (+/-)	Duration (days)	Yield (t ha^{-1})	(%) Yield (+/-)
		Binasarisha-9		**Tori-7**			**BARI Sarisha-14**			**Doli**		
Vaibonchara, Khagrachari	1	94	1.96	80	0.74	+171.83	84	1.31	+49.61	88	1.49	+31.54
Komolchari, Khagrachari	1	91	1.40	84	0.81	+72.84	85	1.20	+16.67	83	1.30	+7.69
Total/ Mean	**02**	**92.5**	**1.68**	**82**	**0.775**	**+122.35**	**83**	**1.255**	**+33.14**	**85.5**	**1.395**	**+19.62**

Table 4 shows that Binasarisha-9 yielded 1.68 t ha^{-1} at 92.5 days; whereas Tori-7 gave 0.775 t ha^{-1} at 82 days. Production is more than double from Tori-7. Average increase in yield of Binasarisha-9 is 122.35% over check variety Tori-7. Similarly, BARI Sarisha-14 gave lower grain yield (1.255 t ha^{-1}) at 83 days compared to Binasarisha-9 (1.68 t ha^{-1}) at 92.5 days. Average yield increase was 33.14% in Binasarisha-9. Binasarisha-9 also yielded higher (1.68 t ha^{-1}) over the local cultivar Doli (1.395 t ha^{-1}) although Binasarisha-9 took more duration (92.5 days) than Doli (85.5 days) but it gave 19.62% increased yield than Doli.

Table 5: Performance of Binasarisha-10 with Tori-7, Bari sarisha-14 and *Doli* (local cultivar) during 2017-18

Location	No. of trials	Duration (days)	Yield (t ha^{-1})	Duration (days)	Yield (t ha^{-1})	(%) Yield (+/-)	Duration (days)	Yield (t ha^{-1})	(%) Yield (+/-)	Duration (days)	Yield (t ha^{-1})	(%) Yield (+/-)
		Binasarisha-10		**Tori-7**			**BARI Sarisha-14**			**Doli**		
Vaibonchara, Khagrachari	1	88	1.74	80	0.74	+135.13	84	1.31	+32.82	88	1.49	+16.77
Komolchari, Khagrachari	1	92	1.85	84	0.81	+128.39	85	1.20	+54.17	83	1.30	+42.31
Total/Mean	**02**	**90**	**1.80**	**82**	**0.775**	**+131.76**	**83**	**1.255**	**+43.49**	**85.5**	**1.395**	**+29.54**

From Table 5 it is revealed that, yield of Binasarisha-10 (1.80 t ha^{-1}) is almost 2.5 times more than Tori-7 (0.775 t ha^{-1}). Gross increased Binasariaha-10 yield was 131.76% over Tori-7. Binasarisha-10 took 8 days more to mature than Tori-7. Binasarisha-10 gave 43.49% increased grain yield than Barisarisha-14. BARI Sarisha-14 (83 days) matured 7 days earlier compared to Binasarisha-10 (90 DAS). Binasarisha-10 produced higher yield (1.80 t ha^{-1}) over the local cultivar Doli (1.395 t ha^{-1}), but Binasarisha-10 matured 4.5 days later than Doli (85.5 days). Binasarisha-10 produced 29.54% more yield than Doli.

Farmers of Khagrachari were interested to cultivate the BINA developed HYV mustard varieties Binasarisha-4, Binasarisha-9 and Binasarisha-10 because of high yield potential and less pest incidence. Therefore these varieties can be recommended for the farmer of Khagrachari district.

Establishment of BINA Technology village in surrounding area of BINA Sub-station, Khagrachari

In order to establish BINA-Technology village, demonstrations and other extension work were done in surrounding area of BINA-substation, Khagrachari at the farmer's fields. Results of overall promotional activities related to BINA-Technology village establishment at Satvaiya Para, Harinath Para and RangaPanichara of Golabari union are presented below.

Table 6. Performance of BINA developed varieties at Satvaiya Para, Harinath Para and RangaPanichara during 2017-18

Sl. No.	Crops	Variety Name	Demonstration No.	Av. Duration in days	Av. Yield (t ha^{-1})
1.	Rice	Binadhan-7	25	120.6	4.58
		Binadhan-13	05	145	2.76
		Binadhan-16	35	105.5	4.28
		Binadhan-17	35	112.67	4.63
2.	Mustard	Binasarisha-4	15	87.3	0.88
		Binasarisha-9	15	93.7	1.36
		Binasarisha-10	20	88.2	1.21

Agricultural lands of Satvaiya Para, Harinath Para and RangaPanichara villages of Golabari union, Khagrachari district are mostly plain and in a valley which is suitable area for growing rice, oilseeds and vegetables. Results indicated that Binadhan-7 and Binadhan-17 have higher grain yield with less duration (Table 3). Transplanted aman varieties Binadhan-7, Binadhan-16 and Binadhan-17 have higher grain yield than the other local cultivars. Farmers were interested to cultivate BINA developed aman rice varieties for their high yield and short duration and for good cooked rice. Binadhan-13 though being a promising aromatic variety but locally cultivated *Kalijira* has much better grain and aroma quality and higher market price than Binadhan-13 thus farmers were not interested to adopt Binadhan-13. Mustard variety Binasarisha-4, Binasarisha-9 and Binasarisha-10 showed immense potentials in terms of yield and duration. Most of these are suitable for cultivation in between aman and boro rice. In this area there is no established mustard variety. So, BINA developed mustard varieties can be a possible solution for the mustard growing farmers. Binasarisha-9 had the maximum yield followed by Binasarisha-10. Though the yield of Binasarisha-9 is less but farmers reported that it produced more oil content (%) than rest of the two. BINA technology village establishment beside BINA sub-station is in progress.

Quality seed production of promising BINA released varieties for hill tracts

Seeds of some demanding and promising BINA released crop varieties 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 2017-18 are presented in Table 7. 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 2017-18 period a total of 3.20 tons seeds of different crop varieties of BINA were produced and procured. Among them rice were about 2.50 tons, mustard 0.7 ton.

Table 7. Seeds produced/purchased, distributed/sold during 2017-18

Crop	Season	Varieties	Total seeds produced /purchased (ton)	Total distributed/sold (ton)
Rice	Aus	Binadhan-19	0.20	0.20
	Aman	Binadhan-7	0.40	0.40
		Binadhan-11	0.40	0.40
		Binadhan-16	0.40	0.40
		Binadhan-17	0.50	0.50
	Boro	Binadhan-14	0.50	0.50
		Binadhan-18	0.10	0.10
Mustard	Rabi	Binasarisa-4	0.10	0.10
		Binasarisa-9	0.50	0.50
		Binasarisa-10	0.10	0.10
		Total	**3.20**	**3.20**

Training on the use of BINA developed technologies

In order to transfer BINA developed technologies, a day long 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. Details of the training are presented in Table 8.

Table 8. Farmers Training on the use of BINA developed technologies during 2017-18

Sl. No.	Topic of training	Place of Training	No. of participants	Source of fund
1	Introduction to BINA released technologies, BINA developed mustard and lentil varieties' character, their production technology, seed processing and development of new cropping pattern	BINA substation, Khagrachari	85	Nutrition. .security project
2	BINA developed new AUS rice's variety Binadhan-19's characters, production technology and demonstration establishment	BINA substation, Khagrachari	31	Revenue
3	Introduction to BINA released Boro rice varieties, Binadhan-14's character, production technology, seed processing, demonstration establishment and development of new cropping pattern	BINA substation, Khagrachari	50	SRSD

Field Days

In order to motivate farmers and adopt BINA developed varieties/technologies, 2 field days on rice and mustard were organized in Khagrachari. Details of the field day activities are presented in Table 9.

Table 9. Field days arranged at the farmers' fields on different crop varieties during 2017-18

Sl. No.	Crops	Varieties	Locations	Participants
16.	Mustard	Binasarisha-9 and 10	Baurapara, Ugalchari, Panchari, Khagrachari	150
17.	Rice	Binadhan-14	Mubachari, Mohalchari, Khagrachari	100

BINA Sub-station, Gopalganj

Research Highlights

A total of 150 demonstrations were conducted with BINA developed different crop varieties at the farmers' field in collaboration with the Department of Agricultural Extension (DAE) during the reporting period 2017-18.

A total of 25 demonstrations with short durated T. Aman rice of Binadhan-7, Binadhan-16 and Binadhan-17 were produced average grain yield of 5.41, 5.78 t ha^{-1} and 5.88 t ha^{-1} respectively. Average maturity period of Binadhan-7 was 118 days, Binadhan-16 was 101 days and Binadhan-17 was 115 days. Binadhan-7, Binadhan-16 and Binadhan-17 increased crop production as well as income of farmers. Therefore, farmers were found interested to cultivate Binadhan-7, Binadhan-16 and Binadhan-17.

A total of 6 demonstrations with short durative submergence tolerant T. Aman rice of Binadhan-11 and Binadhan-12 were produced average yields of 5.80 and 4.30 t ha^{-1} respectively. Average maturity period of Binadhan-11 was 127 days and Binadhan-12 was 135 days. Binadhan-11 and Binadhan-12 increased crop production as well as income of farmers. Therefore, farmers were found interested to cultivate Binadhan-11 and Binadhan-12.

A total of 10 demonstrations with aromatic T. aman rice of Binadhan-13 with average yield of 3.15 t ha^{-1}. Average maturity period of Binadhan-13 was 141 days. Farmers were found interested to cultivate Binadhan-13.

A total of 10 demonstrations with Binakhesari-1 showed that Binakhesari-1 produced better yield (16.08% yield increased) with less maturity period than check variety.

One demonstration with short durative, drought tolerant T. aus rice of Binadhan-19 produced average yield of 5.70 t ha^{-1} in 104 days. Farmers were found interested to cultivate Binadhan-19.

A total of 9 demonstrations with short durative high yielding Binasarisha-4, Binasarisha-9 and Binasarisha-10 were produced better yield with less maturity period than check variety of BARI sarisha-14 .

A total of 08 demonstrations with short durative high yielding Binamasur-5, Binamasur-6, Binamasur-7 and Binamasur-8 were produced better yield with less maturity period than check variety of BARI masur-6.

A total of 2 demonstrations with short durative high yielding Chickpea variety Binachola-4 was produced better yield with less maturity period than popular local cultivar.

A total of 10 demonstrations with high yielding Sesame Variety Binatil-2 which was produced better yield with less maturity period than check variety of BARI til-4.

A total of 10 demonstrations with high yielding Mung bean Variety Binamoog-8 which was produced better yield with less maturity period than popular local cultivar.

A total of 25 demonstrations with BINA developed high yielding groundnut variety Binachinabadam-4 and Binachinabadam-7 were produced better yield with less maturity period than popular cultivar BARI chinabadam-8.

A total of 9 demonstrations with high yielding Tomato Varieties Binatomato-10, Binatomato-11 and Binatomato-12 were produced better yield with less maturity period than popular local cultivar.

A total of 30 demonstrations with salt tolerant Boro rice Binadhan-10 which was produced better yield with less maturity period than check variety BRRI dhan61.

A total of 10 field days were arranged to motivate farmers and popularize the BINA developed crop varieties/technologies to the end users.

A total of four farmers' training were also conducted to motivate farmers and popularize the BINA developed crop varieties/technologies to the end users.

Block farming with Grasspea variety Binakhesari-1 in collaboration with DAE

Ten demonstrations were conducted with Binakhesari-1 in Gopalganj region to demonstrate the performance of Binakhesari-1 and widening their adoption by the farmers. Area of demonstration plots was 50 decimal. The check variety was Local khesari. Seeds were sown during November 2017 at the rate of 45 kg ha^{-1}. Recommended doses of all fertilizers were applied. 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 Binakhesari-1 in Gopalganj region during 2017-18

Upazila	No. of demonstration	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binakhesari-1	Local khesari (check)	Binakhesari-1	Local khesari (check)	
Gopalganj Sadar	4	111	125	1.8	1.60	12.5
Kasiani	6	113	123	1.9	1.50	26.66
Total	**10**					
Mean		**112**	**124**	**1.85**	**1.55**	**19.35**

Data in Table 1 revealed that Binakhesari-1 produced average seed yield of 1.85 t ha^{-1} which was 19.35 percent higher compared to check variety. Average maturity period of Binakhesari-1 was 112 days. The check variety produced average gain yield of 1.55 t ha^{-1} with average maturity period of 124 days. The variety of BINA, Binakhesari-1 increased crop production as well as farmer's income. Therefore farmers were found interested to cultivate Binakhesari-1 in Gopalganj region.

Establishment of BINA technology villages in Gopalganj region

In order to establish BINA technology villages, Block demonstrations and other extension works were done in collaboration with the Department of Agricultural Extension (DAE) at the farmers' field in the surrounding areas of BINA substation, Gopalganj. Results of overall promotional activities related to BINA technology villages are presented below:

Block Demonstrations with different BINA developed crop varieties in surrounding areas of BINA substation, Gopalganj

During 2017-18, 150 block demonstrations were conducted with BINA developed nine crop varieties at Paikerdanga and Korpara villages under sadar upazila and Ramdia village under Kasiani upazila of Gopalganj district. Results of demonstrations are presented in Table 2.

Table 2. Performance of BINA developed crop varieties in surrounding areas of Gopalganj district during 2017-18

Variety	Total no. of Demonstrations	Average crop duration in days	Yield (t ha^{-1})
Binadhan-7	10	118	5.41
Binadhan-10	30	128	8.88
Binadhan-11	5	127	5.80
Binadhan-12	1	135	4.3
Binadhan-13	10	141	3.15
Binadhan-16	5	101	5.78
Binadhan-17	10	115	5.88
Binadhan-19	1	104	5.70
Binasarisha-4	03	92	1.67
Binasarisha-9	03	78	1.46
Binasarisha-10	03	80	1.35
Binamasur-5	02	101	1.35
Binamasur-6	02	109	1.30
Binamasur-7	02	108	1.42
Binamasur-8	02	98	1.60
Binachola-4	02	124	1.20
Binachinabadam-4	20	149	2.40
Binachinabadam-7	05	146	2.20
Binakheshari-1	05	112	1.80
Binatil-2	10	95	1.49
Binamoog-8	10	65	1.01
Binatomato-10	03	105	99.60
Binatomato-11	03	102	82.67
Binatomato-12	03	100	78.45
Grand total	**150**	**--**	**--**

Seed Production

During the reporting period a total of 9.10 Metric Ton Truthfully Labeled Seed (TLS) of Binadhan-10, Binadhan-11, Binadhan-17, Binakhesari-1 and Binachola-4 were produced in BINA Substation Gopalganj farm. TLS seeds of Binadhan-11 and Binadhan-17 were distributed among the farmers of Gopalganj, Faridpur and Madaripur districts and seeds of Binadhan-10, Binakhesari-1 and Binatchola-4 were stored in the seed store of BINA sub-station, Gopalganj (Table 3).

Table 3. Amount of Seed production in BINA Sub-station, Gopalganj

Sl. No.	Variety	Amount (ton)
1.	Binadhan-10	5.00
2.	Binadhan-11	0.55
3.	Binadhan-17	0.45
4.	Binakheshari-1	3.00
5.	Binachola-4	0.01
	Total	**9.10**

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, Gopalganj. The participants were farmers (both male and female) and Sub-assistant Agriculture Officer. Details of the training are presented in Table 4.

Table 4. Farmers Training on the use of BINA developed technologies during 2016-17

S.L No	Topic of training	Place of Training	No. of participants	Source of fund
1.	Production Technologies of BINA developed crop varieties	BINA Sub-Station, Gopalganj.	50	GOB
2.	Production Technology of newly released short durative T. Aus rice Binadhan-19	BINA Sub-Station, Gopalganj.	50	SRSD
3.	Effects of Hazardous chemicals used in food on human health and preventive measures	BINA Sub-Station, Gopalganj.	100	GOB
4.	Processing and storage techniques of rice, mustard, mung bean and groundnut.	BINA Sub-Station, Gopalganj.	70	SRSD

Field Day

In order to motivate the farmers to adopt the BINA developed varieties/technologies 10 field days of different varieties of BINA were organized. Details of the field day activities are presented below:

Table 5. Field days arranged at the farmers' fields during 2017-18

Sl. No.	Crops	Varieties	Locations	No. of Participants
1.	Rice	Binadhan-7	Paikerdanga, Sadar, Gopalganj	200
2.	Rice	Binadhan-11	Paikerdanga, Sadar, Gopalganj	205
3.	Rice	Binadhan-16	Joynagar, Kasiani, Gopalganj	196
4.	Rice	Binadhan-17	Paikerdanga, Sadar, Gopalganj	194
5.	Rice	Binadhan-10	Paikerdanga, Sadar, Gopalganj	192
6.	Rice	Binadhan-10	Ramdia, Kasiani, Gopalganj	192
7.	Rice	Binadhan-19	Suchidanga, Sadar, Gopalganj	230
8.	Kheshari	Binakheshari-1	Gopinathpur, Sadar, Gopalganj	220
9.	Chinabadam	Binachinabadam-4	Lebutola, Tungipara, Gopalganj	195
10.	Chinabadam	Binachinabadam-7	Korpara, Sadar, Gopalganj	210

BINA Sub-station, Noakhali

Research Highlights

A total of 8 demonstrations with Binasoybean-2 showed that Binasoybean-2 produced higher yield (22% yield increased) with less maturity period than check variety of Shohag.

A total of 4 demonstrations with Binachinabadam-6 and Binachinabadam-8 showed that Binachinabadam-6 and Binachinabadam-8 produced higher yield (40% and 33% yield increased, respectively) with less maturity period than check variety of Dacca-1.

Up-scaling BINA developed Binasoybean-2 in Noakhali and laxmipur region

During 2017-18, 8 demonstrations were conducted with Binasoybean-2 in Noakhali and Laxmipur region. The check variety was Shohag. The main objectives were to demonstrate the performance of Binasoybean-2 and widening their adoption by the farmers. Area of demonstration plots was one acre. Seeds were sown during last January 2018. 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 Binasoybean-2 in Noakhali and Laxmipur region during 2017-18

Upazila	No. of demonstration	Duration (days)		Yield (t ha^{-1})		Yield increased over check (%)
		Binasoybean-2	Shohag (check)	Binasoybean-2	Shohag (check)	
Shubornochor	5	111	116	2.40	2.00	20.00
Hatia	1	110	115	2.20	1.90	15.79
Laxmipur	2	109	114	2.30	1.80	27.78
Total	**8**					
Mean		**110**	**115**	**2.30**	**1.90**	**21.19**

Data in Table 1 reveal that Binasoybean-2 produced average seed yield of 2.30 t ha^{-1}, which is 22.00 percent higher than check variety Shohag. Average maturity period of Binasoybean-2 was 110 days. The check variety Shohag produced average seed yield of 1.90 t ha^{-1} with average maturity period of 115 days. Therefore the variety of BINA, Binasoybean-2 increased crop production as well as farmer's income. Farmers were found interested to cultivate Binasoybean-2 in Noakhali and Laxmipur region.

Up-scaling BINA developed Binachinabadam-6 and Binachinabadam-8 in Noakhali region

During 2017-18, 4 demonstrations were conducted with Binachinabadam-6 and Binachinabadam-8 in Noakhali region. The check variety was Dhaka-1. The main objectives were to demonstrate the performance of Binachinabadam-6 and Binachinabadam-8 and widening their adoption by the farmers. Area of demonstration plots was 33 decimals or one bigha. Seeds were sown during last January 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 2

Table 2: Performance of Binachinabadam-6 and Binachinabadam-8 in Noakhali region during 2017-18

Upazila	No. of demonstration	Duration (days)			Yield (t ha^{-1})			Yield increased over check (%)
		Binachinabadam-6	Binachinabadam-8	Dacca-1 (check)	Binachinabadam-6	Binachinabadam-8	Dacca-1 (check)	
Shubornochor	3	145	-	150	2.10	-	1.50	40.00
Hatia	1	-	140	145	-	1.60	1.20	33.34
Total	**4**							
Mean		**145**	**140**	**143**	**2.10**		**1.35**	**36.67**

Data in Table 2 reveal that Binachinabadam-6 and Binachinabadam-8 produced average seed yields of 2.10 and 1.60 t ha^{-1}, respectively which is 40.00 and 33.34 percent higher than check variety Dhaka-1. Average maturity period of Binachinabadam-6 and Binachinabadam-8 was 145 and 140 days, respectively. The check variety Dhaka-1 produced average seed yield of 1.35 t ha^{-1} with average maturity period of 143 days. Therefore the variety of BINA, Binachinabadam-6 and Binachinabadam-8 increased crop production as well as farmer's income. Farmers were found interested to cultivate Binachinabadam-6 in Noakhali region.

Establishment of BINA Technology village, in surrounding area of BINA Sub-station, Noakhali

In order to establish BINA-Technology village demonstrations and other extension work were done in surrounding area of BINA-substation, Noakhali at the farmer's fields. Results of overall promotional activities related to BINA-Technology village establishment at Charbat Union in Shubornochor upazilla are presented below.

Table 3: Performance of BINA developed varieties at Charbata Union during 2017-18

Sl. No	Crops	Variety Name	Demonstration No.	Av. Duration in days	Av.Yield (t ha^{-1})
	Rice	Binadhan-10	7	140	5.60
2.	Groundnut	Binachinabadam-6	3	145	2.10
		Binachinabadam-8	1	140	1.60
3.	Soybean	Binasoybean-2	8	110	2.30

Charbata Union in Shubornochor Upazilla at Noakhali district is very suitable area for growing rice, oilseeds and vegetables. Results indicated that Binadhan-10 produced higher grain yield with moderate crop duration (Table 3). Farmers had been interested to cultivate BINA developed salt tolerant rice varieties for their high yield, short crop duration and varietals diversification. Soybean variety, Binasoybean-2 showed immense potentials in terms of yield and duration for cultivation and adaptation in salt affected areas. Binachinabadam-6 and Binachinabadam-8 also produced higher seed yield than check. BINA technology village establishment in Charbata union is in progress.

Training on the use of BINA developed technologies

In order to transfer BINA developed technologies a training of one day was arranged at BINA Sub-station, Noakhali. The participants were farmers (both male and female) and Sub-assistant Agriculture Officer. Details of the training are presented in Table 5.

Table 5. Farmers Training on the use of BINA developed technologies during 2017-18

S.L No	Topic of training	Place of Training	No. of participants	Source of fund
1.	Introduction of extensionable BINA developed crop varieties, production technology & development of cropping pattern	BINA substation, Noakhali	85	Nutrition safety project
2.	Introduction of BINA developed crop varieties around the season & suitability of cropping pattern development.	DD office, DAE, Noakhali	36	SRSD