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ANNUAL REPORT

2021-22

BANGLADESH INSTITUTE OF NUCLEAR AGRICULTURE

October 2022

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BANGLADESH INSTITUTE OF NUCLEAR AGRICULTURE

BAU CAMPUS, MYMENSINGH-2202, BANGLADESH

October 2022

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PREFACE

Bangladesh Institute of Nuclear Agriculture (BINA) Annual Research Report 2021-22 would inaugurate a new dimension of research findings exposure. I am certainly delighted to note that this report emphasizing key research outcomes dealing with the use of nuclear and other advance techniques. This report covers several very important sectors of agriculture including food security, livelihood enhancement as well as socio-economic improvement of the country. Many technologies, such as varietal development of cereals (rice and wheat), oilseeds (mustard, rapeseed, groundnut, sesame, soybean and sunflower), pulses (lentil, mungbean, blackgram, chickpea, grasspea, pigeonpea), jute, horticultural crops (fruits, vegetables and spices) have already been found suitable for different agro-ecological zones. Apart from the varietal development attention was also placed on non-commodity fields as soil and water management, crop physiological aspects, cropping systems, plant nutrient, pest management, adaptive research and production economics. Emphasis was concentrated on biotechnological research for generating high yielding and climate tolerant crop types and hill farming. This study demonstrates that the scientists of this institute are devoted to create technologies which are appropriate as well as sustainable leading to food and nutritional security of the country. During this period substantial progress was made towards the development of new crop kinds. Five crop varieties were released/registered during this period which were Binamung-11, BINA dhan25, BINA soybean7, BINA khesari2 and BINA kul1. A total of 497 adaptation trials/block farming using BINA developed crop varieties were undertaken at the farmers' field in partnership with the Department of Agricultural Extension (DAE) and BINA Sub-stations. To motivate farmers and popularize the BINA developed crop varieties/technologies to the end users a total of sixty one farmers training courses were organized during this period and 4000 male and female farmers were trained on cultivation of BINA developed improved crop varieties across the country. Besides these, various TV programme were telecasted to market some BINA crop varieties.

I recognize the endeavors that aid with the publication with genuine gratitude to knowledge contribution of deep capacities. This annual report would be highly functional for all scientists, academics, planners, policy makers as well as interested individuals involving agricultural research and development concern in the country and overseas.

Dr. MirzaMofazzal Islam
Director General

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.

CONTENTS

Plant Breeding Division

Research Highlights, 2021-22

Rice

One BLB resistant rice line BSB-24 has been selected for T. Aman season having 6.0-6.5 t/ha of grain yield and 115-120 days growth duration. This line has been sent to SCA for field evaluation to be released as a variety. Two rice lines MEF-10 and MEF-27 produced average yield of 6.76 and 6.91 tha^{-1}, respectively. These two lines matured within 140 days and suitable for the cultivation in Boro season at Haor areas. Another two rice lines BLB-P-19 and BLB-P-26 produced average yield of 5.76 and 6.15 tha^{-1}, respectively. These two lines matured within 110-115 days and suitable for the cultivation in T.Aman season. These lines have been sent to SCA for DUS test. Moreover, two high yielding (5.5-6.0 t/ha) Fe and Zn enriched rice lines (IZSD-26 and IZSD-45) with short duration (110-115 days) and red colored pericarp were selected for T. Aman season.

The mutant RM-Kas-80(C)-1 derived from the phosphorus use efficient cultivar Kasalath produced average yield 5.77 tha^{-1} and one mutant RM-16(N)-10 derived from the NERICA-4 produced average yield 6.07 tha^{-1} which was higher than BRRI dhan49 (5.30 tha^{-1}) and both mutants were 8-13 days earlier than the check variety BRRI dhan49. Fifteen lines have been selected of Biroi in F_5 generation on the basis of short duration (110-120 days), high yielding (4.5-5.0 t/ha), lodging tolerant characters. Two mutant RM-16(N)-10-1 and RM-16(N)-8-1 selected for Aman season developed by irradiating the seeds of NERICA-4 **w**ith N- ion beams whose average yield was 7.2 and 7.7 tha^{-1} and duration was 140-150 days.

Wheat

1 promising lines was selected for Preliminary Yield Trial (AYT) that is high yielding (3.75-3.80 t/ha) and earliness (114-116 days) especially for Barind area. Twenty lines have been selected for BC_1F_3 generation on the basis of bold seeded, early and high yielding.

Oil Crop

One soybean variety has been released named as Binasoybean-7 (2.6 t/ha seed yield). One promising mustard mutant (RM005) was selected having low erucic acid (26%) content. Two advanced lines (RL11 & RL-17) and four advance mutants (RT-32, RT-35, RT-38 and RT-39) of rapeseed-mustard were selected for further evaluation trial. Twenty-two mutants and sixteen advanced mustard lines from different trials also been selected in respect of maturity period along with some others improved yield components. Two advanced sesame mutants (SM-026 and SM-28) were found promising in respect to higher seed yield and improve agronomic characters. Three promising soybean mutants (SBM-12, SBM-23 and SBM-25) were found in regarding to early maturing period along with higher seed yield. Further selection should be needed for early maturing and high yielding mutants/lines in different generations. Thirty promising sunflower mutants were found regarding to early maturing period along with higher seed yield potential from different generations.

Four promising mutant lines of groundnuts were selected for Advanced yield trial (AYT) on the basis of early and high yielding (2.05-2.71 t/ha) characters in Rabi season. 7 F_6 and 7 F_7 lines have been selected for bold seeded, high yielding and 3-4 chambered and high 0/L ratio characters. 50 lines for F_4 generation and 30 lines for F_3 generation have been selected based on bold seeded, high yielding and 3-4 chambered and high 0/L ratio characters.

Mungbean

Application will be made to NSB for variety registration of one promising mungbean mutant line (MBM-656-51-2) in respect of earliness, semi synchronous pod maturity, disease tolerant and high yielding. Four (4) putative mungbean mutants were selected on the basis of synchronous habit, early maturity (75-90 days) and high yielding (>1.6 ton/ha).

Lentils: Six mutants were found promising in respect of seed yield and disease reactions. Apart from these lines, five promising mutant lines were selected on the basis of earliness, erect plant type and higher seed yield. In addition, some high yielding early mutants were selected for further evaluation and trials.

Grasspea: Four mutants performed better in respect of seed yield and earliness which were in regional yield trials. Moreover, a good number of advanced mutants were found promising in respect of higher seed yield and earliness.

Blackgram: Application will be made to register a better performed line, BM-105 as a variety, Binamash3 in 2022. In addition, four advanced mutants were selected on the basis of earliness, disease reaction and erect plant type.

Programme Area: Varietal improvement of cereals
Project: Varietal improvement of rice using induced mutation and other advanced breeding techniques

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

Bacterial leaf blight (BLB) of rice caused by *Xanthomonas oryzae* pv. *oryzae* (*Xoo*) is a major pathogen that negatively impacts rice production. BLB causes yield losses generally ranging between 10 and 30%, but which can be as high as 80%, depending on the location, season, weather, crop growth stage and cultivar. The development of a BB-resistant rice cultivar through a gene introgression breeding program is critically important as there are no chemicals or management practices known to reduce the severity of BLB. The present study was conducted to evaluate the yield potential, earliness and BLB resistance of BSB-24, a BLB introgressed rice line at different locations.

This experiment was carried out with a BLB introgressed rice line, BSB-24 with BRRI dhan49 as a check to assess the yield potential over locations in T. Aman season. Seeds were sown on 3-18 June 2021 and transplanted during 18 July to 13 August 2021 at different locations. This experiment was conducted at BINA HQ farm, Mymensingh, BINA sub-station farm Ishwardi, Jamalpur, Rangpur and Sunamganj. The experiment followed RCB design with three replications. The size of the unit plot was 4.0 m × 5.0 m. Seedlings were transplanted at a 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 needed. Data on plant height, number of total tillers plant^{-1}, effective tillers plant^{-1}, panicle length, filled and unfilled grains panicle-^{1} and thousand seed weight were recorded after harvest from 5 randomly selected competitive plants. Maturity was assessed plot basis. Grain yield was recorded from an area of 10 m^2 which was later converted to t ha-^{1}. Finally, all the recorded data were subjected to proper statistical analyses.

The results obtained from the on-farm and on-station trials of individual locations and mean over locations for all the characters are presented in Table 1. Significant differences were observed between the line and the check variety for yield and yield attributing characters. From mean over locations, it appeared that the BSB-24 line had a significantly higher number of total tiller plant^{-1}, effective tillers plant^{-1}, thousand grain weight, longer panicle length and grain yield at all the locations than the check variety, BRRI dhan49 (Table 1). There was no significant difference between the test line and check for the number of filled grain and plant height. Highest yield was found at Ishwardi (6.99 t ha^{-1}) followed by Sunamganj (6.15 t ha^{-1}), where lowest was at HQ, Mymensingh (6.03 t ha^{-1}). The higher yield of BSB-24 is attributed by the panicle length and thousand grain weight. Molecular study also identified the BLB resistance genes *xa5* and *xa13* in BSB-24 derived from a cross between the rice varieties ‘Tn-1’ and ‘IRBB60. This line matured 6-12 days earlier than the check variety BRRI dhan49 at HQ, Ishwardi, Jamalpur, Rangpur and Sunamganj. Quality assessment was done based on kernel length and L/B ratio. The kernel shape and size of BSB-24 is long-slender where the BRRI dhan49 is medium (Table 2). Based on the yield performance, earliness and resistance against BLB and grain quality, BSB-24 could be selected for further evaluation to release it as a variety.

Table 1. Yield and yield attributes of one rice line along with their check at different locations during T. Aman, 2021-22

Location	Genotypes	Days to 50% Flowering	Days to maturity	Plant height (cm)	Total tiller (no.)	Effective Tillers plant^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	Thousand grain weight (gm)	Grain yield (t ha^{-1})
HQ	BSB-24	87b	115b	120.20a	13.03a	12.66a	28.30a	128.65a	40.00a	22.66a	6.03a
	BRRI dhan49	97a	127a	121.93a	11.40a	10.80a	25.40b	111.83a	35.45a	19.33b	4.69b
Ishwardi	BSB-24	90b	117b	110.06a	12.60a	12.20a	25.26a	125.06a	16.26a	22.16a	6.99a
	BRRI dhan49	98a	125a	108.00a	11.46a	10.93a	22.80b	114.20b	21.20a	19.66b	5.93b
Jamalpur	BSB-24	86b	120b	104.53a	12.13a	11.40a	24.96a	99.17b	24.00a	22.66b	5.74a
	BRRI dhan49	92a	126a	104.33a	11.33a	11.06a	23.83b	151.67a	21.23a	19.33b	4.73b
Rangpur	BSB-24	86b	120b	114.60a	10.60a	9.73a	26.66a	100.53a	16.80a	22.33a	5.82a
	BRRI dhan49	92a	126a	105.27a	8.33b	8.00a	20.93a	92.93a	14.27a	19.50a	4.56b
Sunamganj	BSB-24	87b	111b	105.07a	13.93a	12.86a	28.33a	161.53a	24.93a	22.67a	6.15a
	BRRI dhan49	96a	123a	104.20a	11.20a	9.80b	24.13a	185.93a	25.93a	19.33b	5.56b
Mean over locations	BSB-24	88b	116b	110.85a	12.46a	11.77a	26.70a	122.99a	23.05a	22.50a	6.08a
	BRRI dhan49	96a	125a	108.79a	10.75b	10.12 b	23.42b	131.31a	25.10a	19.43b	4.94b

In a column, values with same latter(s) for individual location/combined means do not differ significantly at .1% level

Table 2. Kernel characteristics of the BLB resistant rice line (BSB-24) with check (BRRI dhan49)

Genotypes	Length (mm)	Breadth (mm)	L/B ratio	Size	Shape
BSB-24	6.94	2.03	3.42	Long	Slender
BRRI dhan49	5.69	2.08	2.74	medium	Medium

On farm and on-station trial of two short duration rice lines for better grain quality and higher yield

On-farm and on-station trials were carried out with two lines along with one check variety (BRRI dhan75) at BINA HQ farm Mymensingh and sub-station Magura, Jamalpur, Rangpur and Nalitabari during Aman season of 2021. Seedlings were planted in RCB design with three replications. Unit plot size was 5.0 m × 4.0 m. Plant to plant and row to row distance were 15 cm was 20 cm, respectively. Data on days to flowering, days to maturity, plant height (cm), total number of tillers plant^{-1} number of effective tillers plant^{-1}, panicle length (cm), filled and unfilled grains panicle^{-1}, 1000 grain weight (g) and grain yield (tha^{-1}) were recorded from five randomly selected plants of each plot. Plot seed yield was converted to tha^{-1}. Recorded data were finally subjected to proper statistical analyses and are presented in Table 3.

The results obtained from the on-farm and on-station trials of individual locations and mean over locations for all the characters are presented in Table 3. Significant differences were observed among the lines and the check variety for yield and yield attributing character. EFSD-58 performed better among the lines and check variety in terms of yield. It produced the highest yield among the lines and the check variety at all the locations (Table 3). Highest yield was found at Rangpur (6.24 t ha^{-1}) followed by Mymensingh, HQ (5.17 t ha^{-1}). The higher yield of EFSD-58 is attributed by the higher number of effective tillers plant^{-1}, number of filled grains panicle^{-1} and panicle length. The duration of this line almost same (101-110days) compare to the check variety BRRI dhan75 at all locations and mean over locations. The grain quality parameters data are presented in the Table 4. The lines EFSD-58 and EFSD-21 had the head rice recovery % 69.78 and 66.36, respectively. The line EFSD-58 had the longest grain (6.54 mm) and the highest L/B ratio (3.17) indicating that the line produced medium slender grain (Table 4). Other line and the check variety produced medium slender grain. Based on the yield performance and grain quality EFSD-58 could be selected for further evaluation to release it as a variety.

Table 3. Yield and yield attributes of two rice lines along with their check at different locations during T. Aman, 2022

Location	Genotypes	Days to 50% Flowering	Days to maturity	Plant height (cm)	Total tiller (no.)	Effective Tillers plant^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	Thousand grain weight (gm)	Grain yield (t ha^{-1})
HQ	EFSD 21	75.00a	105a	99.67b	11.33a	10.00a	23.66a	119.33a	21.33a	24.67a	5.60b
	EFSD 58	77.33a	101b	98.67b	11.33a	9.67a	24.10a	123.33a	25.67a	22.33ab	6.17a
	BRRI dhan75	75.33a	99c	108.00a	10.00a	9.67a	22.00a	119.00a	28.67a	18.33b	5.17ab
Magura	EFSD 21	75.00a	105a	98.67b	11.33a	10.00a	23.67a	119.33a	21.33a	24.67a	5.59b
	EFSD 58	77.33a	101b	99.67b	11.33a	9.67a	24.10a	123.33a	25.67a	22.33ab	6.01a
	BRRI dhan75	75.33a	99c	108.00a	10.00a	9.67a	22.00a	119.00a	28.67a	18.33b	5.17ab
Jamalpur	EFSD 21	73.00b	102.33a	90.33b	10.67a	9.67a	22.03ab	142.33a	20.00ab	22.00a	5.89a
	EFSD 58	75.67a	103.67a	91.33b	10.00a	9.67a	23.37a	133.33ab	22.67a	22.00a	5.95a
	BRRI dhan75	72.00b	100.00a	103.00a	10.67a	9.33a	21.33b	126.00b	15.00b	20.33b	5.15b
Rangpur	EFSD 21	73.67b	105.00a	96.80b	10.67a	8.67b	21.53b	120.67b	21.67a	21.13ab	5.77b
	EFSD 58	78.33a	108.67a	104.34a	12.00a	10.67a	23.27a	137.00a	24.67a	22.20a	6.24a
	BRRI dhan75	73.33b	103.67a	108.57a	11.33a	9.67ab	20.87b	122.67b	20.00a	20.60b	5.23b
Nalitabari	EFSD 21	73.33a	101b	97.33a	10.00a	9.67a	25.03ab	120.00b	30.00ab	22.67a	5.89b
	EFSD 58	75.00a	107a	101.33b	11.00a	10.00a	25.37a	140.00a	32.67a	22.67a	6.08a
	BRRI dhan75	71.00a	100b	106.33b	10.00a	9.33a	24.33b	122.67b	25.00b	21.00b	5.17b
Mean over locations	EFSD 21	53.67b	104.33a	95.49c	10.53a	9.40b	22.94b	122.33b	22.33a	22.89a	5.58b
	EFSD 58	75.87a	105.27a	98.46b	11.47a	10.27 a	23.99a	131.60a	25.00a	22.44a	6.10a
	BRRI dhan75	73.06b	102.33a	105.98a	10.53a	9.53ab	22.02c	121.87b	21.40a	20.32b	5.39b

Table 4. Grain characteristics of the Advanced rice lines (EFSD-58 and EFSD-21) with check (BRRIdhan-75)

Strain/Variety	Head rice yield (%)	Whole grain length (mm)	Dehulled grain/kernel			
			length (mm)	Breadth (mm)	L/B ratio	Size and shape
EFSD-58	69.78	8.96	6.54	2.06	3.17	Medium Slender
EFSD-21	66.36	8.43	6.26	2.13	2.93	Medium Slender
BRRIdhan-75	74.47	8.63	6.28	2.16	2.90	Medium Slender

On-farm and on-station trial with some iron and zinc rich M_{10} rice mutant

This experiment was carried out to assess overall performance for better grain quality and higher grain yield of four iron and zinc conrtent rice lines along with one check variety Binadhan 20 tested in Aman season during 2022 at BINA HQ's farm Mymensingh, BINA Sub-station Nalitabari, Jamalpur and Cumilla. The experiment followed RCB design with three replications. The size of unit plot was 4.0 m × 5.0 m. Plant to plant distance was 15 cm and row to row distance was 20 cm. Data on days to flowering, days to maturity, plant height (cm), total number of tillers plant^{-1}, number of effective tillers plant^{-1}, panicle length (cm), filled and unfilled grains panicle^{-1}, 1000 grain weight (g) and grain yield (tha^{-1}) were recorded after harvesting from 5 randomly selected competitive plants/hills. Maturity was assessed plot basis. Recorded data were finally subjected to proper statistical analyses and are presented in Table 5.

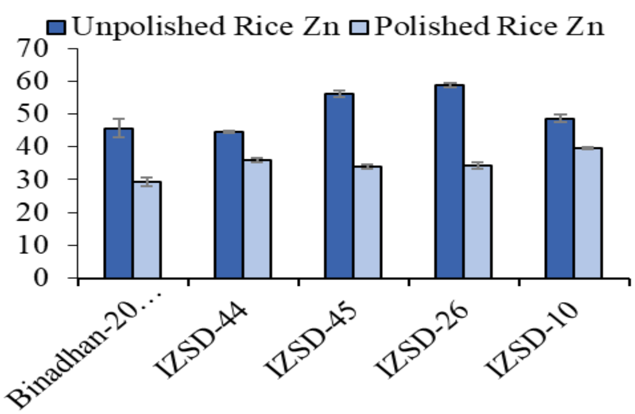
It is observed that the results obtained from regional yield trials of individual location and mean over locations for all characters presented in Table 5. Most of the characters showed significant differences among the lines and check for four individual locations and mean over locations. From mean over locations, it appeared that the IZSD-26 line had significantly shorter duration (109 days) and higher number of filled grains (173) at mean over locations than the check variety, Binadhan-20 (Table 5). There was no significant difference between the test line and check for the number of effective tiller and panicle length. Grain yield of this line was significantly higher (6.06 t/ha) at mean over locations than the check variety Binadhan-20. But the line IZSD-26 and IZSD-45 were matured (109 & 111 days) earlier than check variety, Binadhan-20 (132 days). As these two lines matured earlier (15-20days) than the check variety Binadhan-20, it would be better to select a desirable check for this trial. The grain quality parameters data are presented in the Table 6. The highest head rice recovery % was found in the line IZSD-26 (71.65%). The line IZSD-26 and check, Binadhan-20 had the head rice recovery 68.80% and 59.76%, respectively. The check had the longest grain (8.29 mm) and the highest L/B ratio (4.04) indicating that the line produced very long slender grain. Other lines produced long and medium slender grain (Table 6). The mean grain Fe concentration of rice lines ranged from 9 to 15 mg/kg and 1 to 4 mg/kg in unpolished & polished rice, respectively (Figure 1). The mean zinc concentration of rice lines ranged from 45 to 59 mg/kg and 29 to 40 mg/kg in unpolished & polished rice, respectively (Fig. 1). Considering earliness, Fe, Zn content and high yields, the lines IZSD-26 could be selected for further evaluation with a suitable check to release it as a variety.

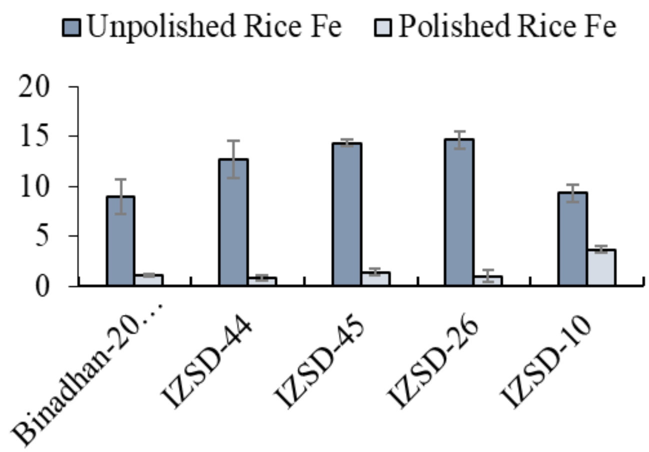
Table 5. Yield and yield attributes of one rice line along with their check at different locations during T. Aman, 2021-22

Location	Genotypes	Days to 50% Flowering	Days to maturity	Plant height (cm)	Total tiller (no.)	Effective Tillers plant^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	Thousand grain weight (gm)	Grain yield (t ha^{-1})
HQ	IZSD-26	76b	109b	97b	13a	11a	25b	155a	23b	22.27a	6.16a
	IZSD-45	79b	108b	98b	10a	9a	25b	148a	25b	23.10a	5.51b
	Binadhan-20	92a	131a	116a	11a	11a	27a	133b	38a	22.47a	5.76b
Nalitabari	IZSD-26	83a	112b	100b	11a	10a	26a	174a	27a	21.67a	6.08a
	IZSD-45	84a	112b	101b	12a	11a	26a	173a	28a	21.80a	5.72a
	Binadhan-20	95a	133a	113a	12a	11a	27a	152b	24a	22.06a	5.61a
Jamalpur	IZSD-26	82b	105c	99b	12a	11a	26a	183a	27b	21.47a	6.03a
	IZSD-45	83b	115b	98b	11a	11a	25a	152b	33ab	22.10a	5.71b
	Binadhan-20	98a	133a	120a	11a	10a	27a	166b	36a	22.13a	5.69b
Cumilla	IZSD-26	82b	111b	100a	12a	11a	27a	171a	33a	21.67a	5.89a
	IZSD-45	81b	109b	103a	11a	10a	26a	160b	28a	22.80a	5.42b
	Binadhan-20	97a	135a	110a	9a	9a	28a	155b	27a	22.07a	5.51b
Mean over locations	IZSD-26	82b	109b	102b	12a	11a	26a	173a	28a	21.07a	6.06a
	IZSD-45	83b	111b	103b	11a	10a	26a	160b	29a	22.20a	5.63b
	Binadhan-20	95a	132a	115a	11a	10a	27a	152b	28a	22.18a	5.65b

Table 6. Grain characteristics of the Advanced rice lines (IZSD-26, IZSD-45) with check (Binadhan-20)

Strain/Variety	Head rice yield (%)	Whole grain length (mm)	Dehulled grain/kernel			
			length (mm)	Breadth (mm)	L/B ratio	Size and shape
IZSD-26	71.65	8.37	5.87	2.04	2.88	Medium Medium
IZSD-45	68.80	9.69	7.16	2.20	3.25	Long Slender
Binadhan-20	59.76	10.09	8.29	2.05	4.04	Very long Slender





Haor is a term used to describe low-lying areas that are prone to flooding and are submerged in water for several months every year. Haors, which are primarily found in Bangladesh's north-eastern region and are large back swamps or bowl-shaped depressions between the natural embankments of rivers. Although artificial irrigation is occasionally used in this region, natural water is primarily used for rice farming. Longer duration and plant height characteristics of boro rice varieties often become the victim of flash flood. Short duration and high yielding boro rice variety can be blessings for these areas. The objectives of the study were to investigate the evaluation of selected lines over locations.

For this experiment, two lines (MEF-10 & MEF-27) with the check variety BRRI dhan28 were used during boro season 2021-22 at different locations under the super vision of BINA HQ and BIAN sub-stations. The experiment followed RCB design with three replications. The size of unit plot was 5.0 m × 6.0 m. Plant to plant distance was 15 cm and row to row distance was 20 cm. Data on days to flowering, days to maturity, plant height (cm), total number of tillers plant^{-1} number of effective tillers plant^{-1}, panicle length (cm), filled and unfilled grains panicle^{-1}, 1000-grain weight (g) and grain yield (tha^{-1}) were recorded after harvesting from 5 randomly selected competitive plants/hills. Maturity was assessed plot basis. The data for the characters under study were statistically analyzed wherever applicable. Data were analyzed using Minitab statistical package.

From the results, significant variations were observed for all the characters at all the locations. Combining mean of over locations, it was observed that MEF-10 & MEF-27 matured earlier (138.91c & 140.70b days) than the check variety BRRI dhan28 (146.04a days). MEF-27 produced highest grain yield (6.91a t/ha) followed by MEF-10 (6.76ab t/ha) and BRRI dhan28 (6.22b t/ha). At farmer's field, early maturity was found in MEF-10 (138.5a days) at Bijoynagar followed by BRRI dhan28 (146.33a days) at mithamoin. Highest yield was found in MEF-10 (7.3a t/ha) at Bijoynagar farmer's field followed by BRRI dhan28 (5.87b t/ha) a5.87b t/ha. Among different BINA stations, MEF-27 produced highest grain yield and filled grain (7.47a t/ha & 144.66a) at BINA sub-station Cumilla and MEF-10 (7.28a, 126.66a) at BINA HQ farm, Mymensingh (Table 7). In our country flash flood usually comes at haor areas from the 1st week of April to 2nd week. It causes huge loss of Boro crop at haor areas. As both of the lines are mature 6-7 days earlier than the check variety BRRI dhan28, it could escape early flash flood at haor areas. Considering short duration and higher yield, further evaluation will be done for these lines (MEF-10 & MEF-27).

Recent years, flash floods were a frequent occurrence that caused rice cultivation in the haor areas to be disrupted, have led to reduced yields of rice production in the Boro season. The study concludes that, cultivation of MEF-10 and MEF-27 lines in proper time can be economically more viable in the haor areas.

Table 7. Agronomic performance of rice lines along with check variety at different locations during Boro season 2021-22

Locations	Genotypes	Days to flowering	Days to maturity	Plant height (cm)	Total tillers plant^{-1} (no.)	Effective tillers plant^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000-grain weight (g)	Grain yield (th^{-1})
BINA HQ farm Mymensingh	MEF-10	109.33b	138.33c	96.83b	13.33a	12.66a	22a	126.66a	30.66b	21.12b	7.28a
	MEF-27	110.66b	140.66b	105.33a	13.66a	12.66a	22.8a	120.66a	19.66b	23.33a	6.96ab
	BRRIdhan28	114a	146a	105.56a	14.33a	13.33a	22.76a	98b	25.33b	22.03ab	6.5b
BINA Sub-station Cumilla	MEF-10	109.15a	139.2a	97.53b	15.71a	14.9a	22.53b	122.45ab	24.2a	22.29a	6.73b
	MEF-27	110.21a	140.2a	106.26ab	16.4a	15.1a	23.26b	144.66a	24.8a	24.43a	7.47a
	BRRIdhan28	115.1b	147.24b	107.46a	12.2b	12.0a	24.93a	116b	33.34a	22.36a	6.61b
BINA Sub-station Ishwardi	MEF-10	107.21a	138.15b	93.9b	12.13a	11.7b	21.93a	110.12b	26.33a	23.26ab	6.63a
	MEF-27	110.51b	140.51b	107.1a	12.43a	12.5a	22.8a	120.41a	19.6b	23.38a	6.47a
	BRRIdhan28	112.35a	146.12a	105.56a	14.33a	13.2a	23.54a	101.5c	25.46a	22.03b	6.03b
BINA Sub-station Magura	MEF-10	109.37c	138.33c	96.83b	13.8a	12.6b	22a	126.3 b	41a	21.12b	6.48ab
	MEF-27	111.3b	141b	105.63a	13.6a	13.1a	23.36a	124a	21.66b	23.33a	7.33a
	BRRIdhan28	113a	146a	105.63a	14.1a	13.6a	22.76a	95.33b	27.66b	22.03ab	6.23b
BINA Sub-station Rangpur	MEF-10	108c	139b	97.5b	13.66a	12.67b	22a	131a	42a	21.45b	6.76ab
	MEF-27	110.33b	140.33b	107.63a	13.33a	12.66b	22.8a	122a	20.66b	23.33a	7.38a
	BRRIdhan28	114.33a	145.33a	106.23a	14.33a	13.33a	22.3a	96.33b	30.69ab	22.36ab	6.23b
Farmer's field at Mithamoin	MEF-10	108.66c	139.64c	93.7a	12.33a	12a	22a	115.33a	27.33a	23.13b	6.26a
	MEF-27	111.66b	141.66b	98.13a	12.65a	12a	21.86a	103.33a	28a	24.12a	6.24a
	BRRIdhan28	113.33a	146.33a	98.8a	13.66a	13a	21.46a	84b	23b	22.9b	5.87b
Farmer's field at Itna	MEF-10	107.66c	139.47c	93.9b	12.56a	11.7a	21.93a	107.33a	26.87a	23.26ab	6.63a
	MEF-27	111b	141.13b	97.86a	13.39a	12.8a	21.93a	97.66b	26.13a	24.5a	6.51ab
	BRRIdhan28	114.66a	145.43a	100.53a	14.1a	13.4a	21.9a	81c	22.56b	22.36b	6.26b
Farmer's field at Bijoynagar	MEF-10	109a	138.5a	96.86b	12.63b	14.78a	21.67b	133.52a	30.89a	23.32a	7.3a
	MEF-27	113.35a	140.1b	104.97ab	14.99a	12.53b	23.88ab	116.65b	35.1a	27.39a	6.83b
	BRRIdhan28	112.67a	145.34c	110.32a	16.53a	15.76a	25.43a	127.39ab	31.74a	23.2a	6.56b
Mean over locations	MEF-10	108.54c	138.91c	95.88b	14.32a	12.8b	22.01b	121.29a	32.33a	22.36b	6.76ab
	MEF-27	111.12b	140.70b	104.11a	14.4a	13b	22.87a	118.67a	24.5b	24.21a	6.91a
	BRRIdhan28	113.33a	146.04a	105.07a	15a	13.99a	23.11a	99.54b	27.45b	22.41b	6.22b
	StDev	3.94	3.17	5.5	2.924	1.661	1.1	16.45	6.999	1.453	0.5234
	SE Mean	0.465	0.373	0.648	0.345	0.196	0.13	1.94	0.825	0.171	0.0617

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

On-farm and on-station yield trial of rice lines for earliness and higher grain yield

Due to the significance impact of rice in ensuring national food security and income for those with low incomes, achieving self-reliance in rice production and maintaining price stability are significant goals in low-income countries. Developing short duration rice cultivars is considered to be one of the most effective and economic approaches for ensuring food security particularly in northern part of the country. Farmer's of these region can better face the manga problem during "karthik" (Oct-Nov) by cultivating this line in proper time. The objectives of the study were to investigate the evaluation the yield potential of the selected line over locations.

For this experiment, line MEF-12 with the check variety BRRI dhan75 were used during Aman season 2021-22 at different locations under the super vision of BINA HQ and different BINA sub-stations. The experiment was followed RCB design with three replications. The size of unit plot was 5.0 m × 6.0 m. Plant to plant distance was 15 cm and row to row distance was 20 cm. Data on days to flowering, days to maturity, plant height (cm), total number of tillers plant^{-1} number of effective tillers plant^{-1}, panicle length (cm), filled and unfilled grains panicle^{-1}, 1000-grain weight (g) and grain yield (tha^{-1}) were recorded after harvesting from 5 randomly selected competitive plants/hills. Maturity was assessed plot basis. The data for the characters under study were statistically analyzed wherever applicable. Data were analyzed using Minitab statistical package.

Significant variations were observed among the lines and check varieties for most of the characters in both of individual location and combined over locations. Results from combined mean of over locations, it was revealed that MEF-12 matured earlier (110.9 days) than the check variety BRRI dhan75 (115.04 days). Again, MEF-12 produced higher grain yield (5.24 t/ha) than BRRI dhan75 (4.91b t/ha). Highest number of total tillers plant^{-1} and number of effective tillers plant^{-1} were observed in the line MEF-12 followed by check variety BRRI dhan75. Highest grain yield was found in MEF-12 (5.39 t/ha) at BINA HQ farm, Mymensingh and lowest was found at BINA sub-station Ishwardi of BRRI dhan75 (4.87b t/ha) (Table 8).

Rice varieties that may mature early without significantly affecting production are needed due to both the crop intensification and climate change. According to reports, one method of reducing the emissions of the greenhouse gases methane and nitrous oxide is to employ short-duration rice cultivars. To sum up, further evaluation of the line MEF-12 can be helpful to release as short duration Aman rice variety.

Table 8. Agronomic performance of rice lines along with check variety at different locations during Aman season 2021-22

Locations	Genotypes	Days to flowering	Days to maturity	Plant height (cm)	Total tillers plant^{-1} (no.)	Effective tillers plant^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000-grain weight (g)	Grain yield (th^{-1})
BINA HQ	MPQR-12	75b	111a	124a	11.6a	11.49a	24.85a	123.7a	24.6a	21.9a	5.39a
Mymensigh	BRRI dhan75	79.6a	115.6b	111.1b	10.1a	9.06a	25.03a	113b	24.0a	21.46a	4.97b
BINA sub-station	MPQR-12	76.1b	113.1a	123.06a	10.9a	10.8a	25a	122a	23a	22.3a	5.16a
Rangpur	BRRI dhan75	78.9a	116.2b	112.6b	10.1b	10.0b	25.03	112b	24.67	21.36a	4.93a
BINA sub-station	MPQR-12	76.1b	109a	122.06a	12.1a	12a	24.86a	121.9a	23.4a	22.46a	5.2a
Nalitabari	BRRI dhan75	80a	115b	116.1b	10.9b	10.6b	24.43a	114.1b	23.5b	21.41b	4.9b
BINA sub-station	MPQR-12	77b	110.3a	124.1a	11.3a	11.1a	25.03a	124.3a	23.4b	22.2a	5.27a
Ishwardi	BRRI dhan75	81a	114.1b	114.5b	10.4a	10.1a	25.16b	117.8b	26a	21.1a	4.87b
BINA sub-station	MPQR-12	78b	111.1a	123.8a	11.1a	11.0a	24.97a	122.9a	23.6a	22.1a	5.21a
Sunamganj	BRRI dhan75	80a	114.3b	114.4b	10.5a	10.3a	25.1a	114.4b	25.1b	21.3a	4.91b
Mean	MPQR-12	76.5b	110.9a	123.39a	11.4a	11.27a	24.94a	122.96a	23.6b	22.19a	5.24a
Over locations	BRRI dhan75	8o.a	115.04b	113.74b	10.4b	10.01a	25.95a	114.26b	24.65a	21.32b	4.91b
	StDev	2.278	3.19	6.04	0.932	0.974	0.518	5.19	1.484	0.62	0.2702
	SE Mean	0.465	0.65	1.23	0.19	0.199	0.106	1.06	0.303	0.126	0.0552

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

Regional yield trial of introgressed bacterial leaf blight resistant rice lines at Aman season

This experiment was carried out to assess high yield attributes of two BLB resistant rice lines along with two check varieties BRRI dhan75 tested in Aman season during 2021 at BINA HQ's farm, Mymensingh and BINA Sub-station Rangpur and Nalitabari. The size of unit plot was 4.0 m × 3.0 m. Plant to plant distance was 15 cm and row to row distance was 20 cm. Data on days to flowering, days to maturity, plant height (cm), total number of tillers plant^{-1} number of effective tillers plant^{-1}, panicle length (cm), filled and unfilled grains panicle^{-1}, 1000 grain weight (g) and grain yield (tha^{-1}) were recorded after harvesting from 5 randomly selected competitive plants/hills. Maturity was assessed by plot basis. Recorded data were finally subjected to proper statistical analyses and are presented in Table 3.

The results obtained from Regional yield trials of individual location and mean over locations for all characters are presented in Table 9. Most of the characters showed significant differences among the lines and check for three individual locations and mean over locations. In respect of yield, BLB-P-26 produced the highest yield (6.01 t/ha) followed by BLB-P-19 (5.79 t/ha). This higher yield is contributed by the higher number of filled grains panicle^{-1} than the check variety at all the locations (Table 9). It also produced the higher thousand grain weight and panicle length than check the check variety at from mean over locations. There was no significant difference between the test line and check for the number of total tiller, effective tiller and days to maturity. These lines were found resistant to BLB while check showed susceptible in visual observation at all locations. Quality assessment was done based on kernel length and L/B ratio. The kernel shape and size of BLB-P-19 and BLB-P-26 was long-slender and medium-slender where the BRRI dhan75 was medium (Table 10). Considering BLB resistance and high yield the lines BLB-P-19 and BLB-P-26 will be evaluated for on-farm and on-station yield trial in next Aman season.

Table 9. Yield and yield attributes of one rice line along with their check at different locations during T. Aman, 2021-22

Location	Genotypes	Days to 50% Flowering	Days to maturity	Plant height (cm)	Total tiller (no.)	Effective Tillers plant^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	Thousand grain weight (gm)	Grain yield (t ha^{-1})
HQ	BLB-P-19	87a	104a	108a	11a	9a	24.67a	156.67a	22.33a	19.85a	5.84a
	BLB-P-26	83a	106a	110a	11a	10a	26a	154.33ab	29.33a	21.31a	6.02a
	BRRI dhan75	80a	103a	108a	10a	8a	23a	136.33b	20a	20.31a	5.48a
Rangpur	BLB-P-19	80a	105c	114a	9a	8a	26.16a	163a	19a	21.33a	5.89a
	BLB-P-26	85a	109b	111a	10a	10a	24.36b	161a	18a	22a	6.01a
	BRRI dhan75	84a	111a	104a	9a	9a	22.50c	127.33a	17a	21a	5.61a
Nalitabari	BLB-P-19	83a	108b	115a	12a	11a	24.89a	171.53a	19.67ab	21.67a	5.61a
	BLB-P-26	86a	111a	113a	11a	10a	23.93	165.80a	21.23a	22.33a	5.97a
	BRRI dhan75	84a	110a	100b	10a	10a	22.72b	137.67b	16.93b	20.33a	5.53a
Mean over locations	BLB-P-19	81b	107a	112a	10a	9a	24.57a	163.73a	20.33a	20.95ab	5.79ab
	BLB-P-26	84a	109a	111a	10a	10a	24.43a	160.37a	21.42a	21.88a	6.01a
	BRRI dhan75	80ab	108a	104b	9a	9a	22.07b	133.78b	23.31a	20.54b	5.54b

Table 10. Grain characteristics of the Advanced rice lines (BLB-P-19, BLB-P-26) with check (BRRI dhan75)

Strain/Variety	Whole grain length (mm)	Dehulled grain/kernel			
		length (mm)	Breadth (mm)	L/B ratio	Size and shape
BLB-P-19	9.0	7.0	2.2	3.18	Long Slender
BLB-P-26	9.5	6.8	2.3	2.95	Long Medium
BRRIdhan75	8.63	6.28	2.16	2.90	Medium Medium

Regional yield trial of introgressed bacterial leaf blight resistant rice lines at Boro season

This experiment was carried out to assess high yield attributes of three BLB resistant rice lines along with one check variety BRRI dhan28 tested in Boro season during 2021-22 at BINA HQ's farm, Mymensingh and BINA Sub-station Ishwardi, Sunamgonj, Nalitabari and farmers field of Netrokona and Kishargonj, The size of unit plot was 4.0 m × 3.0 m. Plant to plant distance was 15 cm and row to row distance was 20 cm. Data on days to flowering, days to maturity, plant height (cm), total number of tillers plant^{-1} number of effective tillers plant^{-1}, panicle length (cm), filled and unfilled grains panicsle^{-1}, 1000 grain weight (g) and grain yield (tha^{-1}) were recorded after harvesting from 5 randomly selected competitive plants/hills. Maturity was assessed by plot basis. Recorded data were finally subjected to proper statistical analyses and are presented in Table 11.

The results revealed from Regional yield trials of individual location and mean over locations for all the characters are presented in Table 11. Results mean over three locations, on an average, all other characters showed significant differences among the lines and check for both individual locations and mean over locations. Among the lines and check varieties, BLB-P-42 had the longest plant height at all the locations (Table 11). Highest number of total tillers plant^{-1} and number of effective tillers plant^{-1} were observed at almost all the locations by line BLB-P-42 but except at Mymensingh by BLB-P-44. BLB-P-48 had the longest panicle and BLB-P-42 had the highest number of filled grains panicle^{-1} at almost all the locations (Table 4). BLB-P-42 produced the highest yield at almost all the locations except Ishwardi by BLB-P-44. BLB-P-42 (7.59 tha^{-1}) and BLB-P-44 (7.11tha^{-1}) produced significantly highest yield at mean over three locations than the check variety (6.22 tha^{-1}). BLB-P-44 (143 days) matured 10 days earlier than the all lines and check variety but BLB-P-42 had almost same duration with check BRRIdhan58. BLB-P-42 had the lowest thousand grain weight (21.38 g) which indicate fine grain quality. Quality assessment was done based on kernel length and L/B ratio. The kernel shape and size of BLB-P-42 was long-slender and BLB-P-44, BLB-P-48 was medium-slender where the BRRI dhan58 was medium (Table 12). Based on the yield performance and grain quality, BLB-P-42 are suggested for on-farm and on-station yield trial in next Boro season.

Table 11. Yield and yield attributes of one rice line along with their check at different locations during Boro season, 2021-22

Location	Genotypes	Days to 50% Flowering	Days to maturity	Plant height (cm)	Total tiller (no.)	Effective Tillers plant^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	Thousand grain weight (gm)	Grain yield (t ha^{-1})
HQ	BLB-P-42	123a	156a	104.80a	12b	12a	22.93b	158a	37a	21.57b	7.57a
	BLB-P-44	117b	142b	97b	14a	12a	22.60b	142ab	31a	22.62ab	7.48a
	BLB-P-48	118b	154a	98.40ab	11b	10b	24.40a	121b	32a	23.44a	6.01b
	BRRI dhan58	123a	158a	101.87ab	13a	12a	22.33b	154a	34a	22.97a	6.30b
Ishwardi	BLB-P-42	122a	153a	105.40a	12a	12a	25.27b	133a	18a	21.25b	5.79a
	BLB-P-44	115b	142b	98.80b	11a	11ab	25.47b	133a	14a	23.12a	5.85ab
	BLB-P-48	125a	158a	101.27ab	10b	10b	27.33a	110b	20a	23.18a	5.23ab
	BRRI dhan58	124a	157a	105.67a	10b	10b	22.47c	120ab	17a	22.63a	4.96b
Kisharganj	BLB-P-42	119a	151ab	103.93a	14a	13a	21.80a	168a	34b	21.15b	7.70a
	BLB-P-44	112a	143c	96.60bc	12b	12a	22.03a	139b	34b	22.57a	7.53ab
	BLB-P-48	120a	147b	97.73c	11b	10b	21.90a	124b	54a	23.06a	6.84bc
	BRRI dhan58	119a	154a	101.33ab	12b	11b	21.82a	138b	29b	22.81a	6.72c
Netrokona	BLB-P-42	125a	151ab	108.07a	12a	11a	23.90ab	161a	31a	21.56b	7.33a
	BLB-P-44	115b	143c	95.83c	11a	10b	22.90ab	144ab	28a	22.87a	6.14b
	BLB-P-48	123a	148b	99.32bc	11a	9b	24.67a	120c	32a	23.28a	5.22c
	BRRI dhan58	124a	154a	103.22b	12a	10b	22.53b	130bc	27a	23.31a	5.99b
Sunamganj	BLB-P-42	119a	152a	112.20a	15a	13a	24.95a	171a	35a	21.37a	7.54a
	BLB-P-44	114b	143b	102.13b	14ab	12ab	23.67b	158ab	44a	23.13a	7.10ab
	BLB-P-48	117ab	149a	102.20b	12b	10c	24.86a	127b	44a	22.68a	5.71b
	BRRI dhan58	119a	152a	111.13a	13b	12ab	23.22b	141ab	38a	22.58a	6.29b
Nalitabari	BLB-P-42	123a	156a	105.73a	13b	12a	23.40a	145a	24a	21.37a	6.84a
	BLB-P-44	136a	143b	100bc	12a	12a	22.80a	125a	29a	22.13a	6.65a
	BLB-P-48	124a	158a	97.16c	11a	11ab	23.83a	123a	27a	22.68a	5.67b
	BRRI dhan58	123a	157a	103.97ab	11a	10b	22.67a	124a	26a	22.58a	6.30a
Mean over locations	BLB-P-42	122a	153b	106.69a	13a	12a	23.70b	156a	30ab	21.38c	7.59a
	BLB-P-44	118a	143c	98.39c	13a	12a	23.24b	140b	29ab	22.52b	7.11a
	BLB-P-48	121a	152b	98.39c	12b	11b	24.49	121c	34a	23.06a	5.85c
	BRRI dhan58	122a	155a	104.53b	12b	11b	22.51c	134b	28b	22.81b	6.22b

Table 12. Grain characteristics of the Advanced rice lines (BLB-P-42, BLB-P-44 & BLB-P-48) with check (BRRI dhan58)

Strain/Variety	Whole grain length (mm)	Dehulled grain/kernel			
		length (mm)	Breadth (mm)	L/B ratio	Size and shape
BLB-P-42	9.5	7.0	2	3.5	Long Slender
BLB-P-44	9.5	6.8	2.3	2.95	Long Medium
BLB-P-48	9.0	6.8	2.3	2.95	Long Medium
BRRIdhan58	8.5	6.0	2.5	2.4	Medium Medium

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

For smallholder farmers, securing a high and reliable income from farming despite rising cultivation costs is a regular difficulty. Premium quality rice varieties have a 20–60 percent price advantage and 50 percent higher profit over other rice varieties, indicating that there could be significant interest in expanded production. The objectives of the study were to investigate the selected rice lines with premium quality.

For this experiment, three rice lines (MPQR-62, MPQR-72 & MPQR-81) with the check variety BRRI dhan49 were used during Aman season 2021-22 at different locations (BINA HQ, Mymensingh, BINA sub-station farm Nalitabari & Ishwardi). The experiment was followed RCB design with three replications. The size of unit plot was 5.0 m × 4.0 m. Plant to plant distance was 15 cm and row to row distance was 20 cm. Data on days to flowering, days to maturity, plant height (cm), total number of tillers plant^{-1} number of effective tillers plant^{-1}, panicle length (cm), filled and unfilled grains panicle^{-1}, 1000-grain weight (g) and grain yield (tha^{-1}) were recorded after harvesting from 5 randomly selected competitive plants/hills. Maturity was assessed plot basis. The data for the characters under study were statistically analyzed wherever applicable. Data were analyzed using Minitab statistical package.

Significant variations were observed among the lines and check varieties for most of the characters in both of individual location and combined over locations. From the table it was observed that, MEF-72 matured early (130.55c) than others. Comparing with the check variety BRRI dhan49, plant height of MEF-62 and MEF-72 were 104.75cm and 104.68bcm respectively. Effective tiller (10.35a) was found in MEF-62 in compare with the check variety BRRI dhan49 (9.23). Although MEF-62 (4.83 tha^{-1}) has lower grain yield than BRRI dhan49 (5.03 tha^{-1}). Less 1000-grain weight (g) in MEF-62 (22.35 g) against the check variety BRRI dhan-49 (23.40a) proved that the line has premium quality rice grain (Table 13).

Cultivation of fine grain rice has been gaining popularity in Bangladesh over the recent years, because of its huge demand both for internal consumption and export. The line MPQR-62 having slender grain with pleasant yield will be evaluated furthermore.

Table 13. Agronomic performance of rice lines along with check variety at different locations during Aman season 2021-22

Locations	Genotypes	Days to maturity	Plant height (cm)	Total tillers plant^{-1} (no.)	Effective tillers plant^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000-grain weight (g)	Grain yield (th^{-1})
BINA HQ Mymensingh	MEF-62	128.65c	108.13bc	10.26b	9.73b	26.86a	106.35c	25.28bc	22.03b	4.61c
	MEF-72	131.62b	105.06c	10.40b	9.94b	24.56bc	127.00a	40.65a	21.12c	5.29a
	MEF-81	131.00bc	127.00a	12.80a	12.20a	25.83ab	93.00d	19.57c	23.21a	3.94d
	BRRI dhan49	140.65a	111.96b	9.56b	9.23b	22.93c	115.00b	29.63b	23.53a	4.93b
BINA sub-station Nalitabari	MEF-62	132.50bc	106.12b	11.97a	11.36a	24.85a	101.08b	25.23ab	21.96	4.96a
	MEF-72	129.26c	103.98b	11.03a	10.30a	24.18ab	122.16a	33.35a	22.72a	5.13a
	MEF-81	140.65a	122.98a	10.90a	10.43a	24.64a	91.00c	19.00b	23.23a	4.05b
	BRRI dhan49	134.83b	107.32b	10.63a	10.37a	22.11b	116.41a	28.00ab	21.96a	5.17a
BINA sub-station Ishwardi	MEF-62	131.23b	102.56b	11.23a	10.56a	23.15a	112.65b	18.27ab	22.27b	4.93a
	MEF-72	133.00b	106.10b	10.35ab	9.65ab	22.93a	120.24a	24.00a	23.90a	4.97a
	MEF-81	138.23a	119.47a	8.25c	8.25ab	22.10a	82.35c	16.00b	22.25b	3.95b
	BRRI dhan49	136.00a	105.07b	9.35bc	9.00b	23.10a	118.23ab	25.00a	23.90a	5.23a
BINA sub-station Sunamganj	MEF-62	131.4c	106.3b	11.3a	10.8a	23.29b	105.8b	21.9b	21.8b	4.87b
	MEF-72	131.7c	105.7b	10.6b	9.8b	23.8b	123.8a	32.8a	22.8b	5.04a
	MEF-81	139.8a	122.8a	10.8ab	10.1ab	25.2a	91.7c	21.5b	22.87b	4.03c
	BRRI dhan49	135.4b	108.9b	10.1b	9.4b	23.2b	114.9ab	27.9a	23.1a	5.14a
Mean over location	MEF-62	130.68c	105.13b	11.05b	10.46a	24.52b	105.61b	21.72bc	22.21b	4.83a
	MEF-72	130.83c	104.93b	11.5a	10.01a	23.76a	122.12a	30.86a	23.04a	5.06a
	MEF-81	139.89a	122.05a	10.23b	9.82b	24.15a	89.0c	18.87c	22.3b	4.02b
	BRRI dhan49	134.01b	107.67b	9.76c	9.27b	22.67b	115.30a	26.64ab	23.32a	5.05a
	StDev	4.4	8.26	1.386	1.205	3.933	13.86	6.79	0.966	0.4788
	SE Mean	0.734	1.38	0.231	0.201	0.655	2.31	1.13	0.161	0.0798

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

Regional yield trial with some heavy ion beams irradiated mutants derived from Kasalath and NERICA-10

Kasalath, a traditional rice variety, is grown in Sylhet region and in parts of north-eastern India, and IRRI has recently developed some varieties from Kasalath, which could increase rice production by 25%. Kasalath is infused with "phosphorus Starvation Tolerance" gene called PSTOL-1. The gene has potentials to enable rice plants to produce 25% more grain by increasing uptake of phosphorus at limited plant nutrient. NERICA-10 is a variety of Africa has a good tolerance against blast, Moderate tolerance to lodging. Meanwhile, Sterility is the main problem of NERICA-10 that hinders to obtain optimum yield. Kasalath and NERICA-10 was irradiated to develop early, high yielding and fine grain rice lines over the parents.

Seeds of one M_{10} mutant of Kasalath (derived from the irradiation by 80Gy carbon ion beams) and two M_6 mutants *viz*. RM-16(N)-8 and RM-16(N)-10 of rice (derived from nitrogen ion beams) were sown at five locations during 07 to 15 July 2021 and seedlings were transplanted during 31 July to 29 August 2021 along with a check variety BRRI dhan49 presented in Table 1. Plant to plant and row to row distance were maintained 15cm and 20cm respectively. The experiment was followed by Randomized Complete Block Design (RCBD) with three replications. The size of the unit plots were 4m × 5m. 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 plant^{-1}, panicle length, and filled and unfilled grains panicle^{-1} were recorded after harvest from 5 randomly selected competitive plants. Maturity was assessed plot basis. Grain yield was recorded from an area of 10 m^2 which was later converted to t ha^{-1}. Finally, all the recorded data were analyzed statistically as per design and are presented in Table 14.

Significant variation among the mutants and the check for most of the characters were showed in combined and individual locations. In combined locations, it was observed that the mutant RM-Kas-80(C)-1 had statistically higher plant height (123.49 cm) comparing to the mutants RM-16(N)-8 (96.29 cm), RM-16(N)-10 (94.48 cm) and the check variety BRRI dhan49 (105.87 cm) (Table 16). Panicle length was highest in RM-Kas-80(c)-1 mutant (26.91 cm) comparing to the check variety BRRI dhan49 (22.77 cm). The mutants RM-16(N)-8, RM-16(N)-10 represented statistically higher effective tillers (10.40, 9.66 respectively) comparing to the check variety BRRI dhan49 (9.28). Highest number of filled grain was observed in check variety BRRI dhan49 (140.58) comparing to the RM-16(N)-8 (102.89), RM-16(N)-10 (105.99) and Kas-80(c)-1 (134.51). Statistically significant variation was found in yield for three mutants. Mutants RM-Kas-80(C)-1 RM-16(N)-10 produced higher yield (5.77 t/ha) and (6.07 t/ha) than the check variety BRRI dhan49 (5.30 t/ha).Considering the yield performance of the mutant RM-Kas-80(C)-1 and RM-16(N)-10 will be put into the next trail for next Aman season (Table 16). Duration of the mutants RM-Kas-80(C)-1, RM-16(N)-8-1 and RM-16(N)-10-1 ranges from 121-129 days, 122-127 days and 127-131 respectively whereas the duration of the check variety BRRI dhan49 varies from 135-140 days. The mutant RM-Kas-80(C)-1 was 14 days earlier than the check variety BRRI dhan49 (Table 15) whereas the mutant RM-16(N)-8-1 and RM-16(N)-8-1 are 8-13 days earlier contrasting to the check variety BRRI dhan49 (Table 15 and Table 16).

Table 14. Date of sowing and transplanting of the short duration, high yielding M_{10} Kasalath and M_6 NERICA-4 mutants with check variety at different locations of Bangladesh

Location	Date of sowing	Date of transplanting	Seedling age (days)
BINA Hqs farm, Mymensingh	07 July 2021	31 July 2021	23
BINA sub-station farm, Rangpur	10 July 2021	31 July 2021	21
BINA sub-station farm, Magura	15 July 2021	8 August 2021	24
BINA sub-station farm, Chapai Nawbabganj	07 July 2021	29 August 2021	22
BINA sub-station farm, Iswardi	10 July 2021	2 August 2021	23

Table 15. Duration of Kasalath and NERICA-4 mutants with check variety at different locations of Bangladesh

Location	Mutants	Duration (days)
BINA Headquarter, Mymensingh	RM-Kas-80(C)-1	129
	RM-16(N)-8	127
	RM-16(N)-10	131
	BRRI dhan49	140
Rangpur Substation	RM-Kas-80(C)-1	128
	RM-16(N)-8	123
	RM-16(N)-10	127
	BRRI dhan49	135
Magura Substation	RM-Kas-80(C)-1	125
	RM-16(N)-8	123
	RM-16(N)-10	129
	BRRI dhan49	138
Chapainawabganj Substation	RM-Kas-80(C)-1	121
	RM-16(N)-8	122
	RM-16(N)-10	130
	BRRI dhan49	135
Ishwardi Substation	RM-Kas-80(C)-1	125
	RM-16(N)-8	123
	RM-16(N)-10	130
	BRRI dhan49	136

Table 16. Yield and yield attributes of M_{10} Kasalath and M_6 NERICA-4 mutant along with BRRI dhan49 in T. aman season, 2021-22

Location	Mutant	Plant height (cm)	Effective tiller	Panicle length (cm)	Filled grain/panicle	Unfilled grain/Panicle	Yield (t/ha^{-1})
BINA Headquarter, Mymensingh	RM-Kas-80(C)-1	134.33a	7.6a	29.40a	169.0b	30.73a	5.6ab
	RM-16(N)-8	97.80c	8.8a	25.00b	104.6c	23.13a	4.80c
	RM-16(N)-10	99.93c	7.8a	28.06a	121.87c	30.60a	5.74a
	BRRI dhan49	114.87b	7.8a	22.33b	232 .0a	22.13a	5.08bc
Rangpur Substation	RM-Kas-80(C)-1	125.80a	8.23a	23.76a	101.80a	23.20b	5.76bc
	RM-16(N)-8	92.43c	8.16a	23.56a	104.83a	20.17b	6.40ab
	RM-16(N)-10	88.60c	8.40a	24.30a	74.20b	33.80a	6.70a
	BRRI dhan49	102.67b	6.7a	23.13a	97.73a	21.71b	5.46c
Magura Substation	RM-Kas-80(C)-1	120.40a	8.93a	27.53a	116.53a	16.60a	6.20a
	RM-16(N)-8	92.47c	10.40a	22.06a	92.80a	18.00a	5.20c
	RM-16(N)-10	89.20c	10.00a	22.90a	109.53a	16.06a	5.70b
	BRRI dhan49	99.80b	9.40a	23.86a	114.27a	15.53a	5.47bc
Chapainawabganj Substation	RM-Kas-80(C)-1	121.20a	8.66c	29.40a	169.80b	30.73a	5.77b
	RM-16(N)-8	97.00c	12.66a	25.00b	104.60c	23.13a	5.72bc
	RM-16(N)-10	96.80c	11.40b	28.06a	121.87c	30.60a	6.62a
	BRRI dhan49	108.27b	11.20b	23.33b	232.0a	22.13a	5.55c
Ishwardi Substation	RM-Kas-80(C)-1	115.73a	9.93a	24.60ab	131.67a	29.46a	5.53a
	RM-16(N)-8	101.73b	11.93a	23.66b	124.07a	28.46a	5.06b
	RM-16(N)-10	97.87b	10.06a	26.60a	94.13a	36.46a	5.60a
	BRRI dhan49	103.73b	11.26a	21.20c	120.03a	23.60a	4.97c
Combined over location	RM-Kas-80(C)-1	123.49a	8.68c	26.91a	134.51a	27.86ab	5.77b
	RM-16(N)-8	96.29c	10.40 a	23.88b	102.89b	25.31bc	5.53bc
	RM-16(N)-10	94.48c	9.66b	26.01a	105.99b	31.88a	6.07a
	BRRI dhan49	105.87b	9.28bc	22.77b	140.58a	21.91c	5.30c
	CV	2.93	9.53	7.32	11.26	28.11	4.97
	LSD	2.27	1.49	3.01	10.06	12.42	0.22

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

Considering the yield & yield attributes, the promising line RM-16(N)-10 and RM-Kas-80(C)-1 will be evaluated for the next trial.

Regional yield trial with two high yielding M_7 NIRICA mutants

A minimum of an average rice yield target of 9.1 ton/ha has been roughly set for 2050. However, this target cannot be achieved equally across all the geographic regions of Bangladesh. Because, the country has various ‘rice types’ based on specific ecosystems, and also due to the pressing ‘needs’. All these ‘rice types’ have different situation-specific yield potentials and area coverage. The breeding objective was to develop a high yielding rice variety for boro season that will achieve the future target of genetic yield potential (GYP) in Bangladesh

Two promising M_7 mutants [RM-16(N)-8-1 and RM-16(N)-10-1] of rice derived from heavy ion (nitrogen) beam irradiation were evaluated at eight locations, six at different stations and two at farmer’s field. This trial was carried out with the objectives of high temperature tolerant, short duration, high yielding with non shattering grains as well as to assess the yield potential over locations. Seeds were sown during 25 November to 09 December, 2021 and transplanted during 5 January to 6 February 2021 (Table 17). The experiment was conducted by following RCB design with three replications. The size of the unit plots were 4m × 5m. 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^{-1}, panicle length and number of filled and unfilled grains panicle^{-1} were recorded after harvesting from five randomly selected competitive hills. Days to 50% of flowering, Days to maturity was assessed on plot basis. Grain yield was recorded from an area of 10.0 m^2 which was later converted into tha^{-1}. Finally, all the recorded data were subjected to proper statistical analyses and are presented in Table 19.

Results showed significant variation among the mutants and check for most of the characters in individual and over locations in combined analysis. From combined analysis, it was observed that plant height of two mutants lines RM-16(N)-8-1 and RM-16(N)-10-1 were 93.80 cm and 93.69 cm respectively and which were statistically shorter than the check variety BRRI dhan58 (109.08cm). RM-16(N)-8-1 and RM-16(N)-10-1 had statistically higher number of effective tillers (14.53 and 13.70 respectively) comparing to BRRI dhan58 (11.76). Panicle length of RM-16(N)-8-1 and RM-16(N)-10-1 were recorded as 23.79 and 25.03 cm respectively. The highest number of filled grain panicle^{-1} were observed in RM-16(N)-10-1 (101.97) and RM-16(N)-8-1 (115.99) followed by BRRI dhan58 (123.15). BRRI dhan58 had statistically maximum number of unfilled grain panicle^{-1} contrasting to RM-16(N)-10-1 and RM-16(N)-8-1 mutants. The mutants RM-16(N)-8-1 and RM-16(N)-10-1 had produced higher yield (7.2 & 7.6 tha^{-1} respectively) than the BRRI dhan58 (7.1) (Table 19). Duration of the mutants RM-16(N)-8-1, RM-16(N)-10-1 ranges from 140-145 days and 145-150 days respectively whereas the duration of the check variety BRRI dhan58 varies from 144-150 days. The mutant RM-16(N)-8-1 was 4 days earlier than the check variety BRRI dhan58 (Table 18) whereas the mutant RM-16(N)-10-1 had similar duration but gave higher yield contrasting to the check variety BRRI dhan58 (Table 18 and Table 19).

Table 17. Date of sowing and transplanting of the short duration, high yielding with non shattering grains rice mutant and check variety at different locations of Bangladesh

Location	Date of sowing	Date of transplanting	Seedling age (days)
BINA Headquarter farm, Mymensingh	25 November 2021	5 January 2022	36
Farmer's Field, Mymensingh	25 November 2021	7 January 2022	38
BINA sub-station farm, Rangpur	11 December 2021	13 January 2022	33
BINA sub-station farm, Magura	09 December 2021	18 January 2022	40
Farmers Field, Magura	09 December 2021	20 January 2022	42
Chapainawabganj sub-station farm	02 December 2021	12 January 2022	33
Ishwardi sub-station Farm	30 December 2021	6 February 2022	38
BINA sub-station farm, Jamalpur	08 December 2021	11 January 2022	34

Table 18. Duration of the short duration, high yielding with non shattering grains rice mutant and check variety at different locations of Bangladesh

Location	Mutants	Duration (days)
BINA Headquarter farm, Mymensingh	RM-16(N)-8-1	143
	RM-16(N)-10-1	148
	BRRI dhan58	150
Farmer's Field, Mymensingh	RM-16(N)-8-1	145
	RM-16(N)-10-1	150
	BRRI dhan58	150
Ishawrdi Sub-station	RM-16(N)-8-1	142
	RM-16(N)-10-1	147
	BRRI dhan58	146
Magura Sub-station	RM-16(N)-8-1	142
	RM-16(N)-10-1	146
	BRRI dhan58	148
Magura Farmer's Field	RM-16(N)-8-1	144
	RM-16(N)-10-1	148
	BRRI dhan58	148
Rangpur Substation	RM-16(N)-8-1	145
	RM-16(N)-10-1	149
	BRRI dhan58	150
Jamalpur Substation	RM-16(N)-8-1	144
	RM-16(N)-10-1	148
	BRRI dhan58	147
Chapainawabganj Sub-station	RM-16(N)-8-1	140
	RM-16(N)-10-1	145
	BRRI dhan58	144

Table 19. Yield and yield components of rice mutants with check varieties at different locations

Location	Mutant	Plant height (cm)	Effective tiller (no.)	Panicle length (cm)	Filled grain panicle^{-1} (no.)	Unfilled grain panicle^{-1} (no.)	Yield (tha^{-1})
BINA Headquarter, Mymensingh	RM-16(N)-8-1	91. 53b	14.26a	23.53b	104.67b	38.73b	7.68ab
	RM-16(N)-10-1	93.73b	10.80b	26.00a	97.60b	38.67b	8.49a
	BRRI dhan58	105.53a	11.06b	22.06b	149.00a	56.13a	6.82b
Farmer's Field, Mymensingh	RM-16(N)-8-1	89.8b	14.26a	23.33b	102.67b	38.33b	5.81b
	RM-16(N)-10-1	93.73b	11.00b	26.26a	139.27a	53.40a	6.72a
	BRRI dhan58	105.53a	10.80b	21.73b	95.00b	51.46a	5.54a
Ishawrdi Sub-station	RM-16(N)-8-1	95.13b	18.46a	23.86ab	108.73a	18.93a	6.83a
	RM-16(N)-10-1	95.53b	13.46a	25.20a	99.80a	22.20a	7.02a
	BRRI dhan58	107.20a	14.20a	21.73b	113.53a	24.80 a	6.91a
Magura Sub-station	RM-16(N)-8-1	93.23b	12.6a	26.7a	95.33a	18.86ab	9.72a
	RM-16(N)-10-1	98.13b	16.00a	22.40b	88.27a	23.13a	8.91b
	BRRI dhan58	111.87a	12.53a	23.47b	125.33a	17.33b	9.30b
Magura Farmer's Field	RM-16(N)-8-1	92.93b	17.46a	24.13b	113.20b	21.66a	6.86c
	RM-16(N)-10-1	96.07b	16.46a	27.53a	159.33a	28.20a	8.14a
	BRRI dhan58	106.73a	11.06b	22.76b	119.07b	25.80a	7.50b
Rangpur Substation	RM-16(N)-8-1	84.0c	12.06a	22.60a	64.40b	34.20a	7.16a
	RM-16(N)-10-1	91.53b	14.67a	22.60a	61.00b	10.86b	7.13a
	BRRI dhan58	112.20a	12.60a	20.26b	103.33a	18.86b	7.30a
Jamalpur Substation	RM-16(N)-8-1	94.77a	12.86a	22.25b	92.07b	25.53a	6.00b
	RM-16(N)-10-1	97.43a	13.06a	26.87a	131.97a	21.73a	6.81a
	BRRI dhan58	108.63a	10.43b	21.57b	125.17a	12.86a	6.13ab
Chapainawabganj Sub-station	RM-16(N)-8-1	96.60b	14.26a	23.86a	134.67b	25.33a	7.85a
	RM-16(N)-10-1	95.80b	14.40a	26.87a	150.67a	34.00a	8.35a
	BRRI dhan58	114.93a	11.3a	23.60b	150a	44.67a	8.10a
Combined location	RM-16(N)-8-1	93.80b	14.53a	23.79b	101.97c	27.70b	7.27b
	RM-16(N)-10-1	93.69b	13.70a	25.03a	115.99b	29.02ab	7.67a
	BRRI dhan58	109.08a	11.76b	22.15c	123.15a	31.49a	7.15a
	CV	6.63	12.68	4.19	9.40	20.20	5.88
	LSD	3.81	0.98	0.57	6.21	NS	0.71

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

Considering the Duration, yield & yield attributes of the mutants RM-16(N)-10-1 and RM-16(N)-8-1 will be evaluated in the next trail to release as a variety

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

Numerous biotic and abiotic factors have a negative effect on rice productivity. Every year, biotic factors cause damage to about 52 percent of the world's rice production, with insect pest attacks accounting for nearly 21 percent of that loss. BPH can consume more than 28% of the dry matter of infected rice plants at the reproductive stage and also it can transmit various viral diseases. For controlling BPH damage, selection of BPH resistant line is the main objective of this research.

For this experiment, six rice lines with the check variety BRRI dhan96 were used during Boro season 2021-22 at different locations (BINA HQ, Mymensingh, BINA sub-station farm Rangpur & Ishwardi). The experiment was followed RCB design with three replications. The size of unit plot was 5.0 m × 4.0 m. Plant to plant distance was 15 cm and row to row distance was 20 cm. Data on days to flowering, days to maturity, plant height (cm), total number of tillers plant^{-1} number of effective tillers plant-1, panicle length (cm), filled and unfilled grains panicle^{-1}, 1000-grain weight (g) and grain yield (tha^{-1}) were recorded after harvesting from 5 randomly selected competitive plants/hills. Maturity was assessed plot basis. The data for the characters under study were statistically analyzed wherever applicable. Data were analyzed using Minitab statistical package.

From the results, significant variations were observed for all the characters at all the locations. Combining mean of over locations, it was observed that BRRI dhan96 matured earlier (140.22 days) than the other lines. BPH-P-065 produced highest grain yield (7.62a t/ha) followed by BPH-P-034 (7.58 t/ha) and BPH-P-043 (7.53 t/ha). Highest Filled grain was also found in BPH-P-065 (135.78) that also has highest 1000 grain weight (26.23a) in mean of over locations. But BPH-P-034 showed highest 1000 grain weight in three locations, individually. Early maturity was found in BPH-P-009 around 139 days followed by check variety BRRI dhan96 (around 140 days) at BINA HQ's farm, BINA sub-station farm Rangpur,and Ishwardi and also in mean of over locations. Highest number of effective tillers was produced by BPH-P-065 (14.56) in mean of over locations and also at BINA HQ's farm and BINA sub-station farm Rangpur, & Ishwardi (Table 20). According to BPH scoring (Standard protocol by IRRI), BPH-P-065 has very slight damage whereas BPH-P-34, BPH-P-43 and BRRI dhan96 showed that, 1st & 2nd leaves of most plants partially yellowing. As BPH-P-065, BPH-P-034 and BPH-P-043 showed better performance in term of grain yield and other yield contributing characters (Table 21).

To recapitulate, rice lines BPH-P-34, BPH-P-43 & BPH-P-65 performed better than other lines in terms of yield and other characters as well as BPH score. Further evaluation of these lines will be made to release as BPH resistance rice variety.

Table 20. Agronomic performance of rice lines along with check variety at different locations during Boro season 2021-22

Locations	Genotypes	Days to flowering	Days to maturity	Plant height (cm)	Total tillers plant^{-1} (no.)	Effective tillers plant^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000-grain weight (g)	Grain yield (th^{-1})
BINA HQ Mymensingh	BPH-P-009	109.00c	139.43d	101.55ab	12.67ab	12.00bc	23.30bc	112.54c	16.65b	23.30c	5.58e
	BPH-P-020	112.00ab	144.00bc	106.13a	12.56ab	12.23abc	24.23abc	113.64c	19.66b	22.70cd	5.58e
	BPH-P-034	112.00ab	144.00bc	102.53ab	12.53ab	12.65ab	24.07abc	123.35b	17.00b	24.83b	7.76c
	BPH-P-043	111.65abc	143.00c	100.50b	12.57ab	12.35abc	24.63a	124.65b	16.34b	25.17b	7.6b
	BPH-P-057	114.35a	148.34a	100.76b	11.00b	10.00c	23.17c	100.00d	28.00a	22.56d	4.80f
	BPH-P-065	112.00ab	145.65b	103.53ab	14.65a	14.56a	24.37ab	135.54a	13.54b	26.50a	7.7a
	BRRI dhan96	109.56bc	140.25d	101.23ab	12.00b	11.53bc	23.83abc	126.00b	15.65b	24.76b	7.0d
BINA sub-station Rangpur	BPH-P-009	108.00d	138.55d	102.34ab	12.65b	12.35b	24.30b	114.57c	16.00b	23.57cd	5.63d
	BPH-P-020	111.65bc	143.64b	106.46a	12.34b	12.27b	24.23b	114.35c	20.35b	22.78d	5.65d
	BPH-P-034	113.00b	143.31b	103.23ab	13.00ab	12.63ab	24.06a	125.35b	17.00b	24.73bc	7.5b
	BPH-P-043	111.56bc	143.00bc	100.50b	12.54b	12.25b	24.63c	124.56b	16.00b	25.67ab	7.5b
	BPH-P-057	116.00a	148.67a	100.90b	11.00b	10.00c	23.24a	100.23d	28.33a	22.70d	4.74e
	BPH-P-065	111.56bc	145.33b	104.00ab	15.32a	14.67a	24.50c	136.65a	14.24b	26.27a	7.67a
	BRRI dhan96	109.64cd	140.35cd	101.56ab	12.23b	11.67bc	23.17a	126.00b	15.00b	24.43c	6.9c
BINA sub-station Ishwardi	BPH-P-009	108.65d	139.00c	102.00ab	13.00ab	12.23b	23.13b	113.26c	16.65b	23.24c	5.60d
	BPH-P-020	111.65bc	143.67b	106.03a	12.65ab	12.35b	24.23ab	113.65c	19.53b	22.70cd	5.58d
	BPH-P-034	112.00b	144.00b	100.83ab	12.54ab	12.27b	24.63a	124.56b	16.00b	25.54a	7.49ab
	BPH-P-043	111.55bc	143.00b	103.35ab	13.00ab	12.56ab	24.06ab	125.32b	17.00b	24.73b	7.60b
	BPH-P-057	114.23a	148.33a	100.76b	11.00b	10.00c	23.17b	100.00d	28.00a	22.56d	4.80e
	BPH-P-065	111.00bc	144.64b	103.76ab	14.65a	14.34a	24.37a	135.00a	13.00b	25.93a	7.5a
	BRRI dhan96	109.67cd	140.00c	101.57ab	12.25b	11.65bc	23.80ab	126.65b	15.00b	24.70b	6.87c
Mean Over location	BPH-P-009	108.55c	139.11d	102.00bc	12.78b	12.23b	23.58bc	113.56c	16.44c	23.40c	5.61d
	BPH-P-020	111.78b	143.78c	106.21a	12.45b	12.23b	24.23ab	113.88c	19.88b	22.73d	5.61d
	BPH-P-034	112.23b	143.77c	102.23bc	12.77b	12.55b	24.25ab	124.44b	16.65bc	25.08b	7.58b
	BPH-P-043	11.56b	143.00c	101.44bc	12.75b	12.43b	24.45a	124.89b	16.43c	25.19b	7.53b
	BPH-P-057	114.88a	148.44a	100.81c	11.00c	10.00c	23.19c	100.11d	28.11a	22.61d	4.78e
	BPH-P-065	111.55b	145.22b	103.76ab	14.89a	14.56a	24.41a	135.78a	13.56c	26.23as	7.62a
	BRRI dhan96	109.65c	140.22d	101.46bc	12.22b	11.67b	23.60bc	126.22b	15.22c	24.63b	6.92c
	StDev	2.06	2.99	2.35	1.3	1.402	0.655	11.08	4.983	1.332	1.696
	SE Mean	0.26	0.377	0.296	0.164	0.177	0.0825	1.4	0.628	0.168	0.214

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

Table 21: BPH scoring based on IRRI standard

Scale		Line(s) Name	Damage
HT/HR	0	-	None
T/R	1	BPH-P-065	Very slight damage
MT/MR	3	BPH-P-034, BPH-P-043, BRRI dhan96	1st & 2nd leaves of most plants partially yellowing
MS	5	BPH-P-009, BPH-P-020	Half of plants wilting or dead
S	7	BPH-P-057	More than half of plants wilting or dead
HS	9	-	All plants dead

HT/HR- High tolerant/ resistant, T/R- Tolerant/resistant, MT/MR- Moderately tolerant/resistant, MS-Moderately susceptible, S- Susceptible, HS- Highly susceptible

Advanced yield trial of blast resistant rice lines in Boro season

This experiment was carried out to assess the yield and yield attributes of three blast resistant rice lines along with one check variety BRRI dhan58 tested in Boro season during 2021-22 at BINA HQ's farm, Mymensingh and BINA Sub-station farm Rangpur, Comilla, Magura & Jamalpur. Seeds were sown on 20th November 2021 and transplanted to the field on 22 December 2021. The experiment followed RCB design with three replications. The size of unit plot was 2.0 m × 1.0 m. Plant to plant distance was 15 cm and row to row distance was 20 cm. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. Data on days to maturity, plant height (cm), total number of tillers plant^{-1}, number of effective tillers plant^{-1}, panicle length (cm), filled and unfilled grains panicle^{-1} and 1000-grain weight (g) were recorded after harvesting from 5 randomly selected competitive plants/hills. Maturity and yield data were recorded plot basis. Finally, the yield data were converted to t ha^{-1}. Recorded data were finally subjected to proper statistical analyses. The results revealed from advanced yield trials of individual location and mean over locations for all the characters are presented in Table 22 . Results mean over three locations, on an average, all other characters showed significant differences among the lines and check for both individual locations and mean over locations. Among the lines and check varieties, **BRRI dhan58** had the longest plant height at all the locations. Highest number of total tillers plant^{-1} and number of effective tillers plant^{-1} were observed at Mymensingh and Rangpur by line BN-P-318 at Jamalpur and Magura by BN-P-120 and at Comilla by BN-P-317. BN-P-317 had the longest panicle at 3 locations Mymensingh, Magura & Jamalpur **(Table 22**). Highest number of filled grains panicle^{-1} was observed at Comilla by BN-P-318 (147.53). BN-P-318 and BN-P-317 produced the highest yield at all five locations, respectively. BN-P- 317 and BN-P-318 produced significantly highest yield at mean over five locations. Based on the yield performance, BN-P-318 and BN-P-317 are suggested for regional yield trial in next Boro season.

Table 22. Agronomic performance of rice lines along with check variety at different locations during Boro season 2021-22

Location	Genotypes	Days to maturity	Plant height (cm)	Total tillers plant^{-1} (no.)	Effective tillers plant^{-1} (no.)	Panicle length (cm)	Filled grins panicle^{-1} (no.)	Unfilled grins panicle^{-1} (no.)	1000 grain weight (g)	Grain yield (t ha$^{-1)}$
Mymensingh	BN-P=120	145.33b	98.03a	12.533bc	11.800b	23.400ab	128.67bc	13.333b	21.240a	7.6800b
	BN-P=317	146.67b	99.27a	13.333ab	12.767a	24.200a	137.67ab	12.333b	24.033a	8.3067a
	BN-P=318	146.33b	96.87a	13.800a	13.467a	23.767ab	146.00a	12.000b	23.923a	8.6067a
	BRRI dhan58	151.00a	103.40a	11.667c	10.933b	22.400b	121.00c	23.000a	23.267a	7.2000c
Rangpur	BN-P=120	144.67b	98.20 b	11.867bc	11.133ab	23.067bc	125.60b	16.600a	21.840bc	7.5667b
	BN-P=317	146.67b	102.90a	12.967ab	12.133a	23.533b	143.33a	12.600a	23.367ab	8.4567a
	BN-P=318	146.33b	97.80b	13.833a	13.333a	24.933a	147.13a	17.733a	23.923a	8.5433a
	BRRI dhan58	151.00a	104.00a	10.833c	9.867b	22.267c	124.60b	11.133a	21.333c	7.2167b
Comilla	BN-P=120	145.33b	99.70b	14.933ab	14.933a	23.867b	130.83bc	12.933a	21.967ab	7.5667b
	BN-P=317	146.00b	103.77a	16.400a	15.600a	27.800a	143.27ab	12.600a	26.400a	8.4667a
	BN-P=318	146.33b	97.70b	15.100ab	14.533a	24.133b	147.53a	15.333a	19.000b	8.6333a
	BRRI dhan58	151.33a	104.80a	10.900b	10.000a	24.133b	121.87c	12.133a	22.900ab	7.2000b
Magura	BN-P=120	144.00b	108.87a	13.200a	12.533a	22.733bc	130.33ab	16.067ab	21.600b	7.8867ab
	BN-P=317	146.33ab	111.80a	11.800a	11.367a	27.667a	137.20a	12.067b	23.783a	8.1333ab
	BN-P=318	146.00b	108.20a	12.067a	12.067a	22.133c	141.27a	28.667a	25.257a	8.3000a
	BRRI dhan58	151.67a	109.33a	12.200a	11.667a	23.733b	108.13b	19.400ab	23.600a	7.2667b
Jamalpur	BN-P=120	145.33a	99.73b	13.733a	12.667a	24.200a	130.33bc	21.333a	21.533b	7.8233ab
	BN-P=317	141.67b	97.27b	12.867a	11.933a	24.467a	140.00ab	12.867a	23.700a	8.4267a
	BN-P=318	147.33a	97.37b	12.867a	12.533a	23.433ab	146.67a	31.000a	24.923a	8.4567a
	BRRI dhan58	140.00b	103.17a	12.000a	11.267a	22.067b	122.00c	21.467a	23.600a	7.4767b
Mean over location	BN-P=120	144.93c	100.91c	13.253a	12.613a	23.453bc	129.15b	16.053ab	21.636c	7.7047b
	BN-P=317	145.47bc	103.00b	13.473a	12.760a	25.533a	140.29a	12.493b	24.257a	8.3580a
	BN-P=318	146.47b	99.59c	13.533a	13.187a	23.680b	145.72a	20.947a	23.405ab	8.5080a
	BRRI dhan58	149.00a	104.94a	11.520b	10.747b	22.920c	119.52c	17.427ab	22.940b	7.2720c

Advance yield trial of Blast Nursery Rice Lines (IRBN) in *Aman* season

This experiment was conducted to select desirable lines having Blast resistance, higher grain yield, short duration suitable for *Aman* season. Six IRBN rice lines along with two check varieties Binadhan-7 and Binadhan-17 tested in *Aman* season of 2021 at BINA Headquarter farm, Mymensingh and BINA Substation, Cumilla. Seeds were sown on 11 July 2021 and transplanted to the field on 8th August 2021 at Mymensingh and Cumilla. The experiment was laid out in RCBD with tthree replications. Unit plot size was 2m x 3m and spacing between hills and rows were 15 cm and 20 cm, respectively. Data on plant height (cm), effective tillers hill-^{1}(no.), number of filled grains penicle^{-1} and panicle length (cm) were recorded from five randomly selected plants from each plot. Days to fifty % flowering and days to maturity were assessed by plot basis. Grain yield data were recorded from an area of 6.0 m^2. Finally, all the recorded data were subjected to proper statistical analyses and are presented in Table 23

Table 23 Mean performance of IRBBN rice lines along with check varieties during *Aman* season 2021

Lines/ check variety	Days to 50% flowering	Days to maturity	Plant height (cm)	Effective tillersplant^{-1} (no.)	Panicle length (cm)	Filled Grains panicle^{-1} (no.)	Unfilled Grains panicle^{-1} (no.)	Grain yield plot^{-1} (kg)	Thousand Seed Weight (g)
Mymensingh									
IRBN-5	61.68a	129.00a	117.7a	7.89ab	28.22a	116.89ab	42.11bc	2.17c	21.38c
IRBN-11	56.47d	121.0cd	108.78b	5.67b	27.67ab	103.33abc	44.78b	2.18c	23.67a
IRBN-18	62.00a	126.0b	110.67a	6.44b	28.33a	147.78a	37.56c	2.64a	22.14b
IRBN-25	54.00e	120.00de	87.11c	5.78b	25.67bc	113.78bc	40.22cd	2.9bc	20.94e
Binadhan-7	57.5.0d	119.00e	97.56b	7.56ab	26.55b	79.22c	27.99d	1.86c	21.82d
Binadhan-17	59.00b	129.00a	95.00b	8.22ab	24.61bc	145.67a	63.89a	2.43ab	20.50e
Cumilla									
IRBN-5	60.67a	132.00a	118.5a	9.39ab	29.72a	118.39ab	44.21bc	3.35c	21.88c
IRBN-11	56.67d	122.0cd	105.78b	7.17b	29.17ab	104.73ab	46.78b	3.36c	24.17a
IRBN-18	59.00a	130.0b	117.67a	6.44b	29.83a	149.28a	39.5c	3.82a	22.64b
IRBN-25	54.00e	127.00de	98.11c	7.94b	27.17bc	115.28bc	42.12cd	3.91a	21.44e
Binadhan-7	56.6.0d	121.00e	100.56b	8.94ab	28.05b	80.72c	29.89d	2.94c	22.32d
Binadhan-17	58.00b	132.00a	100.00b	9.72ab	26.11c	147.27a	65.89a	3.51ab	21e
Combined									
IRBN-5	60.67a	130.5a	118a	8.64a	28.97a	116.79b	43.11bc	2.76c	21.63c
IRBN-11	56.67d	121.5c	107.28b	6.42b	28.42bc	103.13b	45.78b	2.77c	23.92a
IRBN-18	59ab	128b	114.17a	6.44b	29.08a	147.78a	38.56c	3.23a	22.3b
IRBN-25	54d	123.5c	92.61c	6.86b	26.42c	113.68bc	41.22cd	3.41a	21.19e
Binadhan-7	56.6c	120d	99.06c	8.25a	27.3bc	79.32c	28.99d	2.4c	22.07d
Binadhan-17	58b	130.5a	97.5b	8.97a	25.36c	145.57a	64.89a	2.97ab	20.75e

From the table 23, Days to maturity of IRBBN-31 and IRBBN-9 was the longest and the check varieties took shortest time to mature at both location. All the lines produced taller plant than check varieties. Shortest plant height was found in check variety Binadhan-17 and it was similar with Binadhan-7. There was no significant difference in combined effect of effective tillers per plant in Mymensingh among the lines and check varieties. Binadhan-7 produced highest number of effective tillers at Cumilla and it was similar with other check variety and line IRBBN-9. All lines had produced taller panicle length than check varieties and IRBBN-9 had produced taller panicle length. IRBBN-17, IRBBN-18, IRBBN-31 and check variety Binadhan-17 had produced highest numbers of filled grains panicle^{-1}. The check variety Binadhan-17 had produced highest yield than other lines and check variety. This experiment with these lines will be repeated for further evaluation in next year.

Advance yield trial of Blast Nursery Rice Lines (IRBN) in *Aman* season

This experiment was conducted to select desirable lines having Blast resistance, higher grain yield, short duration suitable for *Aman* season. Six IRBN rice lines along with two check varieties Binadhan-7 and Binadhan-17 tested in *Aman* season of 2021 at BINA Headquarter farm, Mymensingh and BINA Substation, Cumilla. Seeds were sown on 11 July 2021 and transplanted to the field on 8th August 2021 at Mymensingh and Cumilla. The experiment was laid out in RCBD with tthree replications. Unit plot size was 2m x 3m and spacing between hills and rows were 15 cm and 20 cm, respectively. Data on plant height (cm), effective tillers hill^{-1}(no.), number of filled grains penicle^{-1} and panicle length (cm) were recorded from five randomly selected plants from each plot. Days to fifty % flowering and days to maturity were assessed by plot basis. Grain yield data were recorded from an area of 6.0 m^2. Finally, all the recorded data were subjected to proper statistical analyses and are presented in Table 24

Table 24 Mean performance of IRBN rice lines along with check varieties during Aman season 2021

Lines/ check variety	Days to 50% flowering	Days to maturity	Plant height (cm)	Effective tillersplant^{-1} (no.)	Panicle length (cm)	Filled Grains panicle^{-1} (no.)	Unfilled Grains panicle^{-1} (no.)	Grain yield plot^{-1} (kg)	Thousand Seed Weight (g)
Mymensingh									
IRBN-5	61.68a	129.00a	117.7a	7.89ab	28.22a	116.89ab	42.11bc	2.17c	21.38c
IRBN-11	56.47d	121.0cd	108.78b	5.67b	27.67ab	103.33abc	44.78b	2.18c	23.67a
IRBN-18	62.00a	126.0b	110.67a	6.44b	28.33a	147.78a	37.56c	2.64a	22.14b
IRBN-25	54.00e	120.00de	87.11c	5.78b	25.67bc	113.78bc	40.22cd	2.9 bc	20.94e
Binadhan-7	57.5.0d	119.00e	97.56b	7.56ab	26.55b	79.22c	27.99d	1.86c	21.82d
Binadhan-17	59.00b	129.00a	95.00b	8.22ab	24.61bc	145.67a	63.89a	2.43ab	20.5e
Cumilla									
IRBN-5	60.67a	132.00a	118.5a	9.39ab	29.72a	118.39ab	44.21bc	3.35c	21.88c
IRBN-11	56.67d	122.0cd	105.78b	7.17b	29.17ab	104.73ab	46.78b	3.36c	24.17a
IRBN-18	59.00a	130.0b	117.6a	6.44b	29.83a	149.28a	39.55c	3.82a	22.64b
IRBN-25	54.00e	127.00de	98.11c	7.94b	27.17bc	115.28bc	42.12cd	3.91a	21.44e
Binadhan-7	56.6.0d	121.00e	100.56b	8.94ab	28.05b	80.72c	29.89d	2.94c	22.32d
Binadhan-17	58.00b	132.00a	100.00b	9.72ab	26.11c	147.27a	65.89a	3.51ab	21e
Combined									
IRBN-5	60.67a	130.5a	118a	8.64 a	28.97a	116.79b	43.11bc	2.76c	21.63c
IRBN-11	56.67d	121.5c	107.28b	6.42 b	28.42bc	103.13b	45.78b	2.77c	23.92a
IRBN-18	59ab	128b	114.17a	6.44 b	29.08a	147.78a	38.56c	3.23a	22.39b
IRBN-25	54d	123.5c	92.61c	6.86 b	26.42c	113.68bc	41.22cd	3.41a	21.19e
Binadhan-7	56.6c	120d	99.06c	8.25 a	27.3bc	79.32c	28.99d	2.4c	22.07d
Binadhan-17	58b	130.5a	97.5b	8.97 a	25.36c	145.57a	64.89a	2.97ab	20.75e

From the Table 24, it appears that IIBN-5 had the highest plant height (118 cm) which was statistically similar with IIBN-18 and check varieties had shorter plant height. IRBN-5 had produced significantly higher number of effective tillers which was similar with check varieties whereas IRBN-11 had produced lowest number of effective tillers. The panicle length ranged 25.36 cm to 28.97 cm. IRBN-18 had produced longer panicle length (29.08 cm) which was significantly similar with IRBN-5 while shortest panicle length (25.36 cm) was found in Binadhan-17. The number of filled grains panicle^{-1} ranged from 79.32 to 147.78. IRBN-18 had the highest number of filled grains panicle^{-1} (147.78) followed by Binadhan-17. The other check variety Binadhan-7 had the lowest number of filled grains per panicle (79.32). The line IRBN-5 took shortest time to mature which is significantly similar with check variety Binadhan-7. For yield, IRBN-25 had produced higher yield (3.41kg) than others and this lines also took shorter time (123 days) to mature.

Based on short duration and higher yield four lines (IRBN-11, IRBN-18, and IRBN-25) have been selected for next year evaluation.

Advance Yield Trial of brown plant hopper resistant rice lines in *Aman* season

This experiment was carried out to assess insect resistant with high yield attributes of seven rice lines along with two check variety Binadhan-7 and Binadhan-17 tested in Aman at BINA Headquarter farm, Mymensingh and BINA Substation, Cumilla. Seeds were sown on 26th July 2021 and transplanted to the field on 16 August 2021 at Mymensingh and Cumilla. The experiment followed RCB design with three replications. The size of a unit plot was 3.0 m × 2.0 m. Plant to plant distance was 20 cm and row to row distance was 20 cm. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. Data on plant height (cm), number of effective tiller plant^{-1}, panicle length(cm), number of filled grains panicle^{-1} were recorded after harvesting from 5 randomly selected competitive hills. Days to fifty 50% flowering and days to maturity was assessed plot basis. Recorded data were finally subjected to proper statistical analyses and are presented in Table 25.

Table 25. Mean performance of IBPHN rice lines along with check varieties during aman season 2021

Lines/ check variety	Days to 50% flowering	Days to maturity	Plant height (cm)	Effective tillers plant^{-1} (no.)	Panicle length (cm)	Filled Grains panicle^{-1} (no.)	Unfilled Grains panicle^{-1} (no.)	Grain yield (tha^{-1})	Thousand Seed Weight (g)
Mymensingh									
IRBPHN-2	85 c	117 e	106.22 de	10.00 bc	26.78 b	211 ab	62 ab	5.72 ab	23.53 ab
IRBPHN-5	79 d	118 de	103.89 de	10.67 ab	23.78 c	230 ab	72 a	4.90 c	20.22 d
IRBPHN-21	91 ab	122 c	120.33 c	8.00 d	26.11 b	247 ab	73 a	5.10 bc	23.72 a
IRBPHN-35	93 a	123 bc	133.78 a	8.67 d	26.89 b	285 a	44 bc	6.30 a	21.17bd
IRBPHN-38	92 a	126 ab	123.0 bc	11.33 a	29.33 a	199 b	53 abc	6.22 a	22.87a-c
IRBPHN-44	91 ab	126 a	126.45 b	11.67 a	29.00 a	243 ab	45 bc	6.20 a	17.60 e
Binadhan 7	86 bc	116 e	108.2 d2	11.00 ab	26.00 b	230 ab	31 c	4.38 c	21.03 cd
Binadhan-17	89 abc	121 cd	101.56 e	9.00 cd	26.11 b	233 ab	37 bc	4.85 c	20.48 cd
CV (%)	3.34	1.69	2.99	7.33	3.06	19.06	28.46	8.51	6.45
HSD	2.41	1.67	2.82	0.60	0.67	36.53	12.14	0.38	1.12
Cumilla									
IRBPHN-2	69 de	103 d	100.53 d	14.67 a	25.40c-e	219.95 c	48.95 b	5.51 c	23.03 ab
IRBPHN-5	70 de	103 d	102.33 cd	11.27 cd	24.20 e	276.05 a	47.55 b	5.81 c	20.22 c
IRBPHN-21	77 b	112 b	101.43 cd	12.97a-c	24.80 de	244.67 b	48.25 b	7.17 a	23.72 a
IRBPHN-35	72 c	115 a	123.20 a	10.27	27.67 b	210.91 c	51.57 b	7.33 a	21.17 c
IRBPHN-38	78 ab	112 b	114.87 b	11.93	26.47 bc	215.77 c	57.04 ab	6.83 ab	22.20 b
IRBPHN-44	80 a	112 b	126.27 a	10.40	29.13 a	184.76 d	53.36 ab	7.37 a	17.60 d
Binadhan 7	69 e	103 d	103.87 cd	13.47	25.93 cd	148.03 e	46.91 b	5.22 c	21.03 c
Binadhan-17	71 cd	110 c	105.07 c	12.40	22.27 f	166.0 de	66.64 a	6.04 bc	20.48 c
CV (%)	1.38	0.44	2.24	8.49	2.91	6.60	15.04	8.36	2.76
HSD	0.82	0.39	2.00	0.84	0.61	11.29	6.45	0.44	0.47
Combined									
IRBPHN-2	77 d	110 c	103.38 d	12 a	26.09 c	216 a-d	55.47 a	5.62 cde	23.28 a
IRBPHN-5	75 e	111 c	103.11 d	11 bc	23.99 d	253 a	59.94 a	5.35 de	20.22 b
IRBPHN-21	84 ab	117 c	110.88 c	10 cd	25.46 c	246 a-c	60.46 a	6.14 bc	23.72 a
IRBPHN-35	82 bc	119 a	128.49 a	9 d	27.28 b	248 ab	47.95 ab	6.82 a	21.17 b
IRBPHN-38	85 ab	119 a	118.93 b	12 ab	27.90 b	207 cd	55.19 a	6.52 ab	22.53 a
IRBPHN-44	86 a	119 a	126.36 a	11 bc	29.07 a	214 b-d	49.35 ab	6.78 ab	17.60 c
Binadhan 7	78 d	110 c	106.05 d	12 a	25.97 c	189 d	39.12 b	4.80 e	21.03 b
Binadhan-17	80 c	115 b	103.31 d	11 bc	24.19 d	199 d	51.65 ab	5.44 de	20.48 b
CV (%)	2.68	1.27	2.59	7.81	2.97	14.86	21.97	9.47	4.92
HSD	1.25	0.84	1.68	0.50	0.45	19.07	6.65	0.32	0.60

From the Table 25, it is observed that the average range of plant height among the lines were ranged 103.11 cm to 128.49cm. IRBPH-35 had the highest plant height (128.49 cm) whereas IRBPH-5 had the lowest (103.11 cm). The panicle length ranged 23.9 cm to 29.07cm. The longest panicle length was observed in IRBPH-44, while shortest panicle length (23.99 cm) was observed in IRBPH-5. The panicle length of check variety was 25.97 cm for Binadhan-7 and 24.19 cm for Binadhan-17. There were 3 lines had longer panicle length than check varieties. The number of filled grains per panicle ranged from 189 to 253.00. The highest number of filled grains (253.00) was observed in IRBPH-5, while lowest number of filled grains was observed in check varieties.
All lines produced higher yield than check varieties at both locations. Grain yield ranged from 4.80 to 6.82 t ha^{-1}, IBPHN- 35 had maximum yield which was followed by IBPHN- 35, IBPHN-38 and Binadhan-7 had minimum yield (4.80tha^{-1}).

Based on higher grain yield and short duration 5 lines (IRBPH-35, IRBPH-38, IRBPH-44 and IRBPH-21) have been selected and will be evaluated in the Advanced yield trial in next *Aman* season.

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

An experiment was carried out with two early and high yielding rice lines to assess the earliness and yield performance over two different locations of Bangladesh. BRRI dhan-28 was used as a check variety in *Boro* season. This experiment was carried out at four locations (BINA HQ farm, Mymensingh, BINA substation, Sunamganj BINA substation, Cumilla and on-farm, Bijoynagar, Brahmanbaria. Seeds were sown on 5th November 2021 and transplanted on 16th December at Sunamganj and seeds were sown on 28th November 2021 and transplanted on 6,8 and 10th January 2022 at BINA HQ farm, Mymensingh, BINA substation, Cumilla and Onfarm respectively. The experiment followed by RCB design with three replications. The size of the unit plots were 3.0 m × 4.0 m. Seedlings were transplanted at 15 cm distance within rows of 20 cm apart. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MOP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. Data on various characters such as plant height, number of effective tillers $plant^{-1}$, panicle length (cm), and filled grains $panicle^{-1}$ were recorded after harvest from five randomly selected competitive plants. Days to Fifty % flowering and days to maturity was assessed by plot basis. Grain yield data were recorded from an area of 1.0 m^2 which was later converted to tha^{-1}. Finally, all the recorded data were subjected to proper statistical analyses and are presented in Table 26.

Table 26. Mean performance of four IRTON lines along with check variety grown at two locations during Boro season 2021-22.

	Days to 50% flowering	Days to maturity	Plant height (cm)	Total tillers plant^{-1} (no.)	Effective tillers plant^{-1} (no.)	Panicle length (cm)	Filled Grains panicle^{-1} (no.)	Unfilled Grains panicle^{-1} (no.)	Thousand Seed Weight (g)	Grain yield (tha^{-1})
Mymensingh										
IRTON-11	116 b	145.0b	97.94 b	15 a	13.67a	24.89 a	113.67 a	36.0 b	23.42 a	5.2 a
IRTON-13	120 a	147.7 a	104.89 a	15 a	14.33a	25.00 a	181.17 a	91.67 a	23.67 a	5.3 a
BRRI dhan-28	122 a	145.7 b	99.44 b	12.67a	12.33a	27.00a	153.67b	43.67ab	23.07a	4.43a
CV (%)	0.97	0.6	2.19	10.22	10.37	9.40	5.84	37.76	2.33	8.35
HSD	2.62	1.99	5.00	3.30	3.16	5.46	19.81	48.81	1.24	0.94
Sunamganj										
IRTON-11	121b	153.6a	100.2b	18.93a	17.80a	25.45a	92.87c	45.07b	22.93a	6.2ab
IRTON-13	125 a	155a	112.07a	17.47a	15.87a	24.21a	103.4b	61.6 a	22.67a	6.74a
BRRI dhan28	126.3b	150b	108.33a	15.67a	14.40a	24.23a	121.6a	52.2 ab	22.53a	5.6 b
CV (%)	0.85	0.64	1.81	9.77	9.92	3.66	4.37	10.47	2.44	6.66
HSD	2.39	2.20	4.38	3.85	3.60	2.042	10.84	12.571	1.2560	0.94
Cumilla										
IRTON-11	118.67b	150.6b	107.4 b	20.6 a	22.0 a	26.33a	111.23 a	47.07 a	22.8 a	6.2 b
IRTON-13	119.3ab	156.3a	109.67b	20.27a	21.3 a	27.33a	111.07 a	51.4 a	23 a	6.92a
BRRIdhan28	121 a	146.7c	115.6 a	17.33a	17.87a	27.33a	104.7 a	51.53a	23.33a	5.40c
CV (%)	0.68	0.92	1.81	12.92	13.17	5.01	2.59	13.23	3.92	4.26
HSD	1.851	3.16	4.5440	5.68	6.086	3.07	6.41	15.001	2.05	0.60
Bijoynagar										
IRTON-11	118.6a	153.3a	110 a	24.43a	24.03a	26.33a	112.67 a	34.4 a	22.8 a	6.07a
IRTON-13	120 a	155a	111.67a	19.2 b	17.8b	27.0 a	114.33 a	27.46 a	23 a	6.77a
BRRI dhan28	121 a	149.6b	108.67 a	17.1 b	17.3b	25.67a	110.67 a	32.67 a	23.33a	5.3b
CV (%)	0.94	0.53	2.51	9.06	13.52	3.10	8.65	32.89	3.92	4.34
HSD	2.56	1.85	6.25	4.16	6.05	1.8510	22.07	23.49	2.05	0.60
COMBINED										
IRTON-11	118.5c	150.6b	103.9b	19.74a	19.38a	25.75a	105.11 b	40.63 b	22.99a	6.0 b
IRTON-13	121.0b	153.5a	109.57 a	17.9b	17.3b	25.89a	127.51 a	58.03 a	23.08a	6.4 a
BRRI dhan28	122.5a	148 c	108.03 a	15.69c	15.50c	26.06a	117.68 a	45.02 b	23.07a	5.21c
CV (%)	0.91	0.69	2.23	11.30	12.44	5.62	5.93	26.04	3.23	6.45
HSD	0.93	0.88	2.03	1.70	1.83	1.23	6.03	10.56	0.63	0.32

From the Table 26, Results combined over four locations (three of on-station and one on-farm), there were significant difference in days to maturity among the lines and check variety. Days to maturity of BRRI dhan-28 were shortest (148 days) at all locations. IRTON-11 took statistically same time (150.6 days) to mature like BRRI dhan-28. Plant height, in combined effect of varieties /lines IRTON-11 had shorter plant height (103.9 cm) than others. Taller plant height (109.57 cm) was found in IRTON-13 and it was similar at all locations. There were no significant differences of effective tillers per plant at Mymensingh, Cumilla and Sunamganj. At on farm (Bijoynagar) IRTON-11 produced significantly highest number of effective tillers (24.03). In combined effect of effective tillers per plant BRRI dhan-28 produced significantly lowest number of effective tillers (15.50), while IRTON-11 had produced highest number of effective tillers (19.38). In combined effect there was no significant difference in panicle length; BRRI dhan-28 had longer panicle length (26.06 cm). IRTON-13 had produced highest number of filled grains at all locations except Sunamganj. BRRI dhan-28 had produced highest number of filled grains at Sunamganj. In combined effect IRTON-13 had produced highest number (127.51) of filled grains.

Both lines had produced higher yield than check variety BRRI dhan-28 at all locations. IRTON-13 produced the highest yield (6.4tha^{-1}) followed by IRTON-11 (6.0 tha^{-1}). The grain size of the lines (IRTON-13 and IRTON-11) is slender. These two lines IRTON-13 and IRTON-11 have been selected for their higher yield and short duration and grain quality. These two lines (IRTON-13 and IRTON-11) have been selected for next year evaluation at haor areas of Bangladesh

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

This experiment was conducted with six IRBN rice lines to select desirable lines having Blast resistance, higher grain yield, short duration, suitable for *Boro* season. The popular short duration *Boro* variety used as check variety at BINA Headquarter farm, Mymensingh. The seeds were sown on 25th December 2020 and transplanted to the field on 15 February 2021. The experiment was laid out in RCBD with three replications. Unit plot size was 3m x 2m and spacing between hills and rows were 15 cm and 20 cm, respectively. Data on plant height, effective tillers $hill^{-1}$ (no.), filled grains panicle $^{-1}$ and panicle length (cm) were recorded from five randomly selected plants from each plot. Maturity was assessed by plot basis. Grain yield data were recorded from an area of 6.0 m^2. Finally, all the recorded data were subjected to proper statistical analyses and are presented in Table 27.

Table 27. Mean performance of IRBN rice lines along with check varieties during *Boro* season 2020-21

Lines/ check varieties	Days to 50% Flowering	Days to maturity	Plant height (cm)	Effective tillers plant^{-1} (no.)	Panicle length (cm)	Filled Grains panicle^{-1} (no.)	Unfilled Grains panicle^{-1} (no.)	Grain yield plot^{-1} (kg)
IRBN-3	53.00a	150.67b	102.33ab	9.11bc	23.2Zab	123.33cd	27.78a	4.45b
IRBN-9	45.33c	145.67c	102.89ab	8.22cd	25.44a	134.56b	16.00a	4.20b
IRBN-14	45.00c	152.00ab	99.78b	7.22d	23.44ab	149.22a	45.22a	5.31a
IRBN-18	48.67b	142.33d	101.11ab	7.22d	23.44ab	138.56b	16.67a	4.47b
IRBN-32	49.00b	152.67a	105.22a	10.00ab	24.00ab	115.89e	19.45a	4.51b
IRBN-34	48.00b	145.67c	89.11c	10.45a	22.67ab	127.56c	33.22a	5.39a
BRRIdhan-28	41.33d	142.67d	88.89c	7.52d	21.56b	119.78e	17.67a	3.94c
CV	1.12	0.45	1.90	4.67	4.17	1.47	47.63	2.68
SE	0.43	0.54	1.53	0.33	0.80	1.56	9.78	11.33

From the Table 27, it is observed that all IRBN lines had produced taller plant than check variety. IRBN-18 had the highest plant height (105.22 cm) whereas the check variety BRRIdhan-28 had the lowest. The highest number of effective tillers plant^{-1} (14.45) was observed in IRBN-34 which was significantly similar with IRBN-32 (10.00. The lowest number of effective tillers plant^{-1} (7.22) was found in IRBN-14 and IRBN-18. The panicle length ranged 21.56 cm to 25.44 cm. The longest panicle length (25.44 cm) was observed in IRBN-9 which was significantly similar with other IRBN lines, while shortest panicle length (21.56 cm) observed in check variety BRRIdhan-28. The number of filled grains panicle^{-1} ranged from 115.89 to 149.00. IRBN-14 had produced significantly higher number of filled grains while IRBN-32 had the lowest. The check variety took the lowest time to mature than the all IRBN lines and IRBN-32 took the highest time to mature. There are all IRBN lines had produced higher grain yield than check variety BRRI dhan-28. Grain yield (kg) ranged from 3.94 kg to 5.39 kg. IRBN-32 and IRBN-14 had maximum statistically same yield while check variety BRRIdhan-28 had minimum yield per plot (3.94 kg).

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

<u>Preliminary yield trial of advanced rice lines</u>

This trial was carried out with four rice lines derived from Binadhan-16×NERICA-4 along with BRRI dhan49 as check variety to assess the yield performance over locations. The experiment was conducted at BINA HQs farm Mymensingh, BINA sub-stations farm Sunamganj and Magura during the T. Aman season of 2021. The trial followed the RCB design with three replications having the unit plot size of 4m × 3m. The row-to-row and plant-to-plant distances were 20cm and 15cm, respectively. Standard production practices for water and nutrition management, and disease and pest control were followed.

Data on the agronomic performances across the three locations were summarized in Table 28. Plant height varied from 97.5 cm (B-32-3-4) to 125.1 cm (B-32-2-3) indicating all the lines were intermediate in case of plant height. The height of the check variety (BRRI dhan49) was 110.9 cm. The line R-30-1-1 took the shortest period (108 days) to mature while the check variety matured at 130 days. Yield was varied from 5.4 t/ha (R-30-1-1 and B-33-1-2) to 6.4 t/ha (B-32-2-3). The check variety produced 5.8 t/ha yield indicating that line B-32-2-3 produced 10.34% more yield than the check.

Estimation of the heritability% depicted that the plant height (0.92) and growth duration (0.96) were highly heritable traits in the studied lines while heritability in case of yield (0.35) was lower.

Table 28: Agronomic performances of the tested lines/variety in Preliminary Yield Trial during *T. Aman* 2021

Designation	**Plant height (cm)***	**Growth duration (days)***	**Yield (t/ha) ***
R-30-1-1	123.8	108	5.4
B-32-2-3	125.1	119	6.4
B-32-3-4	97.5	109	6.0
B-33-1-2	116.0	109	5.4
BRRI dhan49	110.9	130	5.8
LSD (0.5)	5.2	2.6	0.7
Heritability (%)	0.92	0.96	0.35

*Mean of three locations (Mymensingh, Sunamganj and Magura)

Data on the grain quality parameters across the three locations were summarized the Table 29. The highest head rice recovery % was found in the line R-30-1-1 which was almost similar to the check variety (69.61). The lines B-32-2-3 and B-33-3-4 had the head rice recovery% 68.00 and 64.37, respectively. The line B-32-2-3 had the longest grain (6.70 mm) and the highest L/B ratio (3.10) indicating that the line produced long slender grain. Other lines produced long medium grain and the check variety produced medium grain.

Table 29: Grain quality parameters of the tested lines/variety in Preliminary Yield Trial during T. Aman 2021

Designation	**Head rice recovery (%)**	**Grain length (mm)**	**Grain breadth (mm)**	**L/B ratio**	**Size & shape**
R-30-1-1	70.01	6.03	2.04	2.94	LM
B-32-2-3	68.00	6.70	2.16	3.10	LS
B-32-3-4	64.37	6.48	2.45	2.66	LM
B-33-1-2	57.83	6.32	2.43	2.62	LM
BRRI dhan49	69.61	5.83	1.93	2.99	MM

Considering all the aspects it is quite evident that the line B-32-2-3 and B-32-3-4 were selected for further evaluation.

Preliminary Yield Trial of Brown plant hopper resistant rice lines in *Boro* season

This experiment was conducted to evaluate rice lines for insect resistance with high yield attributes. Four rice lines along with one check variety BRRI dhan-28 tested in *Boro* season at BINA Headquarter farm, Mymensingh. Seeds were sown on 22nd December 2020 and transplanted to the field on 10th February 2021. The experiment followed RCB design with three replications. The size of a unit plot was 3.0 m × 4.0 m. Plant to plant distance was 15 cm and row to row distance was 20 cm. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. Data on plant height (cm), number of effective tiller plant^{-1}, panicle length (cm) and filled grains panicle^{-1} were recorded after harvesting from 5 randomly selected competitive hills. Days to 50% flowering and maturity were assessed plot basis. Recorded data were finally subjected to proper statistical analyses and are presented in Table 30.

Table 30. Mean performance of IBPHN rice lines along with check varieties at BINA Hqs, Mymensingh during boro season 2020-21

Lines/ check varieties	Days to fifty % flowering	Days to maturity	Plant height (cm)	Effective tillers plant^{-1} (no.)	Panicle length (cm)	Filled Grains Panicle^{-1} (no.)	Unfilled Grains Panicle^{-1} (no.)	Grain yield plot^{-1} (kg)
IRBPHN-2	67.33c	144.00b	93.56b	10.11a	25.00a	118.33a	23.67a	7.39a
IRBPHN-5	72.67b	151.67a	92.33b	10.00a	21.22b	155.56a	23.56a	6.79b
IRBPHN-18	76.33a	153.33a	103.33a	8.89a	24.56a	112.78a	21.78a	6.11c
IRBPHN-38	76.33a	151.33a	97.78b	9.78a	24.78a	125.67a	36.78a	5.68c
BRRI dhan-28	67.00c	142.00b	94.67b	8.55a	21.78b	114.78a	19.44a	6.09c
CV	1.22	0.58	1.27	2.57	2.94	2.63	14.76	1.46
SE	0.72	0.70	1.00	0.20	0.56	2.69	3.02	7.66

From the Table 30, it was observed that the average range of plant height among the lines and check variety were 92.33 cm to 103.33 cm. The line IRBPH-18 had the highest plant height whereas IRBPH-5 had the lowest and statistically similar with other lines. For effective tillers plant^{-1}, there was no significantly difference among the rice lines and check varieties. The panicle length ranged 21.22 cm to 25.00 cm. All lines had longer panicle length than check varieties except IRBPH-5. The longest panicle length (25.00cm) was observed in IRBPH-2 statistically similar with IRBPH-18 and IRBPH-38 while the shortest panicle length (21.22) in IRBPH-5.There were no significant differences in filled and unfilled grains per panicle. There were no lines earlier than check varieties.

Grain yield plot^{-1} ranged from 6.68 kg to 7.39 kg. IBPHN-2 had maximum yield (7.39kg) whereas IBPHN-38 had minimum yield (5.68 kg). There are four lines (IRBPH-2, IRBPH-5, IRBPH-18 and IRBPH-44) produced higher grain yield (kg/plot) than check variety BRRI dhan-28.

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

Preliminary Yield Trial of upland (IURON) rice lines

Fifteen IURON rice lines were evaluated through this observation trial to assess the performance of improved yield component for *Boro* season. This experiment was conducted at the BARD experimental field, Kotbari, Cumilla during Boro season 2021-22. Seeds were sown on 25th December 2020 and transplanted to the field on 1st February 2021. The experiment was laid out in RCBD with two replications. Unit plot size was 2m x 2m and spacing between hills and rows were 15 cm and 20 cm, respectively. Data on plant height (cm), effective tillers hill-^{1}(no.), number of filled grain plant^{-1} and panicle length (cm) were recorded from five randomly selected plants from each plot. Days to 50% flowering and days to maturity were assessed by plot basis. Grain yield data were recorded from an area of 6.0 m^2. Finally, all the recorded data were subjected to proper statistical analyses and are presented in Table 31.

Table 31. Mean performance of IURON rice lines during *Boro* season 2020-21

Lines	Days to Maturity	Plant height (cm)	Panicle length (cm)	Total tiller /plant	Effective tiller/ plant	Filled grain/ panicle	Unfilled grain/ panicle	1000 seed wt (gm)	Grain yield (kgm^{-2})
IURON- 38/1	126 f	108.0 ab	23.8 bc	12 a	12 a	79 b	56 bc	25.8 ab	0.676 a-d
IURON -05/1	127 f	98.7 b	23.2 bc	17 a	16 a	83 b	32 cd	20.7 ab	0.630 b-d
IURON- 05/2	131 de	109.2 ab	24.4 abc	14 a	13 a	109 a	37 cd	23.2 ab	0.505 d
IURON- 15/1	131 de	103.3 ab	24.2 abc	15 a	15 a	74 bc	28 cd	25.1 ab	0.655 a-d
IURON -15/2	133 cd	112.4 ab	25.2 ab	14 a	13 a	122 a	54 bc	21.0 ab	0.627 cd
IURON- 17/36	128 e	112.0 ab	25.0 ab	15 a	14 a	62 c	104 a	21.9 ab	0.814a
IURON- 17/16	132 d	113.0 ab	25.7 ab	13 a	13 a	122 a	27 cd	21.2 ab	0.714 a-c
IURON- 17/15	137 b	113.7 ab	25.3 ab	16 a	16 a	113 a	36 cd	27.3 a	0.683 a-c
IURON- 17/12	132 d	112.0 av	25.3 ab	14 a	14 a	110 a	42 cd	22.6 ab	0.713 a-c
IURON -16/05	135 c	104.3 ab	25.0 ab	14 a	14 a	108 a	32 cd	23.5 ab	0.697 a-c
IURON- 17/30	132 de	110.3 ab	27.7 a	14 a	12 a	107 a	80 ab	23.8 ab	0.783 a-c
IURON- 17/38	140 a	120.0 a	25.7 ab	17 a	13 a	74 bc	57 bc	21.5 ab	0.697 a-c
IURON- 21/1	137 b	105.7 ab	27.0 ab	15 a	14 a	112 a	42 cd	20.5 b	0.732 a-c
BRRI dhan74	**137 b**	105.5 ab	23.3 bc	13 a	13 a	77 bc	22 d	25.9 ab	0.800 ab
Binadhan-24	**130 e**	102.9 b	21.0 c	17 a	15 a	80 b	31 cd	27.1 ab	0.790 abc
CV(%)	**0.93**	5.15	5.08	19.67	16.85	7.77	21.71	9.31	8.07
Hsd	**2.06**	16.94	3.81	8.75	7.08	22.369	29.783	6.598	0.1712

It appeared that IURON-17/38 had the highest plant height (120.00cm) whereas IURON-05(1) had the lowest (98.7cm). Days to maturity ranged from 126 days to 140 days. IURON-38/1 took the shorter period (126 days) to mature which was significantly similar with IURON-05/1. IURON- 17/30 had longest panicle length (27.7 cm) whereas Binadhan-24 had shortest panicle length (21.0 cm). Total tiller /plant and effective tiller/plant had not significantly differed among the lines and check varieties. The highest number of effective tillers/hill (16) was found in IURON -05/1, and IURON- 17/15. The number of filled grains per panicle ranged from 57.00 to 122.00. IURON- 17/16 and IURON -15/2 had the highest number of filled grains per panicle and IURON- 17/36 had the lowest number of filled grains per panicle. Grain yield (kg) ranged from 0.505 kg to 0.814kg. IURON- 17/36 had maximum yield while IURON- 05/2 had minimum yield. Only line IURON- 17/36 had produced higher yield than check varieties.
Based on early maturity and higher seed yield 5 IURON rice lines (IURON- 38/1), IURON -05/1, IURON- 17/36, IURON- 17/16 and IURON- 17/30 have been selected and will be evaluated in next Boro season and Aus season in Cumilla.

Observation yield trial of high yielding Boro rice mutants

This trial was carried out with 18 rice mutants derived from NERICA-4 and Binadhan-17. The experiment was conducted at BINA HQs farm Mymensingh. The unit plot size was 2m × 2m. The row-to-row and plant-to-plant distances were 20cm and 15cm, respectively. Standard production practices for water and nutrition management, and disease and pest control were followed.

Six mutants were selected from the trial based on their agronomic performance. The mutants matured in between 146 and 147 days. All the mutants, except for the mutant B17-19-1, had intermediate plant height. The plant height ranged from 94cm (N4/M6/P-5 (1)-1) to 122cm (B17-19-1). Four mutants produced yield greater than 8 t/ha namely N4/M6/P-3-4-1 (9.69 t/ha), N4/M6/p-5(1)-1 (9.04 t/ha), N4/M6/P-9(1)-1 (8.58 t/ha), N4/M6/P-12(2)-1 (8.26 t/ha). The other two mutants, N4/M6/P-1(1)-1 and B17-19-1 produced 7.72 t/ha and 7.59 t/ha yield, respectively. The parent NERICA-4 and Binadhan-17 produced 4.01 t/ha and 6.80 t/ha yield, respectively.

Table 32: Agronomic performance of the selected mutants in the Boro 2021-2022 season

Mutants	Days to flowering	Days to maturity	Plant height (cm)	Yield (t/ha)
N4/M6/p-5(1)-1	111	146	94	9.04
N4/M6/P-9(1)-1	113	146	100	8.58
N4/M6/P-3-4-1	110	146	102	9.69
N4/M6/P-12(2)-1	117	146	111	8.26
N4/M6/P-1(1)-1	113	147	95	7.72
B17-19-1	118	147	122	7.59
NERICA-4	110	142	105	4.01
Binadhan-17	113	145	100	6.80

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

This experiment was carried out to assess disease tolerant, short duration with high yield attributes of five rice lines along with two check variety Binadhan-7 and Binadhan-17 tested in Aman' 2021 at BINA Headquarter farm, Mymensingh and BINA substation, Cumilla . Seeds were sown on 4th July 2021 and transplanted to the field on 8th August 2021. The experiment followed RCB design with three replications. The size of a unit plot was 3.0 m × 2.0 m. Plant to plant distance was 20 cm and row to row distance was 20 cm. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. Data on plant height (cm), number of effective tiller plant^{-1}, panicle length (cm) and number of filled grains panicle^{-1} were recorded after harvesting from 5 randomly selected competitive hills. Days to 50% flowering and days to maturity were assessed plot basis. Recorded data were finally subjected to proper statistical analyses and are presented in Table 33.

Table 33. Mean performance of IRBBN rice lines along with check varieties during *Aman* season 2021

Line/Variety	Days to fifty % flowering	Days to maturity	Plant height (cm)	Total tiller plant^{-1} (no.)	Effective tiller plant^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	Thousand Seed Weight (gm)	Grain yield plot^{-1} (kg)
Cumilla										
IRBBN-17	81a	107b	111.67b	7d	7d	27.40b	128bc	40a	25.87a	5.51b
IRBBN-9	79ab	106b	119.53a	12ab	12abc	29.20a	105d	36ab	22.48c	5.74ab
IRBBN-18	78b	106b	123.20a	9c	9cd	27.20b	147a	35ab	22.70c	5.59ab
IRBBN-31	80a	110a	118.73a	9c	10bc	25.07c	142ab	30b	25.12a	5.73ab
Binadhan-7	78ab	106b	98.4c	13a	13a	25.60c	107d	39ab	20.82d	5. 56ab
Binadhan-17	70c	110a	105.07bc	12ab	12ab	22.27d	126c	36ab	23.93b	6.27a
CV	1.68	1.08	3.28	6.93	14.64	2.31	6.11	14.13	2.21	6.86
SE	1.07	0.95	3.02	0.57	1.25	0.49	6.29	4.18	0.42	0.32
Mymensingh										
IRBBN-17	71c	105b	119.33b	6a	5a	26.22ab	127a	33b	25.87a	4.86ab
IRBBN-9	79ab	106b	121.00ab	8a	6a	28.22a	105bc	46a	22.47c	4.26b
IRBBN-18	78b	107b	118.44b	7a	4a	27.32a	98c	42ab	22.7bc	4.45b
IRBBN-31	81a	110a	122.56a	8a	6a	25.67ab	117ab	32b	25.12ab	4.25b
Binadhan-7	78b	107b	108.00c	8a	5a	26.11ab	111b	32b	18.82d	4.74ab
Binadhan-17	71c	110a	98.00d	8a	6a	24.11b	125a	37ab	23.07bc	5.45a
CV	1.88	1.27	1.48	16.13	30.28	6.32	6.99	18.74	6.23	11.58
SE	1.17	1.12	1.38	1.00	0.49	1.36	5.65	5.65	1.17	0.44
Combined over locations										
IRBBN-17	76c	106b	115.50b	7d	4c	26.81b	127a	37ab	25.87a	5.19b
IRBBN-9	79ab	106b	120.27a	10ab	6ab	28.71a	105b	41a	22.47b	5.00b
IRBBN-18	78b	107b	120.82a	8cd	5bc	27.26b	123a	39a	22.70b	5.03b
IRBBN-31	81a	110a	120.65a	9bc	6ab	25.37c	129a	31b	25.12a	4.99b
Binadhan-7	79b	107b	103.42c	10a	a	25.85bc	109b	38ab	19.82c	5.15b
Binadhan-17	71d	110a	101.42c	10a	6ab	23.19d	125a	34ab	23.5b	5.85a
CV	1.70	1.14	2.42	12.18	22.49	4.56	5.98	15.95	4.67	9.17
SE	0.76	0.70	1.58	0.62	0.76	0.69	4.14	3.37	0.63	0.28

From the Table 33, Days to maturity of IRBBN-31 and check variety Binadhan-17 took longest time (110 days) and IRBBN-9, IRBBN-17 took shortest time (106 days) to mature at both locations. All the lines produced taller plant than check varieties. The mean data of plant height in combined over locations, shortest plant height (101.42 cm) was found in check variety Binadhan-17 and it was statistically similar with Binadhan-7 (103.42 cm). Total tillers were found highest in check variety Binadhan-7 (13.00) at Cumilla but it was statistically similar among the lines and check varieties at Mymensingh. Binadhan-7 produced highest number of effective tillers (13.00) at Cumilla and it was similar with other check variety and line IRBBN-9. All lines had produced taller panicle length than check varieties and IRBBN-9 (28.71 cm) had produced tallest panicle length at both locations. IRBBN-17, IRBBN-18, IRBBN-31 and check variety Binadhan-17 had produced highest numbers of filled grains panicle^{-1} (125). The check variety Binadhan-17 had produced highest yield (5.85tha^{-1}) than other lines and check variety. This experiment with these lines will be repeated for further evaluation in next year.

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

This experiment was carried out to assess disease tolerant, short duration with high yield attributes of seven rice lines along with one check variety BRRIdhan-28 tested in *Boro*' 2020-21 season at BINA Headquarter farm, Mymensingh. Seeds were sown on 15th December 2020 and transplanted to the field on 31st January 2021. The experiment followed RCB design with three replications. The size of a unit plot was 3.0 m × 2.0 m. Plant to plant distance was 15 cm and row to row distance was 20 cm. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. Data on plant height (cm), number of effective tiller plant^{-1}, panicle length (cm) and number of filled grains panicle^{-1} were recorded after harvesting from 5 randomly selected competitive hills. Days to 50% flowering and days to maturity were assessed plot basis. Recorded data were finally subjected to proper statistical analyses and are presented in Table 34.

Table 34. Mean performance of IRBBN rice lines along with check variety at BINA Hqs, Mymensingh during *Boro* season 2021-22

Lines/ check variety	Days to fifty % flowering	Days to maturity	Plant Height (cm)	Effective tillers/plant (no.)	Panicle length (cm)	Filled grains/panicle (no.)	Unfilled grains/panicle (no.)	Grain yield plot^{-1} (kg)
IRBBN-6	72.67b	144.00a	107.89ab	10.55a	23.78a	112.33bc	18.22a	4.85a
IRBBN-9	71.00c	144.00a	104.44abc	8.56b	23.44a	107.34c	20.67a	4.98a
IRBBN-21	71.00c	144.00a	97.56c	9.00b	23.45a	190.44a	19.22a	3.93b
IRBBN-22	71.00c	144.00a	109.56a	10.11a	25.67a	134.56b	34.56a	4.31b
IRBBN-26	65.67d	144.00a	96.33c	7.44c	26.11a	123.00bc	35.78a	4.13b
IRBBN-31	75.00a	143.00a	105.33abc	8.78b	26.56a	128.89bc	33.33a	3.64d
IRBBN-32	70.33cd	137.33a	99.89bc	10.78a	24.22a	188.33a	23.44a	4.80a
BRRIdhan-28	66.00d	134.00a	97.22c	10.44a	23.44a	109.45c	28.56a	3.77c
CV	0.59	0.29	3.12cv	8.56	4.42	5.73	28.81	2.36
SE	0.33	O.33	2.64se	0.66	0.89	6.40	6.29	12.54

From the Table 34, it appeared that Days to maturity among the IRBBN lines and check variety ranged from 134.33 days to 144.00 days. There were no earlier lines than check variety BRRIdhan-28. IRBBN-26 had shorter plant height than others and IRBBN-22 had taller plant height (107.89 cm) which is significantly similar with IRBBN-9 and IRBBN-31. There was no significant difference in panicle length.

All the IRBBN lines had produced higher grain yield than check variety BRRI dhan-28 except IRBBN-31. Grain yield (kg) ranged from 3.64 kg to 4.98kg. IRBBN-9 had maximum yield which was significantly similar with IRBBN-6, IRBBN-32 while IRBBN-31 and BRRIdhan-28 had minimum yield (3.64 and 3.77kg).

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

<u>Handling of segregating population</u>

Screening of advanced breeding lines of rice (*oryza sativa* l.) for salinity tolerance at the seedling stage through morphological and molecular marker(s)

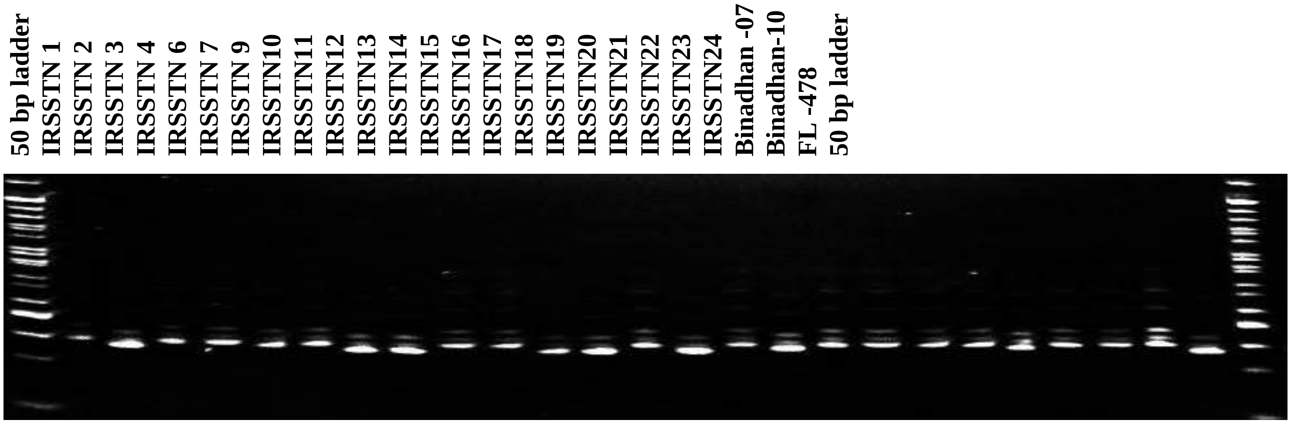
This experiment was set up to evaluate injury of salt stress on different rice genotypes at seedling stage in hydroponic system followed IRRI standard protocol (1997). After two or three days of salinization, salt stress symptoms were visualized. Injury scoring of rice genotypes was performed by Standard Evaluation Score (SES) (IRRI, 1997) chart at seedling stage under 8, 10 and 12 dS/m salinity levels. The range of scoring was 1 to 9. Final scoring was done at 21 and 23 days after salinization of rice seedlings. Table 35 shows the tolerance level of different rice genotypes under different saline conditions. In salinized setup, different genotypes showed wide variation. None of the genotypes showed high salt tolerance at EC-8, 10 or 12 dS/m. Among the 25 genotypes, 18 genotypes (IRSSTN 1, IRSSTN 2, IRSSTN 3, IRSSTN 4, IRSSTN 6, IRSSTN 7, IRSSTN 10, IRSSTN 11, IRSSTN 12, IRSSTN 13, IRSSTN 14, IRSSTN 16, IRSSTN 19, IRSSTN 20, IRSSTN 23, IRSSTN 24, FL-478 And Binadhan-10) showed tolerance at 8 dS/m, SEVEN genotypes (IRSSTN 9, IRSSTN 15, IRSSTN 17, IRSSTN 18, IRSSTN 21, IRSSTN 22, Binadhan-7) showed moderate tolerance. Eleven genotypes (IRSSTN 1, IRSSTN 2, IRSSTN 4, IRSSTN 6, IRSSTN 12, IRSSTN 13, IRSSTN 16, IRSSTN 20, IRSSTN 23, FL-478 and Binadhan-10) were identified as tolerant at 10 dS/m whereas twelve of the genotypes (IRSSTN 3, IRSSTN 10, IRSSTN 11, IRSSTN 13, IRSSTN 14, IRSSTN 15, IRSSTN 17 IRSSTN 18, IRSSTN 19, IRSSTN21, IRSSTN 22 and IRSSTN 24) were moderately tolerant, 2 genotypes (IRSSTN 9 and Binadhan-7) were susceptible. At EC-12 dS/m, nine genotypes (IRSSTN 2, IRSSTN 6, IRSSTN 12, IRSSTN 13, IRSSTN 16, IRSSTN 20, IRSSTN 23, FL-478 and Binadhan-10) showed tolerance. Six genotypes (IRSSTN 1, IRSSTN 10, IRSSTN 14, IRSSTN 15, IRSSTN 17 and IRSSTN 18) were found as moderately tolerant, nine genotypes (IRSSTN 3, IRSSTN 4, IRSSTN 7, IRSSTN 11, IRSSTN 19, IRSSTN 21, IRSSTN 22, IRSSTN 24 and Binadhan-7) were identified as susceptible and IRSSTN 9 found highly susceptible to salt stress at12dS/m.

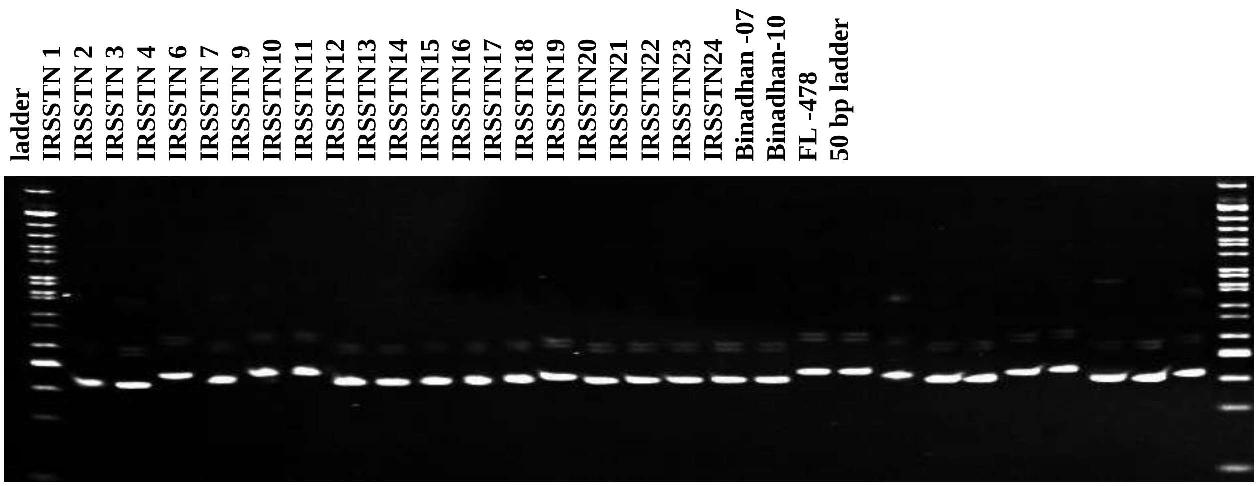
Table 35: SES score of 25 rice genotypes under salinized condition grown in hydroponic system at the seedling stage

Genotypes	EC- 8dS/m		EC- 10dS/m		EC- 12dS/m	
	SES score	Tolerance	SES score	Tolerance	SES score	Tolerance
IRSSTN 1	3	T	3	T	3	MT
IRSSTN 2	3	T	3	T	3	T
IRSSTN 3	3	T	5	MT	7	S
IRSSTN 4	3	T	3	T	7	S
IRSSTN 6	3	T	3	T	3	T
IRSSTN 7	3	T	5	T	5	S
IRSSTN 9	5	MT	7	S	8	HS
IRSSTN 10	3	T	4	MT	5	MT
IRSSTN 11	3	T	4	MT	6	S
IRSSTN 12	3	T	3	T	3	T
IRSSTN 13	3	T	3	MT	3	T
IRSSTN 14	3	T	4	MT	5	MT
IRSSTN 15	5	MT	5	MT	5	MT
IRSSTN 16	3	T	3	T	3	T
IRSSTN 17	5	MT	5	MT	5	MT
IRSSTN 18	5	MT	5	MT	5	MT
IRSSTN 19	3	T	5	MT	7	S
IRSSTN 20	3	T	3	T	3	T
IRSSTN 21	5	MT	5	MT	7	S
IRSSTN 22	4	MT	5	MT	7	S
IRSSTN 23	3	T	3	T	3	T
IRSSTN 24	3	T	5	MT	6	S
Binadhan-7	5	MT	7	S	7	S
Binadhan-10	3	T	3	T	3	T
FL-478	3	T	3	T	3	T

1-9 Scale, where 1 = highly tolerant (HT), 3 = tolerant (T), 5 = moderately tolerant (MT), 7 = susceptible (S) and 9 = highly susceptible (HS)

Twenty-five rice genotypes were analyzed exploiting 12 loci for SSR marker-based DNA fingerprinting technique for salinity tolerance. The bands obtained, were compared to the band of salt tolerant variety FL478, Binadhan-10 and susceptible one Binadhan-7 as these three genotypes were used as check. The detailed information which were found after analyzing the fingerprinting data are briefly discussed and presented below.





Both the phenotypic and molecular screening found some lines of rice those showed tolerance for salinity these are: IRSSTN 12, IRSSTN 13 and IRSSTN 16. These lines can be used for further improvement for developing salinity and tolerant rice varieties.

Growing F_2 & F_3 population rice through Field RGA

This experiment was set up for rapid advancement of segregating population for shortening breeding cycle and development of large RIL population. A total of 20 F_2 and 25 F_3 populations were grown in T. Aman 2021 season. Single seed progenies from single panicle of one plant were grown in the RGA nursery in field. In the field, part of the panicle was sown directly on the soil. No thinning or pruning was done. Around 30 days old seedlings were transplanted in a 5.4 m × 2 rows plot with a spacing of 25cm × 15cm. Single seedlings was used for transplanting. Fertilizers were applied @ 200 kg urea, 62 kg TSP, 50 kg MoP, 56 kg gypsum and 5 kg zinc sulphate/ha. Urea was applied in equal three splits at 10, 25 and 40 days after transplanting. The fertilizers other than urea were applied as basal during final land preparation. Water stress was imposed at 30 days after transplanting and it was continued until PI stage. Appropriate pest management practices were done as and when necessary.

During harvesting at maturity, one panicle was collected from each plant of all the crosses in different times and the plant was uprooted. Harvested seeds remaining in the panicles were dried and subjected for dormancy breakage to initiate next cycle of RGA immediately. For dormancy breaking, at first, sun-drying was done for three days followed by oven drying with 50°C temperature for 72 hours. Panicles of 305 individuals from 20 F_2 and 25 F_3 populations were harvested at the time of maturity and preserved and processed with proper labels.

Growing of F_2 generation of Binadhan-17, BRRI dhan29 & Binadhan-24 with Binadhan-5 cross

Accordingly, a minimum of an average rough rice yield target of 9.11 t ha-1 has been set for 2050. However, this target cannot be achieved equally across all the geographic regions of Bangladesh. Because, the country has various ‘rice types’ based on specific ecosystems, and also due to the pressing ‘needs’. All these ‘rice types’ have different situation-specific yield potentials and area coverage. The breeding objective was to develop a high yielding rice variety will be grown in boro season that will achieve the future target genetic yield potential (GYP) in Bangladesh

70 F_2 populations were developed from crossing between Binadhan-5 with Binadhan-17 and Binadhan-24 to select high yielding, short duration, and lodging resistant plant/progenies. This experiment was conducted at Boro season, 2021 for selecting desirable characters at BINA Head quarters farm, Mymensingh. The F_2 population was put at Rapid Generation Advance (RGA) trail to develop F_3 population

Considering the yield & yield attributes, the promising lines will be evaluated for the next generation

Screening of F_5 population of Binadhan-7 × Biroi crosses

Biroi is a traditional local rice variety of Bangladesh containing red pericarp in grain and considered as red rice. Higher plant height, longer duration and lodging susceptibility are the key characteristics of Biroi cultivar. Stem lodging hindrances the photosynthetic effectiveness of the canopy that affects the grain filling. Hence the rice grain yield and quality reduced by 60-80% as photosynthesis is directly associated with lodging. Modern breeding techniques including mutation could improve the lodging and yield of red rice to overcome this problem. Successful breeding for crop improvement, however, depends on genetic variation in the parents which limit breeding progress and/or yield and quality crop improvements. The objective of this research is to develop a lodging tolerant premium quality red pericarp rice variety that will maintain the nutritional balance as well as the food demand in the world prospective.

Seeds of F_5 population of Binadhan-7 × Biroi were sown on 13 July, 2021 and transplanted on 12 August, 2021 at BINA Headquarter, Mymensingh by maintaining plant to plant and row to row distance 15cm and 20cm respectively. The experiment was followed by non-replicated design. The size of the unit plots were 1m × 2m. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. Data on plant height, number of effective tillers plant^{-1}, panicle length, and filled and unfilled grains panicle^{-1} were recorded after harvest from 5 randomly selected competitive plants. Maturity was assessed plot basis. Finally, all the recorded data were subjected to proper statistical analyses as per design and are presented in Table 36.

Table 36. Grain yield and yield components of F_5 population of Binadhan-7 × Biroi cross that were sown at BINA Headquarter, Mymensingh

Variety/Mutant	Duration	Plant height(cm)	Effective Tiller	Panicle length(cm)	Filled grain	1000 seed wt.(g)
B-P-2-38-1-1	134±1.47	94±2.97	11±0.73	26±0.44	100±4.95	21±0.34
B-P-2-38-1-2	130±1.47	94±2.97	15±0.73	24±0.44	129±4.95	20.8±0.34
B-P-2-38-1-3	124±1.47	104±2.97	13±0.73	27±0.44	100±4.95	21.6±0.34
B-P-2-38-1-4	129±1.47	96±2.97	11±0.73	25±0.44	96±4.95	21.44±0.34
B-P-2-38-1-5	127±1.47	92±2.97	9±0.73	25±0.44	90±4.95	22.1±0.34
B-P-2-38-1-6	130±1.47	97±2.97	11±0.73	26±0.44	98±4.95	20±0.34
B-P-2-38-1-7	121±1.47	91±2.97	11±0.73	25±0.44	92±4.95	20.21±0.34
B-P-2-38-1-8	125±1.47	94±2.97	8±0.73	24±0.44	112±4.95	23±0.34
B-P-2-38-1-9	121±1.47	102±2.97	15±0.73	27±0.44	146±4.95	21.1±0.34
B-P-2-38-1-10	129±1.47	102±2.97	19±0.73	29±0.44	140±4.95	22±0.34
B-P-2-38-1-11	130±1.47	103±2.97	11±0.73	24±0.44	101±4.95	20.42±0.34
B-P-2-38-1-12	127±1.47	100±2.97	12±0.73	25±0.44	105±4.95	20.31±0.34
B-P-2-38-1-13	135±1.47	94±2.97	8±0.73	23±0.44	95±4.95	20.1±0.34
B-P-2-38-1-14	131±1.47	103±2.97	9±0.73	27±0.44	100±4.95	20.6±0.34
B-P-2-38-1-15	125±1.47	93±2.97	13±0.73	26±0.44	138±4.95	21.6±0.34
Biroi (P)	140±1.47	143±2.97	8±0.73	22±0.44	76±4.95	23.6±0.34
Binadhan-7(P)	115±1.47	98±2.97	12±0.73	23±0.44	121±4.95	24.9±0.34

Significant variation was observed in term of duration among the crossing population. All the progenies had shorter plant height comparing to the parent Biroi. The population B-P-2-38-1-7 had shorter plant height (91cm) comparing to the parent Biroi. The population B-P-2-38-1-10 had higher (19) effective tillers comparing to the check variety Binadhan-7 (12). In B-P-2-38-1-10 population had longest Panicle length (29 cm). The progeny B-P-2-38-1-15 had highest number (138) of filled grains panicle^{-1} contrasting to other crossing population and the check variety Binadhan-7 (121). All the crossing population had lower 1000 grain weight comparing to the Biroi and Binadhan-7 parents (Table 36).

Considering the yield & yield attributes, the promising lines will be evaluated for the next generation.

Growing M_3R_1 population of sticky rice

To create genetic variability mainly for stickiness, seeds of three rice varieties (Huachinbio, Fukunishiki and Nipponbare) were irradiated with $Cobalt_{60}$ gamma rays at 200, 250, 300 & 350Gy doses. Experiment was carried out during Boro season 2021-22. The experiment was followed non-replicated design with spacing 15cm and 20cm. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as when necessitated. Seeds were harvested separately for next generation.

Growing M2 and M3 of Chinigura and Kataribhog

The M_2 population of Chinigura and Kataribhog (250 Gy, 300 Gy, and 400 Gy) were grown in Aman 2021-2022 season. In the M_2 population 43 plants from Chinigura and 35 plants from Kataribhog were selected based on plant height and earliness. The selected Kataribhog plants matured as early as 106 days and as late as 144 days while the parent took 155 days to mature (Table 37). The plant height ranged from 64cm to 196cm while parent's plant height was 138cm. The selected Chinigura plants matured in between 106 to 144 days while the parent matured at 148 days. The plant height ranged between 83cm to 195cm while the parent's height was 154cm (Table 38).

Table 37: Descriptive statistics of the selected M_2 population of Kataribhog

Feature	Days to maturity	Plant height (cm)	Total tiller	Effective tiller
Parent	**155**	**138**	**18**	**16**
M_2 population of Kataribhog				
Avg.	129	144	14	13
Min	106	64	5	5
Max	144	196	37	35
SD	11.56	31.34	8.51	7.58

Table 38: Descriptive statistics of the selected M_2 population of Chinigura

Feature	Days to maturity	Plant height (cm)	Total tiller	Effective tiller
Parent	**148**	**154**	**16**	**15**
		M_2 population of Chinigura		
Avg.	121	133	11	10
Min	106	83	5	5
Max	144	195	25	23
SD	13.09	37.52	4.69	4.55

The selected plants were grown in Boro 2021-2022 season. Based on photo-insensitivity, uniformity, semi-dwarf plant stature (plant height below 110cm), grain color and quality M_3 population were selected (Table 39).

Table 39: Classification of the selected M_3 population

Homogenous lines		**Semi-dwarf lines**		**Lines with Red pericarp**
K-250-*2	C-250-12	K-250-*2	C-250-16	K-250-6
K-250-6	C-250-14	K-300-2	C-250-30	K-300-7
K-300-8	C-250-16	K-300-8	C-300-6	K-T-1
K-300-9	C-250-30	K-400-1	C-400-1*	K-T-3
K-T-1	C-300-2	K-T-1	C-400-3	C-300-3
K-T-2	C-300-6	K-T-2	C-400-6	
K-T-3	C-400-1*	K-T-3	C-400-7	
C-250-1	C-400-3	C-250-1	C-400-10	
C-250-2	C-400-6	C-250-2		
C-250-3	C-400-7	C-250-3		
C-250-9	C-400-10	C-250-12		
C-250-10				
Total=23		Total=19		Total=5

Generation advancement through field RGA

To develop high-yielding and fine-quality rice with aroma or without aroma total of 4 crosses were made and true hybrid was confirmed with SSR markers.

Ping 3×Binadhan-11

To increase the heterosis for the yield and yield contributing traits, Ping 3 and Binadha-11 were crossed. The F_2 generation was cultivated under field settings utilizing the Field Rapid Generation Advancement (RGA) method after the F_1 seeds were harvested. In Aman 2021–2022, 540 F_2 genotypes were raised. At maturity, a single panicle from each genotype was collected. A similar approach was used in the next Boro season (2021-2022) to manage the F_3 population. Sixty genotypes in Aus 2021–2022 failed to germinate, making the F_4 population size 480.

Binadhan-12 × Binadhan-17

Binadhan-12 and Binadhan17 were crossed to increase grain yield and quality. After the F_1 seeds were harvested, the F_2 generation was grown using the Field Rapid Generation Advancement (RGA) technique in field conditions. There were 300 F_2 genotypes produced in Aman 2021–2022. Each genotype's mature panicle was harvested as a single unit. The F_3 population was managed using a similar strategy over the next Boro season (2021–2022). The F_4 population in Aus 2021–2022 has 260 members since 40 genotypes failed to germinate.

Kataribhog × Binadhan-17

The cross has been made to improve the plant's grain quality and phenotypic attributes. Partial hybrid sterility was observed in the F_1 population. The mature, healthy seeds were collected from the F_1 population and raised in the Boro 2021-2022 season by following the Pedigree method. From the F_2 population, the selection was based on grain quality and lodging tolerance. The selected plant progeny was grown in the subsequent Aus season. More importantly, all the F_2 genotypes were preserved by collecting single panicle from each genotype and were raised in Aus following the Field RGA method.

Black Rice

The M_3 population was grown in bulk in Aman 2021-2022 season. The selection was made based on the grain attributes and tillering capacity. A total of 10 plants were selected from the M_3 population. In the Boro 2021-2022, individual plant progeny was grown following the pedigree method. The selection was based on grain quality in the M_4 population. The subsequent progeny was produced in the Aus 2021-2022 following the Field RGA method.

Population screening

Screening of upland rice lines for drought tolerance

The experiment was conducted to identify suitable rice genotypes with drought tolerance and higher grain yield. Total 25 IURON (International Upland Rice Observational Nursery) rice lines along with five negative and positive controls were screened for drought tolerance at vegetative and reproductive stage.

The vegetative stage screening was done hydroponically in a glass house using Polyethylene Glycol (PEG) -6000. Drought was initially imposed for seven days by 10% PEG on 14 days old seedlings. With 15% PEG, a progressive drought was induced for the following seven days. The experiment ended on day 28, and data regarding the drought were gathered. The reproductive stage screening was done in trays beneath the polythene shed. Drought was imposed for 28 days at the peak of tillering to screen the reproductive stage. At that point, the volumetric soil moisture had dropped to 3%, and lifesaving irrigation had been used to recover from the drought. At 80% maturity, the experiment was harvested. Data regarding seed setting % were gathered. RCB design with two replications was used in both instances.

The analysis employed curated data. Utilizing the following method, it was determined how much each trait was affected by drought.

$$\% \text{ Reduction of the trait} = \frac{performance\ of\ the\ trait\ in\ control - performance\ of\ the\ triat\ in\ drought}{\text{performance of the trait in control}} \times 100$$

The genotypes were ultimately divided into precise tolerance or susceptible levels based on how well they performed under drought and how satisfactory they scored during drought, according to the IRRI SES 5th edition.

The statistics illustrate how the genotypes responded to drought. The genotypes BN-UR-1014, BN-UR-1016, BN-UR-1012, BN-UR-1004, BN-UR-1005, and BN-UR-1024 performed better in terms of the percent reduction in plant height (Table 40), which indicates that these genotypes demonstrated drought tolerance for this specific character and their plant height reduction percentage was under 30%. The genotypes BN-UR-1023, BN-UR-1010, BN-UR-1020, and BN-UR-1009 displayed vulnerability to drought, with plant height drop percentages ranging from 40% to 50%. Other genotypes performed moderately when exposed to drought and exhibited plant height reductions between 30% and 40%. Regarding this trait, the checks BRRI dhan96, Binadhan-17, and Binadhan-19 performed much better than the others, while BRRI dhan58 did the worst. More intriguingly, the plant height reduction percentage in this instance was 33.02 percent for the susceptible check IR-64, indicating that the global check behaved moderately.

The genotype BN-UR-1014 seemed to have the highest performance (2.5%) when it came to the percent reduction in root length, followed by the genotypes BN-UR-1006 (3.64%), BN-UR-1003 (5.61%), BN-UR-1002 (9.57%), BN-UR-1008 (9.75%), BN-UR-1015 (10.40%), and BN-UR-1004 (10.62%). BN-UR-1001 saw the greatest root length reduction (40.77%), followed by BN-UR-1013 (38.06%), BN-UR-1018 (36.82%), and BN-UR-1025. (33.27%). Root length reduction among the checks ranged from 14.30% (Binadhan-19) to 33.60% (IR-64).

Table 40: Reduction percentage in different traits in the studied genotypes

Genotype	% Reduction in plant height	% Reduction in root length	% Reduction in root number	% Reduction in shoot dry weight	% Reduction in root dry weight
BN-UR-1001	29.15	40.77	33.68	30.76	37.5
BN-UR-1002	31.32	9.57	13.88	32.75	18.75
BN-UR-1003	33.98	5.60	37.57	38.33	21.42
BN-UR-1004	26.62	10.62	7.77	20.30	-10.0
BN-UR-1005	27.50	25.63	-9.04	12.99	22.5
BN-UR-1006	34.76	3.64	30.70	44.13	30.95
BN-UR-1007	36.78	29.69	45.65	44.33	0.0
BN-UR-1008	34.92	9.75	42.88	21.25	2.38
BN-UR-1009	41.95	27.84	27.27	58.08	2.85
BN-UR-1010	45.98	20.61	49.02	51.66	-29.16
BN-UR-1011	36.03	25.37	20.09	52.84	41.66
BN-UR-1012	23.75	27.45	29.41	45.072	37.5
BN-UR-1013	37.02	38.06	45.66	59.92	54.16
BN-UR-1014	14.81	2.5	39.38	9.92	-60.00
BN-UR-1015	31.88	10.40	16.54	40.16	-5.55
BN-UR-1016	19.45	20.11	36.25	0.18	2.77
BN-UR-1017	32.60	14.49	13.33	44.64	38.14
BN-UR-1018	34.02	36.82	31.87	45.16	48.21
BN-UR-1019	37.17	28.05	4.99	59.20	50.00
BN-UR-1020	42.02	24.72	12.39	56.16	-16.66
BN-UR-1021	35.35	24.12	23.81	46.18	26.66
BN-UR-1022	36.83	31.13	-4.76	50.27	26.78
BN-UR-1023	47.70	21.12	15.68	69.94	63.69
BN-UR-1024	27.36	16.76	-2.94	52.97	67.5
BN-UR-1025	38.56	33.27	34.89	45.31	52.34
BRRI dhan58	40.66	19.09	-2.63	42.39	36.50
BRRI dhan96	21.40	21.051	5.85	5.55	8.92
Binadhan-17	26.98	20.26	42.46	18.55	23.33
Binadhan-19	29.52	14.30	32.11	18.33	41.6
IR-64	33.02	33.60	17.73	55.76	56.25

The genotypes BN-UR-1005, BN-UR-1022, and BN-UR-1024 produced more roots than the control condition in terms of root number (Table 1). In BN-UR-1019 and BN-UR-1004, the reduction of the root number was less than 10%. However, the roots of BN-UR-1010, BN-UR-

1013, BN-UR-1008, and BN-UR-1007 were reduced by nearly 50%. The experiment results showed that BRRI dhan58 and dhan96 performed better among the checks.

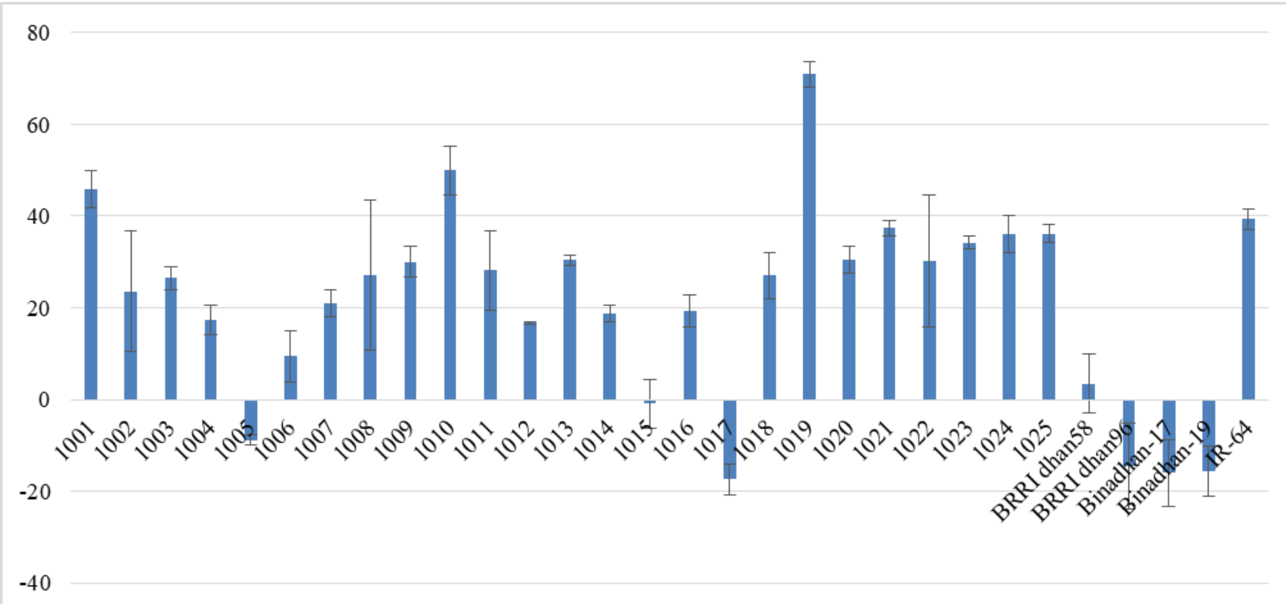
Shoot dry weight decreased slightly in BN-UR-1014 and BN-UR-1016 but significantly in BN-UR-1023, BN-UR-1019, BN-UR-1013, BN-UR-1020, BN-UR-1009, BN-UR-1010, and BN-UR-1011 (Table 1). However, the genotypes BN-UR-1014, BN-UR-1010, BN-UR-1004, BN-UR- 1015, and BN-UR-1020 generated higher dry root weight than the control condition. In contrast, the root weight significantly decreased in the genotypes BN-UR-1023, BN-UR-1024, BN-UR-1025, and BN-UR-1013 (Table 40). When both the shoot and root dry weights were considered, BRRI dhan96, Binadhan-17, and Binadhan-19 outperformed IR-64.

Considering the studied trait at the vegetative stage and the SES drought scoring, the genotypes were classified into tolerant, moderately tolerant, moderately susceptible, and susceptible groups (Table 41).

Table 41: Classification of rice lines for drought tolerance based on IRRI SES score

Tolerant	Moderately tolerant	Moderately susceptible	Susceptible
BN-UR-1004	BN-UR-1002	BN-UR-1001	BN-UR-1013
BN-UR-1005	BN-UR-1003	BN-UR-1009	BN-UR-1019
BN-UR-1014	BN-UR-1006	BN-UR-1010	BN-UR-1023
BN-UR-1015	BN-UR-1007	BN-UR-1020	BN-UR-1025
Binadhan-17	BN-UR-1008	BN-UR-1021	IR-64
BRRI dhan96	BN-UR-1018	BN-UR-1022	
	BN-UR-1011	BN-UR-1024	
	BN-UR-1012		
	BN-UR-1016		
	BN-UR-1017		
	BN-UR-1018		
	BRRI Dhan58		
	Binadhan-19		
Total= 6	Total= 13	Total= 7	Total= 5

Different genotypes responded differently to drought when they were in the reproductive stage. Compared to control conditions, the genotypes BN-UR-1017, BN-UR-1005, and BN-UR-1015 produced more seeds. In contrast, the seed setting was drastically reduced in BN-UR-1019, BN-UR-1010, and BN-UR-1001 (Figure 4). In drought, BRRI dhan96, Binadhan-17, and Binadhan-



19 produced more seeds, whereas IR-64 suffered an almost 40% decrease in seed setting.

Figure 4: % Reduction in seed setting in the studied genotypes.

The genotypes performed essentially the same in various developmental phases. In both the vegetative and reproductive stages, the genotypes BN-UR-1004, BN-UR-1005, BN-UR-1014, BN-UR-1015, and BN-UR-1017 can be regarded as tolerant. However, the genotypes BN-UR-1013, BN-UR-1019, BN-UR-1023, and BN-UR-1025 are vulnerable to drought. The tolerant genotypes were selected for further evaluation to assess the adaptability and stability for drought tolerance under field condition.

AGGRi Network Trial 2021 Wet Season

Rice (Oryza sativa L.) is the world's second most extensively grown cereal crop and the staple food for more than half of the world's population, particularly in Asia and Africa. The rapidly growing population is generating pressures for increasing the food production. Thus, increase in grain yield potential is the major goal of almost all rice breeding programs. But increasing yield is a major challenge as it is a complex trait and controlled by polygenes with high influence of environmental interactions. Therefore, major impacts are related to the development of new strategies to increase the genetic gain for the development of high yield potential rice varieties. On that account, a trial of IRRI developed advanced breeding lines was conducted at BINA sub-station Barisal to understand and select the best performing breeding lines with highest genetic merits in long duration environment of Bangladesh.

The trial was conducted with IRRI developed 188 advanced breeding lines and 12 international and local check varieties. The seeds were sown on 15 July 2021 and thirty days old seedlings were transplanted on 15 August 2021 following alpha lattice experimental design with 2 replications. The unit experimental plot size was 5.4 m^2 [5.4 m (27 hills) x 1.0 m (4 rows)]. Two-three seedlings per hill were transplanted, maintaining a 20 cm distance between plant to plant and row to row. BRRI Transplanted Aman Recommendation SOP was followed for the crop management. All the rice plants were harvested from each plot separately, and data were recorded on days to 50% flowering, days to 80% maturity, plant height, plot yield (kg), and grain moisture content (%). Plant height was recorded from randomly selected 5 hills of each plot. Plot yield data were adjusted to t/ha. Finally, the recorded data were tabulated and analyzed using single-environment analysis following Alpha-Lattice Design.

A wide range of variation was observed for the phenotypic developments of the tested genotypes. All the tested genotypes showed significant differences for days to 50% flowering. The days to 50% flowering ranged from 93 to 101 days (Table 1). The entry IR126952:173-AC 16-1-B and IR16F1097 had the shortest and longest flowering time, respectively.

The tested genotypes showed a wide range of variation in plant height ranged between 84 to 158 cm (Table 42). Among them, the shortest and tallest plant height was exhibited by IR 99853-B-B-B-752 and IR15F1931, respectively.

Table 42. Raw data report

Trait	Range	Mean	Sd	CV (%)
Days to 50% Flowering	93-101	96.44	6.98	7.24
Plant Height (cm)	84-158	115.88	14.89	12.85
Yield (t/ha)	1.9-5.6	3.76	1.15	30.58

Sd=Standard Deviation, CV=Co-efficient of Variation

Table 43. Descriptive statistics

Trait	Genetic Variance	Error Variance	Heritability
Days to 50% Flowering	9.5	37.75	0.33
Plant Height (cm)	168.52	35.91	0.90
Yield (t/ha)	0.62	0.58	0.68

The grain yield varied from 1.9 to 5.6 t/ha (Table 42). Some of the breeding lines were showed promising field performance with high yield potentiality. The lowest yield was found in SAN DU BAI MI HONG GU, and IR15F1921 produced the highest grain yield among the tested genotypes.

In addition, heritability is important to quantify the precision of field trials and determine the response to selection. Therefore, the heritability for days to 50% flowering, plant height, and yield were calculated as 0.33, 0.90, and 0.68, respectively (Table 43).

Finally, based on the available dataset, IR126952-29-65-22-5-52-B, IR126952-41-58-26-4-12-5-3, IR15F1921, IR16F1066, IR16F1072, IR16F1144, IR16F1234, IR16T1159, IR19L1011, and IR19L1050 were selected considering yield performance (Figure 5). Besides, some of the lines would be useful for further use as a parental line.

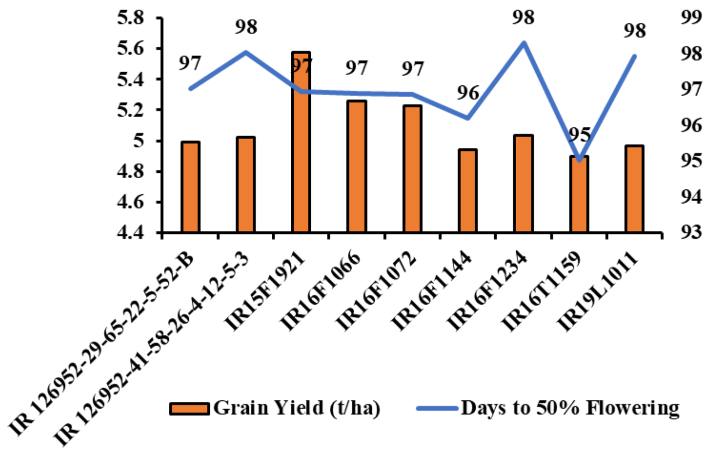


Figure 5. Yield performance of top ten breeding lines along with their flowering time

AGGRi Network Trial 2022 Dry Season

Rice (Oryza sativa L.) is one of the most important food crops and is the primary staple food for nearly half of the world's population. It is expected that the world population will continue to grow and exceed nine billion by 2050, which demands a nearly 70% increase in food production. The rapidly growing population is generating pressures for increasing the food production. Therefore, ensuring the food security and sustainable development of agriculture has become a key strategic concern worldwide. Thus, increase in grain yield potential is the major goal of almost all rice breeding programs. But increasing yield is a major challenge as it is a complex trait and controlled by polygenes with high influence of environmental interactions. Therefore, major impacts are related to the development of new strategies to increase the genetic gain for the development of high yield potential rice varieties. On that account, a trial of IRRI developed advanced breeding lines was conducted during dry season 2022 at BINA sub-station Barisal to understand and select the best performing breeding lines with highest genetic merits in long duration environment of Bangladesh.

The trial was conducted with IRRI developed 188 advanced breeding lines and 12 global and local check varieties. The seeds were sown on 18 December 2021 and forty-five days old seedlings were transplanted on 2 February 2022 following alpha lattice experimental design with 2 replications. The unit experimental plot size was 5.4 m^2 [5.4 m (27 hills) x 1.0 m (4 rows)]. Two-three seedlings per hill were transplanted, maintaining a 20 cm distance between plant to plant and row to row. BRRI Transplanted Boro Recommendation SOP was followed for the crop management. All the rice plants were harvested from each plot separately, and data were recorded on days to 50% flowering, days to 80% maturity, plant height, plot yield (kg), and grain moisture content (%). Plant height was recorded from randomly selected 5 hills of each plot. Plot yield data were adjusted to t/ha. Finally, the recorded data were tabulated and analyzed using single-environment analysis following Alpha-Lattice Design.

A wide range of variation was observed for the phenotypic developments of the tested genotypes. All the tested genotypes showed significant differences for days to 50% flowering. The days to 50% flowering ranged from 101 to 147 days (Table 43). The entry SAN DU BAI MI HONG GU and IR 126952-29-65-16-2-10-B had the shortest and longest flowering time, respectively.

The tested genotypes showed a wide range of variation in plant height ranged between 76 to 153 cm (Table 43). Among them, the shortest and tallest plant height was exhibited by IR16L1886 and IR 126953:192-AC 74-1-B, respectively.

Table 43. Raw data report

Trait	Range	Mean	Sd	CV (%)
Days to 50% Flowering	101-147	121	7.93	6.55
Plant Height (cm)	76-153	108.83	13.13	12.06
Yield (t/ha)	0.5-7.5	4.09	1.22	29.82

Sd=Standard Deviation, CV=Co-efficient of Variation

Table 44. Descriptive statistics

Trait	Genetic Variance	Error Variance	Heritability
Days to 50% Flowering	49.58	13.44	0.88
Plant Height (cm)	101.57	69.6	0.74
Yield (t/ha)	0.79	0.71	0.69

The grain yield varied from 0.5 to 7.5 t/ha (Table 43). Some of the breeding lines were showed promising field performance with high yield potentiality. The lowest yield was found in IR 129462-B-46-B-1-1, and IR 126972-B-12-4-2-1 produced the highest grain yield among the tested genotypes.

In addition, heritability is important to quantify the precision of field trials and determine the response to selection. Therefore, the heritability for days to 50% flowering, plant height, and yield were calculated as 0.88, 0.74, and 0.69, respectively (Table 44). Finally, based on the available dataset for yield performance top 20 lines including IR 99853-72-4-2-1, IR16T1159, IR 126975-B-40-3-5-2, IR 126972-B-12-4-2-1 and IR17L1041 were selected for stage 2 trial as well as to be used in breeding program as parental lines.

Screening advanced rice mutants for higher salt tolerance

Thirty-five rice mutants were developed from Binadhan-7 and FL-478 to select desirable mutants for higher salt tolerance. This experiment was conducted Boro season, 2021-22 at farmers field of Shyamnagar. From them a total of ten lines have been selected for further generations.

Screening dual tolerant rice lines

Twenty rice lines were developed from Binadhan-11 and Binadhan-23 to select desirable mutants for dual tolerance (salinity and submergence). This experiment was conducted Aman season, 2021 at farmers field of Barisal. From them a total of ten lines have been selected for further generations.

Growing BC_3 F_4 population for drought tolerance

In Boro 2021-22, the seeds of 15 selected BC_3F_5 plants derived from crossing between Binadhan-11×NERICA-4 were sown on 22 December, 2020 at experimental fields were set at the Plant Breeding Division, BINA, Mymensingh.Another Binadhan-17×NERICA-4 combination, selected BC_3F_5 15 lines were sown on same date and same place in plant progeny rows. All the plants were selfed and harvested BC_3F_5 seeds.

Growing of M_4 populations of rice cultivars for earliness and higher yield

To select high yielding premium quality, the seeds of irradiated populations derived from Noor Basmoti were sown 25th July 2021 and transplanted on 31th August at BINA Headquarter farm, Mymensingh along with the parent. The experiment followed non replicated design with the spacing 15cm and 20cm. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. Based on earliness, plant height, grain quality 50 individual plants have been selected and will be grown in next aman season.

Growing M_4 generation of coastal rice landraces for salt tolerance

A large number of M_5populations from Nonabokra, Mondeshore, Ghunshi, Holdegotal and Dhakshail (from three different doses) were grown in plant progeny rows for selecting desirable mutant at BINA Headquarters farm, Mymensingh during Aman season 2021. From them a total of 30 plants have been selected for future selection in subsequent generations.

Growing $M_{3\ generation}$ of rice for drought tolerance

Seeds of Binadhan-17, Binadhan-19 and NERICA-10 were irradiated with ^{60}Co gamma rays. Irradiation doses were 200, 250, 300, 350, 400, 450, 475 and 500 Gy. A large number of M_3 generation were grown in plant progeny rows for selecting desirable mutant at BINA Headquarters farm, Mymensingh during Aman season 2021. From them a total of 20 plants have been selected primarily for future selection in M_4 generation.

Growing M_2 generation of rice for higher yield and earliness

To create genetic variability, seeds of Nepali Swarna were irradiated with 100, 150, 200, 250, 300 and 350 Gy of gamma rays. Experiment was carried out during Aman and Boro season 2021-2022. The experiment was followed by non-replicated design and sown separately as dose wise. Recommended doses of nitrogen, phosphorus, potassium, sulfur and zinc were applied in the form of Urea, TSP, MoP, Gypsum, Zinc Sulphate. Cultural and intercultural practices were followed as when necessitated. Based on earliness, plant height and grain quality 32 mutants have been selected for next generation.

Growing of M5 populations of Noor Basmati for earliness and higher yield

To select high yielding premium quality, the seeds of irradiated populations derived from Noor Basmoti were sown 25th July 2021 and transplanted on 20th August at BINA Substation farm, Cumilla along with the parent. The experiment followed RCB design with two 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 (cm), number of effective tiller plant^{-1}, panicle length (cm) and number of filled grains panicle^{-1} were recorded after harvesting from 5 randomly selected competitive hills. Days to 50% flowering and days to maturity were assessed plot basis. Recorded data were finally subjected to proper statistical analyses and are presented in Table 45.

Table 45. Mean performance of M5 rice mutants with parent during aman season 2021

Lines/ variety	Plant Height (cm)	Total tillers plant^{-1} (no.)	Effective tillers plant^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	Days to maturity	Grain yield plant^{-1} (g)
Noor Basmati	122.6	18	17.2	29.8	102.68	82.44	126	10.18
350-EP1	98.8	14.6	14.4	26.5	103.78	171.40	**108**	12.29
350-EP2	100	13.8	13.6	25.7	126.36	136.08	106	10.63
350-EP3	96.3	16.1	14.1	15.1	112.62	116.22	104	10.9
350-EP4	104.2	12.5	12.1	30.7	122.38	76.38	102	11.02
350-EP5	101.5	12.5	12.1	30.7	122.38	76.38	102	16.71
350-EP6	124	12	12.1	30.7	122.38	76.38	114	10.75
350-EP7	125.52	12.765	11.5	30.95	128.62	62.16	113	7.88
350-EP8	122.5	12.5	12	30.9	185.06	60.10	114	17.37
350-EP9	117.1	9.9	9.9	28.4	199.54	89.60	115	5.86
350-EP10	133.6	14.4	14.3	29.8	77.52	148.60	115	11
350-EP11	126.8	13.3	12.9	32	217.72	108.16	126	21.32
350-EP12	122.3	12.3	12.5	30.5	206.32	106.80	117	8.94
350-P2	122.9	11.7	10.2	30.2	208.44	93.72	131	8.93
350-P3	123.5	11.3	10.7	33	187.40	160.10	126	24.63
350-P4	127.625	13	12.5	33.25	197.85	191.30	134	13.5
350-P5	131	**9.5**	**9.5**	30	176.85	170.50	135	9.50
350-P6	132.1	13.9	14.2	30.8	166.90	118.14	117	14.54
350-P7	114	15	14	28.5	115.60	118.30	114	9.00
350-P8	129	15.5	15	25.5	85.00	113.40	118	8.00
350-P9	129.2	11	10.1	26.6	84.20	87.34	116	5.00
350-P10	**145.75**	13.5	13.5	30	220.50	37.70	132	12.53
350-P12	123.25	13.25	13.25	28	**377.20**	57.96	132	15.83
300-P1	131.7	17.1	15.7	30.4	72.66	183.42	117	7.41
300-P2	122.4	16.1	15.6	29.7	102.62	169.14	117	7.25
300-P3	130.5	15.5	15.5	27	102.32	150.61	117	5.51
300-P5	129.5	14	14	27	102.32	150.61	118	6.97
250-P1	123.8	15.6	15.3	31.2	180.40	73.20	125	9.21
250-P4	112.3	13.7	12.7	31	172.30	81.10	117	14.03
250-P5	118.7	13	12.8	33.1	178.70	70.80	117	15.43
250-P6	113.5	14.5	14.5	31	207.20	61.30	117	14.05
250-P9	122	10.5	**9.5**	30.2	124.40	127.70	132	11.36
Maximum	**145.75**	**18**	**17.2**	**33.25**	377.2	191.3	**135**	**24.63**
Minimum	**96.3**	**9.5**	**9.5**	**15.1**	72.66	37.7	**102**	**5**
SD	**11.29**	**2.01**	**1.97**	**3.30**	61.93	5.54	**9.14**	**4.54**

Days to maturity of the mutants and parent ranged from 102-135 days and 350-EP4, 350-EP5 took the shortest time to mature and 350-P5 took the longest time to mature. Plant height ranged between 96.3cm to 145 cm with 350-EP3 being the shortest and 350-P10the tallest. Number of eeffective tillers plant^{-1} ranged 9.5 to 17.2 with the parent being highest and 350-P5 being the lowest. Panicle length ranged from 15.1cm to 33.25 cm with the mutant 350-P4 being longest and 350-EP3 being the shortest. Filled grains per panicle ranged between 72.66 to 377.2 with the mutant 350-P12 being highest and 350-EP10 being lowest. Grain yield plant^{-1} (g) ranged from 5-24.63 g with the 350-P3 produced highest yield while 350-P9 being lowest.
Based on early maturity 20 mutant lines had selected and will be evaluated in the preliminary yield trial.

Growing of M_4 generations of BR22, BRRI dhan71, BRRI dhan76 and BRRI dhan77

Efforts were made to develop varieties with multiple traits viz. seedling emergence, vigorous growth, short duration (90-100 days), tolerance to lodging, medium bold to medium slender grains and good eating quality. Four popular rice varieties were irradiated with five gamma doses. A total of 96 individuals were selected from M_3 generation during T. Aman, 2021 based on identical flowering, grain type traits and phenotypic acceptability under field condition.Seeds of M_4 mutant of BR22, BRRI dhan71, BRRI dhan76 and BRRI dhan77 were sown on 14 July, 2021 and transplanted on 17 August 2021 at BINA Headquarter, Mymensingh by maintaining plant to plant and row to row distance 15cm and 20cm respectively. The experiment was followed by non- replicated design. The size of the unit plots were 1m × 2m. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. Data on plant height, number of effective tillers plant^{-1}, panicle length, and filled and unfilled grains panicle^{-1} were recorded after harvest from 5 randomly selected competitive plants. Maturity was assessed plot basis. Finally, all the recorded data were subjected to proper statistical analyses as per design used and are presented in Table 46.

Table 46. Grain yield and yield components of M_4 generations of BR22 that were sown at BINA Headquarter, Mymensingh

Variety/Mutant	Duration	Plant height(cm)	Effective Tiller	Panicle length(cm)	Filled grain	1000 seed wt.(g)
BRM22-200-7	149±1.0	115±1.36	10±0.28	28±0.39	101±5.26	17.44±0.34
BRM22-200-9	147±1.0	108±1.36	7±0.28	22±0.39	98±5.26	18.4±0.34
BRM22-200-10	151±1.0	121±1.36	11±0.28	28±0.39	100±5.26	18.4±0.34
BRM22-200-16	149±1.0	123±1.36	8±0.28	30±0.39	105±5.26	18.63±0.34
BRM22-200-17	149±1.0	131±1.36	9±0.28	31±0.39	170±5.26	19.3±0.34
BRM22-250-15	143±1.0	137±1.36	10±0.28	25±0.39	140±5.26	17.8±0.34
BRM22-250-18	145±1.0	123±1.36	11±0.28	29±0.39	125±5.26	20.5±0.34
BRM22-250-27	144±1.0	129±1.36	10±0.28	31±0.39	170±5.26	20.8±0.34
BRM22-250-21	150±1.0	112±1.36	10±0.28	28±0.39	145±5.26	19±0.34
BRM22-250-25	149±1.0	125±1.36	11±0.28	29±0.39	180±5.26	20.2±0.34
BRM22-300-5	143±1.0	132±1.36	9±0.28	29±0.39	100±5.26	25.5±0.34
BRM22-300-12	147±1.0	123±1.36	8±0.28	28±0.39	117±5.26	20.6±0.34
BRM22-300-21	145±1.0	126±1.36	9±0.28	29±0.39	132±5.26	20.9±0.34
BRM22-300-27	142±1.0	121±1.36	10±0.28	30±0.39	128±5.26	20.3±0.34
BRM22-300-35	139±1.0	117±1.36	9±0.28	29±0.39	115±5.26	20.5±0.34
BRM22-300-36	141±1.0	126±1.36	10±0.28	31±0.39	123±5.26	20.8±0.34
BRM22-300-37	143±1.0	131±1.36	11±0.28	29±0.39	100±5.26	20.7±0.34
BRM22-350-3	137±1.0	120±1.36	9±0.28	28±0.39	155±5.26	22.5±0.34
BRM22-350-14	135±1.0	123±1.36	8±0.28	31±0.39	120±5.26	19.1±0.34
BRM22-350-15	139±1.0	110±1.36	9±0.28	28±0.39	142±5.26	20.1±0.34
BRM22-350-16	136±1.0	119±1.36	9±0.28	29±0.39	100±5.26	18.8±0.34
BRM22-350-17	135±1.0	126±1.36	12±0.28	29±0.39	105±5.26	20.37±0.34
BRM22-350-24	139±1.0	120±1.36	11±0.28	28±0.39	122±5.26	16.3±0.34
BRM22-350-31	140±1.0	122±1.36	12±0.28	31±0.39	125±5.26	19.5±0.34
BRM22-350-35	141±1.0	127±1.36	10±0.28	30±0.39	190±5.26	20.7±0.34
BR22(P)	152±1.0	131±1.36	13±0.28	27±0.39	112±5.26	20.3±0.34

Significant variation was observed in term of duration among the mutants. Mutant line BRM22-350-17 had shorter duration (135 days). All the mutant lines had lower effective tillers comparing to the check variety BR22 (13). In BRM22-200-17, BRM22-250-27, BRM22-350-14 and BRM22-350-3l had longest Panicle length (31 cm). The mutant line BRM22-350-35 had highest number (190) of filled grains panicle^{-1} contrasting to other mutant lines and the check variety BR2 (112). Highest 1000 seed weight (22.5) was observed in BRM22-350-3 mutant line comparing to the check variety BR22 (20.3) and other mutants (Table 47-50).

Table 47. Grain yield and yield components of M_4 generations of BRRI dhan71 at BINA Headquarter, Mymensingh

Variety/Mutant	Duration	Plant height(cm)	Effective Tiller	Panicle length(cm)	Filled grain	1000 seed wt.(g)
BRM71-200-2	120±0.46	110±0.59	9±0.16	26±0.33	130±3.37	22.6±0.14
BRM71-200-3	121±0.46	108±0.59	9±0.16	24±0.33	125±3.37	23.4±0.14
BRM71-200-4	124±0.46	109±0.59	9±0.16	26±0.33	106±3.37	23.9±0.14
BRM71-200-5	121±0.46	110±0.59	10±0.16	27±0.33	100±3.37	23.8±0.14
BRM71-200-6	120±0.46	108±0.59	11±0.16	28±0.33	105±3.37	23.5±0.14
BRM71-250-3	121±0.46	104±0.59	8±0.16	25±0.33	118±3.37	23.6±0.14
BRM71-250-4	119±0.46	107±0.59	9±0.16	25±0.33	120±3.37	22.1±0.14
BRM71-250-5	117±0.46	114±0.59	8±0.16	25±0.33	145±3.37	23.7±0.14
BRM71-250-6	118±0.46	108±0.59	9±0.16	25±0.33	125±3.37	22.6±0.14
BRM71-250-7	115±0.46	110±0.59	9±0.16	26±0.33	145±3.37	21.9±0.14
BRM71-250-8	117±0.46	112±0.59	10±0.16	25±0.33	105±3.37	23.5±0.14
BRM71-250-9	118±0.46	107±0.59	9±0.16	24±0.33	108±3.37	21.3±0.14
BRM71-250-10	121±0.46	105±0.59	9±0.16	27±0.33	135±3.37	22±0.14
BRM71-350-1	120±0.46	100±0.59	10±0.16	27±0.33	125±3.37	23.6±0.14
BRM71-350-2	117±0.46	110±0.59	9±0.16	25±0.33	155±3.37	23.4±0.14
BRM71-350-3	115±0.46	107±0.59	9±0.16	21±0.33	157±3.37	22.1±0.14
BRM71-350-4	119±0.46	105±0.59	8±0.16	24±0.33	177±3.37	22.5±0.14
BRM71-350-5	121±0.46	109±0.59	9±0.16	28±0.33	149±3.37	22.8±0.14
BRM71-350-6	117±0.46	112±0.59	8±0.16	30±0.33	132±3.37	24.1±0.14
BRM71-350-7	115±0.46	108±0.59	8±0.16	26±0.33	127±3.37	22.5±0.14
BRM71-350-8	120±0.46	103±0.59	9±0.16	27±0.33	138±3.37	23.1±0.14
BRM71-350-9	121±0.46	109±0.59	10±0.16	25±0.33	145±3.37	22.9±0.14
BRM71-350-10	116±0.46	108±0.59	9±0.16	25±0.33	149±3.37	22.7±0.14
BRM71-350-11	115±0.46	104±0.59	8±0.16	28±0.33	147±3.37	23.5±0.14
BRM71-350-12	117±0.46	107±0.59	9±0.16	27±0.33	125±3.37	23.1±0.14
BRM71-350-13	120±0.46	104±0.59	11±0.16	26±0.33	121±3.37	22.5±0.14
BRRI dhan71(P)	121±0.46	108±0.59	9±0.16	27±0.33	105±3.37	23.8±0.14

Significant variation was observed in term of duration among the mutants. Mutant line BRM71-200-4 had longer duration (124 days). The mutant line BRM71-200-6 had higher effective tillers comparing to the check variety BRRI dhan71 (11). In BRM71-350-6 mutant line had longest Panicle length (30 cm). The mutant BRM71-350-4 had highest number (177) of filled grains panicle^{-1} contrasting to other mutant line and the check variety BRRI dhan71 (105). Highest 100 seed weight (22.5) was observed in BRM71-200-4 mutant line comparing to the check variety BRRI dhan71 (23.9) and other mutants (Table 47).

Table 48. Grain yield and yield components of M_4 generations of BRRI dhan76 at BINA Headquarter, Mymensingh

Variety/Mutant	Duration	Plant height(cm)	Effective Tiller	Panicle length(cm)	Filled grain	1000 seed wt.(g)
BRM76-200-1	147±1.13	145±1.18	10±0.77	29±0.45	146±7.87	26.45±0.28
BRM76-200-2	151±1.13	147±1.18	9±0.77	26±0.45	126±7.87	26.3±0.28
BRM76-200-3	153±1.13	141±1.18	8±0.77	28±0.45	155±7.87	27±0.28
BRM76-200-4	157±1.13	146±1.18	8±0.77	23±0.45	110±7.87	27.3±0.28
BRM76-200-5	153±1.13	151±1.18	7±0.77	30±0.45	115±7.87	26.3±0.28
BRM76-250-1	151±1.13	147±1.18	17±0.77	26±0.45	140±7.87	29±0.28
BRM76-200-2	153±1.13	150±1.18	8±0.77	26±0.45	98±7.87	27.6±0.28
BRM76-200-3	147±1.13	143±1.18	13±0.77	28±0.45	14±7.873	27.1±0.28
BRM76-300-1	139±1.13	143±1.18	16±0.77	28±0.45	50±7.87	25±0.28
BRM76-300-2	141±1.13	158±1.18	7±0.77	28±0.45	155±7.87	25.7±0.28
BRM76-300-3	144±1.13	159±1.18	12±0.77	26±0.45	69±7.87	24.34±0.28
BRM76-300-4	139±1.13	150±1.18	7±0.77	29±0.45	128±7.87	27.4±0.28
BRM76-300-5	141±1.13	153±1.18	19±0.77	28±0.45	150±7.87	24.1±0.28
BRM76-300-6	147±1.13	149±1.18	12±0.77	29±0.45	49±7.87	26.53±0.28
BRM76-300-7	151±1.13	151±1.18	12±0.77	29±0.45	100±7.87	26±0.28
BRM76-350-1	142±1.13	146±1.18	9±0.77	25±0.45	110±7.87	26.7±0.28
BRM76-350-2	143±1.13	142±1.18	16±0.77	26±0.45	75±7.87	23.33±0.28
BRM76-350-3	141±1.13	144±1.18	12±0.77	30±0.45	212±7.87	25.2±0.28
BRM76-350-4	139±1.13	145±1.18	13±0.77	29±0.45	125±7.87	24.7±0.28
BRM76-350-5	147±1.13	137±1.18	10±0.77	30±0.45	135±7.87	23.8±0.28
BRM76-350-6	145±1.13	136±1.18	8±0.77	31±0.45	154±7.87	25.2±0.28
BRM76-350-7	141±1.13	140±1.18	19±0.77	31±0.45	64±7.87	25.7±0.28
BRM76-350-8	145±1.13	141±1.18	13±0.77	33±0.45	127±7.87	25.1±0.28
BRRI dhan76(p)	155±1.13	143±1.18	8±0.77	28±0.45	140±7.87	25.6±0.28

Significant variation was observed in term of duration among the mutants. The mutant line BRM76-350-6 had shorter plant height (136 cm). The mutant line BRM76-300-5 had higher effective tillers comparing to the check variety BRRI dhan76 (8). In BRM76-350-8 mutant line had longest Panicle length (33 cm). The mutant line BRM76-350-3 had highest number (212) of filled grains panicle^{-1} contrasting to other mutant line and the check variety BRRI dhan76 (140). Highest 1000 seed weight (29) was observed in BRM76-250-1 mutant line comparing to the check variety BRRI dhan76 (25.6) and other mutants (Table 48).

Table 49. Grain yield and yield components of M_4 generations of BRRI dhan77 at BINA Headquarter, Mymensingh

Variety/Mutant	Duration	Plant height(cm)	Effective Tiller	Panicle length(cm)	Filled grain	1000 seed wt.(g)
BRM77-200-1	145±0.67	132±1.24	9±0.73	21±0.73	115±6.48	22.9±0.54
BRM77-200-10	143±0.67	136±1.24	7±0.73	25±0.73	101±6.48	24.6±0.54
BRM77-250-3	141±0.67	147±1.24	7±0.73	24±0.73	103±6.48	23.29±0.54
BRM77-250-4	145±0.67	140±1.24	8±0.73	24±0.73	180±6.48	25.5±0.54
BRM77-300-5	139±0.67	138±1.24	9±0.73	31±0.73	135±6.48	28.3±0.54
BRM77-300-6	135±0.67	140±1.24	11±0.73	21±0.73	105±6.48	23.8±0.54
BRM77-300-7	141±0.67	137±1.24	8±0.73	29±0.73	110±6.48	27.2±0.54
BRM77-300-8	137±0.67	144±1.24	9±0.73	32±0.73	200±6.48	24.3±0.54
BRM77-300-9	141±0.67	142±1.24	16±0.73	30±0.73	198±6.48	26±0.54
BRM77-300-10	145±0.67	139±1.24	9±0.73	29±0.73	175±6.48	25.1±0.54
BRM77-300-11	141±0.67	142±1.24	10±0.73	24±0.73	129±6.48	24.8±0.54
BRM77-300-12	139±0.67	152±1.24	11±0.73	29±0.73	200±6.48	23.9±0.54
BRM77-300-13	140±0.67	138±1.24	17±0.73	24±0.73	121±6.48	26.2±0.54
BRM77-300-14	145±0.67	145±1.24	10±0.73	30±0.73	140±6.48	26±0.54
BRM77-300-15	137±0.67	147±1.24	11±0.73	25±0.73	125±6.48	26.8±0.54
BRM77-350-11	135±0.67	140±1.24	9±0.73	29±0.73	155±6.48	31.3±0.54
BRM77-350-12	139±0.67	126±1.24	10±0.73	32±0.73	135±6.48	27.5±0.54
BRM77-350-13	141±0.67	133±1.24	17±0.73	30±0.73	131±6.48	29.8±0.54
BRM77-350-14	139±0.67	136±1.24	12±0.73	32±0.73	128±6.48	27.1±0.54
BRM77-350-15	142±0.67	133±1.24	10±0.73	30±0.73	134±6.48	27.76±0.54
BRM77-350-16	141±0.67	142±1.24	11±0.73	29±0.73	150±6.48	31.9±0.54
BRM77-350-17	140±0.67	145±1.24	12±0.73	31±0.73	125±6.48	31.4±0.54
BRRI dhan77(p)	147±0.67	147±1.24	9±0.73	26±0.73	115±6.48	27.3±0.54

Significant variation was observed in term of duration among the mutant lines. Mutant line BRM77-350-12 had shorter plant height (126 cm). The mutant line BRM77-300-13 and BRM77-350-13 had higher (17) effective tillers comparing to the check variety BRRI dhan77 (9). In BRM77-300-8, BRM77-350-12, BRM77-350-14 mutant line had longest Panicle length (32 cm). The mutant line BRM77-300-8 and BRM77-300-12 had highest number (200) of filled grains panicle^{-1} contrasting to other mutant line and the check variety BRRI dhan77 (115). Highest 100 seed weight (31.9) was observed in BRM77-350-16 mutant line comparing to the check variety BRRI dhan77 (27.3) and other mutant (Table 49).

Considering the yield & yield attributes, the promising lines will be evaluated for the next generation.

Evaluation of M_6 generation of rice for short duration, premium quality and higher yield

Every rice improvement program strives to replace low-yielding, high-quality with high-yielding varieties. To date, rice breeders have generally failed to combine high yields with optimal quality because not all quality traits are defined. Quality evaluation programs have been measuring the same traits for many decades, and current tools of evaluating grain quality cannot distinguish an old variety from a potential replacement, though consumers are readily able to do so. The objective of this experiment is to find out the rice lines higher yield coupled with the qualitative attribute such as slender grain and preferable to the consumers.

The seeds of M_3 generation of LIRG-2 and LIRG-4 were sown on 12 December, 2021 and transplanted on 24 January, 2021 at BINA Headquarter field by maintaining Plant to plant and row to row distance 20cm and 15cm respectively. The experiment was followed by non replicated design. A unit plot size was 2m × 1m. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. Data on plant height, effective tiller hill^{-1}, panicle length, filled and unfilled grains panicle^{-1} and grain yield hill^{-1} was recorded from randomly selected five competitive hills at maturity. Maturity was assessed pot basis.

Table 50. Grain yield and yield components of some M_4 generation of LIRG-2 and LIRG-4 at Mymensingh

Variety/Mutant	Duration (days)	Plant height (cm)	Effective tiller (no.)	Panicle length (cm)	Filled grain panicle^{-1} (no.)	Unfilled grain panicle^{-1} (no.)	Yield (tha^{-1})
LIRG-2-17 Seg-1	150±0.63	109.6±0.91	5±0.25	28.6±0.27	236±6.65	34.4±2.22	5.79±0.21
LIRG-2-17 Seg-2	145±0.63	123±0.91	6.8±0.25	27.6±0.27	211±6.65	58.2±2.22	6.27±0.21
LIRG-2-17 Seg-3	150±0.63	101.6±0.91	4.4±0.25	26.2±0.27	197.4±6.65	30.6±2.22	4.37±0.21
LIRG-2-17 Seg-1-1	145±0.63	108.8±0.91	5±0.25	26±0.27	246.4±6.65	39±2.22	5.89±0.21
LIRG-4 Seg-1 (AL)	142±0.63	112.2±0.91	7.8±0.25	24±0.27	179±6.65	40.6±2.22	6.95±0.21
LIRG-4 mut-10 (AL)-1	145±0.63	112.8±0.91	8±0.25	24.8±0.27	191±6.65	29.4±2.22	6.56±0.21
LIRG-4 mut-10 (AL)-2	145±0.63	115.2±0.91	8.2±0.25	25±0.27	253.8±6.65	25.2±2.22	6.66±0.21
L4-P-1-1	145±0.63	123±0.91	5.8±0.25	23.6±0.27	199.2±6.65	30.6±2.22	5.83±0.21
L4-P-1-2	150±0.63	118.4±0.91	4.2±0.25	30.8±0.27	253.2±6.65	44±2.22	7.42±0.21
LiRG-4 Seg-1(1)-1	143±0.63	128.6±0.91	7.8±0.25	23.8±0.27	189±6.65	29.6±2.22	7.43±0.21
LIRG-4 Seg-1(1)-2	142±0.63	117.8±0.91	7.8±0.25	26.2±0.27	191.6±6.65	24.8±2.22	7.47±0.21
L4-P-1(1)-2	150±0.63	108.2±0.91	4.6±0.25	27.3±0.27	285±6.65	57.2±2.22	6.58±0.21
LIRG-4Seg-1(1)-8	150±0.63	105±0.91	4.8±0.25	27.6±0.27	196.6±6.65	35.2±2.22	3.63±0.21
L4-P-3(2)-1	145±0.63	121.8±0.91	8±0.25	25±0.27	210±6.65	32±2.22	7.47±0.21
L4-P-5(1)	150±0.63	103.8±0.91	4.4±0.25	27.6±0.27	229±6.65	77.2±2.22	3.93±0.21
L4-P-5(2)	145±0.63	111.6±0.91	8.2±0.25	26.2±0.27	233±6.65	52±2.22	7.32±0.21
L4-P-5(3)	150±0.63	112.6±0.91	6.2±0.25	25.6±0.27	210.6±6.65	23.2±2.22	6.49±0.21
L4-P-6(3)-1	152±0.63	114.2±0.91	7.4±0.25	26.8±0.27	225±6.65	39.4±2.22	9.58±0.21
L4-P-1(1)	155±0.63	110.8±0.91	4.6±0.25	25.4±0.27	262.4±6.65	62.4±2.22	3.3±0.21
L4-P-1-P-2	155±0.63	117.4±0.91	3.8±0.25	26.4±0.27	264±6.65	37.2±2.22	4.02±0.21
L4-P-1(1)-P-1	155±0.63	114.6±0.91	3.4±0.25	29.4±0.27	289±6.65	51.8±2.22	5.14±0.21
L4-P-1(1)-P-2	152±0.63	112±0.91	3.4±0.25	28.4±0.27	272.8±6.65	49.6±2.22	4.55±0.21
L4-P-1(1)-P-3	152±0.63	111.2±0.91	3.2±0.25	29.4±0.27	329±6.65	52.6±2.22	5.24±0.21
L4-P-3(2)-P-2	152±0.63	115±0.91	3.4±0.25	29.2±0.27	283.6±6.65	38.8±2.22	6.46±0.21
L4-P-3(2)-P-3	152±0.63	112.6±0.91	3.6±0.25	28.4±0.27	259.4±6.65	53.2±2.22	4.62±0.21

L4-P-2(4)-P-1	154±0.63	109.6±0.91	4±0.25	28.2±0.27	207±6.65	65.4±2.22	6.86±0.21
L4-P-2(4)-P-2	155±0.63	112±0.91	4.8±0.25	27.2±0.27	260.6±6.65	58.8±2.22	5.24±0.21
L4-P-4(1)-P-1	155±0.63	107.8±0.91	4.2±0.25	26.2±0.27	275.5±6.65	36.8±2.22	6.27±0.21
L4-P-4(1)-P-2	155±0.63	106.4±0.91	4.8±0.25	28.6±0.27	263±6.65	36.8±2.22	8.01±0.21
L4-P-4(1)-P-3	152±0.63	105±0.91	4.6±0.25	26.6±0.27	176.6±6.65	28.4±2.22	7.21±0.21
L4-P-5(1)-P-1	145±0.63	114.8±0.91	6.6±0.25	25.2±0.27	201±6.65	37.4±2.22	6.88±0.21
L4-P-5(1)-P-2	145±0.63	113.8±0.91	7.4±0.25	24±0.27	170±6.65	36.6±2.22	7.24±0.21
L4-P-3(2)-P-1	150±0.63	112±0.91	4±0.25	29.4±0.27	342±6.65	78.8±2.22	4.86±0.21
LIRG-2(P)-P-1	152±0.63	107.2±0.91	3.4±0.25	25.2±0.27	206.4±6.65	46.8±2.22	3.95±0.21
LIRG-2(P)-P-2	154±0.63	118.8±0.91	3.4±0.25	25±0.27	281.6±6.65	32.2±2.22	4.55±0.21
LIRG-2(P)-P-3	154±0.63	116.2±0.91	4.4±0.25	23.6±0.27	268±6.65	36.4±2.22	3.28±0.21
LIRG-2(P)-P-4	154±0.63	108±0.91	4.6±0.25	24.2±0.27	259±6.65	26.8±2.22	4.47±0.21
LIRG-2(P)-P-5	154±0.623	109.4±0.91	3.8±0.25	24.6±0.27	235±6.65	33.8±2.22	3.61±0.21
LIRG-2-17Seg P-1	140±0.63	98±0.91	7±0.25	27.2±0.27	194.6±6.65	32.6±2.22	7.42±0.21
LIRG-2-17Seg-1-P-3	156±0.63	109±0.91	6±0.25	29±0.27	238±6.65	94±2.22	5.44±0.21
LIRG-2-17Seg-1-P-4	156±0.63	115.8±0.91	3.8±0.25	27±0.27	249±6.65	64±2.22	5.13±0.21
LIRG-2-Seg-1-P-1	152±0.63	108.8±0.91	4±0.25	28±0.27	265.6±6.65	56.6±2.22	4.71±0.21
LIRG-2-Seg-1-P-2	152±0.63	112±0.91	4±0.25	28.8±0.27	331±6.65	61.6±2.22	8.21±0.21
L4-P-3(2)-4	152±0.63	114.4±0.91	4±0.25	29.6±0.27	312.8±6.65	49.6±2.21	5.61±0.21
L4-P-4(1)	152±0.63	112.8±0.91	3.4±0.25	28.4±0.27	240±6.65	42.8±2.21	5.16±0.21
LIRG-2(P)	150±0.63	103.8±0.91	3.4±0.25	25.2±0.27	223.4±6.65	40±2.21	4.73±0.21
LIRG-4(P)	152±0.63	114.8±0.91	6.2±0.25	26.2±0.27	217.4±6.65	37±2.21	5.94±0.21
BRRI dhan29	156±0.63	93.8±0.91	8.8±0.25	24.4±0.27	106±6.65	52.6±2.21	5.28±0.21

Significant variation was observed in term of duration among the mutants. Mutant LIRG-2-17Seg P-1, LIRG-4 Seg-1(1)-2 and LIRG-4 Seg-1 (AL) had shorter duration (140 days, 142 days and 142 days respectively). Although the mutants had lower no. of effective tillers comparing to the check variety BRRI dhan29 (8.8) but because of long panicle and higher no. of filled grain some mutants performed better over the check. Longest Panicle length (30.8 cm) was observed in L4-P-1-2 mutant. The mutant L4-P-3(2)-P-1 had highest number (342) of filled grains panicle^{-1} contrasting to other mutants and the check variety BRRI dhan29 (106). Lowest unfilled grains paicle^{-1} (28.4) was observed in the mutant L4-P-4(1)-P-3. The mutants L4-P-6(3)-1, LIRG-2-Seg-1-P-2, L4-P-4(1)-P-2, and LIRG-2-17Seg P-1 exhibited higher yield (9.58, 8.21, 8.01 and 7.42 ton/ha respectively) than the other mutants and the check variety BRRI dhan29 (5.28 t/ha) (Table 50).

Considering the yield & yield attributes, the promising mutants will be evaluated for the next generation

Growing of BC_1F_5 generation of Binadhan-18 x Luxmidigha cross

The deep water rice cv, Luxmidigha is cultivated in the low laying areas in Bangladesh where water stand up to 3 months. It has broad leaves with stem elongation (> 5cm/day) ability, knee capacity and floatability. However, this cultivar is not well practiced now-a days due to its low yield (0.7-1.0 ton/ha). To introgress the characteristics of luxmidigha to the recipient parent and form a backcross family by which desirable characteristics can be attained in F_2 progenies have been observed in several studies. Several morphological traits, such as height of the plant, floatability, stem elongation can be found among the progenies of a single cross. Many traditional transplanting Aman rice varieties do not have these special traits and unable to survive in this deep water table. The present study was undertaken to evaluate the morpho-physiological, agronomic & yield performances of backcross families that will accelerate chance of obtaining desirable lines.

The seeds of 15 BC_1F_4 populations derived from crossing between Laksmi digha and Binadhan-18 were sown on 31 July, 2021 and transplanted on 13 November at BINA HQs farm, Mymensingh. The parents were also included in this experiment by maintaining plant to plant and row to row distance 15cm and 20cm respectively. The experiment was conducted by following non replicated design. A unit plot size was 2m ×1m. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. Data on plant height, effective tiller, panicle length, filled and unfilled grains panicle^{-1} and grain yield hill^{-1} was recorded from randomly selected five competitive hills at maturity. Maturity was assessed pot basis. The recorded data were finally subjected to proper statistical analysis and are presented in Table 51.

Table 51. Grain yield and yield components of backcross population derived from Binadhan-18 x Luxmidigha at BINA Headquarter, Mymensingh

Genotypes	Plant height (cm)	Effective tillers plant^{-1}	Filled grains panicle^{-1}	Grain yield (g plant^{-1})
RC-2-7-6-3-7	120 ±1.43	10.20±0.45	120.4±1.98	18.6±0.83
RC-2-5-3-1-9	132±1.43	12.7±0.45	122.2±1.98	16.6±0.83
RC-2-7-6-2-5	128±1.43	8.6±0.45	133.4±1.98	19.3±0.83
RC-2-7-6-1-1	138±1.43	10.5±0.45	121.5±1.98	14.1±0.83
RC-3-7-5-2-6	127±1.43	11.6±0.45	105.5±1.98	22.2±0.83
RC-2-4-7-2-12	133±1.43	12.8±0.45	98.4±1.98	21.7±0.83
RC-2-4-7-3-6	145 ±1.43	11.5±0.45	125.6±1.98	19.4±0.83
RC-1-6-9-1-3	133±1.43	10.4±0.45	125.4±1.98	16.5±0.83
RC-2-7-6-4-5	120±1.43	15.3±0.45	125.6±1.98	13.9±0.83
RC-2-5-3-3-4	128±1.43	12.7±0.45	116.8±1.98	18.6±0.83
RC-2-5-3-2-19	139±1.43	12.3±0.45	122.5±1.98	21.4±0.83
RC-2-6-3-1-8	125±1.43	11.6±0.45	135.5±1.98	21±0.83
RC-1-6-1-3-5	139±1.43	15.4±0.45	102.4±1.98	15.6±0.83
RC-1-6-1-2-7	120±1.43	12.6±0.45	105.6±1.98	17.6±0.83
RC-4-1-15-2-11	141±1.43	11.5±0.45	118.2±1.98	22.6±0.83
Binadhan-18(P)	116±1.43	11.6±0.45	145.6±1.98	21.5±0.83
Luxmidigha(P)	162±1.43	8.5±0.45	134.5±1.98	16.3±0.83

Most of the lines had significantly shorter plant height than the parent Laksmi digha (Table 51). The line RC-2-4-7-3-6 had the highest plant height (145 cm) comparing to the other lines. Number of effective tiller was highest in the RC-1-6-1-3-5 line (15.4) Table 51). The line RC-2-6-3-1-8 had significantly higher number of filled grains panicle^{-1} (135) than other progenies. The line RC-4-1-15-2-11 had highest grain yield (22.6 g plant $^{-1}$) than the other lines and parents. All these high yielding crossing lines with Luxmidigha (parent) will be screened in Deep water Rice Screening Tank (DWRST) to check the floatability, stem elongation ability in the next growing season (Table 51).

Considering the yield & yield attributes, the promising lines will be evaluated for the next generation.

Evaluation of backcross population (BC_1F_5) crossing Binadhan-17 with Monjusree-2 and Chandanath-3

Cold injury is one of the prime abiotic factors which reduce rice yield in several countries. In Bangladesh, Boro paddy is the main crop of the haor people. Boro season usually begins in mid-November but many farmers start sowing in late October to avoid flash floods. As a result, the harvesting time fall sometime in January-February triggers yield loss due to cold stress. Percentage of germination, poor seedling establishment, yellowing of the leaves, growth retardation, and decreased tillering is the symptoms caused by cold stress. The objectives of this study are to screen high yielding cold-tolerant rice cultivars through backcross breeding and cold tolerance can be traced by the molecular breeding approach to strengthen food security to the next generations

The seeds of BC_1F_5 populations derived from crossing between Binadhan-17 with Monjusree-2 and Chandanath-3 were sown on 02 December, 2021 and transplanted on 15 January 2022 at BINA Headquarter field by maintaining Plant to plant and row to row distance 20cm and 15cm respectively. The parents were also included in this experiment. The experiment was followed by non replicated design. A unit plot size was 2m × 1m. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. Data on plant height, total tiller hill^{-1}, effective tiller hill^{-1}, panicle length, filled and unfilled grains panicle^{-1} and grain yield hill^{-1} was recorded from randomly selected five competitive hills at maturity. Maturity was assessed pot basis.

Table 52. Grain yield and yield components of some backcross population (BC_1F_5) sown at Mymensingh

Mutant/line	Plant height(cm)	Effective Tiller	Panicle length(cm)	Filled grain	Unfilled grain	Yield(t/ha)
RM-M2-P-2	108±2.49	9±0.26	24.2±0.27	132±4.04	16±3.10	6.65±0.19
RM-M2-P-3	111.9±2.49	7±0.26	24.9±0.27	152±4.04	28±3.10	6.4±0.19
RM-M2-P-4	118.1±2.49	7±0.26	25.1±0.27	140±4.04	26±3.10	6.72±0.19
RM-M2-P-5	116±2.49	9±0.26	24.9±0.27	132±4.04	25±3.10	6.76±0.19
RM-M2-P-8	113.9±2.49	8±0.26	25.9±0.27	179±4.04	19±3.10	8.6±0.19
RM-M2-P-9	115±2.49	9±0.26	24.8±0.27	161±4.04	37±3.10	7.76±0.19
RM-M2-P-10	143.4±2.49	7±0.26	25.9±0.27	148±4.04	27±3.10	7.1±0.19
RM-M2-P-11	105.9±2.49	7±0.26	25.7±0.27	150±4.04	23±3.10	7.75±0.19
RM-M2-P-12	106.5±2.49	11±0.26	25.2±0.27	111±4.04	27±3.10	7.9±0.19
RM-M2-P-13	110.2±2.49	8±0.26	25±0.27	173±4.04	15±3.10	7.85±0.19
RM-M2-P-14	102.6±2.49	8±0.26	25.5±0.27	130±4.04	35±3.10	6.5±0.19
RM-M2-P-15	117.1±2.49	8±0.26	27.2±0.27	164±4.04	26±3.10	6.6±0.19
RM-M2-P-16	101.2±2.49	10±0.26	23±0.27	146±4.04	18±3.10	5.97±0.19
RM-M2-P-17	101.9±2.49	9±0.26	24.8±0.27	127±4.04	30±3.10	6.68±0.19
RM-M2-P-19	114.4±2.49	8±0.26	25.9±0.27	118±4.04	30±3.10	7.26±0.19
RM-M2-P-20	105±2.49	9±0.26	23.9±0.27	146±4.04	21±3.10	7.51±0.19

RM-M2-P-21	110.7±2.49	9±0.26	25±0.27	151±4.04	25±3.10	7.67±0.19
RM-M2-P	123.9±2.49	7±0.26	24.4±0.27	111±4.04	18±3.10	7.59±0.19
RM-C3-P-1	98.6±2.49	8±0.26	23.6±0.27	147±4.04	72±3.10	6.1±0.19
RM-C3-P-5	115.6±2.49	7±0.26	25.1±0.27	151±4.04	70±3.10	5.31±0.19
RM-C3-P	134.5±2.49	6±0.26	23±0.27	118±4.04	18±3.10	4.54±0.19
BINAdhan-17	89.5±2.49	9±0.26	22.5±0.27	110±4.04	21±3.10	6.93±0.19
BRRIdhan-55	95.3±2.49	6±0.26	21.3±0.27	134±4.04	15±3.10	6.35±0.19

All the lines had statistically significant variation in plant height (Table 52). Significant statistical variation was observed in effective tiller among the lines. The line RM-M2-P-15 and RM-M2-P-8 exhibited longer panicle length (27.2 cm) and higher filled grains/panicle (179) respectively comparing to the both parents. The line RM-C3-P-1 showed significantly maximum unfilled grains/panicle (72) comparing to the parent. The line RM-M2-P-8 had higher yield (8.6 t/ha) comparing to the parents (Table 52).

Considering the yield & yield attributes, the promising lines will be evaluated for the next generation

Evaluation of backcross population (BC_1F_5) crossing Binadhan-17 with Kamol-7 and Kamol-9

The seeds of BC_1F_5 populations derived from crossing between Binadhan-17 with Kamol-7 and Kamol-9 were sown on 02 December, 2021 and transplanted on 11 January, 2022 art BINA Headquarter field by maintaining Plant to plant and row to row distance 20cm and 15cm respectively. The parents were also included in this experiment. The experiment was followed by non replicated design. A unit plot size was 2m × 1m. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. Data on plant height, effective tiller hill^{-1}, panicle length, filled and unfilled grains panicle^{-1} and grain yield hill^{-1} was recorded from randomly selected five competitive hills at maturity. Maturity was assessed pot basis.

Table 53. Grain yield and yield components of some backcross population (BC_1F_5) sown at Mymensingh `

Mutant/line	Plant height(cm)	Effective Tiller	Panicle length(cm)	Filled grain	Unfilled grain	Yield(t/ha)
RM-K7-P-1	148.8±4.34	10±0.37	25.8±0.42	145±6.93	25±2.60	6±0.19
RM-k7-P-2	145.7±4.34	10±0.37	25.8±0.42	179±6.93	41±2.60	6.05±0.19
RM-k7-P-4	142.7±4.34	8±0.37	20.5±0.42	122±6.93	22±2.60	5.08±0.19
RM-k7-P-5	135.1±4.34	11±0.37	22.3±0.42	130±6.93	17±2.60	6.65±0.19
RM-k7-P-6	138.2±4.34	7±0.37	22.7±0.42	162±6.93	19±2.60	6.78±0.19
RM-K7-P-7	148.6±4.34	8±0.37	23±0.42	137±6.93	19±2.60	7±0.19
RM-K7-P-9	151.2±4.34	8±0.37	26.1±0.42	178±6.93	35±2.60	6.33±0.19
RM-K7-P	145.4±4.34	7±0.37	22±0.42	71±6.93	42±2.60	4.78±0.19
RM-K9-P-3	93.6±4.34	10±0.37	23.9±0.42	123±6.93	63±2.60	7.8±0.19
RM-K9-P-10	139.5±4.34	9±0.37	22.7±0.42	121±6.93	23±2.60	6.75±0.19
RM-K9-P-11	143±4.34	9±0.37	21.4±0.42	118±6.93	27±2.60	6.48±0.19
RM-K9-P-12	143.3±4.34	7±0.37	23±0.42	103±6.93	29±2.60	6.05±0.19
RM-K9-P-16-16	141±4.34	10±0.37	21.6±0.42	115±6.93	27±2.60	6.38±0.19
RM-K9-P-17-17	94.3±4.34	10±0.37	21±0.42	105±6.93	36±2.60	5.55±0.19
RM-K9-P-18	142.3±4.34	9±0.37	23.4±0.42	93.3±6.93	24±2.60	6.05±0.19
RM-K9-P	144.7±4.34	13±0.37	20.5±0.42	80±6.93	24±2.60	5.5±0.19
BRRIdhan-55	104.3±4.34	8±0.37	22.7±0.42	121±6.93	31±2.60	4.68±0.19

In Mymensingh, All the line had statistically significant variation in plant height Table 53). Significant statistical variation was observed in effective tiller among the lines. The line RM-K7-P-9 exhibited longer panicle length (26.1 cm) and higher filled grains/panicle (178) respectively comparing to the parents. The line RM-K9-P-3 showed significantly maximum unfilled grains/panicle (63) comparing to the parent. All the line including RM-K9-P-3 had higher yield (7.8 t/ha) comparing to the parents (Table 53).
Considering the yield & yield attributes, the promising lines will be evaluated for the next generation.

Evaluation of short duration and cold tolerant rice lines suitable for haor and northern area

The seeds of backcross populations were sown on 17-24 October, 2021 and transplanted at 12-25 November at BINA Headquarter, Rangpur and Sunamganj Substation by maintaining plant to plant and row to row distance 20cm and 15cm respectively. The parents were also included in this experiment. The experiment was followed by non replicated design. A unit plot size was 2m × 1m. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. Data on plant height, effective tiller hill^{-1}, panicle length, filled and unfilled grains panicle^{-1} and grain yield hill^{-1} was recorded from randomly selected five competitive hills at maturity. Maturity was assessed pot basis.

Table 54. Grain yield and yield components of some backcross population at BINA Headquarter, Mymensingh

Name of line	Plant height (cm)	Effective tillers	Panicle length (cm)	Yield (t/ha)
RM-1	77±1.64	15±0.46	21.2±0.22	9.75±0.31
RM-2	84.2±1.64	14.2±0.46	21.8±0.22	7.83±0.31
RM-3	97±1.64	13.8±0.46	22.4±0.22	8.13±0.31
RM-4	87±1.64	15.6±0.46	21±0.22	7.19±0.31
RM-5	78.4±1.64	19.4±0.46	21.6±0.22	12.82±0.31
RM-6	73.8±1.64	12.4±0.46	21.4±0.22	8.41±0.31
RM-7	80.4±1.64	11.8±0.46	22.8±0.22	4.89±0.31
RM-8	76.4±1.64	13.4±0.46	22.4±0.22	7.29±0.31
RM-9	106.4±1.64	10±0.46	20.8±0.22	7.65±0.31
RM-10	110.6±1.64	19.6±0.46	22.6±0.22	11.37±0.31
RM-11	96±1.64	11.4±0.46	21.8±0.22	6.63±0.31
RM-12	112.8±1.64	9.4±0.46	25.6±0.22	6.47±0.31
RM-13	112.8±1.64	11.4±0.46	24.6±0.22	6.49±0.31
RM-14	86.8±1.64	9.6±0.46	23.4±0.22	6.55±0.31
RM-15	85±1.64	13.4±0.46	21±0.22	7.47±0.31
RM-16	70.8±1.64	19.6±0.46	20.4±0.22	8.21±0.31
RM-17	88.8±1.64	19.4±0.46	23.8±0.22	14.25±0.31
RM-18	82.8±1.64	18.8±0.46	24±0.22	13.31±0.31
RM-19	84.6±1.64	15.8±0.46	21±0.22	10.87±0.31
RM-20	80.4±1.64	12.8±0.46	21.6±0.22	7.96±0.31
RM-21	88±1.64	16.6±0.46	22±0.22	11.3±0.31
RM-22	78.66±1.64	15±0.46	23.33±0.22	11.22±0.31
RM-23	82±1.64	14.4±0.46	20.8±0.22	6.88±0.31
RM-24	93.33±1.64	12.33±0.46	21.66±0.22	9.2±0.31
RM-25	87.6±1.64	15.2±0.46	23±0.22	6.33±0.31
RM-26	87±1.64	12±0.46	21.8±0.22	6.18±0.31
RM-27	105.6±1.64	14.2±0.46	24.2±0.22	9.38±0.31
RM-29	92.4±1.64	20.4±0.46	26.4±0.22	8.29±0.31
RM-30	109.4±1.64	16.8±0.46	27.6±0.22	12.88±0.31
RM-31	79.8±164	13±0.46	22.4±0.22	6.84±0.31
RM-32	87.8±1.64	11.6±0.46	22.6±0.22	7.36±0.31
RM-33	88.8±1.64	14.6±0.46	22.4±0.22	6.47±0.31
RM-34	85.8±1.64	13.8±0.46	23.2±0.22	10.03±0.31

RM-35	93.8±1.64	15.8±0.46	22.8±0.22	13.08±0.31
RM-36	111.4±1.64	12.4±0.46	23.8±0.22	9.73±0.31
RM-37	107±1.64	12.6±0.46	25.2±0.22	10.82±0.31
RM-38	85.8±1.64	14.4±0.46	23.4±0.22	9.4±0.31
RM-39	89.4±1.64	13.4±0.46	23.6±0.22	8.95±0.31
RM-40	84.25±1.64	7.6±0.46	18.4±0.22	5.19±0.31
RM-41	88±1.64	12.4±0.46	22.8±0.22	8.1±0.31
RM-42	87.4±1.64	13.2±0.46	21±0.22	9.03±0.31
RM-43	73±1.64	14.2±0.46	21.6±0.22	5.27±0.31
RM-44	87±1.64	17±0.46	21.67±0.22	8.68±0.31
RM-45	63.2±1.64	18.25±0.46	21±0.22	8.77±0.31
RM-46	82.4±1.64	12.6±0.46	23.4±0.22	8.22±0.31
RM-56	126.8±1.64	18±0.46	24±0.22	9.07±0.31
RM-60	127.66±1.64	27.66±0.46	29.66±0.22	15.12±0.31
RM-67	111.8±1.64	11.4±0.46	22.2±0.22	8.38±0.31
RM-68	107.6±1.64	11.2±0.46	25±0.22	10.26±0.31
RM-69	112.2±1.64	12.2±0.46	23.2±0.22	9.13±0.31
RM-70	86.6±1.64	11.8±0.46	21.2±0.22	4.95±0.31
RM-71	96±1.64	14.4±0.46	21±0.22	6.71±0.31
RM-72	97.6±1.64	17.2±0.46	20.4±0.22	8.56±0.31
RM-73	92.4±1.64	10.8±0.46	21±0.22	5.38±0.31
RM-74	88.8±1.64	12.2±0.46	20.6±0.22	4.69±0.31
RM-90	91±1.64	28.2±0.46	25±0.22	15.84±0.31
RM-102	91.2±1.64	17.6±0.46	25±0.22	12.63±0.31
RM-107	81.4±1.64	17.2±0.46	24.2±0.22	11.22±0.31
RM-108	82±1.64	14.2±0.46	23.2±0.22	8.48±0.31
RM-109	108.8±1.64	14±0.46	24.6±0.22	9±0.31
RM-114	85±1.64	21.2±0.46	21.6±0.22	12.79±0.31
RM-115	85.6±1.64	16±0.46	22.4±0.22	7.44±0.31
RM-117	85±1.64	14±0.46	23.2±0.22	7.72±0.31
RM-118	82.2±1.64	17.2±0.46	21.4±0.22	13.02±0.31
RM-119	82±1.64	20.6±0.46	23±0.22	9.93±0.31
RM-120	117.8±1.64	12.4±0.46	25.2±0.22	8.56±0.31

In Mymensingh, All the lines had statistically significant variation in plant height (Table 54). The line RM-16 had shorter plant height (70.8 cm) comparing to other lines. Highest effective tiller (28.2) was observed in the RM-90 line. Significant statistical variation was observed in panicle length among the lines. In addition, longer panicle length (29.66 cm) was found in the

RM-60 line. The lines RM-90 and RM-60 showed highest yield (15.84 and 15.12 t/ha respectively) comparing to the other mutants (Table 54).

Table 55. Grain yield and yield components of some mutants were sown at BINA substation, Sunamganj

Genotypes/mutants	Plant height	Effective tiller number	Panicle length (cm)	yield (t/ ha)
RM-1	79 ±1.75	14.6±0.70	19.26±0.39	9.32±0.54
RM-2	74±1.75	16±0.70	17.92±0.39	7.86±0.54
RM-3	83±1.75	15±0.70	19.36±0.39	8.99±0.54
RM-4	77±1.75	10.4±0.70	20.5±0.39	6.86±0.54
RM-5	85.4±1.75	14±0.70	22.1±0.39	7.39±0.54
RM-6	81.6±1.75	14.8±0.70	17.84±0.39	5.4±0.54
RM-7	79.6±1.75	12.8±0.70	21.3±0.39	7.63±0.54
RM-8	77±1.75	13.4±0.70	22±0.39	6.86±0.54
RM-12	93.2±1.75	16±0.70	20.92±0.39	6.29±0.54
RM-14	73.6±1.75	13±0.70	20.94±0.39	7.29±0.54
RM-27	99.8±1.75	18.8±0.70	26.66±0.39	9.93±0.54
RM-29	83±1.75	16.6±0.70	20.74±0.39	3.8±0.54
RM-32	94.6±175	18±0.70	22.3±0.39	7.08±0.54
RM-33	84.6±1.75	17.4±0.70	23.24±0.39	8.32±0.54
RM-39	102.8±1.75	25.6±0.70	21.96±0.39	15.1±0.54
RM-42	90.4±1,.75	22.2±0.70	21.98±0.39	7.73±0.54
RM-44	86.4±1.75	17.2±0.70	21.14±0.39	6.33±0.54
RM-45	83.6±1.75	19.6±0.70	22.06±0.39	8.05±0.54
RM-46	84±1.75	19.6±0.70	20.7±0.39	12.83±0.54
RM-47	106.8±1.75	22.4±0.70	24.84±0.39	11.98±0.54
RM-71	102.6±1.75	13.6±0.70	20.68±0.39	3.74±0.54
RM-91	75.2±1.75	11.6±0.70	21.86±0.39	5.13±0.54
RM-93	85.8±1.75	16.4±0.70	16.48±0.39	4.62±0.54
RM-95	79±1.75	14.8±0.70	19.26±0.39	6.73±0.54
RM-97	96±1.75	16.6±0.70	22.06±0.39	6.21±0.54
RM-114	84.8±1.75	20.2±0.70	21.84±0.39	13.51±0.54
RM-115	79.2±1.75	23±0.70	20.94±0.39	11.41±0.54
RM-116	93.2±1.75	16.6±0.70	24.46±0.39	11.05±0.54
RM-120	100.8±1.75	23.4±0.70	23.28±0.39	11.64±0.54

In Sunamganj, All the line had statistically significant variation in plant height (Table 55). The line RM-2 had shorter plant height (74 cm) comparing to other population. Highest effective tiller (25.6) was observed in the RM-39 line. Significant statistical variation was observed in panicle length among the lines. In addition, longer panicle length (26.66 cm) was found in the

RM-27 lines. The lines RM-39 and RM-114 showed highest yield (15.1 and 13.51 t/ha respectively) comparing to the other mutants. (Table 55).

Table 56. Grain yield and yield components of some crossing population at BINA substation, Rangpur

Name of line	Plant height (cm)	Effective tillers	Panicle length (cm)	Filled grain	Unfilled grain	Yield (t/ha)
RM-1	75.8±2.30	39.6±0.71	18.8±0.84	42±2.08	20.8±1.12	4.9±0.27
RM-2	84.4±2.30	26±0.71	19.4±0.84	41.6±2.08	30.4±1.12	8.8±0.27
RM-3	80.2±2.30	15.8±0.71	18±0.84	44±2.08	19±1.12	8.94±0.27
RM-4	117.8±2.30	24.6±0.71	23.4±0.84	36±2.08	22±1.12	3.27±0.27
RM-5	86.6±2.30	25±0.71	19.2±0.84	52.2±2.08	22.2±1.12	9.24±0.27
RM-6	88.8±2.30	23.6±0.71	20.2±0.84	43.8±2.08	19.8±1.12	8.91±0.27
RM-7	83.4±2.30	11±0.71	21.8±0.84	50.8±2.08	31.8±1.12	9.16±0.27
RM-8	101.2±2.30	12.6±0.71	18.8±0.84	23±2.08	48.6±1.12	7.15±0.44
RM-9	124.4±2.30	26.2±0.71	20.4±0.84	47.8±2.08	18±1.12	5.88±0.44
RM-10	89.6±2.30	23±0.71	19.6±0.84	56.6±2.08	14.6±1.12	6.94±0.44
RM-11	80±2.30	31±0.71	18.2±0.84	29±2.08	17.4±1.12	3.5±0.44
RM-12	90.4±2.30	20.2±0.71	20.6±0.84	67±2.08	24.8±1.12	7.69±0.44
RM-13	109.8±2.30	26±0.71	21.2±0.84	94±2.08	29.6±1.12	6.1±0.44
RM-14	73±2.30	29.4±0.71	18±0.84	69.6±2.08	15±1.12	7.92±0.44
RM-15	76.4±2.30	26.6±0.71	16.6±0.84	14.6±2.08	19.2±1.12	4±0.44
RM-16	127±2.30	23.2±0.71	22±0.84	35.4±2.08	40.8±1.12	5.6±0.44
RM-17	78.8±2.30	25±0.71	19.4±0.84	44.2±2.08	13.8±1.12	8.94±0.44
RM-18	80±2.30	25.8±0.71	19.8±0.84	24.4±2.08	25.2±1.12	7.48±0.44
RM-19	92.2±2.30	27±0.71	19.8±0.84	37.2±2.08	54±1.12	4.1±0.44
RM-20	80±2.30	29.4±0.71	19.4±0.84	65.4±2.08	36.4±1.12	7.76±0.44
RM-21	107.2±2.30	26±0.71	19.8±0.84	32±2.08	25.8±1.12	6.51±0.44
RM-22	93±2.30	30.6±0.71	20.5±0.84	16.6±2.08	15±1.12	4.87±0.44
RM-23	82.2±2.30	33.2±0.71	18.4±0.84	48.6±2.08	24.6±1.12	8.27±0.44
RM-24	77.4±2.30	44.6±0.71	17.2±0.84	50.6±2.08	16.8±1.12	6.34±0.44
RM-25	104.2±2.30	27.6±0.71	20.8±0.84	26.6±2.08	36.6±1.12	6.44±0.44
RM-26	80.2±2.30	38.6±0.71	19.2±0.84	26±2.08	37±1.12	7.11±0.44
RM-27	77.6±2.30	35.2±0.71	17.2±0.84	27.8±2.08	16.4±1.12	5.92±0.44
RM-28	115.6±2.30	19.33±0.71	22±0.84	11.6±2.08	50.8±1.12	5.53±0.44
RM-29	75.2±2.30	37±0.71	17.8±0.84	19±2.08	28.4±1.12	3.54±0.44
RM-30	91.8±2.30	20.4±0.71	20.6±0.84	45.8±2.08	28.2±1.12	8.67±0.44
RM-31	88±2.30	21.2±0.71	21.4±0.84	7±2.08	35.2±1.12	6.75±0.44
RM-32	99.8±2.30	20.4±0.71	22±0.84	33.8±2.08	36.4±1.12	7.09±0.44
RM-33	80.4±2.30	24.4±0.71	21.8±0.84	41±2.08	4±1.12	7.07±0.44

RM-34	108.2±2.30	18.2±0.71	23±0.84	50.8±2.08	33±1.12	10.42±0.44
RM-35	87.6±2.30	24±0.71	23±0.84	57.6±2.08	38±1.12	10.17±0.44
RM-36	125.6±2.30	19±0.71	21.8±0.84	35.6±2.08	43.4±1.12	4.09±0.44
RM-37	90.8±2.30	20.6±0.71	22.2±0.84	35±2.08	24.2±1.12	8.42±0.44
RM-38	92±2.30	20.8±0.71	19.6±0.84	55.2±2.08	37±1.12	10.27±0.44
RM-39	88.4±2.30	20.8±0.71	22.4±0.84	49.8±2.08	31.6±1.12	7.71±0.44
RM-40	109.6±2.30	13.2±0.71	23.2±0.84	57±2.08	39.6±1.12	10.43±0.44
RM-41	89±2.30	27.4±0.71	20±0.84	26.8±2.08	36.8±1.12	7.22±0.44
RM-42	107±2.30	39.4±0.71	21±0.84	50.8±2.08	19.4±1.12	5.12±0.44
RM-43	94.4±2.30	13.8±0.71	20±0.84	65.2±2.08	19.4±1.12	5.3±0.44
RM-44	86.8±2.30	18.6±0.71	20.8±0.84	24.8±2.08	30.8±1.12	7.3±0.44
RM-45	84.4±2.30	26.8±0.71	19.4±0.84	26.33±2.08	33.8±1.12	5.71±0.44
RM-46	106.2±2.30	30.8±0.71	22.4±0.84	40.4±2.08	19.6±1.12	2.57±0.44
RM-47	105.2±2.30	25.6±0.71	22.8±0.84	56.4±2.08	22.8±1.12	4.5±0.44
RM-48	168.6±2.30	16±0.71	22.8±0.84	0.2±2.08	31.6±1.12	1.35±0.44
RM-49	140.8±2.30	17±0.71	22±0.84	74.8±2.08	26.2±1.12	1.03±0.44
RM-50	173.8±2.30	15.2±0.71	23.6±0.84	46.2±2.08	20.6±1.12	1.71±0.44
RM-51	167.6±2.30	12.4±0.71	23.8±0.84	17.6±2.08	49.6±1.12	1.61±0.44
RM-52	177.2±2.30	15.2±0.71	23.2±0.84	13±2.08	36±1.12	2.19±0.44
RM-53	169.4±2.30	13.8±0.71	25.2±0.84	62.5±2.08	31±1.12	5.02±0.44
RM-54	139.8±2.30	20.6±0.71	20±0.84	52±2.08	22.6±1.12	8.99±0.44
RM-55	74.2±2.30	18±0.71	19.2±0.84	24.4±2.08	21.2±1.12	8.03±0.44
RM-56	82.8±2.30	24.2±0.71	20.2±0.84	54.4±2.08	23.2±1.12	6.28±0.44
RM-57	132.75±2.30	19.4±0.71	18.6±0.84	16.6±2.08	41.4±1.12	3.56±0.44
RM-58	99.6±2.30	15.4±0.71	19.6±0.84	77.8±2.08	12.6±1.12	11.7±0.44
RM-59	121±2.30	20.6±0.71	19.2±0.84	38.6±2.08	15.4±1.12	4.2±0.44
RM-60	130±2.30	14.2±0.71	22.6±0.84	65.8±2.08	36.4±1.12	10.29±0.44
RM-61	141.4±2.30	22.8±0.71	18.6±0.84	6.6±2.08	50.8±1.12	3.09±0.44
RM-62	78±2.30	24.4±0.71	18.2±0.84	41±2.08	29.4±1.12	3.02±0.44
RM-63	150±2.30	29.6±0.71	20.8±0.84	12.6±2.08	59.4±1.12	2.54±0.44
RM-64	112.8±2.30	16.8±0.71	20.8±0.84	28±2.08	42.8±1.12	2.29±0.44
RM-65	92.2±2.30	17.2±0.71	21±0.84	44.4±2.08	47.6±1.12	3.98±0.44
RM-66	104.2±2.30	27.8±0.71	21.4±0.84	9.6±2.08	37.2±1.12	2.08±0.44
RM-67	129±2.30	16.6±0.71	19.6±0.84	44.6±2.08	19.2±1.12	3.51±0.44
RM-68	117.4±2.30	18.2±0.71	21.4±0.84	5.6±2.08	47.6±1.12	4.82±0.44
RM-69	135.8±2.30	17.6±0.71	25.4±0.84	63.8±2.08	34.2±1.12	5.14±0.44
RM-70	106.4±2.30	22.6±0.71	20.2±0.84	70.8±2.08	8±1.12	4.8±0.44
RM-71	121±2.30	22.2±0.71	19±0.84	30.4±2.08	36.2±1.12	3.53±0.44
RM-72	127.4±2.30	19.4±0.71	19.4±0.84	97.8±2.08	42.2±1.12	3.82±0.44

RM-73	104.4±2.30	22.2±0.71	19.4±0.84	55.8±2.08	49.8±1.12	2.45±0.44
RM-74	104.8±2.30	22±0.71	20.2±0.84	37.4±2.08	33.2±1.12	1.83±0.44
RM-75	80.8±2.30	19±0.71	19.2±0.84	44.4±2.08	2.8±1.12	5.9±0.44
RM-76	75±2.30	26.6±0.71	18.6±0.84	35.2±2.08	18.3±1.12	2.76±0.44
RM-77	81.2±2.30	37.6±0.71	20.4±0.84	16.4±2.08	13.4±1.12	4.5±0.44
RM-78	85.2±2.30	41.6±0.71	20.6±0.84	34.8±2.08	24±1.12	5.65±0.44
RM-79	65.2±2.30	36.4±0.71	18±0.84	35.8±2.08	40.8±1.12	1.68±0.44
RM-80	73±2.30	30.6±0.71	17±0.84	10±2.08	25.4±1.12	3.65±0.44
RM-81	71.8±2.30	36.4±0.71	17.8±0.84	10±2.08	37.8±1.12	2.78±0.44
RM-82	69.8±2.30	41.2±0.71	16.6±0.84	19.6±2.08	29±1.12	1.1±0.44
RM-83	74±2.30	36.4±0.71	18.6±0.84	17.6±2.08	37.8±1.12	2.7±0.44
RM-84	73.2±2.30	39.4±0.71	18.8±0.84	13.8±2.08	30.6±1.12	1.32±0.44
RM-85	64.6±2.30	28.4±0.71	18±0.84	72±2.08	47.2±1.12	0.56±0.44
RM-86	41.4±2.30	35.2±0.71	14.2±0.84	16±2.08	46.6±1.12	1.8±0.44
RM-87	61.2±2.30	30.8±0.71	15±0.84	1.8±2.08	38.8±1.12	0.38±0.44
RM-88	74.6±2.30	29.44±0.71	16.2±0.84	31±2.08	25.6±1.12	1.45±0.44
RM-89	76.4±2.30	40±0.71	17±0.84	53±2.08	20.8±1.12	4.63±0.44
RM-90	81.2±2.30	28.2±0.71	22.4±0.84	53.4±2.08	29.6±1.12	7.7±0.44
RM-91	78.6±2.30	35.2±0.71	17.6±0.84	13.2±2.08	23.6±1.12	3.66±0.44
RM-92	73.8±2.30	43.8±0.71	16.4±0.84	4±2.08	43.8±1.12	0.27±0.44
RM-93	73.2±2.30	26.4±0.71	18±0.84	32±2.08	14.2±1.12	4.23±0.44
RM-95	73.6±2.30	29.2±0.71	18.7±0.84	3.2±2.08	34±1.12	2.79±0.44
RM-96	80.2±2.30	22.6±0.71	19±0.84	45±2.08	39.2±1.12	6.12±0.44
RM-97	69.8±2.30	30.8±0.71	15.6±0.84	5.6±2.08	63.2±1.12	2.88±0.44
RM-98	80.6±2.30	23.2±0.71	19.4±0.84	16.2±2.08	13.2±1.12	7.18±0.44
RM-99	80.4±2.30	47.2±0.71	15.4±0.84	3.2±2.08	32±1.12	1.86±0.44
RM-100	88.4±2.30	25±0.71	21.4±0.84	59±2.08	27.8±1.12	6.72±0.44
RM-101	84.8±2.30	32.2±0.71	20.2±0.84	49.8±2.08	26±1.12	5.01±0.44
RM102	79.4±2.30	30±0.71	17.6±0.84	34.6±2.08	30.6±1.12	3.62±0.44
RM-103	81.8±2.30	19.2±0.71	22.8±0.84	56.4±2.08	19.2±1.12	7.66±0.44
RM-104	88.4±2.30	21.8±0.71	23.8±0.84	48.6±2.08	15.4±1.12	6.09±0.44
RM-105	89.6±2.30	22.4±0.71	21.4±0.84	43.2±2.08	34.4±1.12	7.23±0.44
RM-106	90.4±2.30	25.6±0.71	22.6±0.84	79.8±2.08	43±1.12	9.74±0.44
RM-107	99.6±2.30	15.8±0.71	22.2±0.84	34.8±2.08	19±1.12	2.67±0.44
RM-108	100.6±2.30	21.2±0.71	22±0.84	80.6±2.08	36.8±1.12	9.2±0.44
RM-109	113.6±2.30	18.2±0.71	21.2±0.84	76±2.08	18.6±1.12	7.91±0.44
RM-110	79.8±2.30	22.8±0.71	21.6±0.84	49.8±2.08	12.4±1.12	5.62±0.44
RM-111	80.6±2.30	16.2±0.71	20.2±0.84	21±2.08	17.4±1.12	6.26±0.44

RM-112	87.4±2.30	24.6±0.71	21.6±0.84	38.8±2.08	43.6±1.12	10.51±0.44
RM-113	71±2.30	24.4±0.71	20±0.84	38±2.08	16.2±1.12	4.09±0.44
RM-114	87.4±2.30	22.8±0.71	21±0.84	95.8±2.08	12.6±1.12	8.32±0.44
RM-115	90±2.30	24±0.71	21.8±0.84	98.4±2.08	9.4±1.12	8.83±0.44
RM-116	89.4±2.30	23.4±0.71	22.6±0.84	63.6±2.08	25.2±1.12	9.54±0.44
RM-117	86.6±2.30	20.6±0.71	20.6±0.84	64.8±2.08	25.8±1.12	9.81±0.44
RM-118	90±2.30	19.6±0.71	19.8±0.84	83.6±2.08	40.4±1.12	10.52±0.44
RM-119	78.2±2.30	23.2±0.71	19.8±0.84	43±2.08	5±1.12	9.81±0.44
RM-120	85.6±2.30	17.2±0.71	19.4±0.84	32.6±2.08	18.2±1.12	14.14±0.44

In Rangpur, All the lines had statistically significant variation in plant height (Table 56). The line RM-82 had shorter plant height (69.8 cm) comparing to other progenies. Highest effective tiller (47.2) was observed in the RM-99 line. Significant statistical variation was observed in panicle length among the lines. In addition, longer panicle length (25.2 cm) was found in the RM-53 line. Highest filled grain/panicle (98.4) was found in RM-115 line. The line RM-120 showed highest yield (14.1 t/ha respectively) comparing to the other lines (Table 56)
Considering the yield & yield attributes, the promising lines will be evaluated for the next generation

Evaluation of BC_3F_6 population derived from Binadhan-14

Varieties with moderate shattering are favored where rice is harvested by large combined harvester–threshers, while harvesting using a small head-feeding combine is most efficient when hard-shattering to non shattering varieties are used. Farmers who harvest and thresh rice by hand prefer moderate-shattering varieties, similar to those used in the most heavily mechanized systems. Easy-shattering varieties are not acceptable to any of the farmers because they cause severe yield loss no matter what type of harvesting is practiced. Shattering also causes unexpected mixing of varieties due to germination of shattered seeds in rice fields, resulting in deterioration of rice quality

The seeds of backcross populations were at BINA Headquarter, Mymensingh on 5 December, 2021 and transplanted on 5 January, 2022 by maintaining plant to plant and row to row distance 20cm and 15cm respectively. The parents were also included in this experiment. The experiment was followed by non replicated design. A unit plot size was 2m × 1m. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. Data on plant height, effective tiller hill^{-1}, panicle length, filled and unfilled grains panicle^{-1} and grain yield hill^{-1} was recorded from randomly selected five competitive hills at maturity. Maturity was assessed pot basis.

Table 57. Grain yield and yield components of BC_3F_1 population derived from Binadhan-14

Variety/Mutant	Plant height (cm)	Effective Tiller number	Days of 50% flowering	Panicle length (cm)	Days of maturity (DOM)	1000 seed wt. (g)	Yield (t/ha)
B-P-1-1	98.00e-h	9.70n	120.00fg	23.27b-e	144.67d-f	23.50e	7.55c-g
B-P-2-1	96.20h-k	14.22bc	121.00ef	23.87bc	145.67de	23.77d	8.05a-e
B-P-2-2	96.53h-j	11.87e-m	123.00b-c	22.30e-g	143.67d-g	21.60lm	7.99a-f
B-P-3-1	98.93e-g	14.20bc	122.67cd	23.30b-e	141.67gh	21.83k	7.72b-g
B-P-3-2	94.53jk	13.20b-f	124.00bc	23.60b-d	143.33e-h	21.80kl	7.54c-g
B-P-3-3	97.20g-i	12.20d-k	123.67bc	23.13b-f	145.00de	22.50hi	7.53d-g
B-P-3-4	96.30h-k	12.33c-j	123.67bc	23.63b-d	149.00b	22.80fg	7.52d-g
B-P-4-1	95.40i-k	12.87c-h	124.00bc	23.03c-f	148.67b	23.00f	7.66b-g
B-P-6-1	96.40h-j	14.87ab	123.00b-c	23.80bc	149.00b	21.80kl	7.29f-g
B-P-16-1	95.40i-k	12.73c-i	121.67de	22.53d-f	149.00b	22.40i	7.67b-g
B-P-1-1-1	96.47h-j	14.07b-d	117.67h	23.33b-e	149.00b	22.66gh	7.42e-g
B-P-2-1-2	98.67e-g	10.93i-n	123.00b-c	23.20b-f	149.00b	22.10j	7.14g-i
B-P-2-1-3	94.20kl	16.27a	129.00a	22.33e-f	160.00a	22.50hi	7.49d-g
B-P-2-1-4	99.07d-g	11.47f-n	124.33b	22.60d-f	148.33bc	23.80d	7.48e-g
B-P-2-2-1	98.93e-g	12.53c-j	123.00b-c	21.33g	149.00b	24.33bc	7.53c-g
B-P-2-2-2	101.07b-d	11.40f-n	118.33h	22.73c-f	146.00cd	24.67a	7.75a-g
B-P-2-2-3	96.07h-k	13.13b-g	117.33hi	22.93c-f	143.67d-g	24.53ab	7.51d-g
B-P-2-1-1	99.47c-f	12.13e-l	118.67gh	22.93c-f	138.33j	21.60lm	7.98a-f
B-P-3-3-1	99.40c-f	11.27g-n	114.67j	25.13a	139.00ij	19.90o	8.24a-c
B-P-5-1-1	99.97c-e	11.13h-n	116.00ij	22.07fg	141.00hi	21.50m	6.39j
B-P-5-1-2	104.80a	10.73j-n	118.00h	25.27a	141.67gh	23.63de	8.45a
B-P-5-1-4	102.47b	10.20mn	114.67j	24.20ab	142.33f-h	20.80n	8.20a-d
B-P-2-2-4	97.60f-h	12.93c-h	120.00fg	22.93c-f	141.00hi	22.60g-i	8.32ab
Binadhan-7	97.00g-i	13.40b-e	123.33bc	22.73c-f	150.00b	23.70de	7.20gh
Binadhan-14	92.40l	10.40k-l	110.00k	23.40b-e	132.33k	23.00f	6.48ij
BRRI dhan28	101.40bc	10.27l-n	120.00fg	23.26b-e	143.33e-h	24.20c	6.62h-i
CV	1.33	9.48	0.77	3.06	1.05	0.54	5.74
LSD	2.1323	1.9158	1.5199	1.1653	2.4966	0.2016	0.7122

Significant variation was observed in term of plant height among lines. The line B-P-5-1-2 had taller plant height (102.47) comparing to the parent Binadhan-7, Binadhan-14 and Binadhan-28. The line B-P-1-1-1 had higher effective tillers (14.07) comparing to the other lines. In B-P-5-1-2 backcross population, longest Panicle length (25.27 cm) was found. The two lines B-P-2-1-1 and B-P-3-3-1 took comparatively less time (138 days and 139 days) to get 80% maturity comparing to the other progenies. Higher 1000 seed weight (24.67 gm.) was found in B-P-2-2-2 line comparing to the check variety Binadhan-7, Binadhan-14 and BRRI dhan28. The line B-P-5-1-2 gave higher yield 8.45 ton/ha comparing to the check variety Binadhan-7 (7.20 t/ha), Binadhan-14 (6.48 t/ha) and BRRI dhan28 (6.62 t/ha) respectively (Table 57). Considering the yield & yield attributes, the promising lines will be evaluated for the next generation

Hybrid Rice

Source Nursery and Test cross Nursery

The source nursery was constructed with the mutant CMS line SQR-6 (Figure 5) and other 20 Aman season variety/advanced lines. Eighteen successful test crosses were made, and the test cross hybrids were used to construct the test cross nursery. In the following Boro 2021-2022 season, the test cross hybrids were evaluated for maintenance or restoring capacity. The results showed that among the pollen parents, Binadhan-17 and MAGIC-62-2 had the restoring ability

Figure 6: Male sterile plants from the irradiated mutant population and confirmation of the male sterility type by pollen viability test.

Table 58: Classification of the pollen parents based on IRRI Hybrid Rice Breeding Manual

Genotype	Pollen Parent	Filled Grain	Unfilled Grain	Sterility%	Fertility %	Comments
21 AHRTR-1	Binadhan-16	8	165	97.05	2.95	Partial Maintainer
21 AHRTR-2	3012	47	78	62.47	37.53	Partial Maintainer
21 AHRTR-3	MAGIC-62-1	54	162	75.17	24.83	Partial Maintainer
21 AHRTR-4	MAGIC-62-2	93	27	16.47	83.53	Restorer
21 AHRTR-6	Binadhan-7	113	93	45.22	54.78	Partial Restorer
21 AHRTR-7	BRRI dhan75	85	58	40.47	59.53	Partial Restorer
21 AHRTR-8	Rajashail	96	93	49.03	50.97	Partial Restorer
21 AHRTR-9	3035	92	79	46.25	53.75	Partial Restorer
21 AHRTR-10	3035	153	43	15.93	84.07	Partial Restorer
21 AHRTR-11	Binadhan-17	118	66	35.80	64.20	Restorer
21 AHRTR-12	3019	82	88	51.67	48.33	Partial Maintainer

Handling of Mutant population for hybrid rice

Seeds of Binadhan-16 and Binadhan-17 were irradiated with 250Gy of gamma ray. The M_1 population was grown with closed spacing. After maturity the seeds were harvested by picking single healthy panicle from each plant.

Resistant Breeding of Rice Blast:

Introgression blast resistant genes *Piz, Pi2, Pi9* derived from Pongsu Seribu 2 into Binadhan17 through marker-assisted backcrossing

Marker-assisted foreground selection

For the development of blast resistant rice variety, the F_1 generations derived from cross between Binadhan-17 and blast resistant rice variety Pongsu Seribu-2, were evaluated for hybridity using the *Piz, Pi2, Pi9* and *Piz* linked molecular markers RM6836 and RM8225 (Table 59) in Aman 2018-2019. F_1 was backcrossed with Binadhan-17 to generate BC_1F_1 population. 100 BC_1F_1 seeds were grown in pot in Aman, 2019-2020. BC_1F_1 plants have been confirmed using blast resistant linked gene markers (RM8225 and RM6836). Rest of the plants were discarded. Based on highest recipient parent recovery (RPG), four BC_1F_1 plants were backcrossed with Binadhan-17 to generate BC_2F_1 population. 150 BC_2F_1 seeds were grown in pot in Aman, 2020-2021. In the BC_2F_1 generation, plants having the genes *Piz, Pi2, Pi9* and *Piz* have been confirmed using blast resistant linked gene markers (RM8225 and RM6836). Rest of the plants were discarded**.** Based on highest recipient parent recovery (RPG), four BC_2F_1 plants were forwarded to generate the BC_2F_2 and BC_2F_3 population in 2021-2022. BINA-BR-4-10-18, BINA-BR-4-10-12, BINA-BR-4-10-15 and BINA-BR-4-10-19 lines were selected from BC_2F_3 population. All foreground selections are shown in Figure 7.

Table 59: Gene linked SSR markers for foreground selection of the blast resistance genes *Piz, Pi2, Pi9*

SSR Markers	Gene	Reference	Primer Sequences(5´-3´)		Chromosome	Repeat Motif	Expected PCR Product Size (bp)
			F: Sequence of forward primer	R: Sequence of reverse primer			
RM6836	*Piz, Pi2, Pi9*	Ashkani *et al.*, 2011	TGTTGCATATGGTGCTATTTA	GATACGGCTTCTAGGCCAAA	6	(TCT)14	240
RM8225	*Piz.*	Ashkani *et al.*, 2011	ATGCGTGTTCAGAAATTAGG	TTGTTGTATACCTCATCGACAG	6	A11N(AAG)14	221

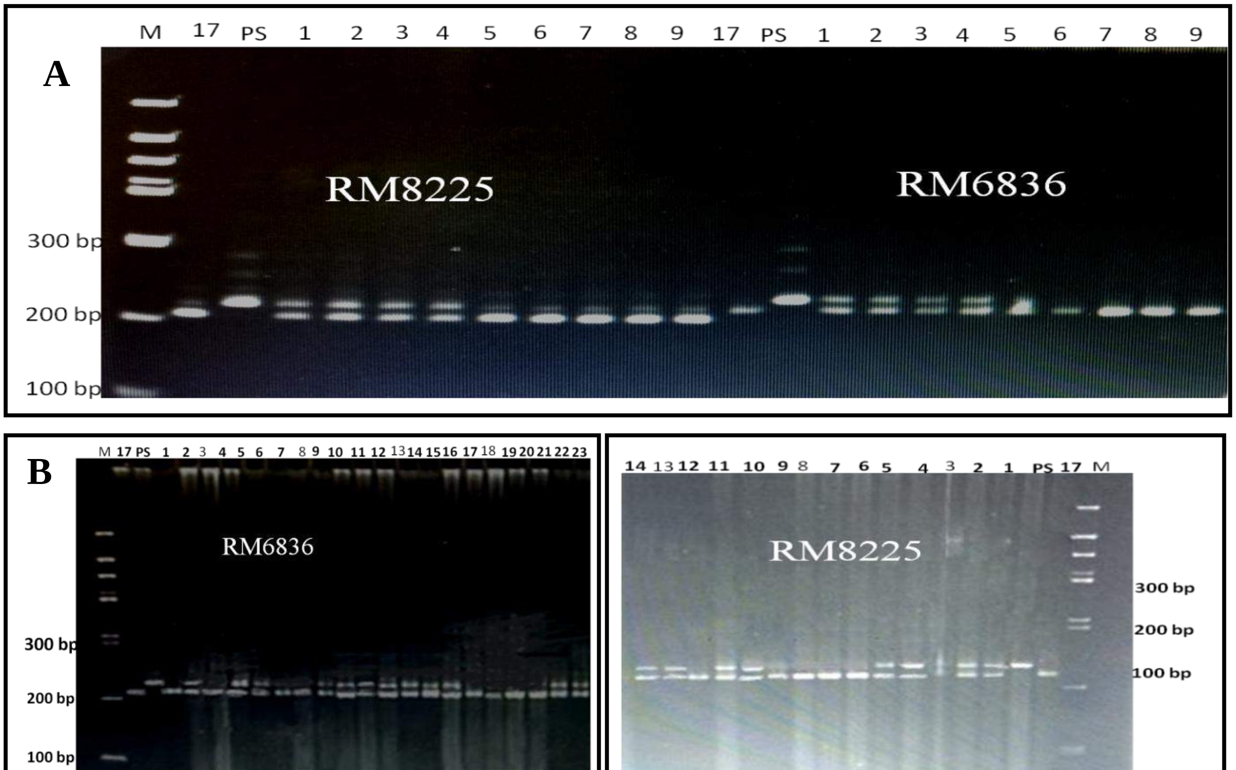
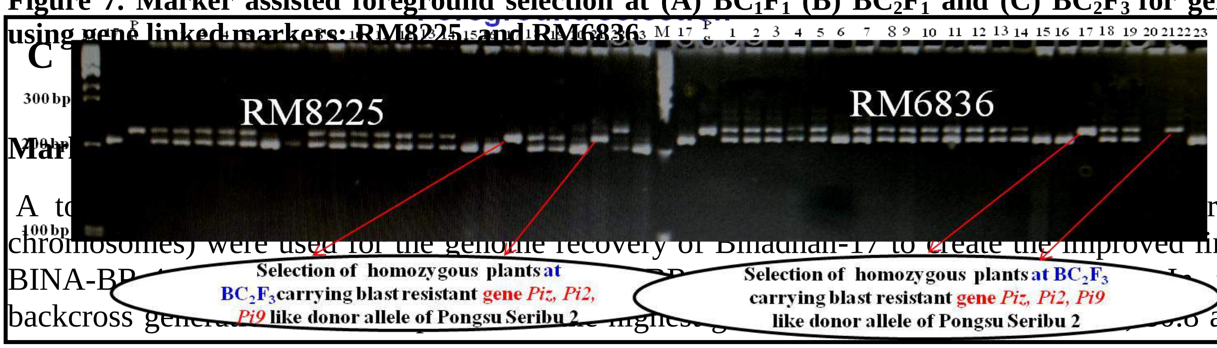


Figure 7. Marker assisted foreground selection at (A) BC$_1$F$_1$ (B) BC$_2$F$_1$ and (C) BC$_2$F$_3$ for genes using gene linked markers: RM8225 and RM6836.



Mar...

A t... rice chromosomes) were used for the genome recovery of Binadhan-17 to create the improved lines BINA-BR ... the backcross gener... highest ... and

76.9% respectively. In the backcross generation BC_2F_1, best four plants had been selected based on the highest genome recovery i.e; 82.4, 89.4, 86.8 and 92.9% respectively. The number of polymorphic markers per chromosome ranged from four to six. Chromosome 6 contained the *Piz*, *Pi2*, *Pi9* and *Piz* genes, (Fig. 8). All of the chromosomes were fully recovered in all of the improved lines except for the region carrying the resistance genes on chromosome 6 (Fig. 9). The greatest recovery ratio of the RPG was 96.1% in BINA-BR-4-10-12 (Fig. 10) and 94.3% in BINA-BR-4-10-19.

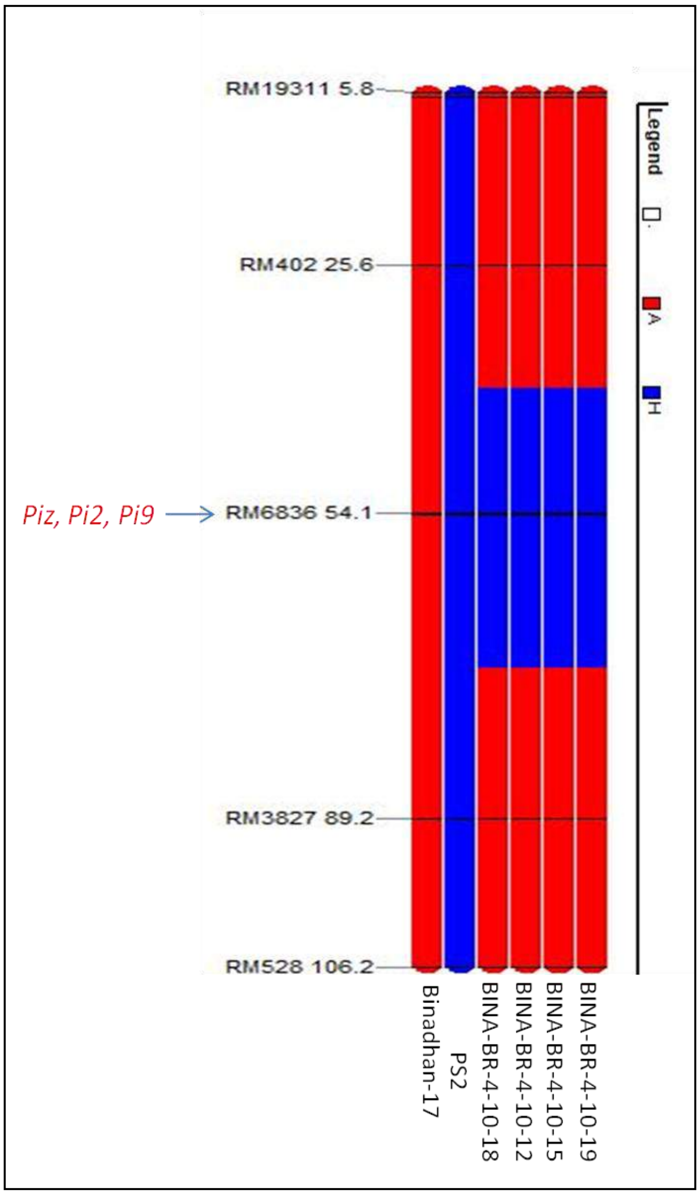


Figure 8. Genome introgression associated with blast resistance genes *Piz, Pi2, Pi9* on chromosome 6

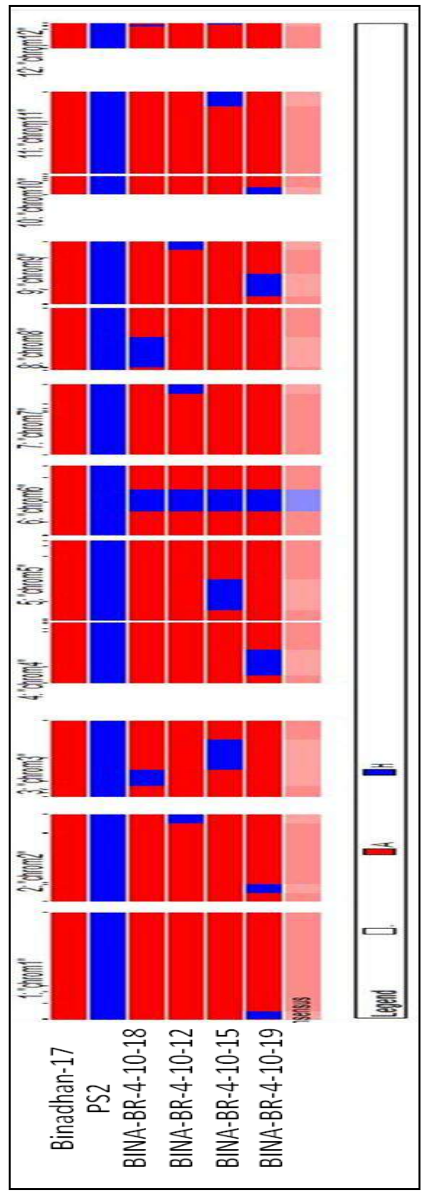


Figure 9.Genome introgression among four best improved lines (BINA-BR-4-10-18, BINA-BR-4-10-12, BINA-BR-4-10-15 and BINA-BR-4-10-19)

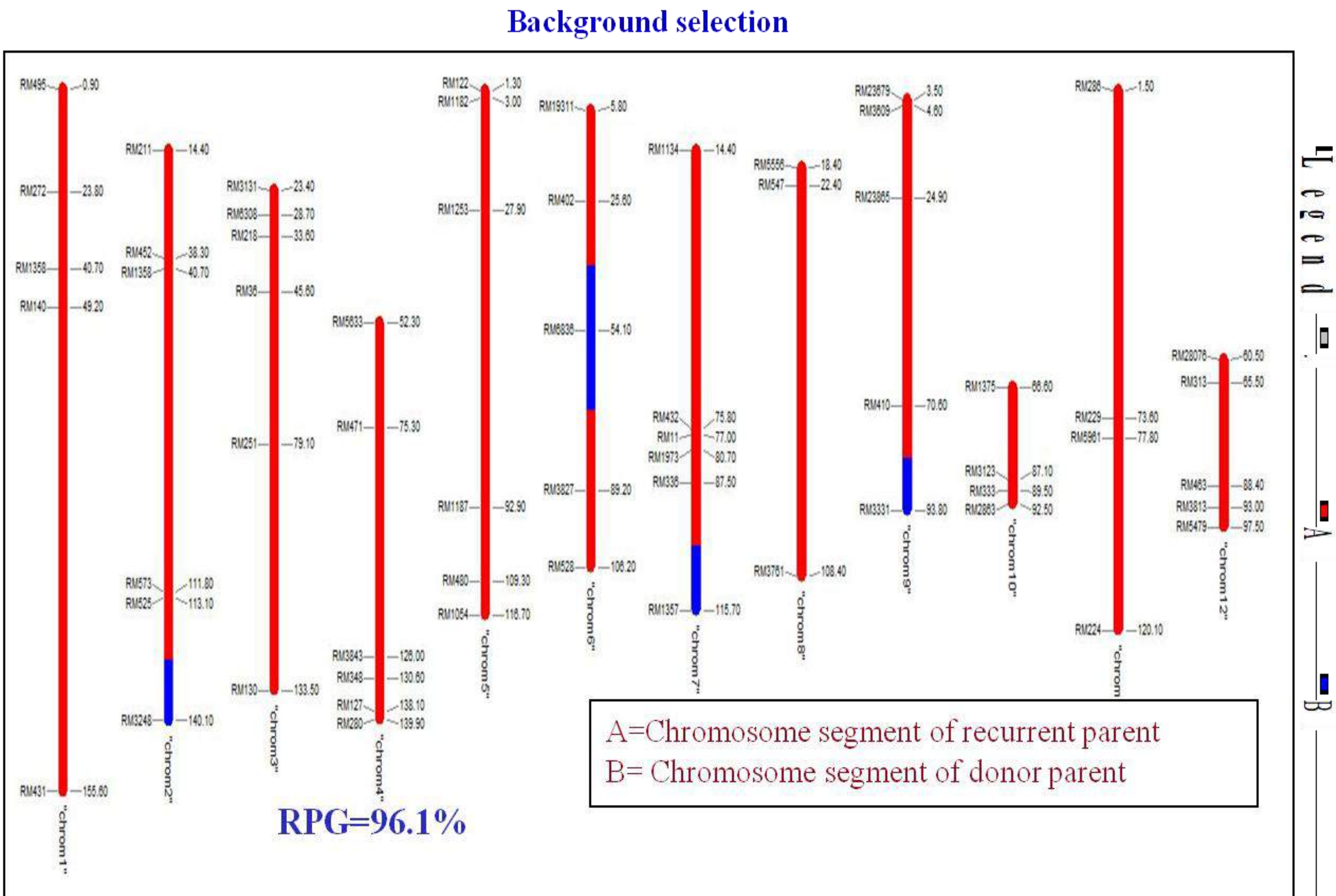
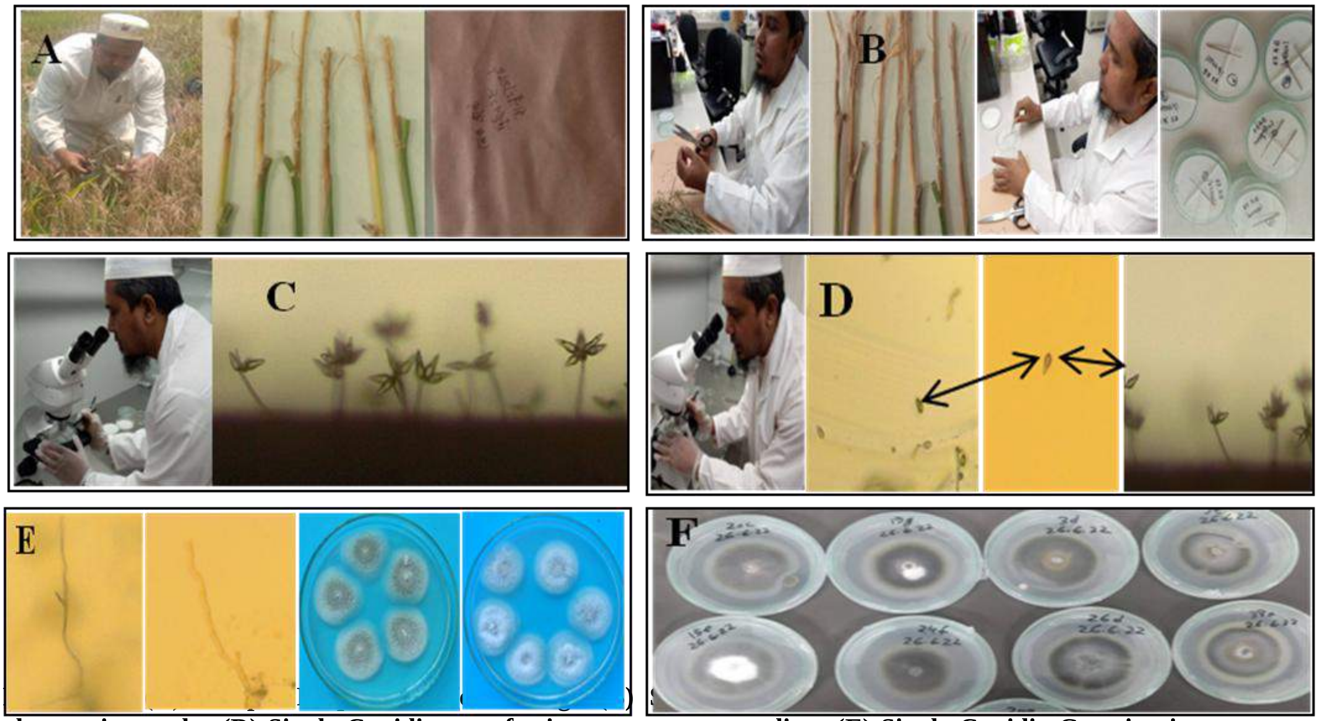


Figure 10. **Chromosome wise recurrent parent recovery as well as gene of *Piz, Pi2, Pi9 in* best line BINA-BR-4-10-12**

Diversity of rice blast pathogen (*Pyricularia oryzae*) in Bangladesh

Collection, isolation and Preservation of blast isolates

In total, 120 blast isolates (*Pyricularia oryzae*) were collected from the infected leaves and panicles of 12 rice (*O. sativa* L.) cultivars, including high- yielding inbred lines, and hybrid rice of Mymensingh, Rangpur, Sylhet divisions in Bangladesh. Sampling will be covered all of the administrative divisions of Bangladesh. Single spores were isolated from infected leaves or panicles incubated on moist filter paper in a petri dish at room temperature for 24 h in accordance with the protocols of Hayashi et al. (2009). Colonies from single conidia were grown on water agar for 5 to 7 days; two or three cut pieces of single colony were then transferred to sterile filter paper placed on water agar medium. Finally, to enable repeated access to the original isolates, the fungi were grown on filter paper and 20 isolates were stored aseptically in filter paper at −20°C after the necessary drying for the study of morphological, molecular and pathogenocity test. Total activities are shown in Figure11.



observation under (D) Single Conidia transfer into water agar medium (E) Single Conidia Germination and single colony advancement (F) Morphological differentiation of blast isolates on potato sucrose agar medium

Wheat

Preliminary yield trial with one high yielding wheat mutants

Among the abiotic stresses, drought is the most prominent and prevalent limiting factors of wheat production (Daryanto et al, 2016; Zhang et al, 2018; Sarto et al, 2017). Rising temperature and changing in precipitation pattern lead to increasing incidence and intensity of drought events in country like Bangladesh (Shahid et al, 2016). Drought employs expressively adverse effects on production of winter crop wheat in northern and central part of Bangladesh (Abhinandan, et al, 2018). Around 3.5 million ha land is vulnerable to crop production due to drought and wheat is one of the major cereal crops under the radar of this threat (Alam K, 2014). Considering these facts, drought should be highly preferred in future wheat improvement programs. For attaining self-sufficiency in wheat production, wheat breeders of Bangladesh have no alternatives but to develop well adapted drought tolerant varieties (Hossain et al; 2013). There are ample opportunities to increase drought tolerance of wheat through making some alterations in genetic through mutation breeding.

The experiment was conducted to screen the line that will be high yielding in all wheat growing areas including Barind area so that wheat demand in these areas can be alleviated rigorously.

Seeds of BWM-M-1-1 and the check variety BARI Gom-28 were sown at BINA Headquarter, Mymensingh, BINA substation Rangpur, BINA substation Khagrachari and BINA substation Chapainawabganj by maintaining plant to plant and row to row distance 15cm and 20cm respectively. The experiment was followed by RCB with 3 replications. The size of the unit plots were 3.0 m × 4.0 m. Recommended doses of nitrogen, phosphorus, potassium, sulphur, zinc and boron were applied in the form of Urea, T.S.P, MOP, Gypsum, Zinc sulphate and Boric acid. Cultural and intercultural practices were followed as and when necessitated. Data on Days to first flowering, days to 50% flowering, days to maturity, plant height, number of tillers plant^{-1}, number of effective tillers plant^{-1}, spikelet length, number of filled grains spikelets^{-1}, 1000-seed weight, grain yield tha^{-1}.were recorded after harvest from 5 randomly selected competitive plants. Maturity was assessed plot basis. Finally, all the recorded data were subjected to proper statistical analyses as per design used and are presented in Table 60.

Table 60. Yield and yield components of wheat mutants with check varieties at different locations

Location	Mutants	Duration	Plant height (cm)	Number of tillers	Spikelet length (cm)	Filled grains/spikelet	1000 seed weight (g.)	Yield (tha^{-1})
BINA Headquarter	BWM-M-1-1	116.00a	88.80	7.60	8.87	52.47	45.23	3.82a
	BARI Gom-28	102.00b	86.77	6.23	7.70	44.63	47.83	3.70b
	CV	1.12	2.33	10.93	7.11	4.61	7.52	0.50
	LSD	4.30	7.17	2.65	2.06	7.86	12.30	0.06
Rangpur Substation	BWM-M-1-1	116.00a	89.93	7.10	8.93a	53.10	45.23b	3.75
	BARI Gom-28	105.67b	93.93	6.87	7.90b	46.27	53.10a	3.62
	CV	0.37	2.56	4.09	2.11	12.33	1.09	2.53
	LSD	1.4342	8.2689	1.0040	0.6252	21.521	1.8810	0.3280
Khagrachari Substation	BWM-M-1-1	115.00a	75.43	7.90	8.93	52.70	45.23	3.75
	BARI Gom-28	108.00b	74.13	6.97	8.20	49.57	46.53	3.69
	CV	1.10	4.52	5.57	8.31	6.19	1.87	2.74
	LSD	4.3027	11.872	1.4556	2.5006	11.113	3.0119	0.3583
Chapainawabganj Substation	BWM-M-1-1	112.00a	86.47a	15.33	9.87	52.33a	45.17	3.90
	BARI Gom-28	108.67b	77.60b	12.47	9.73	48.67b	43.90	3.88
	CV	0.37	0.36	6.77	4.64	2.10	1.91	1.52
	LSD	1.4342	1.0342	3.3080	1.5971	3.7290	2.9947	0.2083
Combined over location	BWM-M-1-1	114.75a	85.16	9.48	9.15a	52.65a	45.22	3.81a
	BARI Gom-28	106.08b	83.11	8.13	8.38b	46.87b	47.44	3.72b
	CV	2.92	4.44	8.94	3.71	4.22	6.00	1.02
	LSD	7.2597	8.4015	1.7722	0.7311	4.7220	6.2563	0.0863

Results showed significant variation among the mutants and check for most of the characters in individual and over locations in combined analysis. From combined analysis, it was observed that plant height of the line BWM-M-1-1 were 85.16 cm which is statistically taller than the check variety BRRI Gom-28 (83.11 cm). The line BWM-M-1-1 had statistically higher number of effective tillers 9.48 comparing to BARI Gom-28 (8.13). Spike length of BWM-M-1-1 was recorded as 9.15 which are statistically higher than check variety BARI Gom-28 (8.38). The highest number of filled grains panicle^{-1} was observed BWM-M-1-1 (52.65) followed by BARI Gom-28 (46.87). Check variety BRRI Gom-28 had statistically higher number of 1000 grain weight (47.24 g.) to the BWM-M-1-1 line (45.22 g.). The line BWM-M-1-1 had produced higher yield (3.81 tha^{-1}) than the check variety BARI Gom-28 (3.72 tha^{-1}) (Table 1).
Considering the Duration, yield & yield attributes, the promising line BWM-M-1-1 will be evaluated for the next trial.

Improvement of Binagom-1 through hybridization

To increase the heterosis for the yield and yield contributing traits, Binagom-1 and BARI Gom-33 were crossed. The F_2 generation was cultivated under field settings utilizing after the F_1 seeds were harvested. In Rabi 2021–2022, 40 F_2 genotypes were raised. At maturity, a single panicle from each genotype was collected. A similar approach was used in the previous Rabi season (2021-2022) to manage the F_3 population.
To introgress short duration, heat tolerance, lodging resistance traits in Binagom-1 during November, 2020. The BC_2F_1seeds of Binagom-1 × BARI Gom-32 from each plant of each cross were collected them to grow BC_3F_1 population next year.

Considering the Duration, yield & yield attributes, the promising lines will be evaluated for the next generation.

Groundnut

Regional yield trial with some M_8 mutants of groundnut

Groundnut (*Arachis hypogaea* L.) is mainly cultivated in more than 100 countries in the semi-arid and subtropic regions covering an area of 29.59 million hactare with 48.75 million tons production. The seeds and haulms are good sources of income as both cash and fodder crops. As a result, groundnut cultivation can provide sustainability to the mixed crop-livestock production system which mostly prevails in semi-arid and subtropical regions especially in countries like Bangladesh. Mutation breeding can supplement conventional breeding by creating variability and enhancing the opportunity to improve the crop. Through mutation breeding, several high-yielding environmentally stable varieties of groundnut have already been developed in Argentina, India, Myanmar, and China. The key objective of the study was to figure out the adaptation of groundnut in Bangladesh by evaluating the effects of genotype, environment, and their interaction in respect of yield. Responsiveness and yield constancy of genotypes to 07 varying environments were also investigated using stability parameters.

Dry seeds of Binachinabadam-6 were irradiated at 282Gy of X-ray at the Agriculture and Biotechnology Laboratory of IAEA, Seibersdorf, Austria. Continuous evaluation and selection were made to advance the lines until M_8. Five groundnut mutant genotypes (B6/282/80, B6/282/63, RG-KHA-19/1, B6/282/64, and Binachinabadam-4) were used for the evaluation in two different seasons (Rabi). The experiment was conducted in seven different locations (Rangpur, Lalmonirhat, Ishwardi, Pakshi, Khagrachari, Panchari, and

Mymensingh). Thus, locations and seasons combined produced 07 environments for the evaluation (Table 61).

Table 61: Location coordinates and cultivation information of the 07 study area

Location and year	Season	Longitude	Latitude	Sowing Date	Harvesting Date
Mymensingh,2021-22	Rabi	24⁰83’	90⁰41’	31January, 2021	16 June, 2021
Rangpur, 2021-22	Rabi	25⁰75’	89⁰24’	02February, 2021	15 June, 2021
Lalmonirhat, 2021-22	Rabi	25⁰91’	89⁰45’	11February, 2021	17 June, 2021
Ishwardi, 2021-22	Rabi	24⁰12’	89⁰06’	23 January, 2021	05 June, 2021
Pakshi, 2021-22	Rabi	24⁰00’	89⁰19’	25 January, 2021	10 June, 2021
Khagrachari, 2021-22	Rabi	23⁰10’	91⁰98’	27 January, 2021	13 June, 2021
Panchari, 2021-22	Rabi	23⁰29’	91⁰89’	29 January, 2021	15 June, 2021

The experiment was conducted with RCB design with three replicates. A unit plot size was 3.0 m × 1.0 m. Seeds were sown at 15cm distances within rows of 30cm apart. Recommended fertilizer dose, cultural and intercultural operations were also followed. The average monthly maximum temperature was the mean value of the recorded monthly maximum temperatures during the study period, whereas the mean monthly minimum temperature was the mean value of the recorded monthly minimum temperatures (Figure12). No irrigation was used for the evaluation as the rainfall was sufficient enough for the groundnut cultivation.

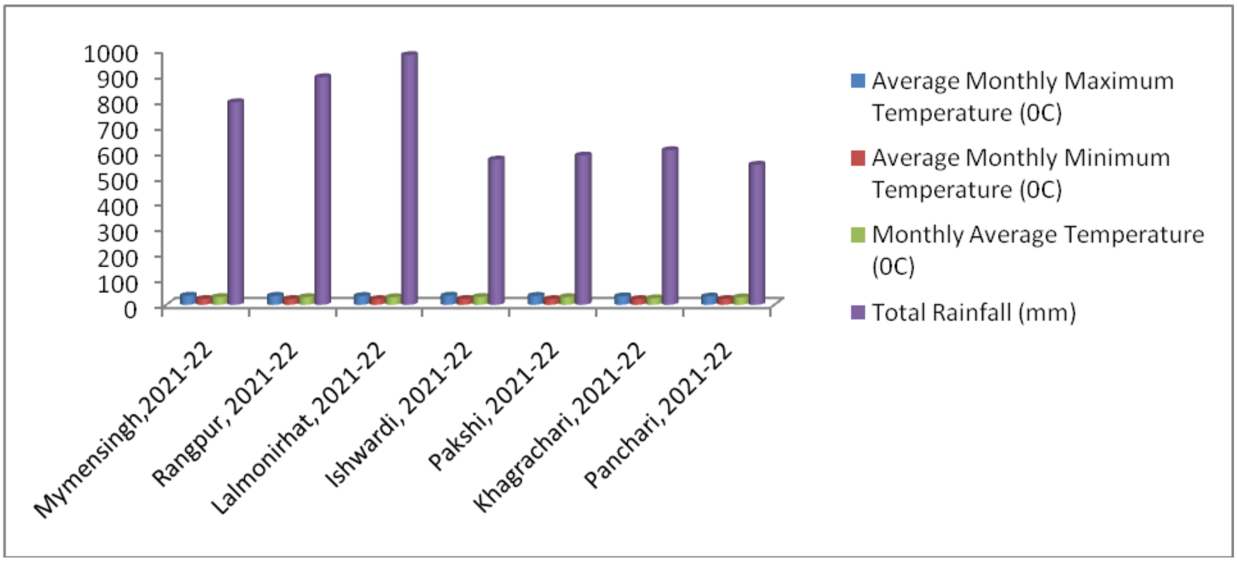


Figure12. Monthly average weather data of the 07 environments during 2021-22

Data were recorded on plant height, pod number, pod yield plant^{-1}, 100-pod and kernel weight from randomly selected 10 competitive plants at maturity. Pod yield was also recorded from an area of 1.0m^2 which later converted to tha^{-1}. Analysis was carried out using Statistix 10 version 1.0 Copyright @ 1985-2013.

Results showed significant variations among the mutants and check for most of the characters in individual locations and over locations in combined analysis (Table 62). On average, it was observed that plant height of B6/282/64, B6/282/80 and B6/282/63 was recorded which ranged from 67.60(cm), 68.42 (cm) and 72.55(cm). Another mutant RG-KHA-19-1 gave highest plant height 101.70 (cm) followed by the check variety Binachinabadam-4 68.39(cm). For pod plant^{-1} no significant differences were found with check variety but higher no. of pod observed (Table-5) and mutant RG-KHA-19-1 gave significantly lower than check for this trait. Pod & kernel weight of the mutant B6/282/80 was 15.56(g.) & 11.03(g.) which showed higher than the check variety Binachinabadam-4. 100 Pod-weights & 100 Kernel-weight of the mutants were observed that B6/282/63, B6/282/64 and B6/282/80 were recorded from 78.45(g), 80.77(g) and 79.21(g) & 31.65(g), 32.71(g) and 35.16(g), other mutant RG-KHA-19-1 was recorded highest 100 Pod-weights & 100 Kernel-weight 114.26(g.) & 40.76(g) than the check variety Binachinabadam-4 (84.14 gm). 100 kernel wt. also recorded higher in mutant RG-KHA-19-1 (47.08 gm) than the check variety Binachinabadam-4 was 78.04(g) & 34.72(g). From table 5 the shelling percentage of the mutant B6/282/80 was 70.74 significantly higher than the check variety Binachinabadam-4. Yield of the mutants of B6/282/80 was (2.71kgha^{-1}) which was higher than the check variety Binachinabadam-4 (2.56kgha^{-1}).

Table 62. Yield and yield components of groundnut mutants with check varieties at different locations

Location	Mutant	Plant Height	Pod/ plant	Pod weight	Kernel weight	100 pod weight	100 Kernel weight	Shelling %	Yield (t/ha)
Mymensingh Headquarter	B6/282/80	73.97bc	16.00a	15.33	11.18	78.80b	35.70b	72.73	2.93
	B6/282/63	77.10ab	15.00a	11.20	8.27	74.43b	32.87c	73.33	2.47
	RG-KHA-19/1	88.97a	6.83b	11.77	8.43	109.27a	42.56a	69.87	2.59
	B6/282/64	61.90c	18.90a	12.53	9.13	81.60b	32.77c	69.40	2.84
	Binachinabadam-4	70.64bc	13.50ab	13.50	10.30	77.53b	34.99b	70.20	2.85
	CV	10.06	25.29	21.14	21.16	12.77	2.33	3.98	18.98
	LSD	14.107	6.6884	5.1224	3.7696	20.276	1.5680	5.3321	0.9783
Rangpur Substation	B6/282/80	80.30b	22.07a	15.03	11.43a	78.47b	35.15b	70.87a	2.75
	B6/282/63	83.93b	19.60ab	12.15	8.63ab	74.60	31.63c	65.97ab	2.37
	RG-KHA-19/1	124.67a	16.05b	12.73	8.00b	124.77a	42.50a	52.10c	1.97
	B6/282/64	92.73b	18.97ab	12.63	9.67ab	79.00b	32.50bc	64.20b	2.48
	Binachinabadam-4	89.38b	20.97a	13.47	10.03ab	78.13b	34.23bc	70.03a	2.51
	CV	7.97	12.14	20.07	16.36	3.91	4.22	4.60	17.73
	LSD	14.139	4.4637	4.9892	2.9427	6.4072	2.7994	5.6006	0.8079
Rangpur Farmer's field	B6/282/80	81.00b	22.80a	15.37	11.63a	80.33ab	36.41b	70.40a	2.78a
	B6/282/63	84.18b	22.13ab	11.70	8.80bc	86.87a	33.37c	69.27ab	2.41a
	RG-KHA-19/1	113.00a	17.3c	13.47	8.10c	81.33ab	39.27a	65.73b	1.99b
	B6/282/64	76.87b	18.37bc	12.77	10.05ab	77.33b	32.77c	68.60ab	2.72a
	Binachinabadam-4	80.87b	20.57a-c	14.10	9.83bc	81.00ab	34.77bc	69.90a	2.75a
	CV	10.02	10.64	15.33	9.52	6.06	3.37	2.90	7.95
	LSD	16.452	4.0646	3.8909	1.7362	9.2797	2.2411	3.7599	0.3788
Ishardi	B6/282/80	61.50bc	23.60a	15.57a	11.18a	82.67b	35.43b	70.40a	2.71a

Location	Mutant	Plant Height	Pod/ plant	Pod weight	Kernel weight	100 pod weight	100 Kernel weight	Shelling %	Yield (t/ha)
Substation	B6/282/63	65.87b	21.93a	11.73b	7.90b	79.67b	31.70c	63.87b	2.35b
	RG-KHA-19/1	102.17a	15.40b	14.63a	7.50b	129.33a	41.37a	56.47c	1.99c
	B6/282/64	59.93c	23.57a	14.27ab	10.13a	82.47b	32.60bc	68.97ab	2.53ab
	Binachinabadam-4	64.50bc	23.30a	15.00a	11.05a	81.47b	35.17b	70.30a	2.60a
	CV	3.78	9.13	10.59	8.90	5.40	4.37	4.57	5.20
	LSD	5.0340	3.7065	2.8395	1.6017	9.2654	2.9003	5.6794	0.2383
Ishardi Farmer's field	B6/282/80	64.83cd	17.00	15.37a	10.57a	79.33b	34.36b	69.43a	2.57a
	B6/282/63	77.73b	13.53	10.12b	8.10b	74.43b	30.90c	65.47ab	2.18b
	RG-KHA-19/1	106.37a	11.80	14.53a	8.10b	109.27a	38.43a	60.57b	1.55c
	B6/282/64	68.43c	14.07	11.37b	9.90a	81.60b	31.07c	66.30a	2.22b
	Binachinabadam-4	58.47d	14.80	14.30a	10.30a	77.53b	34.63b	69.60a	2.37ab
	CV	4.60	17.46	11.69	6.20	12.74	4.20	4.13	7.10
	LSD	6.5162	7.3625	2.8925	1.0728	20.249	2.6807	5.1558	0.2911
Khagrachori Substation	B6/282/80	59.30bc	20.67a	14.83b	10.57a	80.33b	34.47b	71.30a	2.57a
	B6/282/63	65.53b	15.73b	10.10d	7.97b	80.00b	30.00c	70.13ab	2.42ab
	RG-KHA-19/1	103.51a	10.30c	17.30a	7.17b	130.43a	40.37a	68.87b	2.38b
	B6/282/64	55.23c	18.60ab	12.70bc	10.03a	80.33b	33.75b	70.90ab	2.55ab
	Binachinabadam-4	53.67c	18.10ab	10.97cd	10.37a	80.63b	34.70b	70.43ab	2.49ab
	CV	7.71	11.11	9.32	5.23	2.91	4.18	1.66	3.66
	LSD	9.7921	3.4892	2.3119	0.9072	5.0867	2.7305	2.1976	0.1711
Khagrachori Farmer's field	B6/282/80	58.07bc	20.53	17.40	10.63a	74.57b	34.63b	70.07a	2.63a
	B6/282/63	53.53c	17.93	17.53	8.97bc	79.17b	31.10c	69.43ab	2.40a
	RG-KHA-19/1	73.23a	16.00	16.10	7.72c	115.40a	40.87a	66.20b	1.83b
	B6/282/64	58.13bc	19.90	15.83	10.10ab	83.03b	33.50b	70.03a	2.55a
	Binachinabadam-4	61.20b	19.97	15.80	10.47a	69.97b	34.53b	69.27ab	2.34a
	CV	4.48	13.90	9.67	7.81	11.33	2.56	2.91	6.88
	LSD	5.1237	4.9390	3.0117	1.4084	18.011	1.6844	3.7855	0.3048
Combined over location	B6/282/80	68.42b	20.38a	15.56a	11.03a	79.21b	35.16b	70.74a	2.71a
	B6/282/63	72.55b	17.98b	12.08c	8.38d	78.45b	31.65d	68.21a	2.37c
	RG-KHA-19/1	101.70a	13.42c	14.36ab	7.72e	114.26a	40.76a	62.83b	2.05d
	B6/282/64	67.60b	18.91ab	13.16bc	9.86c	80.77b	32.71c	68.34a	2.56b
	Binachinabadam-4	68.39b	18.74ab	13.88b	10.34b	78.04b	34.72b	69.96a	2.56ab
	CV	4.91	9.39	9.62	4.47	9.58	2.60	4.20	5.50
	Isd	7.4427	1.8535	1.4647	0.4667	9.1073	1.0035	3.1490	0.1486

In a column, values with same letter (s) for individual location/ combined means do not differ significantly at 5% level P≥0.05 and significant at 1% level P≥0.01

The results supported from the Table 62 showed that different environment the shelling percentage of the mutant B6/282/80 was 70.74% significantly higher than the check variety Binachinabadam-4. Yield of the mutants of B6/282/80 was (2.71kgha^{-1}) which was higher than the check variety Binachinabadam-4 (2.56kgha^{-1}). Our study delineated that is a suitable genotype B6/282/80 that can be grown across the environment in Bangladesh while the other genotypes are environment-specific. Analysis suggests that an increase in yield can be accomplished by dividing experimental regions as zonal trail and selected as a new variety for both season all the groundnut growing areas of Bangladesh.

Screening F_{6-7} populations for long and bigger pods with 3-4 kernels

In Bangladesh groundnut is grown area of 15,500 acres with a production of 66,000 metric tons in Rabi and Kharif season (BBS, 2017) which is not sufficient for this country over 168 million people. Groundnut is ranked 4th among the oilseed crops in the world after soybean, rape seed and cotton. About 2/3 of the world's total groundnut production is used to produce oil and the remaining1/3 is used in food products (Variath MT & Janila P.2017). It is the third most important oil seed crop after mustard and sesame in Bangladesh (Miah MA & Mondal MRI, 2017). Therefore, Groundnut seeds contain high quality edible oil (35-55 %) that varies depending upon variety (Nelson et al., 1995), season and maturity (Hashim et al 1993), Groundnut oil is considered as stable and nutritive as it contains right proportions of saturated and unsaturated fatty acids. The key objective of the study was to figure out the adaptation of groundnut in Bangladesh by evaluating the effects of yield and yield contributing characters using stability parameters and identify 3-4 seeded higher shelling percentages, early maturing, high quality edible oil and high yielding mutant(s).

Using a 4 × 4 intra-specific diallel cross of groundnut. Breeding material comprised of a set of two mutant groundnut genotypes viz., GC (24)-1-1-1 and China Badam, having diverse origin. Five groundnut partial mutant genotypes (G3×G1-2, G3×G4-1, G3×G4-5, and G3 × G1-3 & G4 × G2-2) with two parents were used for the evaluation in two different seasons (Kharif and Rabi). The experiment was conducted at the field experimental plot of Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, Bangladesh during the period of July 2021 to June 2022.

Table 63. Location coordinates and cultivation information of the study area

Location and year	Season	Longitude	Latitude	Sowing Date	Harvesting Date
Mymensingh,2021-22	Kharif	$24^0$83'	$90^0$41'	03 August, 2021	05 January, 2022
Mymensingh,2021-22	Rabi	$25^0$75'	$89^0$24'	02February, 2022	15 June, 2022

The experiment was conducted with RCB design with three replicates. A unit plot size was 3.0 m × 3.0 m. Seeds were sown at 15cm distances within rows of 30cm apart. Recommended fertilizer dose, cultural and intercultural operations were also followed. No irrigation was used for the evaluation as the rainfall was sufficient enough for the groundnut cultivation. Data were recorded on plant height, pod number, pod yield plant^{-1}, 100-pod and kernel weight from randomly selected 10 competitive plants at maturity. Pod yield was also recorded from an area of 1.0m^2 which later converted to tha^{-1}. Oil content was determined using Soxhlet method (Jambunathan *et al.,* 1993) with minor modifications. Two gram of oven dried groundnut seeds of each genotype were weighed and pulverized into fine powder with amortar and pestle. Then the groundnut meal was extracted with petroleum benzene for 17hrs in Soxhlet apparatus. Powder weight before and after extraction was taken, the difference between the two weights was expressed in terms of oil percentage. The advantage of using Soxhlet extraction is that the solvent used in this method penetrates faster to the kernel powder, dissolve oil in the solvent and make a complete extraction. Additionally, this method is very efficient, quick, requires less solvent and convenient for automation and is more acceptable than other extraction methods. Analysis was carried out using Statistix10 version 1.0 Copyright @1985-2013.

Significant variation was showed among the cross combinations and the parents for most of the characters (Table 64). Highest plant height was observed from the cross G4. Pods Plants^{-1} were higher in G3×G4-5 (23.93) & G3×G1-3 (23.73) than the two parent. For Pod weight & kernel weight no significant differences were found with parents but higher no. of pod observed (Table-7) and partial mutant G3×G4-1 gave significantly lower than check for this trait. 100 pod weight & 100 Kernel weight was recorded highest in G3×G1-3 (145.83 g.) & (67.07g) than the two parent. From table 7 the shelling percentage of the partial mutant G3×G1-3 was 75.14% significantly higher than the check than the two parents. In oil content, the partial mutant line G3×G1-3 showed the highest percentage of oil content (52.30%) where as parent G3 showed the lowest (45.1%) content of oil (Table 63). Highest yield was recorded in the cross combination G3×G1-3 (3.27 tha^{-1}) which was significantly higher than all two parents studied in the experiment.

Table 64. Pod yield and yield attributes of bold seeded groundnut at Kharif-II season

Location	Mutant	Plant Height	Pod/ plant	Pod weight	Kernel weight	100 pod weight	100 Kernel weight	Shelling %	Oil (%)	Yield (t/ha)
BINA Headquarter, Mymensingh	G3×G1-2	31.03bc	21.07ab	23.27	19.84	107.80b	42.17c	73.80a	50.43 ab	3.19ab
	G3×G4-1	35.23a-b	22.47ab	22.90	16.92	102.09b	45.03b	73.83a	51.46 b	3.25a
	G3×G4-5	31.10bc	23.93a	25.97	18.86	108.23b	40.57c	72.67a	51.46 b	3.12ab
	G3×G1-3	32.57a-c	23.73a	29.37	74.99	145.83a	67.07a	75.14a	52.30 a	3.27a
	G4×G2-2	27.93c	19.57ab	25.97	18.61	125.31ab	39.63c	68.87b	49.46 b	2.89b
	G3	34.03a-c	22.70a	30.29	21.97	117.80b	40.00c	72.80a	45.1 c	3.22ab
	G4	37.53a	17.87b	27.68	19.02	124.23ab	46.70b	68.77b	46.3 bc	3.20ab
	CV	10.87	12.37	17.50	13.21	11.61	3.19	2.90	4.48	6.02
	LSD	6.3410	4.7579	8.18	6.38	24.53	2.60	3.73	5.12	0.33

In a column, values with same letter (s) for individual location/means do not differ significantly at 5% level P≥0.05 and significant at 1% level P≥0.01

Significant variation was showed among the cross combinations and the parents for most of the characters (Table 65). Highest plant height was observed from the cross G3×G4-1(82.00 cm).For Pods Plants^{-1} no significant differences were found with parents but higher Pods Plants^{-1} observed (Table-64). Pod & kernel weight of the partial mutant G3×G1-3 was 18.43 (g.) & 12.10 (g.) which showed higher than the check than the two parents. 100 pod weight & 100 Kernel weight was recorded highest in G3×G1-3 (168.57 g.) & (67.93g) than the two parent. From table 8 the shelling percentage of the partial mutant G3×G1-3 (65.80%) was no significantly differences were found with parents but higher than the check than the two parents. Highest yield was recorded in the cross combination G3×G1-3 (4.02 tha^{-1}) which was significantly higher than all two parents studied in the experiment.

Table 64. Pod yield and yield attributes of bold seeded groundnut at Rabi season

Location	Mutant	Plant Height	Pod/ plant	Pod weight	Kernel weight	100 pod weight	100 Kernel	Shelling %	Yield (t/ha)

							weight		
BINA Headquarter, Mymensingh	G3×G1-2	65.77bc	11.80	12.67b	8.47b	115.30b	45.03c	65.80	2.80c
	G3×G4-1	82.00a	11.03	15.03ab	9.47ab	134.93ab	46.83b	62.60	2.88bc
	G3×G4-5	60.20c	9.53	14.40ab	9.20ab	154.93ab	40.56de	63.56	3.27a-c
	G3×G1-3	70.73b	11.17	18.43a	12.10a	168.57a	67.93a	65.80	4.02a
	G4×G2-2	65.50bc	10.50	15.53ab	9.50ab	148.93ab	39.47e	64.63	3.44a-c
	G3	62.63bc	11.23	16.87ab	10.60ab	152.87ab	41.60d	63.20	3.60ab
	G4	67.10bc	10.43	17.63a	11.07ab	167.77a	46.40b	63.37	3.68a
	CV	8.42	16.86	15.12	16.87	15.03	1.35	6.47	12.59
	LSD	10.14	3.24	4.24	3.01	39.85	1.12	7.37	0.75

In a column, values with same letter (s) for individual location/means do not differ significantly at 5% level P≥0.05 and significant at 1% level P≥0.01

It can be concluded that the selected advanced mutants of groundnut genotypes G3×G1-3, G4×G2-2 & G3×G4-5 are good in analysis which might be the excellent source of nutrition. Induced mutation through radiation could be the mentionable variations in the yield and functional properties of genotypes. Considering yield & yield attributes of the partial mutant G3×G1-3, G4×G2-2 & G3×G4-5 is the best performer among all mutants used in this study. The findings presented in this comparative study of biochemical properties will be helpful for the further breeding program.

Rapeseed-Mustard

On-station and on-farm yield trial with advanced F_8 rapeseed (*B. rapa var toria*) lines

Four F_8 rapeseed lines (RL11, RL13, RL14 and RL17) along with two check varieties Tori-7 and Binasarisha-10 were evaluated to assess overall performance for earliness and yield attributes. The trial was conducted at BINA Head Quarter farm, Mymensingh and BINA sub-station farms at Ishurdi, Nalitabari, Rangpur, Magura & Jamalpur. The same experiment was conducted at the farmers' field at Rangpur, Manikgonj and Tangail. The experiment was laid out in a randomized complete block design with three replications. Seeds were sown on 15 November 2021 at all the location. Unit plot size was $16m^2$ (4m × 4m) and line to line distance was 25cm. Recommended production packages i.e., application of fertilizers, weeding, thinning, etc. were followed to ensure normal plant growth and development. Data on plant height, branches plant^{-1}, siliquae plant^{-1}, siliqua length and seeds siliqua^{-1} was taken from 10 randomly selected plants from each plot. Maturity period was counted when 90% siliquae were matured in a plot. Seed yield of each plot was recorded after harvest with proper drying and then converted into kg ha^{-1}. Appropriate statistical analyses were performed for comparison of mean of each character.

Results obtained from the trial of individual location and combined mean over location for all the characters are presented in the Table 66. Significant variation was observed among the lines and check varieties for most of the characters in each location and combined over all location. Average, maturity period ranged from 80 to 83 days. RL-14 and RL-17 required longest maturity period of 83 days and Tori-7 required the 81 days, whereas Binasarisha-10 required 80 days. In case of plant height, RL-14 produced the tallest plant (110cm) followed by RL-13 (101cm) and Binasarisha-10 (100cm). RL-13 produced the highest number of branches plant^{-1} (5) among other genotypes. RL-17 produced the highest number of siliquae plant^{-1} (159) followed by RL-11 (151). The number of seeds siliquae^{-1} and siliquae length is a good indicator for contributing seed yield. Seeds siliquae^{-1} and siliquae length of all the genotype significantly differ from each other. The longest siliquae was found in RL-13 (6.3cm) whereas, the shortest (4.5cm) was in Tori-7.

Table 66. Mean performance of mutants and checks for different character

Location	Mutant & check varieties	Days to maturity	Plant height (cm)	Branches plant^{-1} (no.)	Siliquae length (cm)	Siliquae plant^{-1} (no.)	Seeds siliquae^{-1} (no.)	1000 seed wt (gm)	Seed yield (kg ha^{-1})
BINA Sub-station, Nalitabari	RL-11	80	92.4b	4	4.6c	149a	18bc	3.1b	1966.7a
	RL-13	82	104.8a	4	8.4a	151a	19bc	3.1b	1533.3c
	RL-14	82	105.7a	4	6.0bc	121c	26a	3.3ab	1766.7b
	RL-17	80	91.2b	4	6.6b	141b	14c	3.9a	1900.0a
	Tori-7	80	99.5ab	5	4.9c	153a	19bc	2.9b	1466.7c
	BINA-10	79	96.6ab	5	5.5bc	139b	21ab	2.9b	1266.7d
BINA Sub-station, Jamalpur	RL-11	87b	99.4bc	7	5.1c	188a	14b	3.1	1433.0b
	RL-13	91a	101.7b	7	7.3a	186a	20a	3.1	1292.0c
	RL-14	91a	115.9a	6	5.7bc	134e	20a	3.3	1390.3b
	RL-17	90a	93.9c	6	6.0b	158c	16ab	3.9	1634.7a
	Tori-7	85bc	93.9c	6	5.2c	149d	20a	3.2	1265.3c
	BINA-10	83c	102.4b	7	5.5bc	166b	19a	3.2	1574.7a
Farmer’s field Tangail	RL-11	81	117.3a	3	3.8	125d	17a	3.3	1250.0c
	RL-13	82	118.3a	5	4.8	113e	15ab	3.1	1111.0e
	RL-14	84	117.4a	4	4.4	120de	14ab	3.1	1139.0d
	RL-17	87	115.0b	3	3.7	151b	12b	3.9	1300.0b
	Tori-7	85	105.7c	3	3.5	133c	13b	2.9	1277.0bc
	BINA-10	81	111.0a	3	4.0	159a	16a	3.2	1388.0a
Farmer’s field Manikganj	RL-11	86	102.3bc	4	3.9	145ab	16	3.1	1386.7b
	RL-13	84	94.7d	4	4.4	152a	18	3.1	1435.7a
	RL-14	83	114.3a	5	4.2	142ab	17	2.9	1378.7b
	RL-17	87	106.7b	4	4.4	159a	17	3.4	1455.3a
	Tori-7	81	91.7c	4	3.4	132b	14	3.2	1322.0bc
	BINA-10	83	102.7bc	4	4.0	117c	15	3.1	1270.0c
BINA Sub-station, Rangpur	RL-11	83	102.1c	3	4.2b	179a	17	3.3	1920.3a
	RL-13	81	108.3b	4	6.4a	167b	19	3.2	1870.7a
	RL-14	83	117.7a	3	6.1a	133c	14	3.2	1180.3b
	RL-17	80	104.7bc	4	4.3b	183a	18	3.2	1969.3a
	Tori-7	79	104.0bc	3	4.7b	139c	15	3.1	1217.3b
	BINA-10	79	104.0bc	3	4.6b	122d	18	3.1	1119.7b
BINA Sub-station, Ishurdi	RL-11	80	81.3c	3	6.2	155b	14	2.9	1518.5a
	RL-13	80	88.3b	3	7.6	137c	18	2.9	1250.9b
	RL-14	79	93.7a	3	6.6	128b	17	2.9	1225.0b
	RL-17	82	85.3bc	3	5.3	167a	12	3.2	1675.0a
	Tori-7	79	76.3d	3	4.9	121e	15	3.0	1227.8b
	BINA-10	79	89.3b	3	5.4	119de	15	3.2	1211.1b
BINA Sub-station, Magura	RL-11	81	86.7c	4	5.2	133a	14	3.0	1326.7a
	RL-13	83	93.3bc	4	5.1	111b	14	3.2	1126.7c
	RL-14	83	107.3a	4	5.1	119b	16	3.4	1176.7bc

	RL-17	80	97.0b	4	5.0	135a	16	3.5	1333.3ab
	Tori-7	79	92.0bc	5	5.0	121b	16	3.1	1193.3bc
	BINA-10	79	96.3b	4	4.9	130a	15	3.1	1250.0b
Farmer's field Rangpur	RL-11	81	94.3c	4	4.9	132c	12	3.4	1460.0bc
	RL-13	82	106.3a	3	7.4	163a	12	3.2	1796.7a
	RL-14	80	107.7a	3	5.5	141b	19	3.1	1540.7b
	RL-17	80	102.7b	3	5.7	159a	12	3.1	1743.3a
	Tori-7	81	100.3b	4	5.4	117c	14	3.3	1103.3d
	BINA-10	80	100.7b	4	5.1	127b	16	3.5	1206.7c
BINA HQ, Mymensingh	RL-11	78	85.0d	5	4.0	149a	16	3.1	1240.0c
	RL-13	79	97.0b	5	5.5	120c	19	3.1	1366.7b
	RL-14	83	111.7a	6	4.7	129c	18	3.3	1383.3b
	RL-17	80	93.7c	4	3.8	132b	14	3.5	1483.3a
	Tori-7	80	94.0bc	4	3.9	111d	16	3.2	1153.3d
	BINA-10	78	98.7ab	5	4.0	113d	17	3.1	1150.0d
Combine mean over location	RL-11	82	95c	5	4.6bc	151b	15c	3.1b	1521.2b
	RL-13	82	101b	4	6.3a	139c	18ab	3.2b	1443.4d
	RL-14	83	110a	4	5.4b	132d	19a	3.2b	1461.9c
	RL-17	83	99bc	4	4.9bc	159a	14d	4.4a	1561.4a
	Tori-7	81	95c	4	4.5c	127e	16cd	3.1b	1243.9e
	BINA-10	80	100bc	4	4.8bc	129de	17b	3.2b	1226.3f
Location mean									
BINA Sub-station, Nalitabari		81c	98.38cd	4	5.98a	125d	19.98a	3.18ab	1883.3ab
BINA Sub-station, Jamalpur		87a	101.2 c	6	5.79a	163a	18.55ab	3.29a	1431.7 cd
Farmer's field,Tangail		83b	114.12a	3	4.03c	136c	14.62d	3.23ab	1244.2de
Farmer's field, Manikganj		84 b	102.06	4	4.04c	125d	16.50c	3.14ab	1374.7cde
BINA Sub-station, Rangpur		81 c	106.8b	3	5.03b	148b	17.12bc	3.18ab	2046.3a
BINA Sub-station, Ishurdi		80c	85.72e	3	5.98a	135c	15.38cd	3.00b	1468.1c
BINA Sub-station, Magura		81c	95.44d	4	5.02b	123d	15.61cd	3.22ab	1234.4e
Farmer's field, Rangpur		80c	101.99c	3	5.6667a	145b	14.44d	3.25a	1725.1b
BINA HQ, Mymensingh		80c	96.67d	5	4.3189 c	149b	17.1 bc	3.21ab	1479.4c

N. B.: In a column, values with same letter(s) for individual location/combined mean do not differ significantly at 5% level. BINA-10 means Binasarisha-10.

Among the genotypes, line RL-17 produced highest seed yield 1561.4 kg ha^{-1} followed by RL-11 (1521.2 kg ha^{-1}) which was statistically different from seed yield of check variety Binasarisha-10 (1226.3 kg ha^{-1}) and Tori-7 (1243.9 kg ha^{-1}). Higher seed yielded lines RL-17 and RL-11 have been selected for future trial. Location-wise performance was higher at BINA Sub-station Rangpur (2046.3 kg ha^{-1}) followed by BINA Sub-station Nalitabari (1883.3 kg ha^{-1}) and lowest in BINA Sub-station, Magura (1234.4 kg ha^{-1}). From the above results it can be concluded that RL-17 and RL-11 have been selected for future trial on the basis of their yield stability and other agronomic traits.

Regional yield trial with M_8 rapeseed (*B. napus)* mutant

Three rapeseed mutants (RM22, RM24 and RM26) along with mother variety Binasarisha-9 and check variety Binasarisha-4 was observed in this trial. The trial was conducted at BINA Head Quarter farm, Mymeningh and BINA sub-station farms at Nalitabari, Rangpur, Satkhira and Jamalpur. This experiment was laid out in a randomized complete block design with three replications. Seeds were sown on 17 November 2021. Unit plot size was $16m^2$ (4m × 4m) and line to line spacing was 25cm. Recommended production packages i.e., application of fertilizers, weeding, thinning, etc. were followed to ensure normal plant growth and development. Data on plant height, branches plant^{-1}, siliquae plant^{-1} and seeds siliqua^{-1} were taken from 10 randomly selected plants from each plot. Maturity period was recorded when 90% siliquae were matured in a plot. Seed yield of each plot was converted into kg ha^{-1}. Appropriate statistical analyses were performed for comparison of mean of each character.

Results obtained from the trial of individual location and combined over location for all the characters are presented in the Table 67. Significant variation was observed among the lines and check varieties for most of the characters in both of individual location and combined over location. Average maturity period ranged from 83 to 90 days. All the mutants matured earlier than the mother variety Binasarisha-9 and check variety Binasarisha-4. Check variety Binasarisha-4 produced the tallest plant (107.66cm) followed by RM-22 and RM-26 (101.97cm and 102.38cm) which had statistically similar plant height comparing with Binasarisha-9. Among the mutants, RM-24 was comparatively dwarf having 96.26cm height and produced the equal number of branches plant^{-1}. Among the mutants and checks Binasarisha-4 produced the highest number of siliquae plant^{-1} (138) followed by Binasarisha-9 (133) and RM-26 (121).

Table 67. Mean performance of mutants and checks for different characters

Location	Mutant & check varieties	Days to maturity	Plant height (cm)	Branches plant^{-1} (no.)	Siliquae length (cm)	Siliquae plant^{-1} (no.)	Seeds siliquae^{-1} (no.)	1000 seed wt (gm)	Seed yield (kg ha^{-1})
BINA Sub-station Nalitabari	RM22	85	95.6c	3	8.76a	93d	23.6c	3.41	999.7c
	RM24	86	85.53d	4	6.3c	99c	26.2ab	3.34	999.7c
	RM26	85	95.43c	4	7 .0b	92d	26.6ab	3.66	958.7c
	BINA-4	87	117.93a	4	7.3ab	151a	27.467a	3.68	1533.0a
	BINA-9	88	104.33b	3	6.9b	108b	23.26c	3.24	1291.7b
BINA Sub-station Jamalpur	RM22	97a	109.27b	8	8.70a	102e	34.067a	3.41	1177.7d
	RM24	97a	101.13c	7	6.24d	121c	23.933 b	3.34	1235.0c
	RM26	88b	120.53a	6	6.94c	114d	29.8ab	3.66	1330bc
	BINA-4	98a	110.4 b	8	7.24b	141b	27.8ab	3.68	1518b
	BINA-9	95a	109.8 b	7	6.87c	152a	32.333ab	3.24	2026.7a
BINA Sub-station Rangpur	RM22	85b	120.53ab	3	8.76a	142c	24.6a	3.38	1420.0b
	RM24	86b	111.67c	3	6.3b	127d	17.333 b	3.31	1226.7c
	RM26	82c	115.33b	3	7.1b	187a	17.733 b	3.63	1658.0a
	BINA-4	89a	123.33a	2	7.3b	142c	21.2ab	3.65	1620.0a
	BINA-9	85b	112.67c	3	6.9b	157b	18.333 b	3.21	1463.7ab
BINA HQ, Mymensingh	RM22	85b	94.73a	4	8.68a	120b	26.11a	3.28	1233.3c
	RM24	86b	94.07a	5	6.22c	118b	18.83b	3.73	1213.3c
	RM26	83c	92.80b	6	6.92b	110c	19.23b	3.68	1200.0c
	BINA-4	90a	95.80a	6	7.22b	125a	22.7ab	3.65	1533.3a

	BINA-9	87b	88.21c	5	6.8b	125a	19.83b	3.43	1330.0b
BINA Sub-station Satkhira	RM22	84b	89.737a	5	6.48a	50c	21.1a	3.24	1143.3c
	RM24	83b	89.07a	4	4.02d	55b	13.833 b	3.69	1123.3c
	RM26	82b	87.807b	5	4.72c	55b	14.233 b	3.64	1255.0a
	BINA-4	86a	90.807a	5	5.02b	60a	17.7ab	3.61	1243.3b
	BINA-9	87a	83.21c	4	4.6c	55b	14.833 b	3.39	1240.0a
Combine mean over location	RM22	86b	101.97ab	4	8.28a	114c	25.907a	3.34	1194.8d
	RM24	87b	96.29 b	4	5.81c	115c	20.027 b	3.48	1159.6d
	RM26	83c	102.38ab	5	6.51b	121b	20.853 b	3.65	1371.3c
	BINA-4	90a	107.66a	5	6.81b	138a	23.373ab	3.65	1595.9a
	BINA-9	87b	99.64ab	4	6.44b	133a	22.387ab	3.30	1561.3b
Location mean									
BINA Sub-station Nalitabari		86b	99.77bc	4ab	7.26a	103c	25.44 b	3.46a	1156.5c
BINA Sub-station Jamalpur		96a	110.23b	7a	7.2a	126b	29.587a	3.46a	1457.5b
BINA Sub-station Rangpur		87b	116.71a	3b	7.26a	147a	19.84 cd	3.43a	1677.7a
BINA HQ, Mymensingh		87b	93.13c	5ab	7.18a	115bc	21.34 c	3.5a	1162.0c
BINA Sub-station Satkhira		84c	88.13d	4ab	4.98 b	108c	16.34d	3.51a	1072.0d

N. B.: In a column, values with same letter(s) for individual location/combined mean do not differ significantly at 5% level. BINA-4 & BINA-9 means Binasarisha-4 & Binasarisha-9.

Seeds Siliqua^{-1} and siliquae lengths were also contributing indicator for higher seed yield of rapeseed. Both of these characters are showed significant variation of all the genotypes. Binasarisha-4 produced the highest seed yield (1595.9 kg ha^{-1}) which was significantly different compared to the mutants and Binasarisha-9 (1561.3 kg ha^{-1}). At BINA sub-station Rangpur, RM-26 produce maximum seed yield of 1658.0 kg ha^{-1} and that was higher than any other tested genotypes. Considering with growth duration and agronomic performances and yield at stress prone area RM-26 was selected as a promising mutants for further stress breeding program of rapeseed.

Preliminary yield trial with M_6 rapeseed (*B.rapa var. toria*) mutants

Seven rapeseed mutants (RT-31, RT-32, RT-35, RT-38, RT-39, RT-42 and RT-77) along with the check variety Tori-7 was taken in the present investigation. This trial was conducted at BINA HQ farm, Mymensingh and BINA sub-station farms at Nalitabari, Noakhali, Satkhira and Jamalpur. The experiment was laid out in a randomized complete block design with three replications. Seeds were sown on 27th November 2021 at both locations. Unit plot size was 20m^2 (5m × 4m) and line to line distance was 25cm. Recommended production packages i.e., application of fertilizers, irrigation and pesticide, weeding, thinning, etc. were followed to ensure normal plant growth and development. Data on plant height, branches plant^{-1}, siliquae plant^{-1}, siliqua length and seeds siliqua^{-1} was taken from 10 randomly selected plants from each plot. Maturity period was counted when 90% siliquae were matured in a plot. Seed yield of each plot was recorded after harvest and proper drying and then converted into kg ha^{-1}. Appropriate statistical analyses were performed for comparison of mean of each character.

Results obtained from the trial of individual location and combined over location for all the characters are presented in Table 68. Significant variation was observed among the lines and check variety for most of the characters in both of six individual locations and combined over all locations. On an average, maturity period ranged from 79 to 84 days. Mutant RT-35 required longest maturity period of 84 days and Tori-7 required the shortest maturity period of 79 days. RT-35 (101.67cm) and RT-77 (101.71cm) produced the tallest plant followed by RT-32 (98.58cm). Mutant RT-39 (87.6cm) was comparatively dwarfed plant. The mutants RT-31, RT-35 and check RT-38 produced the similar number of branches (5) which is higher than the all other genotypes and check variety. RT-35 produced the highest number of siliquae $plant^{-1}$ (135) followed by RT-42 and RT-39 which produced 127 & 122 siliquae $plant^{-1}$, respectively. Number of seeds $siliquae^{-1}$ and siliquae length is good indicator contributing seed yields.

Table 68. Mean performance of mutants and the check for different character

Location	Mutant & check varieties	Days to maturity	Plant height (cm)	Branches $plant^{-1}$ (no.)	Siliquae length (cm)	Siliquae $plant^{-1}$ (no.)	Seeds $siliquae^{-1}$ (no.)	1000 seed wt (gm)	Seed yield (kg ha^{-1})
BINA Sub-station Nalitabari	RT- 31	83	115.57b	6	5.50	233b	19	3.38	980bc
	RT- 32	84	110.6c	6	6.30	180c	20	3.31	1320b
	RT- 35	84	119.43a	6	5.09	330a	19	3.07	1670a
	RT- 38	84	110.13c	6	5.19	228b	19	3.0	920d
	RT- 39	82	108.03cd	6	5.26	241b	14	2.9	1010
	RT- 42	84	111.03c	5	5.46	259b	14	2.86	1000c
	RT- 77	82	98.6d	8	5.66	282ab	21	3.47	1610a
	Tori-7	83	115.6b	7	4.9	189bc	17	3.11	1000c
BINA Sub-station Jamalpur	RT- 31	85ab	111.44abc	9	4.79a	142c	18	3.38	1360.7b
	RT- 32	87a	112.55ab	8	4.27bcd	138d	17	3.31	1346.7b
	RT- 35	86a	113.89a	8	4.14bcd	160b	16	3.07	1341.3b
	RT- 38	82c	106.78abcd	6	4.36abc	128e	15	3.08	1419.3b
	RT- 39	78e	95.89d	6	3.88cd	185a	15	2.9	1586.0a
	RT- 42	80d	114.33a	7	4.15bcd	147c	21	2.86	1421.7b
	RT- 77	82c	101.2bcd	9	4.43ab	167b	26	3.51	1022c
	Tori-7	84b	99.56cd	6	3.79d	180a	16b	2.98	1369.3b
BINA Sub-station Rangpur	RT- 31	119a	4.66ab	5	5.50	89c	16	3.38	1247c
	RT- 32	115ab	4.26ab	6	6.31	125a	17	3.31	1218.3d
	RT- 35	112b	3.73b	5	5.06	109b	18	3.07	1277.3b
	RT- 38	116b	4.0ab	5	5.16	117ab	17	3.08	1258.7b
	RT- 39	104c	4.0ab	5	5.23	107ab	16	2.9	1251.7b
	RT- 42	108bc	5.0ab	5	5.43	121a	16	2.86	1220d
	RT- 77	107bc	5.1a	5	5.63	97c	17	3.51	1315a
	Tori-7	111b	4.3ab	4	4.96	117ab	13	2.98	1321a
BINA. HQ, Mymensingh	RT- 31	83	95.8abc	6	4.7a	96bc	17	3.38	1533.3ab
	RT- 32	80	99.33abc	4	4.2bcd	77e	17	3.31	1606.7a
	RT- 35	83	103ab	5	4.1bcd	92c	15	3.07	1316.7abc
	RT- 38	82	107.33a	6	4.3abc	106a	16	3.08	1483.3abc
	RT- 39	83	87.33 c	5	3.8cd	89d	16	2.9	1166.7 c
	RT- 42	80	99.67abc	5	4.1bcd	100b	16	2.86	1193.3 c
	RT- 77	83	98.67abc	5	4.4ab	82cd	17	3.51	1583.3ab
	Tori-7	80b	91.33 bc	5	3.7d	91c	16	2.98	1266.7 bc
BINA	RT- 31	82	80.8abc	4	4.7a	61ab	9	2.3	1051.7e

Sub-station Noakhali	RT- 32	84	84.33abc	3	4.2bcd	42c	9	2.2	1166.7de
	RT- 35	85	88.0ab	4	4.1bcd	57b	7	1.9	1208.3c
	RT- 38	83	92.33a	4	4.3bc	65a	8	2.0	1333.3a
	RT- 39	82	72.33c	3	3.8cd	54b	8	1.8	1250b
	RT- 42	80	84.66abc	4	4.1bcd	65a	8	1.7	925f
	RT- 77	84	83.66abc	3	4.4ab	47c	9	2.4	1185.0d
	Tori-7	75	76.33bc	3	3.7d	56b	8	1.9	941.7f
BINA Sub-station Satkhira	RT- 31	81	65.8abc	2	4.63	66b	10	2.35	1405.4b
	RT- 32	83	69.3abc	2	5.49	47d	10	2.28	1136.7d
	RT- 35	84	73.4ab	2	4.19	62bc	8	2.04	1182.4d
	RT- 38	82	77.33a	2	4.29	76a	9	2.0	1550 .7a
	RT- 39	81	57.33c	1	4.36	59c	9	1.8	1381.7c
	RT- 42	79	69.66abc	2	4.56	61bc	9	1.8	1021.3e
	RT- 77	83	68.66abc	2	4.76	70ab	10	2.4	1462.1b
	Tori-7	74	61.3bc	1	4.09	42cd	9	1.9	911.7f
Combine mean over location	RT- 31	83ab	98.12ab	5	4.99ab	115c	15	3.0ab	1423.6b
	RT- 32	83ab	98.58ab	4	5.17a	101d	15	2.9ab	1533.4a
	RT- 35	84a	101.67a	5	4.45bc	135a	14	2.7bc	1582.6a
	RT- 38	83ab	93.29bc	5	4.88ab	115c	18	3.1a	1509.8a
	RT- 39	81bc	87.6c	4	4.40bc	122b	13	2.5c	1476.9b
	RT- 42	81bc	97.98ab	4	4.64abc	127ab	14	2.5c	1493.1b
	RT- 77	82ab	101.71a	4	4.61abc	121b	14	2.7bc	1429.7b
	Tori-7	79c	91.98bc	4	4.23c	114c	13	2.6bc	1260.7 c
Location mean									
BINA Sub-station Nalitabari		84a	110.95a	5	5.4508a	136a	18a	3.1a	1579.2a
BINA Sub-station Jamalpur		83ab	106.96a	4	4.2308 b	156b	19a	3.1a	1358.4b
BINA Sub-station Rangpur		82ab	111.85a	5	5.420a	110c	16a	3.2a	1268.6c
BINA. HQ, Mymensingh		81ab	97.81b	4	4.20b	91d	16a	3.1a	1393.7c
BINA Sub-station Noakhali		81ab	82.81c	4	4.20b	56d	8b	2.0b	1132.7d
BINA Sub-station Satkhira		80b	67.81d	4	4.55b	61d	9b	2.1b	1263.9c

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

Maximum Seeds Siliquae^{-1} and siliquae length was obtained from RT-38 (18 & 4.88) and RT-32 (15 & 5.17) that was significantly differ from other mutants and check. Among the genotypes, line RT-35 produced higher seed yield of 1582.6 kg ha^{-1} which was statistically similar to seed yield of RT-32 and RT-38 (1533.4 kg ha^{-1} & 1509.8 kg ha-^{1}). Location-wise performance was lowest at BINA sub-station Noakhali (1132.7 kg ha^{-1}) and the highest was at BINA sub-station Nalitabari (1579.2 kg ha^{-1}). But individual performance at southern area was higher for RT-38 and RT-39 indicates that these mutants have stress tolerant potentiality. From the above said results it can be concluded that four mutants (RT-32, RT-35, RT-38 and RT-39) have been selected for future trial.

Screening of rapeseed mutants for salinity tolerance in hydroponic culture

The objective of this experiment is to response of selected rapeseed genotypes in salt stress. Screening of salinity from a vast number of collected genotypes under field condition is quite difficult. It is also difficult to maintain accurate salinity levels in soil media in different treatments. In hydroponic culture solutions, it is easy to maintain the accuracy of salinity in respective treatments. Thus, this study was aimed to find out the salt tolerant genotypes using hydroponic screening techniques. Uniform seeds of RL-13, RL-14, RL-17 and Tori-7 was used in the present investigation. Salinity treatment in Figure 13 (8, 10 and 12 dS/m) was applied after every seven days when the entire seedling is established in hydroponic culture. Data on various characters such as plant height, leaf number, leaf area, shoot and root dry weight was taken from five randomly selected plants of each tray at reproductive stage.
Maximum, minimum and mean values of different plant characters of four rapeseed genotypes grown under different levels of saline condition are presented in Table 69 and visual injury at reproductive stage presented in table 5. All the characters were sharply decreased due to salt injury. The plant height ranged from 35.3 to 52.9cm with a mean of 45.1cm in the control plants. However, at 8 dS/m salinity, the plant height ranged from 26.63 to 41.6cm with a mean of 32.8cm. Number of leaves per plant ranged from 14.3 to 19.1 with a mean of 15.71 in the control plants. At 8 dS/m salinity, that was reduced and found from 9.0 to 22.0 with a mean of 15.33; and 31.3-48.2 with a mean of 29.4 for leaf area (cm^2 $plant^{-1}$). Like other traits root and shoot dry weight also decreased due to salinity effect. Among the different plant characters' leaf number as well as leaf area was more sensitive to salinity than others. RL-13 and RL-14 were found moderately salt tolerant than other genotypes and these two genotypes can be used as a breeding material for developing salt tolerant varieties in near future.

Table 69. Range and mean values of different quantitative characters of four rapeseed genotypes grown at 8 dS/m salinity level

Plant Characters	Control		8 dS/m	
	Range	Mean	Range	Mean
Plant height (cm)	35.3 - 52.9	45.1	26.63-41.6	32.8
Leaf number ($plant^{-1}$)	14.3 - 19.1	15.7	9.0-22.0	15.3
Leaf area (cm^2 $plant^{-1}$)	45.6 - 61.38	53.5	31.3-48.2	29.4
Shoot dry weight (g $plant^{-1}$)	11.02 - 17.57	7.9	7.1-8.62	7.0
Root dry weight (g $plant^{-1}$)	1.15 - 2.3	2.1	0.69-1.9	2.1

Table 70. Visual salt injury at reproductive stage

Mutant/ Variety	7 days after seeding			14 days after seeding			21 days after seeding		
	8 dS/m	10 dS/m	12 dS/m	8 dS/m	10 dS/m	12 dS/m	8 dS/m	10 dS/m	12 dS/m
RL-13	HT	HT	HT	HT	HT	HT	MT	D	D
RL-14	HT	HT	HT	HT	HT	MT	MT	D	D
RL-17	HT	HT	HT	MT	MT	MT	S	D	D
Tori-7	HT	HT	MT	MT	MT	S	HS	D	D

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

Fig 13. Response of rapeseed mutants at different salinity level

Growing of M_6 to M_2 generation of rapeseed mutants

A large number of M_6, M_5, M_4, M_3 and M_2 variants was developed from different irradiated materials were grown for selecting desirable mutant at BINA Head Quarter farm, Mymensingh. The seeds were sown on 20-26th November 2021. All the seeds were space planted in 3m long five rows with 30cm row spacing. Recommended fertilizer was applied and necessary steps were taken to grow the crop uniformly.

Total 146 segregating population (Table 71) was evaluated for yield and yield contributing characters. Among these, 40 segregating families (M_6 & M_5) and others was (106) single plant. All of these segregating populations were obtained from earlier generation, that have been selected from previous trials, whereas, single plant population was from earlier generation of M_4, M_3 and M_2. Total eight populations from M_6 and 14 from M_5 was selected for future advancement of generation. The basis of the selection was considering the maturity period (78-83 days) with other yield contributing characters. From various early generation single plant also selected considering maturity period, seed color, no. of silique and other agronomic traits. Fifty-eight single plants also selected and harvested separately for future utilization of varietal improvement program. From all of these variants a total of 80 true breeding mutants have been selected primarily for further selection that will be grown for respective advance generation on the basis of their agronomic performances.

Table 71: Selected plants & families of M_6, M_5, M_4, M_3 and M_2 population

Segregating population	No. of families planted	No. of families selected	No. of single plant selected
M_6	22	8	-
M_5	28	14	-
M_4	17	-	09
M_3	32	-	17
M_2	47	-	32
Total	146	22	58

Growing of F_5 to F_2 population of rapeseed generation

The objective of this research was to select desirable population on the basis of phenotypic performance for advancing the generation. A large number of F_5, F_4, F_3 and F_2 variants were developed from various cross between Binasarisha-9×BARI Sarisha-14, Binasarisha-9×Tori-7, Binasarisha-9×BARI Sarisha-18, Tori-7×BARI Sarisha-18 were grown at BINA Head Quarter farm, Mymensingh. The seeds were sown on 26-30th November 2021. All the seeds were planted in 3m long five rows with 30cm row spacing. Recommended fertilizer was applied and necessary actions were taken to grow the crop uniformly.

Total 83 segregating population was evaluated for yield and yield contributing characters. Among them 26 was segregating families and other 57 was single plant. All of the segregating populations were obtained from earlier generation that have been selected from previous trials, whereas single plant population was from earlier generation of F_4 to F_2. Five populations from F_5 and 11 from F_4 was selected for future generation advancement. The selection was facilitated considered the early maturity period (78-80 days) with other yield contributing characters. From various early generation single plant also selected considering maturity period, seed color, no. of siliqua and other agronomic traits. Thirty-four single plants have been selected and harvested separately for future utilization of varietal improvement program. A total of 50 true breeding lines have been selected primarily for further selection that will be grown respective advance generation on the basis of their agronomic performances.

Table 72: Selected plant & families of F_5, F_4, F_3 and F_2 populations

Segregating population	No. of families planted	No. of families selected	No. of single plant selected
F_5	9	5	-
F_4	17	11	-
F_3	42	-	27
F_2	15	-	7
Total	83	16	34

Growing of M_1 generation of rapeseed

The well dried seed of BARI Sarisha-18, Binasarisha-11, Binasarisha-9 and Tori-7 was used for the advancement of new generation. Thirty seeds were exposed to four doses of gamma rays (500, 600, 700, and 800 Gy). Prior to mutagenic treatment, seeds were kept in desiccators for moisture equilibration. The seeds were irradiated by gamma rays (^{60}Co irradiator) at BINA Mymensingh. The response variables, percent germination and survival rate was counting after 21 days of sowing.

The highest percentages seed germination occurred with the doses of 500 and 600Gy, whose values were 88-90% and 72-80% respectively decrease progressively as the radiation dose was increased (Figure 14). Survival rate was a consequence of germination percentage. As the radiation dose increased from 700 to 800Gy, the percentage of survival decreased, indicating that the like others rapeseeds also a sensitive species at high levels of radiation (Figure 13). Survived plants that able to produced seeds were harvested separately for growing M_2 generation.

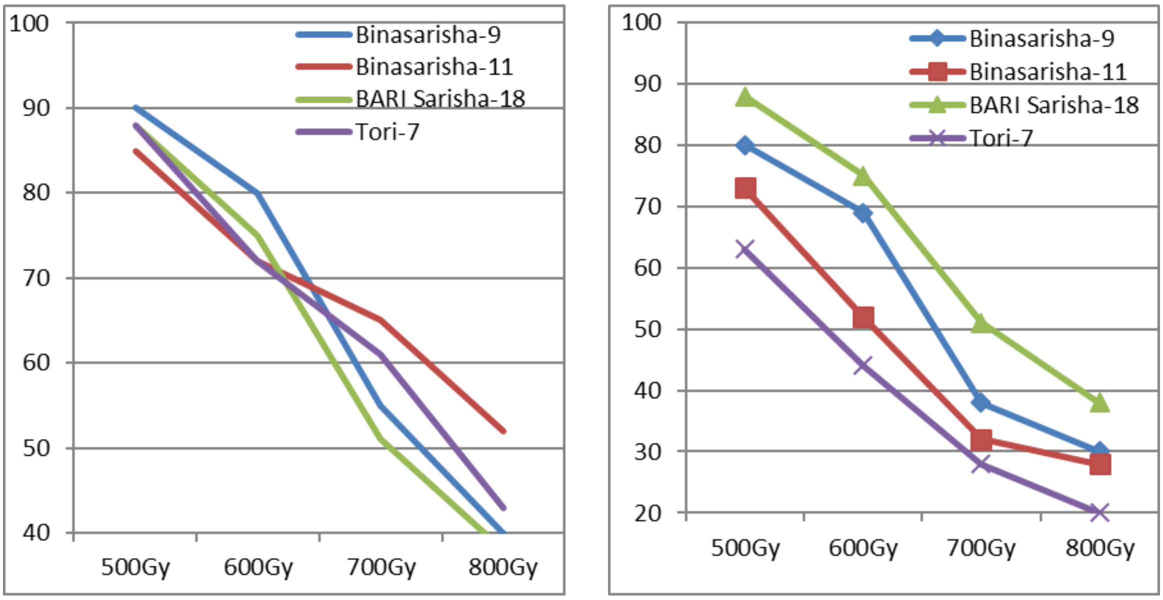


Fig 14: Germination (left) and survival percentage (right) of rapeseed seedlings subjected to four levels of ^{60}Co gamma radiation

Hybridization of Binasarisha-9 and Tori-7 with BARI Sarisha-14, BARI Sarisha-17 & BARI Sarisha-18

The aim of this study is to create genetic variability for varietal development process of rapeseeds. Binasarisha-9 and Toria-7 was crossed with BARI Sarisha-14, BARI Sarisha-17 and BARI Sarisha-18. The seeds were sown on 10 days' interval from 30th November 2021. In early morning the recipient parent was emasculated and pollinated by the respective donor parents followed by bagging and tagging. After 3-5 days the bag was removed and seed setting siliqua was consider as a success of cross.

Maximum cross was conducted between Binasarisha-9×BARI Sarisha-18 followed by Binasarisha-9×BARI Sarisha-14 and success rate was higher in Binasarisha-9×BARI Sarisha-18 56%, followed by Binasarisha-9×Tori-7, 53%. F_1 seeds were harvest separately for growing F_2 population.

Table 72: Crossing detail with success percentage

Cross combination	No of flowers pollinated	No. of success	Percent of success
Binasarisha-9 × BARI Sarisha-14	25	12	48
Binasarisha-9 × Tori-7	15	08	53
Binasarisha-9 × BARI Sarisha-18	30	17	56
Tori-7 × BARI Sarisha-18	30	11	36
BARI Sarisha-18 × Tori-7 (BC)	18	5	27
BARI Sarisha-18 × Binasarsha-9 (BC)	15	6	40

BC= Back cross

Sesame

On-station and on-farm yield trial with promising M_6 sesame mutants in Kharif-I

Two promising mutants along with one check variety Binatil-1 were evaluated through this trial. This experiment was conducted at BINA sub-station farms at Ishurdi, Magura & farmer's field Mymensingh during March to June 2022. The mutants and the check variety were laid out in a randomized complete block design with three replications. Unit plot size was $20m^2$ (4m × 5m) and line to line spacing was maintained 25cm. Seeds were sown on March 2022. Recommended production packages like application of recommended doses of fertilizers, irrigation, weeding, thinning, etc. were followed to ensure normal plant growth and development. Data were taken on plant height, number of branches plant^{-1}, number of capsules plant^{-1} and number of seeds capsule^{-1} from 10 randomly selected plants of each plot. Maturity period was counted when 80% capsules were matured and most of the plants turned into straw or yellowish color in each plot. Seed yield of each plot was converted into kg ha^{-1}. Appropriate statistical analyses were performed for comparison of mean of each character.

Results obtained from the trial of individual location and combined over locations for all the characters are presented in Table 74. Significant variations were found among the mutants and the check variety for most of the characters in both of individual locations and combined over locations. No-significant variation was observed for days to maturity, branches plant^{-1} (no.) and capsule length (cm). On an average, days to maturity ranged from 86 to 87 days. The check variety Binatil-1 produced the tallest (102cm) plant followed by the mutant SM-026 (90cm) and mutant SM-025 produced the shortest plant height of 83cm. The mutant SM-026 bear 2 branches but the mutant SM-025 and the check variety Binatil-1 were uniculm type. Mutant SM-026 produced significantly higher number of capsules plant^{-1} (57) followed by Binatil-1 (48) and the mutant SM-025 produced only 46 number of capsules plant^{-1}. The mutant SM-026 had the highest number of seeds capsaules^{-1} (71) with long capsule (3.9cm) size, which is statistically identical from others. The mutant SM-025 had 56 number of seeds capsaules^{-1} with 2.72cm long where as Binalit-1 had 64 number of seeds capsaules^{-1} with 3.7cm capsule length. On an average, SM-026 produced the highest seed yield of 1293 kg ha^{-1} followed by the check variety Binatil-1 (1159 kg ha^{-1}) and the mutant SM-025 produced lowest seed yield of 1074 kg ha^{-1}. Location-wise performance showed that the highest seed yield was produced at farmer's field Mymensingh (1232 kg ha^{-1}).

Table 74. Mean performance of sesame mutants along with one check variety for different quantitative characters

Locations	Mutants & check variety	Days to maturity	Plant height (cm)	Branches plant^{-1} (no.)	Capsules plant^{-1} (no.)	Seeds capsaules^{-1} (no.)	Capsule length (cm)	1000 seed weight (gm)	Seed yield (kg ha^{-1})
Ishurdi	SM-025	84b	67c	0.0b	34c	47c	2.5c	2.5c	1033c
	SM-026	84b	74b	2.0a	49a	64a	3.9a	3.2a	1236a
	Binatil-1	85a	84a	0.0b	42b	56b	3.6b	3.1b	1154b
Magura	SM-025	90a	115b	0.0b	59b	75c	2.8 b	3.3b	1032c
	SM-026	87ab	115b	2.1a	68a	85a	4.0 a	3.5a	1317a
	Binatil-1	86b	134a	0.0b	56c	82b	4.2a	3.3b	1110b
Farmer's field Mymensingh	SM-025	83b	66 c	0.0b	44b	47c	2.8c	2.6c	1157 c
	SM-026	85a	82b	2.0a	53a	63a	3.8a	3.6a	1326a
	Binatil-1	85a	87a	0.0b	46b	55 b	3.2b	3.2 b	1214b
Combined mean over locations	SM-025	87^{NS}	83c	0.0	46c	56c	2.7c	2.5c	1074c
	SM-026	86	90b	2.0	57a	71a	3.9a	3.4a	1293a
	Binatil-1	86	102a	0.0	48b	64b	3.7b	3.2b	1159b
Location mean									
Ishurdi		84b	75c	0.7^{NS}	42 c	56b	3.3 b	2.9c	1141c
Magura		88a	121a	0.7	60a	81a	3.7a	3.1b	1153b
Farmer's field mymensingh		84b	78b	0.7	48b	55**c**	3.3 c	3.1a	1232a

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

From this trial it was observed that, SM-026 was the best mutant among the mutants and check. This mutant will be applied to the NSB for releasing as a new variety.

Preliminary yield trial with promising M_5 sesame mutants at Kharif-I

Six promising mutants along with two check varieties Binatil-4 & BARI Til-4 were evaluated through this trial. This experiment was conducted at BINA HQ farm Mymensingh and BINA sub-station's farm at Ishurdi during March to June 2022. The mutants and the check varieties were laid out in a randomized complete block design with three replications. Unit plot size was 20m^2 (4m × 5m) and line to line spacing was maintained 25cm. Seeds were sown on March 2022. Recommended production packages like application of recommended doses of fertilizers, irrigation, weeding, thinning, etc. were followed to ensure normal plant growth and development. Data were taken on plant height, number of branches plant^{-1}, number of capsules plant^{-1} and number seeds capsule^{-1} from 10 randomly selected plants from each plot. Maturity period was counted when 80% capsules were matured and most of the plants turned into straw or yellowish color in each plot. Seed yield of each plot was converted into kg ha^{-1}. Appropriate statistical analyses were performed for comparison of means of each character.
Results obtained from the trial of individual location and combined over locations for all the characters are presented in Table 75. Significant variations were observed among the mutants and two checks for most of the characters in both of individual locations and combined over locations. On an average, days to maturity ranged from 78 to 97 days. Mutants ESE-01, ESE-

04 and check variety BARI Til-04 produced the tallest plant (127cm) whereas mutant ESE-06 produced the shortest plant height (114cm). Both the mutants and checks were profusely branched and BARI Til-04 provided maximum (4) branches plant^{-1} followed by the mutant ESE-02 (3). Mutant ESE-03 produced significantly higher number of capsules plant^{-1} (61) which is statistically different from others. Lowest number of capsules plant^{-1} (49) was obtained from ESE-05. Mutant ESE-03 produced highest number of seeds capsaule^{-1} (80) followed by the mutant ESE-01 (73). Mutant ESE-01 had long capsule length (2.65cm) and highest thousand seed weight (3.36g) which is statistically identical from others. On an average, Mutants ESE-01 and ESE-03 produced the highest seed yield of (1515 kg ha^{-1}) and (1509 kg ha^{-1}), respectively followed by mutant's ESE-06 (1468kg ha^{-1}) and ESE-04 (1406 kg ha^{-1}). Location-wise performance showed that the highest seed yield was produced at BINA HQ farm, Mymensingh (1391 kg ha^{-1}).

Table 75. Mean performance of sesame mutants along with two check varieties for different quantitative characters

Locations	Mutants & check variety	Days to maturity	Plant height (cm)	Branches plant^{-1} (no.)	Capsules plant^{-1} (no.)	Seeds capsaule^{-1} (no.)	Capsule length (cm)	1000 seed weight (gm)	Seed yield (kg ha^{-1})
Mymensingh	ESE-01	88a	123c	2.3f	37e	78d	2.9a	3.1bc	1561a
	ESE-02	78c	114e	3.1bc	39a	73e	2.4d	2.7e	1199g
	ESE-03	86b	130ab	2.7d	36b	84c	2.4e	3.0c	1499c
	ESE-04	78c	131a	2.7d	37c	66g	2.7b	3.5a	1467d
	ESE-05	78c	128b	3.3a	38b	87b	2.4e	2.9d	1244f
	ESE-06	79c	114e	3.0c	38a	68f	2.4d	3.2b	1515b
	Binatil-4	79c	111f	2.5e	34d	69e	2.5c	2.9d	1379e
	BARI Til-4	79c	120d	3.2b	35b	75a	2.4d	2.8e	1265f
Ishurdi	ESE-01	96b	131a	3.5bc	78b	60e	2.4e	3.1b	1469b
	ESE-02	97a	124b	3.8b	74c	66c	2.4e	2.7e	1209g
	ESE-03	96b	102e	3.4c	84a	58f	2.8a	3.0c	1521a
	ESE-04	97a	122bc	3.3d	75c	95a	2.2g	3.3a	1345d
	ESE-05	95c	113d	2.7f	61e	60e	2.6c	2.9d	1200g
	ESE-06	97a	114d	2.6g	76bc	63d	2.7b	3.1b	1420c
	Binatil-4	96b	120c	3.1e	67d	66c	2.5c	2.9d	1242f
	BARI Til-4	97a	129ab	4.5a	75a	62b	2.4e	2.9d	1282e
Combined mean over locations	ESE-01	92a	127a	2.9c	55c	73b	2.7a	3.4a	1505a
	ESE-02	87cd	119c	3.5b	57b	69c	2.4b	2.7e	1254de
	ESE-03	91b	116d	3.0c	61a	80a	2.7ab	3.1b	1490b
	ESE-04	87cd	127a	3.0c	56bc	71c	2.4b	3.0a	1406c
	ESE-05	86e	121b	3.0c	49d	69cd	2.5ab	2.9cd	1222e
	ESE-06	88c	114de	2.8c	57b	65d	2.5ab	3.1b	1478bc
	Binatil-4	87d	115d	2.8c	50d	68cd	2.5ab	2.9cd	1380d
	BARI Til-4	88c	127a	3.8a	55c	65d	2.4b	2.8d	1374d
Location mean									
Mymensingh		81b	122a	2.9b	36b	76a	2.5a	3.0a	1391a
Ishurdi		96a	119b	3.4a	74a	69b	2.5a	3.0a	1336b

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

From this result, it was concluded that mutant’s ESE-01 and ESE-03 performed better in yield and other yield contributing characters. Further trials will be needed to confirm this result.

Growing of M_5 population

A large number of M_5 populations from local landrace Pahari Til were grown in plant progeny rows at BINA HQ farm, Mymensingh. The purpose of this study was to select the true breeding mutants having higher seed yield and early maturity. Recommended production packages like as application of recommended doses of fertilizers, irrigation and pesticide, weeding, thinning, etc. were followed to ensure normal plant growth and development. Data was considered for plant height, number of branches plant^{-1}, number of capsules plant^{-1} and number seeds capsule^{-1}. From these data, a total of 5 mutants have been selected based on early maturity and higher seed yield potentiality. All of those mutants need further evaluation in subsequent generations.

Growing of M_4 population

A large number of M_4 populations from Binatil-2 (from three different doses) were grown in plant progeny rows at BINA HQ farm, Mymensingh. The purpose of this study was to select the true breeding mutants having higher seed yield and early maturity. Recommended production packages like as application of recommended doses of fertilizers, irrigation and pesticide, weeding, thinning, etc. were followed to ensure normal plant growth and development. Data was considered for plant height, number of branches plant^{-1}, number of capsules plant^{-1} and number seeds capsule^{-1}. From these, a total of 10 mutants have been selected based on early maturity and higher seed yield potentiality. All these mutants need further evaluation in subsequent generations.

Growing of M_3 population

A large number of M_3 population from two popular sesame varieties Binatil-2 and Binatil-4 (from four different doses) were grown in plant progeny rows for selecting desirable mutants at BINA HQ farm, Mymensingh. The objective of this study was selecting true breeding desirable mutants having higher seed yield, single husk and early maturity. Recommended production packages like application of recommended doses of fertilizers, irrigation, weeding, thinning, etc. were followed to ensure normal plant growth and development. Data was considered for plant height, number of branches plant^{-1}, number of capsules plant^{-1} and number seeds capsule^{-1}. From them primarily, a total of 16 mutants have been selected based on early maturity and higher seed yield potentiality. All of these mutants need further evaluation in subsequent generations.

Growing of M_2 population

To create genetic variability, seeds of popular sesame varieties Binatil-2 were irradiated earlier with 600, 700, 800 and 900Gy of gamma rays. Seeds were sown on 27 March 2021 at BINA HQ farm, Mymensingh. This experiment was followed by non-replicated design and sown separately (variety and dose wise). Finally, the survived plants that produced seeds were harvested separately for growing M_3 population.

Soybean

On-station and on-farm yield trial with selected M_7 soybean mutants

Three promising mutants (SBM-12, SBM-15 and SBM-17) along with two checks Binasoybean-2 and Binasoybean-6 were evaluated through this trial. The experiment was conducted at BINA HQ farm Mymensingh, BINA sub-station farms at Magura, Rangpur, Satkhira and farmers' field at Noakhali, Laxmipur, Chandpur and Barishal during January to April 2022. This experiment was laid out in a randomized complete block design with three replications. Sowing was done within first week of January. Spacing between rows was 30cm and 5-8cm between plants in a row. Unit plot size was $12m^2$ (4m × 3m). Recommended management practices 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 spill. Seed yield of each plot was recorded and converted into kg ha^{-1}. Data recorded from the experiment was analyzed following appropriate statistical analysis.

Results obtained from this trial of individual location and combined over locations for all the characters are presented in Table 76. Significant variations were observed among the mutants and check varieties for most of the characters in both of individual locations and combined over locations. On an average, maturity period ranged from 108 to 113 days and there were no statistical differences among the mutants and check varieties. Binasoybean-2 earlier than other and it requires 108 days to mature where Binasoybean-6 requires highest 113 days to mature. Similar days to maturity 111 days were obtained from SBM-12, SBM-15 and SBM-17. Plant height ranged from 34cm in Binasoybean-2 to 59cm in Binasoybean-6. There were no significant differences for Branches plant^{-1} among the mutants and check varieties. The mutants SBM-12 and SBM-15 produced the highest number of pods plant^{-1} (46) and seeds pod^{-1} (3). Two check varieties Binasoybean-2 and Binasoybean-6 produced 43 and 41 pods plant^{-1}, respectively. Pod length ranged from 4.0cm (Binasoybean-6) to 3.0cm (SBM-17 and Binasoybean-2). The highest hundred seed weight was found from the mutants SBM-15 (12.5g) and SBM-17 (12.6g). Mutant SBM-12 produced the highest seed yield of 2592 kg ha^{-1} followed by Binasoybean-2 (2457 kg ha^{-1}) and SBM-15 (2215 kg ha^{-1}). Among the locations the highest seed yield of 2650 kg ha^{-1} was obtained from BINA HQ Mymensingh followed by BINA sub-station farm Rangpur (2608 kg ha^{-1}).

Table 76. Mean performance of soybean mutants along with check varieties for different quantitative characters

Locations	Mutants & check varieties	Days to maturity	Plant height (cm)	Branches plant^{-1} (no.)	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	Pod length (cm)	100 seed wt	Seed yield (kg ha^{-1})
BINA HQ Mymensingh	SBM-12	116d	36c	2.1ab	44c	2.9a	3.6b	12.4a	2818a
	SBM-15	119b	37c	2.2a	50b	2.6b	3.7a	11.5c	2588d
	SBM-17	118c	41b	1.8b	44c	2.6b	3.6b	12.3a	2375e
	BINA-2	118c	32d	2.1ab	54a	2.7b	3.7a	11.2c	2758b
	BINA-6	120a	52a	1.7b	44c	2.9a	3.6b	12.0b	2708c
BINA Substation Magura	SBM-12	108a	39bc	3.3b	42a	2.5a	3.8b	13.0a	2683a
	SBM-15	109a	41b	3.7a	32c	2.3c	3.5c	13.2a	2684a
	SBM-17	109a	37c	2.8c	27d	2.4b	4.2a	12.5c	2192d
	BINA-2	106b	41b	3.6a	37b	2.5a	3.2c	12.2d	2450c
	BINA-6	110a	57a	3.2b	35bc	2.3c	3.7b	12.7b	2505b
BINA Substation Rangpur	SBM-12	114b	36c	3.1c	48a	2.7a	3.7b	13.6b	2820a
	SBM-15	111c	40b	3.7b	40c	2.4b	3.8b	13.6b	2472d
	SBM-17	116a	35c	3.3c	35d	2.6a	3.7b	14.4a	2403d
	BINA -2	109d	35c	3.9a	42bc	2.4b	4.0a	12.4c	2713b
	BINA-6	114c	56a	3.6b	44b	2.3b	3.8b	12.7c	2630c
BINA Substation Satkhira	SBM-12	107a	39b	1.5c	45a	2.4	3.7b	13.1a	2806a
	SBM-15	105b	37b	1.8b	38c	2.4	3.8b	13.3a	2396c
	SBM-17	101d	34c	2.3a	30d	2.4	3.7b	12.3c	2191d
	BINA-2	103c	34c	1.8b	42b	2.4	4.0a	12.8b	2774b
	BINA-6	112d	56a	1.9b	37c	2.5	3.8b	12.4c	2421c
Farmer's Field Noakhali	SBM-12	111c	42bc	1.5c	45a	2.9ab	4.0b	12.2a	2149a
	SBM-15	112b	46b	2.1b	31d	3.1a	4.4a	12.0a	2066b
	SBM-17	112b	38c	2.0b	36c	2.7b	4.0b	11.3c	1973c
	BINA -2	112b	34d	2.7a	42b	3.1a	4.1b	11.2c	2155a
	BINA -6	113a	58a	2.6a	43b	3.0a	4.4a	12.2a	2015b
Farmer's Field Laxmipur	SBM-12	111b	39bc	2.8c	47a	2.8	3.0c	12.5b	2489a
	SBM-15	105c	44b	3.2bc	36c	2.8	3.2c	12.0b	1900d
	SBM-17	111b	43b	3.6b	44b	2.8	3.6b	12.4a	1872e
	BINA-2	112a	34c	3.3bc	47a	2.8	3.2c	12.0b	2153b
	BINA-6	112a	72a	4.0a	43b	2.6	3.8a	12.3b	2088c
Farmer's Field Chandpur	SBM-12	112a	39cc	3.9b	40a	3.1a	3.0	12.5a	2454a
	SBM-15	113a	38c	5.0a	27b	2.7b	2.9	11.2b	2086c
	SBM-17	107b	48b	4.0b	34c	3.1a	3.0	11.2b	1982d
	BINA-2	101c	35d	3.8b	40a	3.0a	2.8	12.2a	2262b
	BINA-6	112b	57a	3.3c	39a	2.8ab	3.0	12.1a	2063c
Farmer's Field Barishal	SBM-12	106b	30d	3.6a	53a	2.8b	2.1b	12.5bc	2512a
	SBM-15	110ab	39c	1.5cd	41b	2.8b	1.9b	12.8b	2088d
	SBM-17	112a	52b	3.1b	43b	2.8b	1.8b	12.9b	1969e
	BINA-2	101c	27d	1.8c	42b	2.8b	1.8b	13.7a	2388b
	BINA-6	112a	60a	3.5a	43b	3.0a	3.2a	12.2c	2190c
Combined mean over	SBM-12	111b	37cd	2.7	46a	2.8a	3.2c	12.5a	2592a
	SBM-15	111b	43b	3.0	39b	2.7b	3.5b	12.6a	2215d

locations	SBM-17	111b	39c	2.8	35c	2.7b	3.0c	12.2b	2189e
	BINA-2	108c	34d	2.9	43a	2.7b	3.0c	12.2b	2457b
	BINA-6	113a	59a	3.0	41b	2.7b	4.0a	12.3b	2328c
Location mean									
BINA H.Q. Mymensingh		118a	40c	2.0d	47a	2.7a	4a	12.0c	2650a
BINA Sub-station Magura		108c	43b	3.3b	35c	2.4b	4a	12.7b	2503b
BINA Sub-station Rangpur		112b	40c	3.5b	42b	2.5b	4a	13.3a	2608a
BINA Sub-station Satkhira		103d	40c	1.9d	38bc	2.4b	4a	12.8b	2518b
Farmer's Field Noakhali		112b	44b	2.2d	39bc	3.0a	4a	11.7d	2072e
Farmer's Field Laxmipur		110c	46a	3.4b	43b	2.8a	3b	12.2c	2100d
Farmer's Field Chandpur		108c	44b	4.0a	36c	2.9a	3b	11.8d	2170d
Farmer's Field Barishal		108c	41c	2.7c	44b	2.8a	2.5c	12.7b	2230c

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

From this trial, it was observed that SBM-12 and SBM-15 was the best performer among the mutants. Mutant SBM-12 has been released as a new mutant variety named as BINA soybean 7.

Regional yield trial with selected M_6 soybean mutants

Three promising mutants (SMB-22, SMB-23 and SMB-25) along with two check varieties Binasoybean-2 and Binasoybean-6 were evaluated through this trial. This experiment was conducted at BINA sub-station farms at Noakhali, Barishal, Satkhira, Magura and Rangpur during January to April 2022. This experiment was laid out in randomized complete block design with three replications. Sowing was done on 14 January 2022. Spacing between rows was 30cm and 7-10cm between plants in a row. Unit plot size was 12m^2 (4m $\times$ 3m). Recommended management practices were followed to ensure proper growth and development of plants. Data on various characters such as plant height, number of branches plant^{-1}, pods plant^{-1} and seeds pod^{-1} were taken from 10 randomly selected plants of each plot. Maturity period was counted when the plant and pods of each plot turned into yellowish brown color and almost all the leaves shed. Seed yield of each plot was recorded and converted into kg ha^{-1}. Data recorded from the experiment were analyzed following appropriate statistical design.

On an average, maturity period ranged from 109 days (Binasoybean-2) to 114 days (SBM-23). Plant height ranged from 34cm (Binasoybean-2) to 62cm (SBM-23) and branches plant^{-1} ranged from 2.9 (Binasoybean-2) to 3.6 (SBM-22). Mutant SBM-22 produced highest pods plant^{-1} (77); whereas, the check varieties Binasoybean-2 and Binasoybean-6 produced 43 and 53 pods plant-1, respectively. Binasoybean-6, SBM-22 and SBM-23 produced the highest number of seeds pod^{-1} (4). Mutant SBM-25 had the highest pod length (2.88) followed by Binasoybean-2 (2.70) and mutants SBM-23 (2.67). Hundred seed weight was higher in Binasoybean-2 (13.34g) and lower hundred seed weight was obtained from SBM-23 (11.1g).

Seed yield obtain from the mutants and checks were significantly differ from each other's. Mutant SBM-25 produced the highest seed yield of 2836 kg ha^{-1} followed by SBM-22 (2696 kg ha^{-1}). Among the locations the highest seed yield was obtained from BINA sub-station farm Satkhira (2758 kg ha^{-1}) followed by the BINA sub-station farm at Barishal (2714 kg ha^{-1}).

Table 76. Mean performance of soybean mutants along with check varieties for different quantitative characters

Locations	Mutants/ varieties	Days to maturity	Plant height (cm)	Branches plant^{-1} (no.)	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	Pod length (cm)	100 seed wt. (g)	Seed yield (kgha^{-1})
BINA Sub-station Noakhali	SBM-22	115a	52 c	4.3b	55a	3.9b	1.8d	12.5c	2639b
	SBM-23	114ab	73a	3.7cd	46b	3.4d	2.2b	10.3d	2521c
	SBM-25	113b	62b	4.4a	64c	4.0a	2.6a	12.0b	2843a
	BINA-2	105c	25e	3.6d	44d	3.5c	2.2b	13.3a	2542c
	BINA-6	114ab	47d	3.5e	47d	3.5c	2.0c	12.7b	2520c
BINA Sub-station Barishal	SBM-22	111c	60c	3.3a	85a	3.9d	2.8c	12.5c	2781c
	SBM-23	114ab	72a	3.0b	84a	4.30a	3.0a	10.5d	2537b
	SBM-25	115a	61c	3.0b	85a	3.63e	2.8c	12.2d	2874d
	BINA-2	112b	38d	2.0c	39c	4.04c	2.9b	13.7a	2668a
	BINA-6	111c	67b	2.2c	62b	4.2 b	2.8c	12.5b	2710b
BINA Sub-station Satkhira	SBM-22	112b	47c	3.6c	85a	3.9b	1.8 d	12.0c	2806b
	SBM-23	114a	59a	3.3d	75b	4.0a	2.2b	11.2d	2547c
	SBM-25	112b	53b	4.4a	44c	3.5c	2.3a	12.5c	2940a
	BINA-2	111bc	38d	3.3d	24d	3.5c	2.2b	13.0a	2715d
	BINA-6	113ab	46c	3.8b	27d	3.5c	2.0c	12.2b	2783d
BINA Sub-station Magura	SBM-22	112b	57b	4.3a	84a	3.9d	2.8c	12.7b	2574b
	SBM-23	114a	67a	2.9d	77c	4.30a	3.0a	12.3c	2492d
	SBM-25	115a	54c	3.2b	81b	3.6e	2.8c	13.5a	2637a
	BINA-2	110c	36d	2.5d	48e	4.0c	2.9b	12.9b	2510c
	BINA-6	112b	54c	3.1c	62d	4.2b	2.8c	12.4d	2550c
BINA Sub-station Rangpur	SBM-22	110c	40c	2.3d	73b	4.0c	3.4b	12.6b	2681b
	SBM-23	115a	48b	2.0e	55e	3.3e	2.9d	11.2c	2537c
	SBM-25	113b	36d	2.6c	78a	3.8d	3.8a	12.7d	2887a
	BINA-2	108d	31e	3.0b	60d	4.2b	3.2bc	13.9a	2668b
	BINA-6	112b	68a	3.4a	65c	4.6a	3.4b	12.3b	2669b
Combined mean over locations	SBM-22	112ab	51b	3.6a	76a	3.9ab	2.5	12.5b	2696b
	SBM-23	114a	62a	3.0b	67b	3.9ab	2.7	11.1c	2527d
	SBM-25	113a	53b	3.5a	70ab	3.7b	2.9	12.6b	2836a
	BINA-2	109b	34c	2.9b	43d	3.8ab	2.7	13.4a	2620c
	BINA-6	112ab	56ab	3.2b	53c	4.0a	2.6	12.4b	2646c
Location mean									
BINA Sub-station Noakhali		112b	52bc	3.9a	51c	3.7b	2.2c	12.2c	2613c
BINA Sub-station Barishal		113a	60a	2.7c	71a	4.0a	2.9b	12.3c	2714b
BINA Sub-station Satkhira		112b	49c	3.9a	51c	3.7b	2.1c	12.2c	2758a

BINA Sub-station Magura	113a	54b	3.2b	70a	4.0a	2.9b	12.8a	2553d
BINA Sub-station Rangpur	111c	45d	2.7c	66b	4.0a	3.3a	12.5b	2688bc

N.B.: In a column, values with same letter do not differ significantly at 5% level. BINA-2 means Binasoybean-2 & BINA-6 means Binasoybean-6

From this experiment, it was observed that SBM-25 was the best performer among the mutants and checks (Table 12). Further trials will be needed to confirm the result.

Evaluation of promising salt tolerant soybean genotypes in pot culture

Three promising soybean mutants SBM-22, SBM-25 and SBM-26 along with three soybean varieties Binasoybean-2 (Parent), Binasoybean-6 and Lokon were evaluated to investigate the performance in saline condition. The experiment was conducted at BINA HQ, Mymensingh during Jan to April 2022, and laid out in a completely randomized design (CRD) with three replications. Before seed sowing, artificial salinity was created with NaCl and maintained 4 dS/m, 6 dS/m and 8 dS/m in each pot (10 kg soil in each pot). Data on various characters such as plant height, number of leaves plant^{-1}, leaf area and chlorophyll content (SPAD meter) was recorded from five randomly selected plants of each doses.
Comparing with imposed salinity level and time, plant height as well as leaf was decreased. All the germinated genotypes were survived at 4 dS/m up to 21 days (Table 78). All the mutants showed moderately tolerant at 4 dS/m up to 7 days after sowing. Furthermore, Binasoybean-2, Binasoybean-6 and Lokon performed well with the advancement of time.

Table 78. Visual salt injury at seedling stage

Varieties/ mutant	7 days after seeding			14 days after seeding			21 days after seeding		
	4 dS/m	6 dS/m	8 dS/m	4 dS/m	6 dS/m	8 dS/m	4 dS/m	6 dS/m	8 dS/m
SBM-22	MT	NG	NG	MT	NG	NG	S	NG	NG
SBM-25	MT	NG	NG	MT	NG	NG	S	NG	NG
SBM-26	MT	NG	NG	MT	NG	NG	S	NG	NG
Binasoybean-2	HT	NG	NG	HT	NG	NG	MT	NG	NG
Binasoybean-6	HT	NG	NG	HT	NG	NG	MT	NG	NG
Lokon	HT	NG	NG	HT	NG	NG	HT	NG	NG

N.B.: HT= Highly tolerant, T= Tolerant, MT= Moderately tolerant, S= Susceptible, HS= highly susceptible and NG= Not germinated.

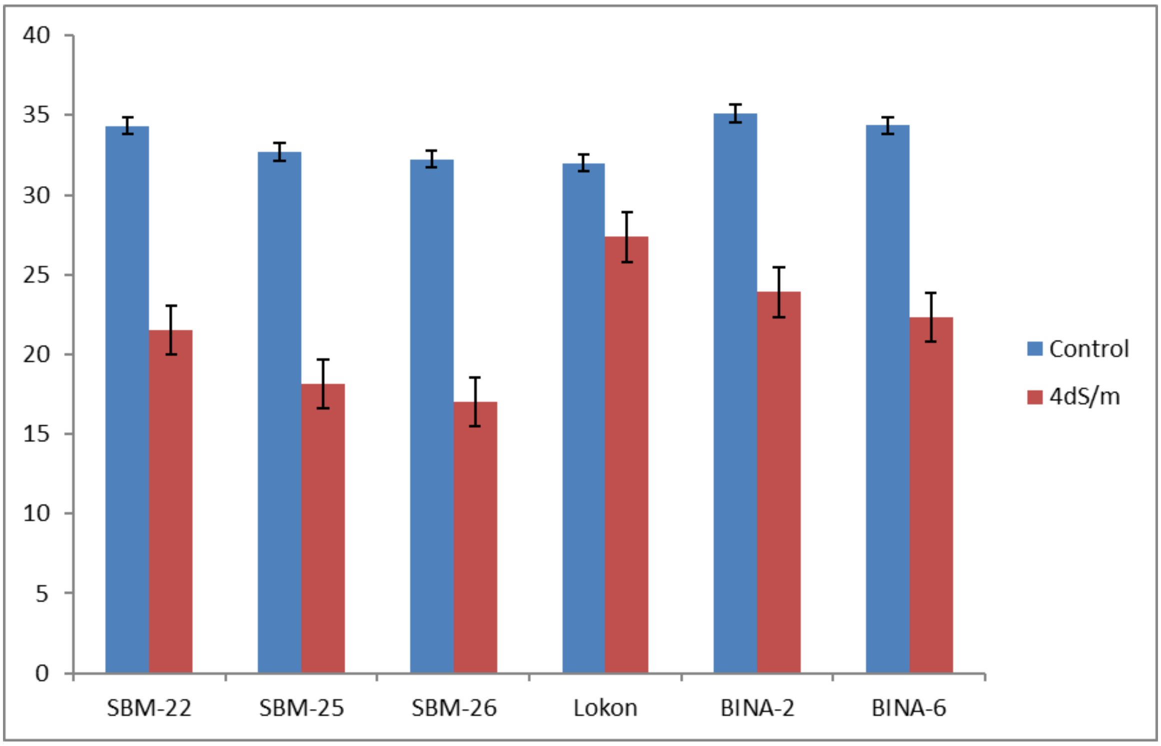


Fig. 15: Chlorophyll content of selected genotypes at saline and non-saline condition (Here, BINA-2 means Binasoybean-2 and BINA-6 means Binasoybean-6)

Total chlorophyll content was shapely decreased at saline condition (Fig. 15). The decreased rate was lower at lokon than other indicating its salt tolerance potentiality. Total chlorophyll content was relatively higher for the mutants SBM-22 and lower for SBM-26. From the visual salt injury score and chlorophyll content it was concluded that the mutants SBM-25 and SBM-26 was susceptible for salinity whereas Binasoybean-2, Binasoybean-6 and Lokon performed well and could be selected for the parent of stress breeding program.

Growing of M_5 population

A large number of M_5 populations from Lokon were grown in plant progeny-rows for selecting desirable mutants at BINA HQ farm, Mymensingh. Sowing was done within first week of January. Spacing between rows was 30cm and 7-10cm between plants in a row. Recommended production packages like application of recommended doses of fertilizers, irrigation, weeding, thinning, etc. were followed to ensure normal plant growth and development. Data were considered for plant height, number of branches plant^{-1}, number of pods plant^{-1} and number seeds pod^{-1}. From them primarily, a total of five mutants have been selected based on their agronomic performances for subsequent generations.

Growing of M_4 population

A large number of M_4 populations from Binasoybean-3, Binasoybean-2, BU Soybean-1 and Taiwan-141 were grown in plant progeny-rows for selecting desirable mutants at BINA HQ farm, Mymensingh. Sowing was done within first week of January. Spacing between rows was 30cm and 7-10cm between plants in a row. Recommended production packages like application of recommended doses of fertilizers, irrigation, weeding, thinning, etc. were followed to ensure normal plant growth and development. Data were considered for plant height, number of branches plant^{-1}, number of pods plant^{-1} and number seeds pod^{-1}. From them primarily, a total of nine mutants have been selected based on their agronomic performances for subsequent generations.

Growing of M_3 population

A large number of M_3 populations from AVRDC366 and BU soybean-2 were grown in plant progeny-row for selecting desirable mutants at BINA HQ farm, Mymensingh. Sowing was done within first week of January. Spacing between rows was 30cm and 7-10cm between plants in a row. Recommended production packages like application of recommended doses of fertilizers, irrigation, weeding, thinning, etc. were followed to ensure normal plant growth and development. Data were considered for plant height, number of branches plant^{-1}, number of pods plant^{-1} and number seeds pod^{-1}. From them primarily a total of 12 mutant variants have been selected based on their agronomic performances for subsequent generation.

Growing of M_2 population

Five bulk population (150, 200, 250, 300 and 400Gy of gamma rays using 50% and 75% attenuation) of salt tolerant soybean variety Lokon were grown in plant progeny-rows for selecting desirable mutants at BINA HQ farm, Mymensingh. Sowing was done within first week of January. Spacing between rows was 30cm and 7-10cm between plants in a row. Recommended production packages like application of recommended doses of fertilizers, irrigation, weeding, thinning, etc. were followed to ensure normal plant growth and development. Data were considered for plant height, number of branches plant^{-1}, number of pods plant^{-1} and number seeds pod^{-1}. From them primarily a total of 15 mutant variants have been selected based on their agronomic performances for subsequent generations.

Growing of M_1 population

To create genetic variability, seeds of soybean variety A-363, PK-416, YESOY-4, PM-78-6-3-13, HISW, LG-92P was irradiated with 150, 200, 250, 300 and 350Gy of gamma rays. Seeds were sown on January 2022 at BINA HQ farm, Mymensingh. This experiment was followed non-replicated design and sown separately (variety and dose wise). At maturity stage the survived plants produced seeds were harvested separately for growing M_2 population.

Maintenance of germplasm (mutants, local and exotic collections)

Thirty germplasms along with four stable mutants were grown at BINA HQ farm, Mymensingh. After harvest, seeds of all germplasms were collected and preserved as breeding materials for future breeding programme.

Sunflower

Evaluation of sunflower germplasms for utilization in varietal improvement program

Twenty-three sunflower germplasm collected from BARI were grown in plant progeny-rows at BINA Head Quarter farm, Mymensingh on 28 December 2021. The experiment was conducted in a non-replicated design and unit plot size was 24m^2 (4m × 6m) with 50cm line to line spacing and 25cm from plant to plant within a line. Recommended production packages i.e., application of fertilizers, irrigation, weeding, thinning etc. were followed to ensure normal plant growth and development. Data on plant height (cm), head diameter (cm) and seeds/head were taken from 5 randomly selected plants from each plot. Maturity period was counted when 90% heads were matured in a plot. Appropriate statistical analysis was performed for comparison of mean of each character.

Data was recorded on average plant height (cm), head diameter (cm) and seeds/head from 5 randomly selected plants of each plot. Recorded data were subjected to proper statistical analyses and presented in the Table 79. On an average, maturity period ranged from 98 to 125 days. BD9328 required shortest maturity period of 98 days and BD9382 required the longest maturity period of 125 days. Plant height ranged from 122 to 204cm. BD9385 produced the tallest plant (204cm) followed by BD9382 (172cm). BD9340 and BD9359 were comparatively dwarf having 122 and 123cm plant height. Head Diameter (cm) is one of the major yield contributing characters of sunflower, it was ranged from 10-20.2cm. Among the genotypes, BD9382 produced highest number of seeds head^{-1} (441) followed by BD9349 (408). Considering yield contributing traits lines BD9340, BD9359, BD9349, BD9396, BD9391, BD9382 and BD9358 have been selected for future varietal improvements program.

Table 79: Yield and yield attributes of sunflower germplasm

Germplasm & Check variety	Days to maturity	Plant height (cm)	Head Diameter (cm)	Seeds/Head (no.)
BD9340	105	123	11.6	318
BD9359	107	122	11.5	391
BD9333	111	156	15.0	326
BD9328	98	141	16.0	356
BD9349	117	142	11.5	408
BD9358	98	143	11.6	358
BD9363	103	146	16.3	307
BD9369	108	163	13.9	211
BD9380	114	155	15.1	315
BD9382	125	172	18.0	441
BD9385	114	204	14.4	378
BD9386	120	146	15.5	301
BD9386	115	147	13.0	319
BD9390	104	147	14.0	370
BD9391	105	167	17.0	390
BD9392	109	149	10.0	281
BD9393	122	133	15.4	306
BD9394	124	187	16.4	297
BD9395	119	170	20.0	318
BD9396	120	165	15.2	391
BD9397	107	175	20.2	326
BD9398	108	156	16.5	356
BD9401	122	169	13.2	408
BARI Surjomukhi-2	115	140	15.0	359
Range	98-125	122-204	10-20.2	211-441
Mean±SE	120±1.69	156±4.04	14±0.55	342±10.74

Growing of M_4 generation of sunflowers

Twenty-three sunflower mutants and ten selected germplasm with three checks BARI Surjomukhi-2, BARI Surjomukhi-3 and Hycan-33 were used in this experiment. Mutants and germplasm were grown in plant progeny-rows at BINA Head Quarter farm, Mymensingh on 28 December 2021 following augmented block design. BARI Surjomukhi-2, BARI Surjomukhi-3 and Hycan-33 were included in each block with three replications. All the genotypes were sown in a non-replicated design and unit plot size was 24m^2 (4m × 6m) with

50cm line to line spacing and 25cm from plant to plant within a line. Recommended production packages i.e., application of fertilizers, irrigation, weeding, thinning etc. were followed to ensure normal plant growth and development. Data on plant height (cm), head diameter (cm) and seeds/head were taken from five randomly selected plants from each plot. Maturity period was counted when 90% heads were matured in a plot. Percent protein content was determined on the basis of total nitrogen content (from soil science division). Appropriate statistical analysis was performed for comparison of mean of each character.

The key yield contributing characteristics of sunflowers are plant height, Head diameters, hundred seed weight and seeds plant^{-1}. All of the genetic parameters with the coefficient of variation, heritability and genetic advancement for the intended characteristics presented in Table 15. The highest phenotypic component of variance was found for number of seeds, filled grain and unfilled grain (124434.80, 53079.61 & 53539.76), followed by leaf area and plant height (1846.79 & 545.15), where the lowest magnitude of phenotypic component of variance was observed in seed length (0.01) followed by plant diameter (0.20). Phenotypic coefficient of variance was greater than Genotypic coefficient of variance for each characteristic, and it was highest for unfilled grain (77.44 & 84.22). Number of filled grain, seed wt. plant^{-1}, and total seeds plant^{-1} (94.03, 936.83 & 92.18, respectively) had the highest heritability.

Table 80: Genetic parameter of studied sunflower mutants

Trait	VP	VG	VE	GCV	PCV	ECV	h^2b	GA
Days to maturity	125.21	56.55	68.65	6.43	9.57	7.09	45.17	10.43
Plant height (cm)	545.15	479.32	65.83	15.26	16.28	5.66	87.92	42.35
Leaf No.	31.33	24	7.34	18.21	20.81	10.07	76.59	8.84
Leaf arear (m^2)	1846.79	1180.94	665.85	13.05	16.32	9.8	63.95	56.69
Plant diameter (cm)	0.2	0.1	0.11	15.51	22.62	16.46	47.02	0.44
Head diameter (cm)	7.21	4.88	2.33	12.97	15.76	8.95	67.73	3.75
Total no. of seeds	121135	111663	9471	39	40	11	92	662
Filled grain (no.)	53080	49911	3169	38	39	10	94	447
Unfilled grain (no.)	53540	45259	8281	77	84	33	85	404
hundred seed wt.(g)	0.48	0.15	0.33	5.90	10.62	8.83	30.83	0.44
Seed length (cm)	0.01	0.007	0.02	1.05	11.93	14.9	2.04	0.01
Seed width (cm)	0.0008	0.0007	0.0007	1.71	5.70	5.44	9.03	0.01
Seed wt. plant^{-1} (g)	229.19	215.05	14.13	38.53	39.77	9.88	93.83	29.31

VP = Phenotypic component of variance, VG = Genotypic component of variance, VE=Environmental component of variance, GCV = Genotypic coefficient of variance, PCV = Phenotypic coefficient of variance, ECV = Environmental coefficient of variance, h^2b = Broad see heritability, GA = Genetic advance

Data on days to maturity, plant height, head diameter, total no. of seeds, filled and unfilled grain and hundred seed wt. were taken and presented in Table 81. On an average, maturity period ranged from 91 to 139 days. DP150(1) required shortest maturity period of 91 days and LP350(4) required the longest maturity period of 139days. Plant height ranged from 94.21 to 209.31cm. DP150(2), DP150(2), DP250 were the dwarf plant having plant height below 100cm. Head Diameter (cm) is one of the major yield contributing characters of sunflowers, it was ranged from 11.84-22.51cm, whereas fill grain head^{-1} range from 164-

1103. The protein content of the selected genotypes was ranged from 19.27% to13.41%. Maximum protein was recorded from B10 followed by B11.

Table 81: Mean performance of studied sunflower mutants

Treatment	Dm	Ph	Hd	Fg	Ts	Hw
DP150 (2)	99	94.21	16.91	365	506	7.38
DP150(1)	91	96.01	15.91	568	590	6.56
DP250	94	99.31	21.31	574	628	6.13
DP350(1)	120	107.41	20.71	837	870	7.57
DP350	109	105.01	15.71	911	956	6.63
LP150	122	156.31	11.84	909	460	5.22
LP250	131	144.71	15.54	413	691	5.76
LP350(3)	135	147.41	15.74	630	466	6.14
LP350(4)	139	184.31	20.54	931	937	6.24
LP350(5)	134	194.31	20.84	369	115	6.34
LP350(6)	128	185.31	16.79	602	118	6.04
LP350(7)	121	147.31	17.83	585	938	5.43
LP350(1)	118	157.31	15.64	776	941	5.3
LP350(2)	134	165.31	16.54	654	240	4.34
LP350	123	168.31	14.74	378	736	6.55
MH(1)350	124	169.01	21.71	557	648	6.02
MH(2)350	119	152.01	19.51	517	719	8.52
MH(3)350	133	209.31	22.07	341	522	7.39
MH(4)350	124	145.31	16.09	384	560	6.27
MH150	95	129.01	18.91	328	315	7.13
MH250	113	111.11	22.51	816	598	7.24
MP150	102	141.61	17.01	494	643	6.14
MP250	103	152.21	13.71	1103	123	6.62
MP350	101	139.01	14.01	747	826	7.53
B10	124	134.78	17.64	1025	133	6.69
B11	113	118.68	14.04	713	885	7.44
B14	109	133.78	16.64	790	120	6.04
B4	123	133.88	13.54	756	863	7.34
B6	120	125.68	14.74	538	652	6.03
BD93	120	143.68	15.64	164	414	6.34
BD9379	130	132.33	15.91	459	716	6.31
BD9381	119	139.68	18.14	343	474	6.64
BD9401	116	133.98	19.64	239	600	6.54
BD9850	114	141.73	14.89	512	743	6.34
BARI-2	105	151.67	17.18	396	648	6.98
BARI-3	100	154.33	14.44	431	797	7.09
Hycan-33	139	184.31	20.54	931	937	6.24
Range	91-139	94.21-209.31	11.84-22.51	164-1103	315-937	4.34-8.52

Dm=Days to maturity, Ph=Plant height (cm), Hd= Head diameter (cm), Ts= Total no. of seeds, Fg= Fill grain, Hw= Hundred seed wt., BARI-2= BARI Surjomukhi-2 and BARI-3= BARI Surjomukhi-3

Considering the overall performance and protein content (Figure 16) genotypes DP150 (2), DP150(1), DP350(1), DP350, LP150, B10, B11, B14, B4, B6, LP350 (3), LP350 (4), LP350(1) have been selected for future trail.

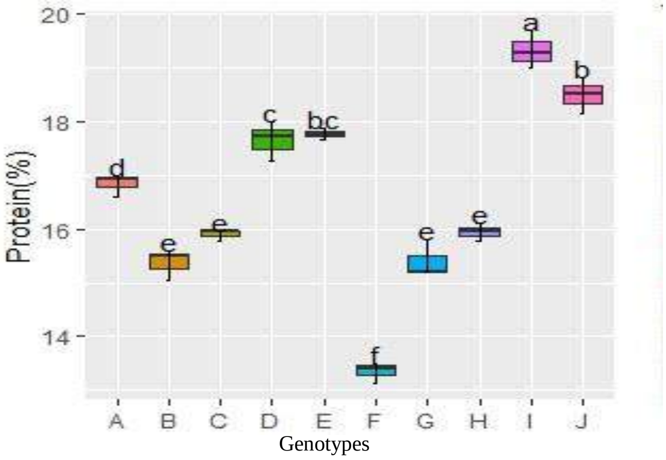


Fig 16. Protein contents of selected sunflower genotypes

Here, A=DP150(2), B=DP150(1), C=DP350(1), D=DP350, E=LP150, F=LP350(3), G=LP350 (4), H=LP350(1) I=B10, J=B11

Growing of M_3 to M_2 generation of sunflower mutants

A large number of M_3 and M_2 variants developed from different irradiated materials were grown for selecting desirable mutant at BINA Head Quarter farm, Mymensingh. The seeds were sown on 20-26th December 2021. All the seeds were space planted in 3m long five rows with 50cm row and 30cm plant spacing. Recommended fertilizer was applied and necessary steps were taken to grow the crop uniformly.

Total 120 segregating population was evaluated for yield and yield contributing characters. Among them 85 was segregating families and other 35 was single plant. All of the segregating populations were obtained from M_2 population that have been selected from previous trials, whereas single plant population was from earlier M_1 population. A total of three families from M_3 and seven families from M_2 was selected and mass for future generation advancement. The selection was facilitated considered the maturity period (90-105 days) with other yield contributing characters. From various early generation single plant also selected considering maturity period, seed color, no. of seeds per head, head diameter and other agronomic traits. Fifty single plant have been selected and harvested separately for future utilization of varietal improvement program. From the variant population a total of 60 true breeding mutants also been selected primarily for further selection that will be grown respective advance generation on the basis of their agronomic performances.

Growing of M_1 generation of sunflower

The well dried seed of BARI Surjomukhi-3 was used here. Ten seeds were exposed to 6 doses of EMS (0.2%, 0.4%, 0.6%, 0.8% and 1%). Prior to mutagenic treatment seeds were kept in desiccators for moisture equilibration. The seeds were subjected to chemical mutagen for 12 hours. The response variables, percent germination (%G) and percent survival (%S) rate were estimate after 21 days of sowing. The highest seed germination percentage occurred with doses of 0.2 and 0.4% EMS, whose values were 78% and 58%, respectively decrease progressively as the mutagenic dose was increased (Figure 17). Percentage of survival was a consequence of percentage germination. As the dose increased from 0.6 to 1.0%, the percentage of survival was decreased, indicating that sunflower also a sensitive species at high levels of radiation (Figure 5). In the present investigation, we found that at the doses of 0.5% EMS, near about 50% of the population dies. Therefore, does near about 0.5% chemical mutagen may be use for the genetic variability in sunflower.

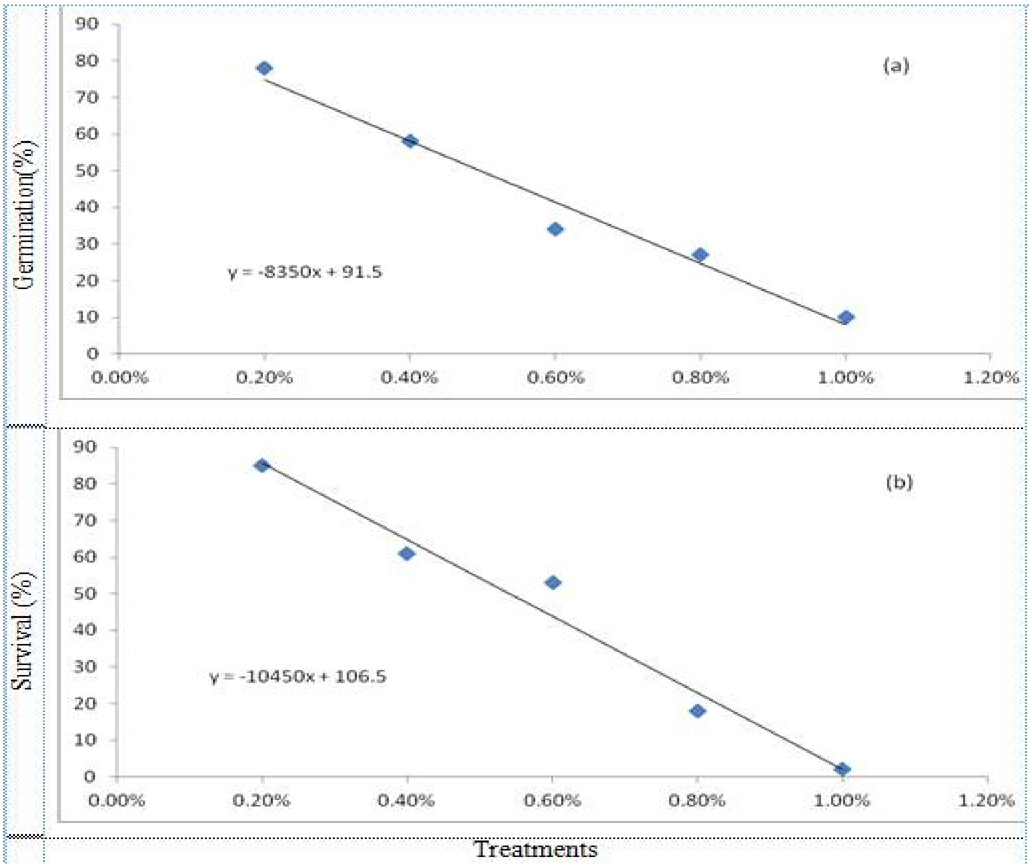


Fig 17: Germination (a) and survival percentage (b) of sunflowers seedlings subjected to five levels of EMS

Programme Area: Varietal Improvement of Pulse Crops
Project: Varietal improvement of mungbean using mutation breeding techniques

On-farm & on-station yield trial of promising summer mungbean mutant

The mung bean (*Vigna radiata L.*), commonly known as green gram, is a long-cultivated pulse crop that originated in South East Asia and is a member of the Papilionoideae family. Mung beans are primarily farmed for human consumption. It can be eaten as a vegetable or as cooked. Thus, it has great value as food and fodder. It is a cheap source of protein for human consumption. Mung bean has special features such as its earliness in maturity, supply of good yield, drought-resilient property that makes it highly responsive in scanty rainfall. Moreover, due to short duration, it can fitted well in cropping pattern. Objectives of this research are to evaluate the overall performance of the mutant for earliness, disease tolerance and seed yield. For this experiment, the mutant line MBM-656-51-2 with the check varieties Binamoog-8 and BARI Mung-6 were used during Kharif-1 season of 2022 at different locations (BINA sub-stations Ishwardi, Magura 7 farmer's field Natore). The experiment was followed RCB design with three replications. The size of unit plot was 5.0 m × 6.0 m. Row to row and plant to plant distances were 40 and 10-15 cm, respectively. Data on days to maturity, plant height, pods plant^{-1}, pod length, seeds pod^{-}1 and seed yield (tha-1) were recorded. Maturity was assessed plot basis. The data for the characters under study were statistically analyzed wherever applicable. Data were analyzed using Minitab statistical package.

Results revealed that significant variations were observed among the mutant and the check varieties at different locations. It was observed from the Table 82 that, the check variety MBM-656-51-2 had shorter plant height than the check varieties at all the locations. From mean over locations, the tested mutant matured earlier (62.3c days) than check varieties. The highest number of pods plant^{-1} (16.9a) was found in MBM-656-51-2. In respect of seed yield, this mutant produced the highest seed yield of 1.76a tha^{-1} followed by BARI Mung-6 (1.47c tha^{-1}) and Binamoog-8 (1.68b t/ha). It will be registered to release this mutant (MBM-656-51-2) as a variety. Based on the present findings, it can be concluded that, the line MBM-656-51-2 can ensure better yield with the highest economic return for the farmers in the study area. Further evaluation of the line MBM-656-51-2 can be helpful to be registered as short duration mungbean variety.

Table 82. Agronomic performance of mungbean lines along with check variety at different locations during Kharif-1season, 2021-22

Location(s)	Mutants/varieties	Days to maturity	Plant height (cm)	Pods plant^{-1} (no)	Pods length (cm)	Seeds pod^{-1} (no)	Seed yield (tha^{-1})
BINA sub-station Ishwardi	MBM-656-51-2	63b	60.26a	17.0a	9.36a	14.0a	1.71a
	Binamoog-8	66a	60.50a	16.8a	8.70a	12.9a	1.67a
	BARI Mung-6	67a	68.8b	13.89b	8.00b	9.66b	1.45b
BINA sub-station Magura	MBM-656-51-2	62b	60.00b	17.1a	8.9a	14.34a	1.78a
	Binamoog-8	63ab	60.59b	15.47ab	8.29ab	13.67a	1.71b
	BARI Mung-6	65a	69.7a	12b	7.95b	10.25b	1.50c
Farmer's field Natore	MBM-656-51-2	62b	60.96b	16.87a	8.43a	14a	1.79a
	Binamoog-8	63b	61.5b	15.12a	8.36a	12.76a	1.70b
	BARI Mung-6	67.33a	70.06a	12.3b	8.13a	10.36b	1.49c
Mean over locations	MBM-656-51-2	62.3c	60.62b	16.9a	8.47a	14.12a	1.76a
	Binamoog-8	64.2b	60.66b	15.88a	8.11b	12.9b	1.68b
	BARI Mung-6	66.5a	66.51a	12.7b	8.25ab	10.1c	1.47c
	StDev	2.332	4.893	2.697	0.2388	1.822	0.1346
	SE Mean	0.449	0.96	0.519	0.046	0.351	0.0259

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

Evaluation of summer mungbean lines for synchronous pod maturity with yield

Despite the importance of synchronous maturity, mungbean pod ripening is not synchronous. Uneven pod maturity leads to low yield and low harvesting index (HI) inmungbean. A high harvest index means high proportion of total biomass production. Thus in order to increase the seed yield, selection of higher harvest index genotypes could be achieved through synchronous maturity. The inverse effects on seed yield due to high leafiness and asynchronous flowering have been observed.

Opportunities further exist to investigate potential synchronously maturing mutants in mungbean through induced mutagenesis. Such induced mutagenesis could help mungbean to be accepted as the main pulse crop in Asian countries in high fertile lands and sufficient without completing directly with major crops like wheat, rice and cotton. The objective of this experiment was to investigate the synchrony in pod maturity with highest yield potential of mungbean

With a view to identify earliness, synchronous pod maturity, disease tolerant and higher yielding mutant(s) MB-03, MB-07, MB-26 and MB-32 and two check variety varieties (Binamoog-8, BARI Moog-6) were sown at 23 February, 2022 at BINA substation, Barishal; 02 March, 2022 at BINA substation farm Magura; and 21 March, 2022 at BINA substation, Ishwardi. The experiment was conducted in RCB design with three replications. The size of the unit plots were 4.0 m × 3.0 m. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied form Urea, TSP, MoP, Gypsum and Zinc Sulphate. Cultural and intercultural practices were followed as and when necessitated. Data on duration, plant height, number of branch plant^{-1}, number of mature pods plant^{-1}, number of immature pods plant^{-1}, Pod length (cm), number of seeds pod^{-1}, 100 seed wt. (g.), and plot yield (g) were recorded after harvest from 5 randomly selected competitive plants. Maturity was assessed plot basis. Plot yield was recorded to t/ha. Finally, all the recorded data were subjected to proper statistical analyses as per design used and are presented in Table 83.

Table 83: Yield and yield contributing characters of some mutants of mungbean

Location	Mutant	Duration	Plant height (cm)	No. of branch plant^{-1}	Mature pod	Immature pod	Pod length (cm)	No. of seed pod^{-1}	100 seed wt. (gm)	Yield (tha^{-1})
Magura Subtation	MB-03	64.67d	30.33c	0.33c	8.93	0.13c	7.93a	11.07	4.94a	1.74a
	MB-07	67.67bc	31.13c	0.80c	9.13	0.40bc	7.92a	10.93	4.98a	1.70a
	MB-32	69.67b	38.33b	1.53b	10.80	2.13bc	7.71ab	11.27	5.12a	1.71a
	Binamoog-8	66.00cd	44.07a	2.47a	10.33	5.87a	7.06b	11.40	4.22b	1.67a
	BARI Mung-6	72.33a	39.87b	1.67b	9.87	3.40ab	8.0a	10.40	4.42ab	1.58b
	CV	2.06	6.44	28.22	35.76	69.07	5.06	4.98	6.80	2.58
	LSD	2.64	4.43	0.72	6.60	3.10	0.73	1.03	0.60	0.08
Barishal Subtation	MB-03	68.00ab	29.70a	2.37NS	11.33	00.00c	7.59ab	12.50a	4.62a	1.79a
	MB-07	67.33b	28.87b	2.67NS	11.80	0.17bc	7.69a	10.43ab	4.38ab	1.78ab
	MB-32	69.33ab	28.60b	2.47	11.53	0.95b	7.53a	9.40b	4.63a	1.64ab
	Binamoog-8	69.33ab	31.27a	2.67	9.33	2.77a	7.73a	11.60ab	4.13b	1.63ab
	BARI Mung-6	70.33a	27.80b	3.33	9.53	2.33a	7.38ab	10.93ab	4.27ab	1.56b
	CV	1.85	8.94	19.32	24.83	35.95	3.60	10.65	4.82	7.20
	LSD	2.3940	4.92	0.98	5.00	0.84	0.5146	2.20	0.40	0.22
Ishwardi Subtation	MB-03	69.00b	53.00b	1.00ab	18.70a	1.62b	7.31ab	10.27ab	5.45a	1.66a
	MB-07	70.67ab	53.80b	1.13ab	18.73a	1.73b	7.63a	10.33b	5.14ab	1.57b
	MB-32	72.33a	53.67b	1.13ab	17.46ab	1.32b	7.42ab	10.33b	5.13b	1.57b
	Binamoog-8	72.00a	64.47a	1.40a	15.46b	4.40a	7.60a	11.00b	4.62c	1.54c
	BARI Mung-6	70.33ab	56.80b	0.67b	13.66ab	2.80ab	7.12b	13.07a	5.20ab	1.57b
	CV	1.86	5.05	32.39	29.18	59.23	2.73	18.38	3.26	6.46
	LSD	2.4789	5.35	0.65	9.23	2.64	0.381	3.81	0.314	0.192
Combined over location	MB-03	67.22b	37.67b	1.23	12.99	0.58c	7.61	11.28	5.08a	1.73a
	MB-07	68.56ab	37.93b	1.53	13.22	0.77c	7.75	10.57	4.81ab	1.68a-c
	MB-32	70.44a	40.20b	1.71	13.27	1.47bc	7.55	10.33	4.92ab	1.64a-c
	Binamoog-8	69.11ab	46.60a	2.18	11.71	4.34a	7.46	11.33	4.32c	1.61bc
	BARI Mung-6	71.00a	41.16ab	1.89	11.02	2.84b	7.50	11.47	4.63b	1.57c
	CV	2.41	7.50	29.56	11.00	38.90	3.92	9.47	3.31	3.16
	LSD	3.14	5.74	0.95	2.57	1.46	0.55	1.96	0.29	0.09

The mutants MB-03, MB-07 and MB-32 gave lower plant height which ranged from 37.67, 37.93 and 40.20 cm respectively than the variety Binamoog-8 (46.60 cm) and BARI Mung-6 (41.16 cm). Among the mutants, higher branch plant^{-1} was observed in Binamoog-8 (2.18) compared to the mutants MB-03 (1.23), MB-07 (1.53) and MB-32 (1.71). Mature pod was higher in the mutant MB-32 (13.27) comparing to the check variety Binamoog-8 (11.71) and

BARI Mung-6 (11.02). Immature pod was greater in the check variety Binamoog-8 (4.34) comparing to the mutant MB-03 (0.58), MB-07 (0.77) and MB-32 (1.47). Pod length was higher in the mutant MB-07 (7.75 cm) contrasting to the variety Binamoog-8 (7.46 cm) and BARI Moog-6 (7.50 cm). Maximum seeds pod^{-1} was found in the check variety BARI mung-6 (11.47) comparing to the mutant MB-03, MB-07 and MB-32 (11.28, 10.57 and 10.33 respectively). Higher 100 seed weight (4.92g) was found in the mutant MB-32 comparing to the Binamoog-8 and BARI Mung-6 (4.32 and 4.63 respectively). Higher yield was obtained from the mutant MB-03 (1.68 t/ha) comparing to the check variety Binamoog-8 (1.61 t/ha) and BARI Mung-6 (1.57 ton/ha). The mutant MB-03 had shorter duration (67 days) than the variety Binamoog-8 (69 days) and BARI Moog-6 (71 days).

Considering the earliness, synchronous pod maturity and yield performance of the mutant further advanced trial will be needed at next Kharif-I season

Growing M_4 generation of mungbean for synchronous pod maturity

For synchronous pod maturity, seeds of Binamoog-8 variety were irradiated with Cobalt$_{60}$ gamma rays. Irradiation doses were 10, 20, 40, 60 and 80Gy. A large number of M_4 population were grown in plant progeny rows for selecting desirable mutant at BINA sub-station Ishurdi during Kharif-I season 2022. A total of 10 mutant variants have been selected primarily for next generation.

Growing M_1 generation of mungbean for synchronous pod maturity

To create genetic variability, seeds of four popular mungbean varieties (Binamoog-5, Binamoog-8, Binamoog-9 & Binamoog-10) were irradiated with with Cobalt$_{60}$ gamma rays at 300, 350, 400 7 450Gy doses. Seed were sown at BINA HQ farm, Mymensingh during Kharif-I season 2022. The experiment was followed by non-replicated design and sown separately (variety and dose wise). Survived plants produced seeds and seeds were harvested separately for growing M_2 population.

Project: Varietal improvement of lentil through induced mutation

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

On-stations yield trials were conducted with four mutant lines along with a check variety, Binamasur-8 at BINA sub-stations Chapainwabganj, Ishurdi and BINA headquarters farm, Mymensingh during 2021-2022. The experiment was laid out in a randomized complete block design with three replications. Unit plot size was 20 m^2 (4 m × 3 m) with 30 cm line to line distance. Recommended production packages i.e., application of fertilizers, weeding, thinning, irrigation, application of pesticide etc. were followed to ensure normal plant growth and development. Data on days to maturity, plant height, number of primary branches plant^{-1} and pods plant^{-1} were recorded from 10 randomly selected plants from each plot. Plot seed yield was converted into kg ha^{-1}. Statistical analysis of different characters of the mutants and the check are presented in the Table 84.

Results revealed that significant variations were observed among the mutants and the check variety for days to maturity, pods per plant^{-1}, 100-seed weight and seed yield at the three locations except number of primary branches per plant. On an average, maturity period varied from 102 days to 114 days. LM-99-8 produced the highest number of pods plant^{-1} and LM-20-4 produced the highest seed yield 1920kg ha^{-1} followed by LM-99-8 with 1825 kg ha^{-1} at Chapainwabganj. In case of 100-seed weight, higher weight was found in LM-20-4 followed by LM-88-9 at Ishurdi. Mutant LM-20-4 and LM-99-8 had the highest 100-seed weight and produced the highest seed yield at Mymensingh. When combined over the three locations, the line LM-20-4 produced the highest seed yield followed by the mutant LM-99-8. Further trials will be conducted in the next season.

Table 84. On-station trial with four lentil mutants/line along with a check variety Binamasur-8 at three locations during 2021-2022

Variety/ mutant	Days to maturity	Plant height (cm)	Primary Branches/ plant (no.)	Pods/plant (no.)	100-seed weight (g)	Seed Yield (kg/ha)
Chapain						
LM-99-8	102b	39.1b	2.9	107a	1.90b	1825ab
LM-118-9	106a	39.4b	2.3	104a	1.59c	1765bc
LM-206-5	104ab	47.1a	3.6	104a	1.48c	1636c
LM-20-4	111a	50.1a	3.1	70.2b	4.79a	1920a
Binamasur-8	103b	49.7a	2.9	83.1b	2.21b	1671c
Ishurdi						
LM-99-8	105d	48.0a	3.1	143a	2.38b	2015a
LM-118-9	108a	45.2b	3.4	152a	1.91c	1913b
LM-206-5	106b	45.1b	2.9	137a	1.58c	2024a
LM-20-4	114a	54.3a	4.1	85.1b	5.22a	2041a
Binamasur-8	104d	48.5a	3.1	89.9b	2.32b	1810ab
Mymensingh						
LM-99-8	106c	40.2b	3.0	112a	2.39b	2018a
LM-118-9	108b	40.4b	2.7	63b	1.80c	1787c
LM-206-5	109b	39.7b	3.5	98a	1.63c	1885b
LM-20-4	116a	52.3a	3.6	61b	4.75a	2045a
Binamasur-8	106c	40.5b	3.1	58b	2.14b	1795c
Combined over locations						
LM-99-8	104	42.4b	3.0	120a	2.22b	1952a
LM-118-9	107	42.5b	2.8	106a	1.76c	1821ab
LM-206-5	106	44.0ab	3.3	113a	1.56c	1848ab
LM-20-4	114	52.2a	3.6	72.1b	4.92a	2002a
Binamasur-8	104	46.2a	3.0	77.0b	2.22b	1758c

On-farm yield trial with some selected lentil mutants

On-farm yield trials were conducted with three mutant lines along with a check variety Binamasur-8 at farmers' field, Magura, Ishurdi and Chapainwabganj during 2021-2022. The experiment was laid out in a randomized complete block design with three replications. Unit plot size was 20 m^2 (5 m × 4 m) with 30 cm line to line distance. Recommended production packages i.e., application of fertilizers, weeding, thinning, irrigation, application of pesticide etc. were followed to ensure normal plant growth and development. Data on days to maturity, plant height, number of primary branches $plant^{-1}$ and pods $plant^{-1}$ were recorded from 10 randomly selected plants from each plot. Plot seed yield was converted into kg ha^{-1}. Statistical analysis of different characters of the mutants and the check are presented in the Table 85.

Results revealed that significant variations were observed among the mutants and the check variety for most of the characters except plant height and primary branches per plant at the three locations. On an average, maturity period varied from 100 days to 105 days for the mutant LM-99-8 and LM-206-5 respectively. LM-99-8 produced the highest number of pods plant^{-1} as well as the highest seed yield 1769 kg ha^{-1} and also LM-20-4 produced the same seed yied of 1769 kg ha^{-1} followed by the mutant LM-118-9 with 1681 kg ha^{-1} at Magura. The mutant LM-206-5 produced the highest seed yield (1821 kg ha^{-1}) followed by the mutant LM-20-4 (1799 kg ha^{-1}) at Ishurdi. The same line LM-20-4 produced the highest seed yield (1800 kg ha^{-1}) followed by the mutant LM-99-8 (1799 kg ha^{-1}) at Chapainowabganj. When combined over the three locations, The line LM-20-4 and the mutant LM-99-8 produced the highest seed yield. Further trial will be conducted in the next season.

Table 85. On-farm trial with three lentil mutants along with a check variety, Binamasur-8 at three locations, Magura, Ishurdi and Chapainowabganj during 2021-2022

Variety/ mutant	Days to maturity	Plant height (cm)	Primary Branches/ plant (no.)	Pods/plant (no.)	100-seed weight (g)	Yield/plot (kg/ha)
Magura						
LM-99-8	101c	39.0	2.5	102a	2.41b	1769a
LM-118-9	106b	41.3	2.3	96a	1.83b	1681ab
LM-206-5	106b	39.5	3.3	65b	1.99b	1498b
LM-20-4	112a	45.2	3.4	62b	4.88a	1772a
Binamasur-8	102c	37.1	2.4	65b	2.31b	1429c
Ishurdi						
LM-99-8	103c	40.5	2.6	108a	2.42a	1723ab
LM-118-9	107a	42.9	2.2	91a	1.73ab	1612b
LM-206-5	106a	41.8	2.9	115a	1.66b	1821a
LM-20-4	114a	47.2	3.1	81b	5.12	1799a
Binamasur-8	103b	39.4	2.6	82b	2.13ab	1734ab
Chapainwabganj						
LM-99-8	100c	36.7	2.8	98a	2.40a	1731ab
LM-118-9	105b	40.1	2.5	88a	1875b	1654c
LM-206-5	105b	38.5	3.2	91a	1.85b	1721ab
LM-20-4	111a	42.3	3.0	68b	4.81	1800a
Binamasur-8	101c	37.25	2.3	71b	2.35a	1652c
Combined mean over locations						
LM-99-8	101	38.7	2.6	102	2.41	1741a
LM-118-9	106	41.4	2.3	91	1.81	1649ab
LM-206-5	106	39.9	3.1	90	1.83	1680ab
LM-20-4	112	44.9	3.1	70	4.94	1790a
Binamasur-8	102	37.9	2.4	72	2.26	1605b

Advanced yield trial with some selected mutants of lentil

The advanced yield trials were conducted with five mutants along with a check variety, Binamasur-8 at Mymensingh during 2021-2022. Seeds were sown in randomized complete block design with three replications. Unit plot size was 3m x 2m and rows were 30cm apart.

Normal cultural practices were done. Data on days to maturity, plant height, number of primary branches, pods plant^{-1} were recorded from 10 randomly selected plants from each plot. Plot seed yield was converted into kgha^{-1}. Statistical analysis of different characters of the accessions and the check are presented in the table 86.

Results revealed that significant variations were observed among the mutants and the check variety for most of the characters except number of primary branches per plant. On an average, maturity period varied from 90 days to 95 days where the mutant LM-250 was the earliest among the mutants and the check variety. The mutant LM-300 and LM-150 produced the highest number of pods plant^{-1} followed by LM-250 and the highest seed yield was produced by LM-300 (1698 kgha^{-1}) followed by LM-150 (1670kgha^{-1}). Further trial will be conducted in the next season at different lentil growing areas.

Table 86. Yield and yield contributing characters of five promising mutants along with a check variety, Binamasur-8 at Mymensingh during 2021-22

Variety/ mutant	Days to maturity	Plant height (cm)	Primary Branches/ plant (no.)	Pods/plant (no.)	Yield (kg/ha)
LM-250	90b	29.4c	2.27	98ab	1516b
LM-137	94a	34.6a	2.63	75b	1473bc
LM-150	94a	38.6a	2.39	113a	1670a
LM-300	95a	32.9ab	2.62	115a	1698a
Binamasur-8	94a	32.3ab	2.31	56c	1401c

Growing of $M_{6/}$ M_5 generation of lentil

A total of 12 M_4 plants were harvested from four doses, 150 Gy, 200 Gy and 250 Gy. Seeds of these M_4 plants were grown in plant-progeny-rows at BINA headquarters farm Mymensingh along with the mother variety. Another set of 17 M_5 lines were grown at BINA headquarters farm Mymensingh. Each row was 2 m long with 30 cm row to row distance. Normal cultural practices were done. Selection was done on the basis of earliness, number of pods plant^{-1}, seed yield and erect plant type and disease reactions. Altogether 19 M_5 and four M_6 lines were selected on the basis of higher yield, earliness and disease reactions. These lines will be grown for further selection in the next generation.

Screening of exotic lentil lines for early maturity, disease tolerance and higher seed yield

Around 280 lentil lines were collected from ICARDA. To select desirable lines with early maturity, high yield and tolerance to diseases, an experiment was set up at BINA regional research station, Gazipur and BINA Sub-station Magura during Rabi 2021-2022. 29 lines were screened based on their yield and yield contributing characters.

Project: Varietal improvement of blackgram through induced mutation

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

The trials were conducted with two promising blackgram mutants along with a check variety. BARI Mash-3 at BINA substations Magura, Chapainawbabganj, Gopalganj and BINA headquarters farm Mymensingh during 2021. The experiment was laid out in a randomized complete block design with three replications. Unit plot size was 20 m^2 (4 m × 3 m). Plant to plant distance was from 5 to 6 cm in a row while line to line distance was 40 cm. Intercultural operations; like weeding, thinning, application of pesticides, etc. were done for proper growth and development of plants in each plot. Harvesting was done depending on maturity of the lines. Data on various characters as plant height, number of primary branches plant^{-1}, pods plant^{-1}, number of seeds pod^{-1}, 100-seed weight were recorded from 10 randomly selected plants of each plot. Seed yield plot plot^{-1} was recorded and converted into kg ha^{-1}. Appropriate statistical analyses were performed by statiatics-10 software.

Table 87. Mean of yield and yield contributing characters of two promising mutants of blackgram grown at four locations Magura, Mymensingh, Chapainawbganj and Gopalganj during 2021

Variety	Plant height (cm)	Primary branches / plant (no.)	Pods/plant (no.)	Seeds/pod (no.)	100-seed weight (g)	Seed Yield (kg/ha)	
Magura							
BM-105	41.20 b	2.5	48.1a	6.51a	5.36a	1596a	
BM-63	52.1 a	2.3	40.6ab	7.02a	4.21b	1389b	
BARI Mash-3	47.31 b	2.4	32.1 b	5.01b	4.19a	1412b	
Mymensingh							
BM-105	42.21b	3.26a	49.05a	6.81a	6.27a	1798a	
BM-63	48.40a	2.35ab	41.83ab	5.40b	4.56b	1523b	
BARI Mash-3	45.21ab	1.92b	30.5b	5.30b	4.41b	1499b	
Chapainawbabganj							
BM-105	40.10b	3.53a	51.2a	6.85a	6.11a	2091a	
BM-63	44.20a	2.21b	41.31ab	5.20b	4.56b	1895b	
BARI Mash-3	45.13a	2.41b	34.5b	6.00b	4.31a	1836b	
Gopalganj							
BM-105	42.26b	3.15a	49.16a	6.82a	5.27a	1783a	
BM-63	45.51a	2.34ab	41.93ab	5.30b	4.56b	1466b	
BARI Mash-3	42.12ab	1.97b	30.5b	6.30b	4.21b	1461b	
Combined over four locations							
BM-105	41.44	3.11	49.37	6.75	5.75	1817a	
BM-63	47.55	2.30	41.42	5.73	4.47	1568b	
BARI Mash-3	44.94	2.17	31.90	5.65	4.28	1552b	

Results revealed that there were significant differences for most of the characters except number of primary branches at Magura. BM-105 was the shortest among the mutants and check at Magura, Mymensingh, Chapainwabganj and Gopalganj. In case of primary branches per plant, BM-105 had the highest number of branches, seeds pod^{-1} and 100-seed weight among the check variety, BARI Mash-3 the other mutant BM-63. Seed yield was the highest for BM-105 because of its bigger seed size and higher number of pods plant^{-1}. Application will be made to register this mutant line as variety soon.

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

The trial was conducted with two promising blackgram mutants along with a check variety. BARI Mash-3 at three locations, Mymensingh, Faridpur and Gopalganj during 2021. The experiment was laid out in a randomized complete block design with three replications. Unit plot size was 20 m^2 (5 m × 4 m). Plant to plant distance was from 5 to 6 cm in a row while line to line distance was 40 cm. Intercultural operations such as weeding, thinning, application of pesticides, etc. were done for proper growth and development of plants in each plot. Harvesting was done depending on maturity of the lines. Data on various characters as plant height, number of primary branches plant^{-1}, pods plant^{-1}, number of seeds pod^{-1}, 100-seed weight were taken from 10 randomly selected plants of each plot. Seed yield plot^{-1} was recorded and converted into kg ha^{-1}. Appropriate statistical analyses were performed by statiatics-10 software.

Table 88. Mean performance of mutants along with a check variety BARI Mash-3 at three locations, Mymensing, Magura and Faridpur during 2021

Variety	Plant height (cm)	Primary branches / plant(no.)	Pods/plant (no.)	Seeds/pod (no.)	100-seed weight (g)	Seed Yield (kg/ha)	
Mymensingh							
BM-105	39.52b	2.60	39.12 a	5.10b	5.62 a	1642a	
BM-63	47.48a	2.3	28.51b	7.33a	4.31b	1590ab	
BARI Mash-3	41.20b	2.14	27.42b	4.20b	4.25b	1563b	
Magura							
BM-105	36.21b	2.66	42.32a	4.51b	5.51a	1699a	
BM-63	43.63a	2.32	36.21ab	5.52b	3.56b	1543b	
BARI Mash-3	38.20b	2.11	29.21b	5.61a	4.47a	1572b	
Faridpur							
BM-105	39.42a	2.64	35.11a	5.51b	6.21a	1485a	
BM-63	45.31b	2.20	26.25b	6.11a	4.11c	1319b	
BARI Mash-3	43.11b	2.12	27.04b	4.71b	5.13b	1308b	
Combined over locations							
BM-105	38.38	2.63	38.85	5.04	5.78	1608	
BM-63	45.47	2.27	30.32	6.32	3.99	1484	
BARI Mash-3	40.83	2.12	27.89	4.84	4.62	1481	

Results revealed that there were significant differences for most of the characters among the tested mutants and the check variety except plant height and number of branches per plant (Table 87). The mutant, BM-105 was the shortest among the mutants and check. The mutant line BM-105 had the highest number of pods plant^{-1}, seeds pod^{-1} and 100-seed weight among the mutant and the check variety, BARI Mash-3. Seed yield was the highest for BM-105 because of its bigger seed size and higher number of pods plant-^{1}. This mutant will be registered as variety soon.

Advanced yield trial with promising blackgram mutants

The trials were conducted with **six** promising blackgram mutants along with a check variety, BARI Mash-3 at Chapainwabganj. The experiment was laid out in a randomized complete block design with three replications. Unit plot size was 2 m × 1.6 m. Plant to plant distance was from 5 to 6 cm in a row while line to line distance was 40 cm. Intercultural operations like weeding, thinning, application of pesticides, etc. were done for proper growth and development of plants in each plot. Harvesting was done depending on maturity of the lines. Data on various characters as plant height, number of primary branches plant^{-1}, number of seeds pod^{-1}, 100-seed weight were recorded from 10 randomly selected plants of each plot. Seed yield plot^{-1} was recorded and converted into kg ha^{-1}. Appropriate statistical analyses were performed by statistics 10.

Table 89. Mean of yield and yield contributing characters of 10 promising mutants of blackgram at Chapainwabganj during 2021

Magura							
Variety	Plant height (cm)	Primary branches/ plant (no.)	Pods/plant (no.)	Seeds/pod (no.)	100-seed weight (g)	Seed yield (kg/ha)	
BM-235	36.22b	1.57	28.9a	5.4ab	4.92a	1236ab	
BM-46	31.71ab	1.70	29.9a	6.3a	4.91a	1350a	
BM-42	27.90c	2.31	23.2ab	4.7b	3.24b	1152bc	
BM-41	25.6c	2.06	19.7b	4.6b	4.57a	1040	
BM-4	27.6c	1.61	20.2b	6.1a	4.89a	1192bc	
BARI Mash-3	42.02a	1.63	23.4ab	5.4ab	4.27a	1072c	

Results revealed that there were significant differences for most of the characters except number of branches per plant. BARI Mash-3 was the tallest among the mutants and the check. In case of number of pods plant^{-1} BM-235 and BM-46 had the highest number of pods plant^{-1} among the other mutants and the check variety, BARI Mash-3. The highest number of seeds pod^{-1} and the highest 100-seed weight was observed in BM-235 and BM-46 followed by BM-4. Seed yield was the highest for BM-46 followed by BM-235 because of their higher number of pods plant^{-1}, seeds pod^{-1} and 100-seed weight. Further trials will be done with the three selected mutants BM-235, BM-46 and BM-4 for further evaluation.

Growing of M_2 generation of blackgram

To create variability local variety Chaita was irradiated with 600 Gy, 700 Gy and 800 Gy of gamma rays and were grown at BINA headquarters farm. There were no better mutants in respect of earliness, higher seed yield and erect plant type.

Project: Varietal improvement of grasspea through induced mutation

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

The on-station yield trials were carried out with three selected mutants along with two check varieties (Binakheshari-1 and BARI khasari-2) at BINA sub-stations Chapaianwabganj and Barishal during 2021-2022. 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 90.

Results revealed that significant variations were present for all the characters except number of primary branches plant^{-1} at all the locations. It was observed that mutant GM-102 was the earliest for maturity and it is the tallest plant among the mutants and checks. The mutant GM-108 and GM-102 produced the highest number of pods and highest seed yield at Chapainwabganj followed by the mutant GM-105. The same mutant GM-108 produced the highest number of pods and the highest seed yield at Barishal. Based on the better performance of the mutant line GM-108 has been registered as a variety, Binakhesari3 in 2022.

Table 90. Mean of yield and yield contributing characters of four promising mutants of grasspea grown at two locations, Chapainwabganj and Barishal during 2021-2022

Variety/ mutants	Days to maturity	Plant height (cm)	No of primary branch	No of pods /plant	100-seed weight (gm)	Seed yield (kgha^{-1})
Chapaianwabganj						
GM -102	104d	108a	6.2	40.1 ab	6.23a	1441a
GM-105	107c	99b	5.1	36.4 b	5.65a	1380 b
GM-108	107c	103a	6.3	50.1 a	5.34ab	1473 a
Binakhasari-1	111ab	103a	5.2	38.1 ab	5.0b	1295 c
BARI Khasari-2	113a	107a	5.1	33.4 b	5.52ab	1270c
Barishal						
GM -102	112bc	92.1a	2.3	45.1 a	6.41a	1301a
GM-105	114bc	87.1a	1.9	35.1 ab	5.63ab	1299b
GM-108	114bc	84.6b	2.9	47.3 a	5.52ab	1315a

Binakhasari-1	117b	87.6a	1.8	36.1 ab	5.34b	1174bc
BARI Khasari-2	120a	88.8a	2.5	31.2 ab	5.81ab	1162c
Combined over two locations						
GM -102	108d	100a	4.3	42.6	6.32	1371a
GM-105	111c	93b	3.5	35.7	5.64	1339a
GM-108	111c	93b	4.6	48.7	5.43	1394a
Binakhasari-1	114b	95a	3.5	37.1	5.17	1234b
BARI Khasari-2	117a	98a	3.8	32.3	5.66	1216b

On-farm yield trial with three promising grasspea mutants along with two check varieties

The on-farm yield trials were carried out with three selected mutants along with two check varieties (Binakheshari-1 and BARI khasari-2) at farmers' field, Ishurd, Chapainwabganj, Magura and Barishal during 2020-2021. The experiment was conducted in a 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 91.

Results revealed that significant variations were found for all the characters except number of primary branches plant^{-1}. It was observed that mutant GM-102 was the earliest for maturity and it was the tallest plant among the mutants and checks. The mutant GM-108 produced the highest number of pods and highest seed yield followed by the mutant GM-105. The better performed mutant, GM-108 has been registered as a modern high yielding variety, Binakhesari3 in 2022.

Table 91. Mean of yield and yield contributing characters of four promising mutants of grasspea at grown at four locations during 2021-2022

Varieties/ mutants	Days to maturity	Plant height (cm)	No of primary branch	No of pods /plant^{-1}	100-seed weight (gm)	Seed yield (kgha^{-1})
Ishurdi						
GM -102	106 c	106a	4.3	47.0b	6.11a	1488bc
GM-105	108bc	101a	3.5	43.1ab	5.21 ab	1513ab
GM -108	110 bc	95a	3.8	61.2a	5.52ab	1598a
Binakhasari-1	112 b	101a	4.1	44.2ab	5.10ab	1281c
BARI Khasari-2	117 a	86b	3.7	38.1b	5.73ab	1247c
Magura						
GM -102	104 c	102a	4.5	42.0 ab	4.91b	1423ab
GM-105	106bc	99a	3.4	40.1 ab	4.24 a	1398b
GM -108	108 bc	95a	3.9	59.8a	4.56ab	1511a
Binakhasari-1	110 b	103a	4.6	41.2ab	4.11ab	1206c
BARI Khasari-2	114 a	83b	3.6	37.1b	4.71ab	1215c
Chapainwabganj						
GM -102	102 c	98a	3.1	45.0 ab	5.61a	1538b
GM-105	106bc	96a	2.3	42.1 ab	5.21 a	1513b
GM -108	106 bc	96a	2.9	67.8 a	4.52ab	1608a
Binakhasari-1	108 b	98a	3.5	49.2ab	4.11b	1318c
BARI Khasari-2	110 a	80b	2.8	44.1b	4.73ab	1333c
Barishal						
GM -102	102 c	102a	4.3	47.0ab	5.33b	1418b
GM-105	107bc	101a	3.4	46.1ab	5.23 a	1413b
GM -108	107 bc	92a	3.9	52.8a	4.22ab	1498a
Binakhasari-1	112 b	98a	4.0	35.2 bc	4.13ab	1228c
BARI Khasari-2	116 a	85b	3.6	32.1c	4.72ab	1261c
Combined over four locations						
GM -102	103e	102a	4.05	45.2ab	5.49a	1466b
GM-105	107d	99a	3.15	42.8ab	4.97b	1459b
GM -108	108cd	95ab	3.6	60.4a	4.70b	1553a
Binakhasari-1	111b	100a	4.0	42.4ab	4.36b	1258c
BARI Khasari-2	114a	83.5b	4.3	37.8b	4.67b	1264c

Regional yield trial with five promising grasspea mutants along with two check varieties

The on-farm yield trials were carried out with six selected mutants along with a check variety BARI khasari-2 at BINA headquarters farm, Mymensingh during 2021-2022. The experiment was conducted in a 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 92.

Results revealed that significant variations were found for all the characters except number of primary branches plant^{-1}. It was observed that mutant GM-304 was the earliest for maturity (103days) and it was the shortest plant among the mutants and check. The mutant GM-304 produced the highest number of pods and highest seed yield followed by the mutant GM-305 and GM-309. The three mutants, GM-304.GM-305 and GM-309 will be evaluated in the next growing season.

Table 92. Mean of yield and yield contributing characters of six promising mutants of grasspea grown at BINA headquarters farm, Mymensingh during 2020-2021

Varieties/ mutants	**Days to maturity**	**Plant height (cm)**	**No of primary branch**	**No of pods /plant^{-1}**	**100-seed weight (gm)**	**Seed yield (kgha^{-1})**
BINA Hqs. Mymensingh						
GM -300	111	62.3a	8.47	32.3b	5.98b	1468bc
GM-309	106	46.6b	7.20	39.7ab	6.58a	1613ab
GM -326	113	61.4a	10.60	39.9ab	5.51b	1598ab
GM -304	103	49.2b	11.27	51.0a	6.49a	1688a
GM -401	110	50.7ab	9.67	31.0b	4.63c	1213c
GM -305	108	59.1a	9.67	44.7a	6.24a	1558ab
BARI Khasari-2	113	62.9a	8.27	36.0b	5.36b	1240c

Growing of M_5 generation of grasspea

To create variability, Binaheshari-1 and BARI Kheshari-2 were irradiated with 250 Gy, 300 Gy and 350 Gy of gamma rays and were grown at BINA Headquarters farm, Mymensingh. A total of 120 M_2 plants were harvested separately from three doses, 250 Gy, 300 Gy and 350 Gy. and subsequent generation of selection was done on the basis of earliness, more number of pods and disease reactions. A total of 11 M_5 mutants were selected on the basis of earliness, more number of pods and disease reactions. Further selection will be done in the next generation.

Screening of exotic grasspea lines for early maturity, disease tolerance and higher seed yield

Around 183 grasspea lines were collected from ICARDA. To select desirable lines with early maturity, high yield and tolerance to diseases, an experiment was set up at BINA regional research station, Gazipur and BINA Sub-station Magura during Rabi 2021-2022. 24 lines were screened based on their yield and yield contributing characters.

Project: Varietal improvement of chickpea for problem areas through induced mutations

Screening of exotic Chickpea lines for early maturity, disease tolerance and higher seed yield

Around 279 chickpea lines were collected from ICARDA. To select desirable lines with early maturity, high yield and tolerance to diseases, an experiment was set up at BINA regional research station, Gazipur and BINA Sub-station Magura during Rabi 2021-2022. 29 lines were screened based on their yield and yield contributing character.

Project: Varietal improvement of garden pea using mutation breeding techniques

Growing M_2 generation of garden pea

Seeds of BARI Motor-3 was irradiated with $Cobalt_{60}$ gamma rays. Irradiation doses were 20, 40, 60 and 80Gy. Dose wise bulk seeds of each variety were grown at BINA Headquarters' farm during Rabi season 2021-2022. Fifteen mutant variants were selected based on bolder seed size, higher seed yield and disease tolerance for further evaluation.

Project: Varietal improvement of pigeon pea using mutation breeding techniques (Collaboration with Plant Pathology and Entomology division)

Growing of M_3 generation of Pigeon pea

Seeds of three local pigeon pea germplasms were irradiated with Co_{60} gamma rays. Irradiation doses were 15, 20, 25 and 30Gy. Dose wise bulk seeds of each variety were grown at BINA Headquarter farm during July 2021. Seventeen mutant variants were selected based on shorter plant height, higher seed yield and disease tolerance for further evaluation.

Collection and Growing of rice landraces for seed

Collection: During the period 2021-22 a total of 40 germplasm of different rice were collected from Farmers of Cumilla and DAE, Bandarban. Collectors visited those areas and recorded passport information of the germplasm at the time of collection. Seeds of different germplasm were cleaned, processed, dried and stored in short term storage of BINA Substation, Cumilla germplasm collection room for seed multiplication and characterization. One team such as * FA, was formed comprising 2 member. Each expedition was conducted for 1-2 days. The teams were equipped with ice box, plastic carton, GPS, compass, digital camera, hand lens, envelop, knife, scissors, drying sheet, pencil, stapler etc. Germplasm of target crops were collected from farmers' field/farm store/threshing floor and market especially from floating seed traders.

Targeted farmers for collection of specific germplasm were located with the help of field level worker of the Department of Agriculture Extension (DAE) and direct contact. Collector's name, number and date were recorded during collection. Name of crop species alongwith English, Bangla, local and cultivar name were recorded. Name of donor with ethnic group, village, union, upazila/thana, district, latitude and longitude were noted. Type of soil, topography, sample status, sample source, habitat, frequency, type of materials, cultural practices, season, sole or mixed with, sample type, sampling method, insect and disease, agronomic score and plant characteristics were noted. A 'Passport Data Form' having passport information was filled up during germplasm collection. The samples were registered in conservation book immediately after collection and conserved in short term conservation storage of following appropriate procedure. Number of upazilas explored and number of germplasm collected from each district is shown in table 91. Passport information of collected germplasm of assigned crops is shown in Table 93

Table 93. Passport information of collected rice (*Oryzae sativa*) germplasm

Sl. #	Collector's No.	Cultivar /local name/cultural practice	Donor's name and address	Collection date
1.	FA-01	Chenger murali	Cumilla	February 2022
2.	FA-02	Gofra	Cumilla	February 2022
3.	FA-03	Kachina	Cumilla	February 2022
4.	FA-04	Surjomukhi	Cumilla	February 2022
5.	FA-05	Takat tara	Cumilla	February 2022
6.	FA-06	Beur-kani	Cumilla	February 2022
7.	FA-07	Sarisaful	Cumilla	February 2022
8.	FA-08	Budhmari	Cumilla	February 2022
9.	FA-09	Kalasatta	Cumilla	February 2022
10.	FA-10	Haitta	Cumilla	February 2022
11.	FA-11	Botessor	Cumilla	February 2022
12.	FA-12	Mainamati	Cumilla	February 2022
13.	FA-13	Uba-marali	Cumilla	February 2022
14.	FA-14	Chira-murali	Cumilla	February 2022
15.	FA-15	Dhola chengri	Cumilla	February 2022
16.	FA-16	Kalo-chengri	Cumilla	February 2022
17.	FA-17	Kharia- murali	Cumilla	February 2022
18.	FA-18	Ghungur bali	Cumilla	February 2022
19.	FA-19	Fununi	Cumilla	February 2022
20.	FA-20	Rani-komol	Cumilla	February 2022
21.	FA-21	Akiyu-taka	Cumilla	February 2022
22.	FA-22	Joria	Cumilla	February 2022
23.	FA-23	Bamura	Cumilla	February 2022
24.	FA-24	Bokri-matha	Cumilla	February 2022
25.	FA-25	Begunkani	Cumilla	February 2022
26.	FA-26	Haitta	Cumilla	February 2022
27.	FA-27	Matichak	Cumilla	February 2022
28.	FA-28	Buri murali	Cumilla	February 2022
29.	FA-29	Dumai kalo	Cumilla	February 2022
30.	FA-30	Budhmari	Cumilla	February 2022
31.	FA-31	**Tarbali**	Cumilla	February 2022
32.	FA-32	Kalasita	Cumilla	February 2022
33.	FA-33	Lenia murali	DAE, Bandarban	March 2022
34.	FA-34	Pedi dhan	DAE, Bandarban	March 2022
35.	FA-35	Kre naisa	DAE, Bandarban	March 2022
36.	FA-36	Mongthong	DAE, Bandarban	March 2022
37.	FA-37	Gunda dhan	DAE, Bandarban	March 2022
38.	FA-38	Lal binni dhan	DAE, Bandarban	March 2022
39.	FA-33	Aungkhapru	DAE, Bandarban	March 2022
40.	FA-34	Kalobinni dhan	DAE, Bandarban	March 2022

B. Characterization:

Morphological Characterization of **aromatic rice germplasm of Bangladesh.**

Continuous effort is needed to develop high yielding rice varieties to feed the ever increasing population. Therefore, study of morphological characterization of the germplasm is very much essential to find the desirable traits to use as potential breeding tool. In this regard, forty two rice germplasm were evaluated to assess the variation considering 10 quantitative and 31 qualitative traits under field condition during the period from July to December 2021 at the BINA Substation, Cumilla following Randomized Complete Block Design (RCBD) with three replications. Qualitative characterization by DUS test revealed that a wide range of variation was observed among the studied germplasms for blade color, leaf angle, flag leaf angle, culm angle, internode color, culm strength, panicle exertion, axis, shattering, threshability, apiculus color, stigma color, lemma and palea color, lemma and palea pubescence, sterile lemma color, seed coat color and leaf senescence. Therefore, this study would be helpful for breeders and researchers to choose and identify the restoration and conservation of beneficial genes for crop improvement.

Materials and Methods:

The experiment was carried out during the period from July to December 2021. In this study, 42 rice germplasm were used as plant materials. The list of the experimental materials along with their sources of collection is shown in Table 94.

Table 94. List of the rice germplasm included in the experiment

SL No.	Rice germplasm	SL No.	Rice germplasm
1	Kalo nunia	22	Khirsabuti
2	Malshira	23	Votirchikon
3	Lalchini	24	Chinisakkhor
4	Padmavog	25	Rajbuti
5	Rajvog	26	Doiorgura-2
6	Oval TAPL-9	27	S-14
7	Modhumadhob	28	Kalijira M-13
8	TAPL-64-1	29	Chinigura-1
9	Chinigura (D-8)	30	Basmati-2
10	Kalijira TAPL-7	31	Nurbasmati
11	Phillipine Katarivog	32	Parbatjira
12	Chinisail-47	33	Tilokkhachori
13	Jirabuti	34	Deshikatari
14	Bibi-46	35	Sadamota
15	Chinigura –M-26	36	Basmati-370
16	Chinigura-1	37	Durgavog
17	Doiorgura-1	38	Kalijira TAPL-51
18	Jotakatari	39	Khirsapati
19	Meni	40	Basmati-India
20	Vabmoti	41	Kalomala
21	ICSS-Balam TAPl-25	42	BD-80

The experiment was carried out in Randomized Complete Block Design (RCBD) with three replications. Unit plot size was 2m× 2m. The seeds were soaked in water for 24 hours. Then it was incubated in moist cloth sacks for 48 hours for quick germination. The pre-germinated seeds were sown in seedbed on 14 July, 2021. When the seedlings were 25 days old, one seedling hill^{-1} was transplanted to the main plot on the 9 August, 2021. Spacing between hills and rows were 15 and 20 cm, respectively. Basal dose of TSP and MP at the rate of 45kg and 25kg per hectare was applied. After transplanting the recommended dose of Urea, 160 kg per hectare was top dressed at three growth stages of rice. Irrigation and drainage were done as per requirement. The crop was kept weed free throughout the growth period. Insects and fungal attacks were negligible. Different germplasm attained their maturity at different times. Harvesting was done when 80% of the plant population of each plot reached to maturity and harvesting was done from 20 October to 05 November, 2021. The experimental plots were visited frequently and as per schedule, required data were collected. A data record book was used for keeping records of data related to the identification of the germplasm. Data were recorded on individual plant basis from 5 randomly selected plants on the following qualitative and quantitative traits.

Characterization based on qualitative characters by DUS test

A total of 37 rice land races were taken for DUS characterization using 42 characters which include 31 qualitative and seven quantitative characters as per BRRI descriptor (2018). The rice landraces undertaken for this study showed wide range of distinctiveness characters for all most all the morphological traits studied. Frequency distribution for all the characters under study was computed (in Table 95) and qualitative and quantitative characters of different agronomic and morphological parameters are given in Table 85 and 86.

Out of 42 germplasm studied, 90.48% germplasm didn't shown anthocyanin coloration of apex while only 9.52% exhibited the anthocyanin colouration on leaf sheath. In case of blade pubescence 69.05% germplasm exhibited glabrous, 28.57% exhibited intermediate and only one germplasm had shown pubiscent.

All most all the landraces were of green colored basal leaf sheath, among the germplasm only one germplasm (S-14) had purple green and 3 had light green basal leaf sheath color. With respect to leaf characters, among 42 germplasm, 36 had shown erect leaf angle, 5 had horizontal and one germplasm Lombaail had drooping type of leaf angle of main axis. In case of legule shape, most of the germplasm (95.25%) had 2-cleft legule shape. For collar color and auricle color most of the germplasm were pale green. Anthocyanin color in culm was absent in 37 germplasm and present in 6 germplasm. Most of the germplasm (64.29%) had erect culm angle, 9 had intermediate, 4 had open and 2 germplasm (Lalchini and Chinigura (D-8) had spreading culm angle. Among 42 germplasm, 23 germplasm had strong lodging resistance while 6 had shown very weak performance to lodging resistance. But at dough stage, 100% plants of 10 germplasm had lodged and the plants of 22 germplasm had not lodged. Compact and enclosed panicle was found in 8 germplasm (Malshira, Lalchini, Ojanabirun, Doiorgura-1, Nur basmati, Parbotjira, Khirsapati, and Basmati India). With respect to panicle characters, 23.81% germplasm were straight and 76.19% germplasm were of drooping type of panicle curvature of main axis.

In case of awn distribution, 71.43% germplasm recorded the absence of awns and 12 germplasm (i.e. Lalchini, Chinigura (D-8), Jirabuti, Meni, Vabmoti , ICSS-Balam TAPl-25, Votirchikon, Rajbuti, S-14, Chinigura-1, Tilokkhachori, Durgavog, Kalomala) recorded the presence of awns. Out of which, six germplasm found straw, four germplasm were brown and two germplasm had purple coloured awns. In stigma colour, 73.80 % cultivars exhibited white stigma, 23.81% landraces were of light green stigma and 2.38% were of purple stigma.

With regard to colour of the lemma and palea, 47.48% of germplasm were straw colour, 33.33% germplasm recorded gold and gold furrows on straw background, 2.38% germplasm were of brown spots on straw, 2.38% germplasm were of brown furrows on straw, 4.76% germplasm were of brown, 4.76% germplasm were reddish to light purple, 2.38% germplasm were of brown (tawny), 4.76% germplasm were purple and 4.76% germplasm were of black. In case of density of pubescence of lemma, 32 germplasm exhibited short hairs, 2 germplasm with long hairs, 6 germplasm with hairs on lemma keel and 22 germplasm had no pubescence. All most all the landraces were of straw coloured sterile lemma, except for 7 germplasm, which have gold and purple colour sterile lemma. For the character seed coat (bran) colour of 11 germplasm were of white in colour, 13 germplasm were of light brown, 14 germplasm were of Speckled brown, 3 germplasm were of brown and 1 14 germplasm exhibited Variable purple type seed coat color. Non-glutinous (no waxy) endosperm was found in 11 germplasm, 22 germplasm had shown glutinous endosperm and 9 germplasm had shown Intermediate type endosperm. Aroma of decorticated grain was recorded in six germplasm, among them Parbotjira was lightly scented and 5 germplasm (Chinisail-47, ICSS-Balam TAPl-25, Nurbasmati, Deshikatari, Sadamota) were of highly scented

Table 95. Characterization of aromatic rice germplasm based on qualitative characters during *Aman* season 2021

Sl. No.	Character and Time of recording	State of characters	No. of germplasm	Germplasm (serial no. in Table 8.1)	Frequency (%)
1	Blade Pubescence Late vegetative stage	Glabrous	29	1,2,3,4,5,6,7,8,9,10,11,12,14,22,23,24,26,27, 28,30,31,32,33,34, 35, 37, 38, 39,42	69.05
		Intermediate	12	15,16.17,18,19,20,21,25,29,36, 40,41	28.57
		pubiscent	1	13	2.38
2	Blade color Booting to heading stage	Pale green (1)	9	4,7,8,15,24,26,34,39,42	21.43
		Green (2)	25	3,5,6, 10,14,16,17,18,19,20,21, 22,23, 25, 27,28,29,30,32,33,35, 36,38,40,41	59.53
		Dark green (3)	6	1,9,11,13,31, 37	14.29
		Purple tips (4)	1	2	2.38
		Purple (7)	1	12	2.38
3	Leaf sheath: Anthocyanin color Late vegetative stage	Absent (1)	38	1,2,3,4,5,6,7,8,9,10,11,12,14, 15,16, 17,18,19,20, 22,24,25,26,27, 28,29, 30,31,32,33,34,35,36, 37,38,40, 41, 42	90.48
		Present (9)	4	13, 21, 23, 39	9.52

Sl. No.	Character and Time of recording	State of characters	No. of germplasm	Germplasm (serial no. in Table 8.1)	Frequency (%)
4	Basal leaf sheath color Late vegetative stage	Green (1)	38	1,2,3,4,5,6,7,8,9,10,11,12,13,14, 15,16.17,18,19,20, 22,23,24,25,26, 28,29, 30,31,32,33,34,35,36, 38,39,40, 42	90.48
		Purple green (2)	1	27	2.38
		Light green(3)	3	21, 37, 41	7.14
5	Leaf angle Prior to heading	Erect (1)	36	1,2,3,4,5,6,7,8,9,10,11,12,13,14, 16,18,19,20,21, 22,23, 24,25,26,27, 28, 30,32,34,36, 37,38,39, 40, 41, 42	85.72
		Horizontal (5)	5	15,17,31,33, 35	11.91
		Drooping (9)	1	29	2.38
6	Flag leaf angle Stem elongation to booting	Erect (1)	38	1,2,3,4,5,6,7,8,9,10,11,12,13,14,16.17,18,19,20, 21, 22,23,24,25,26, 28, 30,32,33,34,36, 37, 38,39,40, 41, 42	90.48
		Semi-erect (3)	1	29	2.38
		Horizontal (5)	3	15,31, 35,	7.14
7	Ligule color Stem elongation to booting	White (1)	27	1,2,3,4,5,6,8, 10,11,12,13,14, 19,20, 21, 22,23,24,25, 28, 33,35,37,39,40,41,42	64.29
		Purple lines (2)	13	7,9,15,16,17,18,27, 30,31,32, 34,36,38	30.95
		Purple (3)	2	26,29	4.76
8	Ligule shape Late vegetative stage	Acute to acuminate (1)	2	7,16,	4.76
		2-cleft (2)	40	1,2,3,4,5,6,8, 9,10,11,12,13,14, 15,17,18,19,20, 21, 22,23,24,25, 26,27,28,29,30,31,32, 33,34,35,36,37,38,39,40,41,42	95.24
9	Collar color Stem elongation to booting	Pale green (1)	39	2,3,4,5,6,8, 9,10,11,12,13,14, 15,16, 17,18,19,20, 21, 22,24,25, 26,27,28,29,30,31,32, 33,34,35,36,37,38,39,40,41,42	92.86
		Purple (3)	3	1,7,23,	7.14
10	Auricle color Stem elongation to	Pale green (1)	37	1,2,3,5,6,7,8, 9,10,11,12,13, 15,16,17,18,19,20, 21,24,25,26,27,28,29,30,31,32,33,34	88.10

Sl. No.	Character and Time of recording	State of characters	No. of germplasm	Germplasm (serial no. in Table 8.1)	Frequency (%)
	booting			,35,36,37, 38,39,40,41,42	
		Purple (2)	5	4, 14,18,22,23	11.91
11	Culm anthocyanin color After flowering	Absent (1)	36	1,2,4,5,7, 9,10,11,13,14, 15,16,17,18,19, 21,22,23,24,25,26,27,28,29,30,31,32 ,33,34,35, 37, 38,39,40,41,42	85.72
		Present (9)	6	3,6,8,12,20, 36	14.29
12	Culm angle After flowering	Erect (1)	27	2,4,7,10,12,13,14,15,17,18,19,20,21, 22, 23,24,25,26,28,29,34,35, 37, 38,39,40,41,42	64.29
		Intermediate ((3)	9	5,6,8,11,27, 30,32, 33,36	21.43
		Open (5)	4	1,16, 20,31	9.52
		Spreading (7)	2	3,9,	4.76
13	Inter node color After flowering	Green (1)	32	4,5,7, 9,10,11,13,14, 15,16,17,18,19, 21,22,23,24,25,26,27,28,29,31,32,34 ,35, 37, 38,39,40,41,42	76.19
		Light gold (2)	4	1,2,30,33	9.52
		Purple lines (3)	4	3,6,8,20,	9.52
		Purple (4)	2	36,12	4.76
14	Culm strength (lodging resistance) After heading by gently pushing the tillers back and for the few times	Strong (1)	23	4,7,13,14,17,18,22,23,24,25,28,29,3 1,32,34,35, 37, 38,39,40,41,42	54.76
		Moderately strong (3)	4	2,5,10,26	9.52
		Intermediate (5)	4	1,12,30, 33	9.52
		Weak (7)	5	6,11,15,19,27	11.91
		Very weak (9)	6	3,8,9,16,20,21,	14.29
15	Lodging incidence (%) (% of plants that lodged) Heading, milk or dough stage	Lodging (0%)	22	2,4,7,13,14,17,18,22,23,24,25,28,29, 31,32,34,35,36,37,38,39,40	52.38
		Lodging ≥ (30-50%)	6	6,10,26,33, 41,42	14.29
		Lodging ≥ (60-90%)	4	5.12,15,21,	9.52
		Lodging (100%)	10	1,3,8,9,11,16,19,20,27,30,	23.81

Sl. No.	Character and Time of recording	State of characters	No. of germplasm	Germplasm (serial no. in Table 8.1)	Frequency (%)
16	Panicle type Dough stage	Compact (1)	23	1,2,4,5,6,7,8, 9,10,11,13,14, 15,16,17, 28,31,32,36, 38,39,40	54.76
		Intermediate (5)	14	3,18,19,20, 21,22,23,24,25,26,27,29,30,41	33.33
		Open (9)	5	28,34,35,37,42	11.91
17	Panicle exertion Near maturity	Enclosed (1)	11	2,4,17,24,25,31,32,33,36,39,40	26.19
		Partly exerted (3)	18	1,3,5,6,7,8,10,11,12,13,14,15,27,29, 30,34,35,37	42.86
		Just exerted (5)	1	9	2.38
		Moderately well exerted (7)	4	21,22,28,41	9.52
		Well exerted (9)	8	16,18,19,20,23,26,38,42	19.05
18	Axis At maturity	Straight (1)	10	1,7,9,11,13,14,15,17,18,24,	23.81
		Droopy (2)	32	2,3,4,5,6,8,10,12,16,19,20,21,22,23, 25,26,27,28,29,30,31,32,33,34,35,36 ,37, 38,39,40,41,42	76.19
19	Shattering At maturity or harvest	Very low (1)	9	3,5,6,11,13,17,18,22,25	21.43
		Low (3)	29	1,2,4,7,12,14,15,16,19,20,21,23,24,2 6,28,32,34,35,36,39,41,42	69.05
		Moderate (5)	3	8,9,10,	7.14
		High (7)	1	31	2.38
20	Threshability At maturity	Moderately Difficult (3)	3	6,11,15,	7.14
		Intermediate (5)	14	3,8,13,16,17,18,19,20,,22,23,25,27,2 9,30,	33.33
		Loose (7)	12	5,14,21,26,28,32,34,35,36,37,39,42	28.57
		Easy(9)	13	1,2,4,7,9,10,12,24,31,33,38,40,41	30.95
21	Awn: distribution Flowering to maturity	None (0)	30	1,2,4,5,6,7,8,10,11,12,13,14,15,16,1 7,18,21,24,26,27,28,30,31,32,34,35, 36,38,39,40,42	71.43
		Tip only (1)	4	9,25,41,37,	9.52
		Upper quarter only (2)	4	3,19,20,29,	9.52

Sl. No.	Character and Time of recording	State of characters	No. of germplasm	Germplasm (serial no. in Table 8.1)	Frequency (%)
		Upper half only (3)	2	13,23,	4.76
		Upper three-quarters only (5)	2	33,21	4.76
22	Awn color At maturity	Straw (1)	6	9,19,20,25,29,37	14.29
		Brown (tawny) (3)	4	3, 23,33,41,	9.52
		Purple (5)	2	13,22,	4.76
23	Length of the longest awn	Very short (1)	3	3,20, 37	
		Short (3)	6	9,23, 25,29,33, 41	
		Intermediate (5)	3	13, 19,22,	
24	Apiculus color At maturity	White (1)	13	1,3,6,7,10,18,24,26,27,30,33,36,40	30.95
		Straw (2)	4	2,4,9,41	9.52
		Brown (3)	21	5,11,14,15,16,17,19,20,21,22,23,25,28,29,32,34,35,37,39,42	50.00
		Red apex (6)	1	8	2.38
		Purple (7)	3	13,31,38	7.14
		Black(9)	1	12	2.38
25	Stigma color At flowering	White(1)	31	1,3,6,7,8,12,13,14,17,18,42,19,20,22,23,24,28,29,30,31,32,33,34,35,36,37,38,39, ,41	73.80
		Light green (2)	10	2,4,5,10,11,15,17,22,25,26,27	23.81
		Yellow (3)	1	40	2.38
26	Lemma and palea color At maturity	Straw (0)	17	1,6,9,10,11, 14,15,17, 19,21,26,29,30, 34,35,36,40	40.48
		Gold and gold furrows on straw background (1)	14	2, 7,13, 20, 25,27,28,32,33,37,38,39,41,42	33.33
		Brown spots on straw (2)	1	24,	2.38
		Brown furrows on straw (3)	1	12,	2.38
		Brown (4)	2	4,18,	4.76

Sl. No.	Character and Time of recording	State of characters	No. of germplasm	Germplasm (serial no. in Table 8.1)	Frequency (%)
		Reddish to light purple (5)	2	5, 8,	4.76
		6	1	23	2.38
		Purple (8)	2	3,8,16	4.76
		Black (9)	2	22, 31	4.76
27	Lemma and palea pubescence	Glabrous (1)	2	38,24	4.76
		Hairs on lemma keel (2)	6	16,21, 25,33,34,40	14.29
	Flowering to maturity	Short hairs (4)	32	1,2,3,4,5,6,7,9,10,11,12,14,15,17,18, 19,20,22,23,24,26,27,28,29,30,31,32 ,35,36,37,38,39, 41,42	76.19
		Long hairs (5)	2	8,13	4.76
28	Sterile lemma color	Straw (1)	35	1,4,6,8,9,10,11,12,14,15,17,18,19,20 ,21,22,23, 24, 25, 26,27,28,29,30,32,33,34,35,36,37,39 ,40,41	83.34
	At maturity	Gold (2)	4	2, 7,38,42	9.52
		Purple (4)	3	3,5,31,	7.14
29	Seed coat (bran) color	White (1)	11	1,4,6,15,24, 26, 27, 28,32,36, 40	26.19
		Light brown (2)	13	7,9,10,11,14,19,21,29, 30,33,34,35,38	30.95
	At maturity	Speckled brown (3)	14	3,8,12,13,16,18,20,22,23, 25,31,37, 41, 42,	33.33
		Brown (4)	3	2,17,39	7.14
		Variable purple (6)	1	5	2.38
30	Endosperm type	Non-glutinous (no waxy) (1)	11	3,8,14, 21, 23, 27, 30,32, 33, 39, 42	26.19
	At maturity	Glutinous (waxy) (2)	22	1,2,4,5, 6,7,9,10, 11,13,17,19,24,25,26,28, 35,36,37,38	52.38
		Intermediate (3)	9	12,15, 16, 18,20, 22, 26, 29.41	21.43
31	Decorticated grain:	Non-scented (0)	36	1,2,3,4,5,6,7,8,9,11, 13,14,15,16,17,18,19,20,22,23,24,25	85.71

Sl. No.	Character and Time of recording	State of characters	No. of germplasm	Germplasm (serial no. in Table 8.1)	Frequency (%)
	Scent (aroma) At flowering or at maturity			, 26, 27, 28, 29.30,32, 33,34,36,37,.38,39,40,41,42	
		Lightly scented (1)	1	10	2.38
		Scented (2)	5	21, 34, 12,31,35	11.90

Characterization based on quantitative characters by DUS test

Observed variables of quantitative characters of included seven traits and five plants from each replication of each germplasm were randomly selected for recording data on plant height (cm), Days to 50% flowering, Days to 80% of maturity, Number of effective tillers, Panicle length (cm), 100 seed weight (g), Grain yield m^{-2}.

The tallest plant was recorded in Chinisail-47 (130.67 cm) followed by Kalonunnia(124.67 cm) and Kalijira TAPL-7 (123.33 cm) whereas the shortest plant was recorded in Padmavog (82.00cm) followed by Doiorgura-1 (84.00 cm). Days to fifty % flowering ranged from 87.67 to 113.67 days. Among the studied germplasms, Kalijira M-13 took longest time (113 days) to 50% flowering followed by Chinisail-47 and Basmati-370 (112.67 days) while Basmati-2 (87.67 days) took the shortest time followed by Oval TAPL (88.33days).

Table 96. Agronomic performance of the studied rice germplasm

Variety	Plant height (cm)	Days to 50% flowering	Days to 80% maturity	Number of effective tillers $hill^{-1}$	Panicle length (cm)	Yield $/m^2$ (g)	100 SW (g)
Kalo nunia	124.67 ab	103.33 hi	133.33 j	10.00 c-j	25.67 a-g	231.67 no	2.22 ef
Malshira	97.67 kl	105.67 ef	133.33 j	10.33 b-i	24.00 b-i	470.00 b-g	1.51 st
Lalchini	114.00 c-g	104.33 gh	132.67 k	9.67 d-k	24.00 b-i	266.67 l-o	2.1 g-i
Padmavog	82.00 m	104.33 gh	133.33 j	9.33 d-l	21.33 e-k	466.67 b-g	1.71 m-o
Rajvog	104.0 h-l	106.67 e	139.33 d	11.33 b-f	21.00 f-k	416.67 d-i	2.12 gh
Oval TAPL-9	111.0 d-i	88.33 l	133.33 j	8.67 f-l	23.00 d-k	416.67 d-i	2.07 hi
Modhumadhob	105.67 f-k	104.33 gh	133.33 j	7.00 k-n	23.33 c-k	553.33 ab	1.47 t
TAPL-64-1	111.33 d-i	106.67 e	139.33 d	7.00 k-n	23.00 d-k	300.00 j-o	1.98 j
Chinigura (D-8)	117.7 b-d	103.67 g-i	139.33 d	8.00 h-m	23.67 b-j	300.00 j-o	2.21 ef
Kalijira TAPL-7	109.00 d-j	103.67 g-i	141.33 c	7.33 j-m	29.67 a	333.33 h-n	1.11 vw
Phillipine Katarivog	117.00 b-d	103.67 g-i	136.33 g	5.67 mn	26.00 a-f	436.67 c-h	2.17 fg
Chinisail-47	130.67 a	112.67 ab	139.33 d	8.67 f-l	28.67 ab	325.00 i-n	1.03 x
Jirabuti	114.67 c-g	111.67 bc	146.33 a	7.67 i-m	27.33 a-d	532.00 bc	1.65 op
Bibi-46	114 c-g	103.67 g-i	137.33 f	11.33 b-f	23.33 c-k	285.00 k-o	1.16 v
Chinigura –M-	111.33 d-i	105.67 ef	139.33 d	12.00 a-d	23.33 c-k	286.67 k-	1.07 wx

26						0	
Chinigura-1	123.33 a-c	111.67 bc	124.33 l	12.67 a-c	23.67 b-j	323.33 i-n	1.57 q-s
Doiorgura-1	84.00 m	111.67 bc	137.33 f	9.00 e-l	23.00 d-k	640.00 a	1.84 k
Jotakatari	101 j-l	104.67 fg	143.33 b	9.33 d-l	18.67 j-k	360.00 h-l	2.31 d
Meni	115.33 b-f	104.67 fg	138.33 e	11.67 a-e	25.33 a-g	250.0 m-o	1.61 pq
Vabmoti	105.33 gk	103.67 g-i	135.33 h	11.67 a-e	21.33 e-k	205.0 o	2.27 de
ICSS-Balam TAPl-25	104 h-k	106.67 e	139.33 d	9.67 d-k	18.33 kl	410.00 e-i	1.75 lm
Khirsabuti	109 d-j	103.67 g-i	139.33 d	13.00 ab	25.33 a-g	250.00 mo	1.78 kl
Votirchikon	117.67 b-	103.67 g-i	137.33 f	6.67 l-n	23.00 d-k	250.0 m-o	2.24 de
Chinisakkhor	118 b-d	104.67 fg	138.00 e	10.67 b-h	28.33 a-c	386.67 f-k	1.05 wx
Rajbuti	106.33 e-k	111.67 bc	141.33 c	8.00 h-m	22.33 d-k	406.67 e-i	2.64 bc
Doiorgura-2	115 b-g	103.67 g-i	139.33 d	11.67a-e	24.67 a-h	360.00 h-l	1.78 kl
S-14	109.67 d-j	104.67 fg	141.33 c	4.33 n	26.33 a-e	243.33 no	2.31 d
Kalijira M-13	110 d-j	113.67 a	141.33 c	11.67 a-e	22.67 d-k	500.00 b-e	1.71 m-o
Chinigura-1	105.3 g-k	104.67 fg	139.33 d	10.33 b-i	26.33 a-e	376.67 g-k	2.31 d
Basmati-2	109.33 d-j	87.67 l	120.33 m	8.33 g-m	23.33 c-k	200.00 0	2.59 c
Nurbasmati	114.67 c-g	106.67 e	139.33 d	9.67 d-k	24.67 a-h	326.67 i-n	0.84 y
Parbatjira	115.67 b-e	110.67 cd	136.33 g	10.33 b-i	19.33 i-l	516.67 b-d	2.04 ij
Tilokkhachori	106.67 e-k	91.67 k	134.33 i	9.33 d-l	21.67 e-k	406.67 e-i	3.03 a
Deshikatari	109.33 d-j	104.67 fg	137.33 f	10.00 c-j	23.00 d-k	420.00 d-i	1.27 u
Sadamota	107 e-k	109.67 d	136.33 g	12.67 a-c	23.00 d-k	350.0 h-m	1.24 u
Basmati-370	117 b-d	112.67 ab	146.33 a	8.00 h-m	20.00 h-l	410.00 e-i	1.72 l-n
Durgavog	117 b-d	110.67 cd	141.33 c	9.67 d-k	21.67 e-k	516.67 b-d	2.68 b
KalijiraTAPL-51	110.67 d-j	102.67 i	135.33 h	11.00 b-g	21.67 e-k	200.00 o	1.68 no
Khirsapati	95.33 l	102.67 i	137.33 f	8.67 f-l	20.67 g-k	490.00 b-f	1.52 r-t
Basmati-India	101.67 i-l	96.67 j	132.33 k	14.33 a	21.67 e-k	393.33 f-j	1.59 p-r
Kalomala	109 d-j	103.67 g-i	139.33 d	10.00 c-j	15.33 l	436.67 c-h	1.71 m-o
BD-80	112 d-h	103.67 g-i	138.33 e	7.00 k-n	23.33 c-k	323.33 i-n	2.04 ij
Range	**82.00 – 130.67**	**87.67-113.67**	**120.33-146.33**	**4.33-14.33**	**15.33-29.67**	**200.00 – 640.00**	**0.84 - 3.03**
Mean	**109.86**	**104.89**	**137.31**	**9.60**	**23.24**	**370.76**	**1.83**
SE	**2.44**	**0.31**	**0.16**	**0.67**	**1.26**	**25.51**	**0.02**
HSD (0.05)	**9.91**	**1.25**	**0.65**	**2.73**	**5.13**	**103.56**	**0.07**
CV (%)	**2.72**	**0.36**	**0.14**	**8.56**	**6.66**	**8.43**	**1.11**

The maturity (80%) of the studied germplasm ranged 120.33- 146.33 days. Shonajuri and Basmati-370 took the maximum time (146.33 days) to mature followed by Jotakatari (143.33 days), while Basmat-2 took only 120.33 days to mature followed by Kalijira TAPL-51 (124.33 days). Number of effective tillers per hill ranged 4.33 to 14.33. Basmat-India had produce maximum number of effective tillers (14.33) followed by Khirsabuti (13.00) and Sadamota (12.67). On the other hand, S-14 had lowest number of effective tillers.

Kalijira TAPL-7 had the longest panicle (29.67 cm) followed by Chinisail-47 (28.67cm), Chinisakkhor (28.33 cm) and whereas Kalomala (15.33cm) had the shortest panicle. Among the studied rice germplasms, the highest grain yield m-^{2} was recorded in Doiorgura-1 (640.00

g) followed by Modhumadhob. The differences among the rice germplasms were also significant.

In this study, 100-grain weight ranged from 0.84 g to 3.03g with an average value of 1.83 g. The variation observed for this trait was highly significant. Hundred-grain weight was marked the highest in Tilokkhachori (3.03 g) followed by durgavog (2.68 g) whereas 100-grain weight was marked the lowest in Noor basmati (0.84g).

Biotechnology Division

Research Highlights of Biotechnology Division

Genetic Engineering and Tissue Culture

- In T. aman 2021 a total of 16,985 anthers were plated on three different type's media from two F1 generations. Finally, only 8 green plants were obtained from calli derived from F1 of Binadhan-12 x Kasalath cross.

- For development lodging resistance and high yield premium quality rice, 19 *in vitro* regenerated plants were obtained from calli treated with gamma rays.

- For development drought tolerant rice variety inducing PEG stress (5%, 8% and 10%) on embryogenic calli and that found growth rate and regeneration capacity were decreased with increasing levels of PEG concentration.

- Salt stress imposed to 100 mM transgenic tomato plants showed higher fresh shoot and root weight compared to wild type plants. All transgenic plants retained higher Na^+ content than the wild type. Increasing salt stress decreasing the chlorophyll content but the rate of decreasing was less compared to wild type.

- The MS medium supplemented with 2.0 mg/L 2, 4-D produced the maximum frequency of callus induction from matured embryo of BRRIdhan89. Eight 0.2% EMS regenerated mutants of BRRIdhan-89 were obtained yielding per plant ranges from 45g to 115g.
- A total of 11 genotypes were studied for improvement of high value sweet pepper genotypes in rabi season 2021. Finally, the four genotypes (CKN- 1, CKN- 2, CKN-8 and CKN- 9) were selected for the further evaluation and subsequent genetic engineering and tissue culture research.
- The efficiency of callus and shoot initiation in hypocotyls explants of rapeseed was best achieved in MS medium containing BAP1 1.0 mg/L + NAA 0.2 mg/L + GA_3 0.02 mg/L + $AgNO_3$ 1.0 mg/L. The shoot regeneration and shoot elongation occurred on MS medium containing with BAP2 0.00125 mg/L + adenine hemisulfate 40 mg/L + PVP 500 mg/L.

Marker Assisted Selection:

- For tidal submerged tolerant rice variety development three F5 and twelve M4 mutant lines were selected in T aman 2021 for further evaluation.

- For high yield and short duration rice variety development thirteen materials were grown with three standard checks In Boro (BRRI dhan96), 2021-22. The line Bina(bio)-BC2-5-2-3-14 produced the higher yield (9.05 t/ha) followed by line Bina(bio)-BC2-5-2-11-2-33 (8.82 t/ha) and line Bina(bio)-BC2-5-2-3-50 (8.65 t/ha).

- For premium quality rice variety improvement about 100 F3 plants were selected from 25 segregating F3 populations in T. aman 2021 and Boro, 2021-22. Twenty nine F4 (Kataribhog x Oryza rufipogon) lines/plants were selected on the basis of better plant types compare to the parents.

Microbial Biotechnology:

- We assessed the growth and production of pea, lentil, and lathyrus in soils using three native strains (BL129, BL153, and BL460). Inoculation of pea with indigenous strain BL460, inoculation of lentil with strain BL129 and inoculation of lathyrus with strain BL460 recorded higher grain yields than all other treatments. Inoculation of indigenous mixed strains also resulted in significantly higher pea, lentil, and lathyrus grain yields than control.

- Three bacterial isolates designated as CD1A, CD2A and CD3 were used with 50% recommended dose of fertilizer were found better in producing effective tillers per hill, filled grain per panicle and grain yield per plant. The present study, therefore, suggests that these bacterial isolates could be used as bio-fertilizers for reducing the use of chemical fertilizers, enhancing growth and yield of rice at field conditions.

- Three strains (TAN-2, TAN-8 and TAN-10) combat the As toxicity in plants and significantly increases plant growth and yield of rice in comparison to control treatment. Among the strains, the strain TAN-2 showed maximum efficiency on growth, yield and yield contributing characters of rice followed by the strain TAN-8.

- Genetic diversity analysis by DNA fingerprint analysis showed four different groups of rhizobia in faba nodules. Among the strains, faba-20, faba- 21 and faba-22 are more diverse than other strains. Taxonomic status analysis by housekeeping gene analysis showed that the strains are belonging to the species *Rhizobium binae.*

PROGRAM AREA I: GENETIC ENGINEERING AND TISSUE CULTURE

1. TRANSFER OF SALINITY AND DROUGHT TOLERANT GENES INTO RICE THROUGH *AGROBACTERIUM* MEDIATED GENE TRANSFORMATION

Most of the indica rice genotypes, the world's most cultivated rice types, still remain less amenable to genetic modifications due to their poor regeneration potential (Hiei Y and Komari T, 2008). The existing protocols for transformation and regeneration of indica rice are tedious, lengthy, and highly genotype-specific with low efficiency of transformation. Considering the significance of genetic transformation in functional genomics and crop improvement the need of the hour is to develop an easy, rapid, reproducible, widely applicable and highly efficient transformation and regeneration protocol for various indica rice genotypes which does not necessitate further genotype specific standardization (Khirod K Sahoo1 et al., 2011). In the present study, we have followed a highly efficient and reproducible *A. tumefaciens* mediated transformation protocol using mature seeds as explants.

Experiments were conducted to establish efficient gene transformation protocol for rice and to find effective method for *Agrobacterium* mediated transformation for developing transgenic rice variety with enhanced salt tolerance. Here, we used one gene like *OsCAL* (Calmodulin like protein1) and embrygenic calli of two rice genotypes (IR64 and Kasalath). The basis of selection for these two genotypes callus producing ability is higher. Mature embryo to induce rice callus used as an explants for gene transformation.

Induction of embryogenic calli from mature embryo

Mature, healthy and diseased free dehusked rice seeds were firstly wash three to five times with sterile distilled water and then sterilized with 70% ethanol (v/v) for 1 followed by 15 minute 50% (v/v) commercial bleach including 2 to 3 drooped of tween20 with shaking at 180 rpm. Seeds were then washed 8-10 times with sterile distilled water and dried on autoclaved whatman paper (3 mm) for five minutes. For callus induction twelve to thirteen seeds were incubated per petridis on callus induction medium (MCI) and incubated at 27 ± 1ºC in dark. MCI was prepared using basal MS medium (Duchefa Biochemie) containing all vitamins supplemented with $30g^{-1}$ sucrose, $0.3g^{-1}$ casein hydrolysate, 0.6 g^{-1} L-proline, 3.0 mg^{-1} 2,4-dichlorophenoxyacetic acid (2,4-D), 0.25 mg^{-1} 6-benzylaminopurine (BAP), gelled with 6.0 g^{-1} gelrite and pH adjusted to 5.8 before autoclaving. After 14-21 days of in dark non-embrygenic calli were discarded and only embryogenic calli were selected. These embryogenic calli subcultured again onto fresh MCI and kept for 4 days (dark, 27 ± 1ºC) before transformation with *Agrobacterium tumefaciens.*

Bacterial strain and plant expression vector construction

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

Co-cultivation and selection of transformed calli

The 4 days subcultured embryogenic calli were collected and *Agrobacterium* infected by immersing them in the *Agrobacterium* culture (GV3101) for 20-25 min with intermittent

gentle shaking at 50 rpm. The *Agro infected* calli were dried on sterile Whatman No. 3 filter paper for 5 min. Calli were then transferred to the co-cultivation medium (MCCM)-MCI containing 10 g/l glucose, pH 5.2, 150 μM acetosyringone and incubated at 27 ± 1°C in the dark for around 48 hours. Once slight growth of *Agrobacterium* appeared around most of the calli. The calli were rinsed 8-10 times with 250 mg/l cefotaxime in sterile distilled water, dried on
sterile Whatman No. 3 filter paper and transferred onto first selection medium-MSM (MCI containing 250 mg/l cefotaxime) and incubated for 12 days at 27 ± 1°C in dark. After the first selection, brown or black calli were removed and only creamish healthy calli were shifted to the fresh MSM media for second selection and maintained at 27 ± 1°C in dark. After second selection for 10 days, microcalli could be observed which were finally transferred to fresh MSM media for third selection and allowed to proliferate for 5 days at 27 ± 1°C in dark.

Regeneration of transformed calli

After third selection, black or brown microcalli were discarded and only granular 'macrocalli' were transferred onto regeneration medium containing either two or three growth regulators comprised of MS salts, 30 gl^{-1} maltose, 2 mgl^{-1} kinetin, 0.2 mgl^{-1} naphthalene acetic acid (NAA), pH 5.8; gelled with 6.0 gl^{-1} and 250 mgl^{-1} cefotaxime added after autoclaving. These microcalli were incubated at 27 ± 1°C in dark for 7 days for the first phase of regeneration. During the second phase of regeneration, these were shifted to fresh regeneration medium and incubated in light for 4 days. For development of roots, the regenerated shoots were shifted to test tube (100ml) containing rooting medium MROM (comprising half strength MS salts, 30 gl^{-1} sucrose, 3.0 gl^{-1} phytagel, pH 5.8 and cefotaxime 250 mgl^{-1}

We have used seeds as the explants, as these would be available to the researchers all round the year. Seed was plating on MS medium and after 14 days old calli for further sub-culturing, only the embryogenic calli were subcultured for 4 days on freshly prepared MS-medium. The table table 1) reveled that callus induction and embryogenic callus induction were found higher Kasalath (64.66 and 62.32%) followed by IR64 (56.99 and 50.33%). After 4 days, only embryogenic calli were subcultured subjected to Agro-infection using *Agrobacterium* carrying the gene construct and co-cultivated for ~48 hours on co-cultivation medium. Once the growth of*Agrobacterium* could be visualized at the periphery of the individual calli, these were shifted to1st selection medium. After ~12 days on the selection medium, some of the calli turned brownish while the other remained creamish. The creamish colored calli were then transferred tofreshly selection medium for a second selection cycle where small microcalli started growing on the mother calli. These microcalli were gently separated from the mother calli and transferred to fresh MS selection medium for the third selection. During the research period a number of embryogenic calli were infected by *OsCAL* gene through *agrobacterium* mediated gene transformation. The research work has been done several of time. Unfortunately the transformed calli were shown bacterial over growth in some of time selection and some of time regenerated stage. This work is going on and optimization will be needed for control the bacterial over growth for infected transformed calli.

Table 1: Varietal differences in percent of callus induction and embryogenic callus of two tested genotypes

Genotypes	No. of Seed plating	Average % of callus induction ±SE	Average % of embryogenic callus ±SE
IR 64	100	56.99±4.20	50.33 ± 4.56
Kasalath	100	64.66± 5.66	62.32 ± 2.93
CV (%) LSD (0.05)	-	19.29 6.29	19.38 6.58

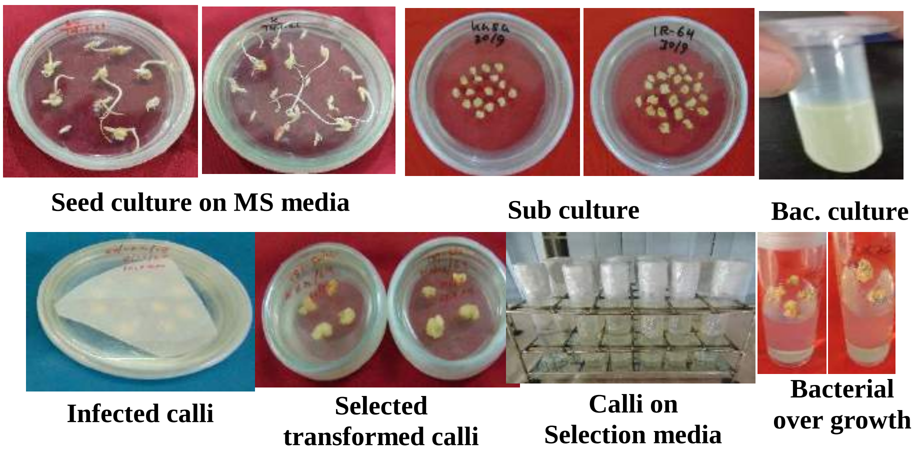


Fig 1: Steps of Genetic transformation (*Oryza sativa* L.)

This speedy, yet less labor-intensive, protocol overcomes major limitations associated with genetic manipulation in rice. Moreover, this protocol uses mature seeds as the explants, which can easily be obtained in quantity throughout the year and kept viable for a long time. Such an easy, efficient and generalized protocol has the potential to be a major tool for crop improvement and gene-function studies on the model monocot plant rice.

2. PRODUCTION OF DOUBLED HAPLOIDS LINE THROUGH ANTHERS CULTURE FROM RICE F_1 HYBRIDS

In vitro androgenesis or anther culture is a where the pollen grains are made to switch from their normal pollen developmental pathway towards an embryogenic route. It is also a tool for the rapid recovery of fixed breeding lines in rice. Haploid and doubled haploid produced through androgenesis have been used in plant breeding for quite a long time as it can shorten the breeding cycle, fix agronomic characters in homozygous state and increase the selection efficiency of useful recessive agronomic traits.

A total of six F_1 populations were grown during the research period in biotechnology research field under optimum management. Out of this two populations (Binadhan-12 x Kasalat and Binadhan-17 x *Oryza rufipogon*) were at T. aman, 2021 and four populations (BRRIdhan50 x Kasalat, BRRIdhan50 x Pokkali, BRRIdhan50 x *Oryza rufipogon* and BRRIdhan48xPokkali) were at Boro, 2021-22 season. Boots with appropriate stage (uninucliate/mid uninucleate at reduction division stages) were collected from F_1 plants. The boots were pre-incubated in a refrigerator at 8ºC for 8-10 days. The panicles were opened from the boots and cut into small pieces. They were then surface sterilized by immersing in 70% ethanol for 2-3 minutes and then placed onto the sterile filter paper in Petri dishes to remove access alcohol. For callus induction, anthers were incubated in three different culture media (Nitsch, Chu N6, and

Gresshoff & Doy Medium, Duchefa) and kept in an incubator under dark condition at 25ºC until callus initiation and subsequent growth up to appropriate size (2.0 mm). Calli were then transferred into regeneration medium (MS medium containing 1.0 mg/l NAA+ 1.0 mg/l Kn) and cultures were incubated in a cultured room under cool white fluorescent lamps (approximately 1000 lux, at 25ºC) for regeneration. Eight weeks after transfer of calli into the regeneration medium, data were taken on number of anther plated, number of callus produced, number of green and albino plant regenerated.

In T. aman 2021 a total of 16,985 anthers were plated three different type's media from two F_1 generations. Out of this only 5 calli M_1 medium and 15 Calli M_2 medium were found from one F_1 generation (Binadhan-12 x Kasalath). Finally only 8 green plant and 6 albino plant were survived which calli were produced from M_1 medium (Nitsch and Nitsch). Seed were collected from green plant. Next season harvested seed were tested for further generation improvement.

On the other hand In Boro 2021-22 a total of 10,441 anthers were plated three different types of media from three F_1 generations. During the reporting period about 15 calli were count. Out of this only 7 calli was found from M_1 medium, 5 calli were found from M_2 medium and 3 calli from M3 medium. The research work is ongoing.

Table 2: Callus induction and Plant regeneration from hybrid anther of two crosses at T. aman, 2021

Sl. No.	Crosses	Anther Plated			Call induction(no.)			Plant regeneration (no.)	
								Green plant	Albino plant
		M1*	M2	M3	M1	M2	M3		
1	Binadhan-12 × Kasalat	14350	5525	2220	5	15	-	8	6
2	Binadhan-17 × *Oryza rufipogon*	4530	3540	1170	-	-	-	-	-
Total		4530	9065	3392	-	-	-	8	6

M1: Nitsch and Nitsch medium, M2: Chu N6 medium and M3: Gresshoff & Doy Medium

Table 3: Callus induction and Plant regeneration from hybrid anther of two crosses at Boro, 2021

Sl. No.	Crosses	Anther Plated			Call induction(no.)			Plant regeneration (no.)	
								Green plant	Albino plant
		M1	M2	M3	M1	M2	M3		
1	BRRI dhan50 × Kasalat	900	99	935	3	-	-	-	-
2	BRRIdhan50 × *Oryza rufipogon*	810	54	560					
3	BRRI dhan50 x Pokkali	128	15	136	1	3	2		
4	BRRI dhan48 x Pokkali	540	62	480	3	2	1		
Total		3530	35765	3335	7	5	3		

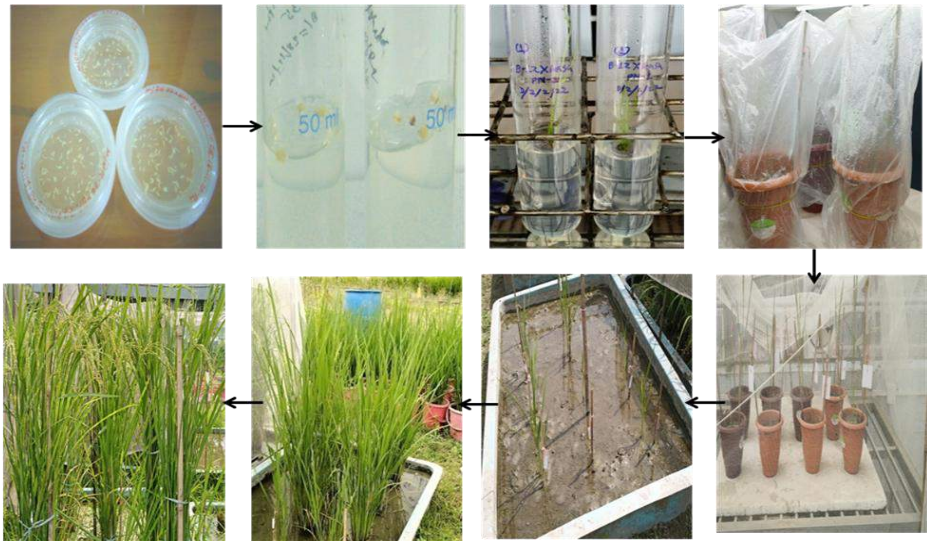


Fig 2 : Steps of Anther culture (anther plating to diploid plant)

In conclusion, this method for anther culture was developed and optimized to produce DH lines for an elite F1 hybrid Binadhan-12 × Kasalat using M2 medium. In this study, a total of eight promising lines were further advanced for on station trial which could be released as varieties, if shows consistent performance in the grain yield and others positive desired characters.

3. DEVELOPMENT OF LODGING RESISTANCE AND HIGH YIELD PREMIUM QUALITY RICE VARIETY THROUGH IRRADIATION ON EMBRYOGENIC CALLUS

Tissue culture techniques offer the great possibilities for selection of mutants through the use of new and expanded genetic variability. The variability in the population leads the chance of effective selection and increase the scope of improvement (khanduja and Goel, 1986). Induced mutagenesis serves a source of variability for better selection. Many researchers have attempted to exploit somaclonal variation for crop improvement particularly treated with gamma radiation. Considerable work has been done on induced mutation in rice callus applied low dosage treatment of gamma rays to callus in rice. The present study was under taken to investigate the extent of variability on callus production and plant regeneration of Kataribhog rice cultivar at different dosages of gamma radiation.

Rice (Oryza sative) cv. Kataribhog seed collected from Chrirbondar Upazila Dinajpur . Mature and healthy seeds of this cultivar were dehusked and surface sterilized in 70% ethanol for 2 minutes followed by 3 times rinses in autoclaved distilled water. Then add 6% commercial bleach supplemented with 8 drops of Tween 20 (Sigma-Aldrich) per liter. After five rinses using sterilized water then dried about 15 minutes in a sterile petridish with tissue paper. Sterilized and dried seed then cultured in MS medium (Murashige and Skoog, 1962, with including vitamins, Duchefa, Netherlands) with 2.5 mgl^{-1} 2,4-D, 30.0 gl^{-1} sucrose and 6.0% gelrite to initiate the callus. After 14-20 days calli were observed and irradiated three different types of doses gama rays (6, 8 and 10 GY). Then only the post embryogenic irradiated calli were transferred to the MS medium supplement with 1.0 mgl^{-1} NAA and 10 mgl^{-1} Kiniten. Repeated sub culturing was done at an interval of 15 days proliferation and organogenesis. When shoots were initiate after 2-3 weeks about 3-4 cm in height, they were separated aseptically from each other and transfer to freshly prepared rooting medium (Half strength of MS + 0.5 5 mgl^{-1} IBA) . The regenerated test tube containing plantlets were incubated in a controlled growth room at 25 ± 2°C and data were recorded to note the response.

In August 2021 to March 2022 an experiment was conducted Biotechnology division, BINA for knowing the ability of embryogenic callus induction and the effect of irradiation on embryogenic calli of Kataribhog rice cultivar and subsequent regeneration of plantlet from irradiated embryogenic calli. Experiments were performed to observe the effect of gamma rays (0, 6, 8 and 10 Gy) on embryogenic calli followed by *in vitro* shoot and root formation in MS medium supplemented with different plant growth regulators. Several parameters such as seed germination percentage, callus initiation, shoot induction and root induction was studied. After callus formation, the calli were treated with different doses of gamma rays (0, 6, 8, 10 Gy) to observe its effect on *in vitro* regeneration. Data revealed that gamma rays negatively affect both shoot and root regeneration ability of embryogenic callus. Shoot regeneration ability was gradually decreased with the increased doses of gamma rays. Shoot regeneration ability (55%) was higher at control (0Gy) condition followed by 37% at 6Gy, 25% at 8Gy and 15% at 10Gy (table 4). The lowest percentage of shoot regeneration was obtained at 10Gy dose. In root induction, the highest root induction ability (68%) was observed at control condition followed by 6Gy (66%), 8Gy (60%) and 10 Gy (50%). Like shoot regeneration 6Gy gamma ray showed better root induction. Finally we got nineteen irradiated *in vitro* regenerated plantlets out of this 10 plants was 6 Gy, 6 plants was 8 Gy and 3 plants was 10 Gays irradiated embryogenic calli. The established regenerated plant hardening and transferred to the pot containing fertile soil. The experiment will be continuing next year for precise results.

Table 4 : Number of calli irradiation and regenerated plant of Different doses of gamma rays.

Cultivar	Dose (Gy)	Calli irradiated (No)	Irradiated calli sub culture (No)	Survived calli on shooting media (No. &%)	Regenerated plant from irradiated calli (No. &%)
Kataribhog	0	40	40	22 (55)	15 (68)
	6	40	40	15(37)	10 (66)
	8	40	40	10 (25)	6 (60)
	10	40	40	6 (15)	3 (50)

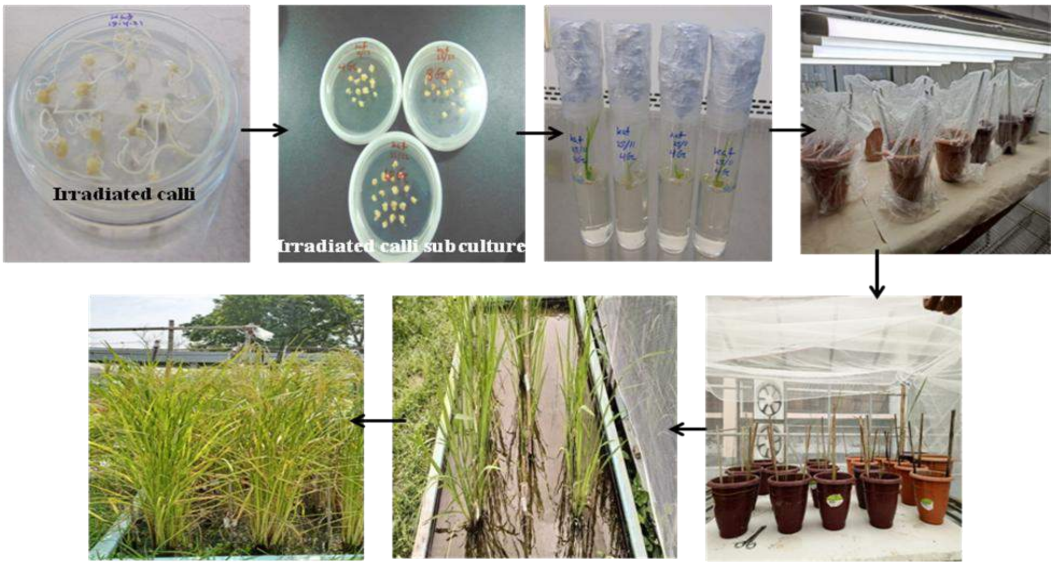


Fig 3: Steps of Irradiated Calli to new Somaclonal plant development

The results of this study revealed that 6 and 8 Gy of gamma ray might be considered as LD50 for this cultivar.

4. DEVELOPMENT OF DROUGHT TOLERANT RICE VARIETY THROUGH PLOYETHYLENE GLYCOL (PEG) STRESSING ON EMBRYOGENIC CALLI OF RICE

Drought is one of the major abiotic stresses causing severe yield loss in crop plants worldwide. In the South and South East Asia, drought causes up to 40% yield loss. In Bangladesh, this loss ranges from 37-73% depending on the grain development stage. Screening drought tolerant plants is a way to sustain production under drought environment. However, screening in field is laborious, time consuming and is dependent on resources such as worker, field and power. *In vitro* selection method could be used as it is simple, ideal and effective for screening large set of germplasms. PEG (6000 MW) has been used in *in vitro* screening of plants such as rice against drought stress. The present study was conducted to determine the effect of artificial drought stress created by PEG (6000 MW) on callus derived shoot regeneration of two drought tolerant varieties, Binadhan-17 and Binadhan-19.

Seeds of two rice cultivars viz. Binadhan-17 and Binadhan-19 were collected from Plant Breeding Division, Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. Mature and healthy seeds of that cultivar were dehusked and surface sterilized in 70% ethanol for 2 minutes followed by 3 times rinses in autoclaved distilled water. Then add 6% commercial bleach supplemented with 8 drops of Tween 20 (Sigma-Aldrich) per liter. After five rinses using sterilized water then dried about 15 minutes in a sterile Petridis with tissue paper. Sterilized and dried seed then cultured in MS mesium (Murashige and Skoog, 1962, with including vitamins, Duchefa, Netherlands) with 2.5 mg^{-1} 2,4-D, 30 mg^{-1} sucrose and 6% gelrite to initiate the callus. After 14-20 days to test the calli survivability, 1L of MS medium supplemented with NAA 1.0 mg^{-1}, BAP & Kinetin Concentration at 2.0 mgl^{-1}, different concentrations of (PEG) (6000) (0%, 5%, 8%, 10%) were added. Cultures were maintained at (25 ± 2)℃ temperature under dark condition. The same experiment was carried out three replications. The data of callus induction, percentage of embryogenic callus induction, percentage of shoot and root regeneration and finally percentage of established plant was recorded.

The rice cultivars (Binadhan-19 and Binadhan-17) were cultured in MS medium supplemented with different concentrations and combinations of plant growth regulators. Under dark condition the average percentage of embryogenic callus induction was obtained in the cultivar from Binadhan-19 (60.45%) which was significantly different from Binadhan-17 (50.20%).

To induce drought stress, different concentrations of PEG (0%, 5%, 8% and 10%) were added in the culture medium. After 14 days, it was clearly observed that the extent of regeneration ability varied from different PEG concentration. In the two cultivars, regeneration percentage was found higher in 0% concentration. Growth rate and regeneration capacity were decreased with increasing levels of PEG concentration. Among the different concentrations of PEG, The lowest value was recorded for the concentration of 10% PEG between the cultivars Binadhan-17 (32%) and Binadhan-19 (40%) respectively (table 5). At 5% PEG, the highest value 48% was recorded in Binadhan-17 and 64%in Binadhan-19. Wani*et al*. (2010) showed both reduced callus induction and shoot regeneration of rice cultivars PAU 201 and PR116 in medium supplement with different concentrations of PEG. Tripathy (2015) also found similar reduction in regeneration frequency with increased concentration of PEG in upland rice. Further, cultivar depended responses with PEG have also been observed. Akte*et al*. (2016) found that rice cultivar Binadhan-10 performed the best against PEG compared to Binadhan-4, Binadhan-5, Binadhan-6 and Iratom-24.In this study, under difference PEG levels Binadhan-19 performed better than Binadhan-17. Shoot regeneration and root induction was higher in Binadhan-19 than Binadhan-17. Both the cultivars show reduction in callus induction with increased levels of PEG.

Table 5. Effect of different concentration of PEG (%) in MS Medium Supplemented with NAA 1.0 mgl^{-1}BAP & Kinetin Concentration at 2.0 mgl^{-1} on shoot regeneration ability.

Cultivars	PEG (%)	No. of calli inoculated	No. of calli showing shoot initiation	Shoot regeneration %
Binadhan-17	0	25	19	76
	5	25	12	48
	8	25	10	40
	10	25	8	32
Binadhan-19	0	25	20	80
	5	25	16	64
	8	25	14	56
	10	25	10	40

Half strength of MS media with supplemented with different concentration of PEG (0%, 5%, 8% and 10%) were used to see the rooting response of the regenerated shoots. MS medium supplemented with different concentrations of PEG and no growth regulator hormones was found most effective for root induction. The lowest value was recorded for the concentration of 10% PEG between the cultivars Binadhan-17 (20%) and Binadhan-19 (30%) respectively. The highest value at 5% PEG was recorded in Binadhan-17 (50%) and Binadhan-19 (60%) respectively.

The small plantlets which attained good shoot development and produced sufficient roots were transfer to pots containing 50% soilrite (1:1:1 ratio of vermiculite, perlite and Sphagnum moss) mixed with soil for hardening. Excess agar around the roots was washed off by tap water to prevent microbial infection. Then the pots were kept in a humidity chamber for 3-5 days in the culture room under 16h light and 8h dark cycle at 28°C and then in green house at (28±2)℃. When the plants grew up to a height of above 10cm and sufficient roots were proliferated, those were transferred to the earthen pot. The tillering capacity and survival rate of the plants in the pots was satisfactory. Finally we got 7 PEG stressing regenerated plant and seed were collected for further evaluation.

Crop genetic improvement for drought stress at the molecular and physiological level is very complex and challenging. The results of this study indicate that, the two rice varieties Binadhan-17 and Binadhan-19 have good callus induction ability as well as inherent tolerance to drought. We suggest that, *in vitro* screening with the induction of chemical drought by using PEG 6000 to modulate drought tolerance would be a feasible strategy to develop drought tolerant lines of rice. The above study will be the base line for future screening experiments.

5. *IN VITRO* CHEMICAL MUTAGENESIS (EMS) ON RICE CALLI FOR GENETIC VARIATION

Plant growth regulators were used to test callus induction and *in vitro* regeneration in rice genotype BRRIdhan89. The objectives of the present study were to evaluate a rice genotype for callus induction and regeneration and examined the possible mutations that may occur due to exposure to mutagens. Four different concentrations (1, 2, 3 and 4 mg/L) of 2,4-D for callus induction and three different concentrations (1,2 and 3 mg/L) of NAA with three doses (5,10 and 15 μ/L) of kinetin for callus regeneration were evaluated. Several EMS concentrations (0.05, 0.10, 0.15, 0.20, 0.25, 0.30, 0.35 and 0.40) % for 120 min was exposed to induce genetic variation. This study found a high callus induction on MS medium enriched with 2 mg/L 2, 4-D. The half-lethal dosage (LD_{50}) of EMS was 0.226% over the duration of 120 minutes. In the regeneration, it was found that an MS medium enriched with 2 g/L Kinetin and 10 μm/L NAA has the ability to induce higher regeneration of BRRIdhan-89 rice variety. From the regenerated plants, eight plants obtained from 0.2% EMS for 120min were availed to complete its life cycle.

Callus induction: *In vitro* callus induction was investigated using mature BRRIdhan-89 embryos by Using media supplemented with various concentrations of 2,4-D (1.0, 2.0, 3.0, and 4.0 mg/L) and without 2,4-D as a control. Different 2,4-D doses have significantly different callus-induction potential (in percent). The callus induction efficiency of BRRIdhan-89 varied from 56 to 85% for various 2, 4-D concentrations. (Fig 1). Without any 2, 4-D treatment, the control did not induce any callus development. At T_2 (2 mg/L 2,4-D), BRRIdhan-89 had the maximum callus induction ability (85%) and T_3 (2 mg/L 2,4-D) and T_4

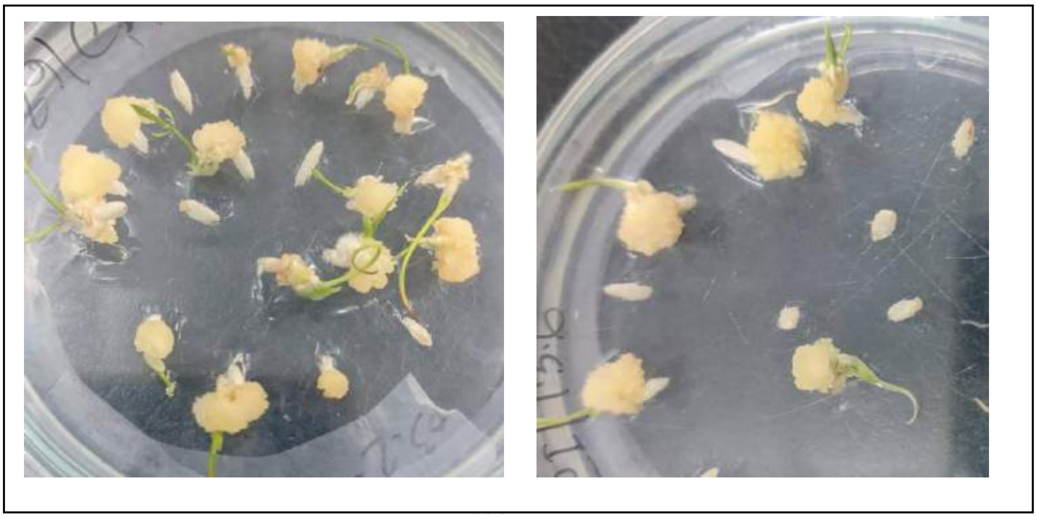


Fig 4: Callus induction of BRRIdhan89 rice from mature embryo.

(2 mg/L 2,4-D) come next.

When the 2,4-D concentration exceeded 2.0 mg/L, it was shown that the frequency of callus induction were reduced. It was observed that different 2,4-D concentrations resulted in

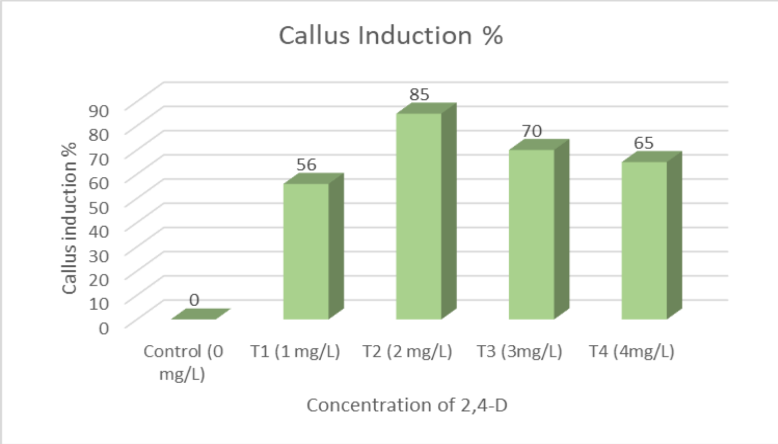


Fig 5: Callus induction percentage of different 2,4-D concentration.

different callus shapes. When 2,4-D levels were high (3 and 4.0 mg/L), calli were yellowish, short or compact, and crumbly. Calli was produced on MS medium with 1.0 and 2.0 mg/L of supplements. 2, 4-D was globular in form and creamy to yellowish.

It has been observed that somatic embryogenesis, which produces embryogenic calli from rice scutellum, benefits from medium optimization as well as from the type and concentration of plant growth regulators. It was observed that interactions between genotypes and culture conditions have an impact on the quantity and quality of embryogenic calli. The most effective auxin for callus induction in rice tissue culture, according to several research, is plant growth regulator 2, 4-D. In this work, callus induction from dehusked seeds of six rice genotypes was tested using varying doses of 2, 4-D alone. Different 2, 4-D concentrations

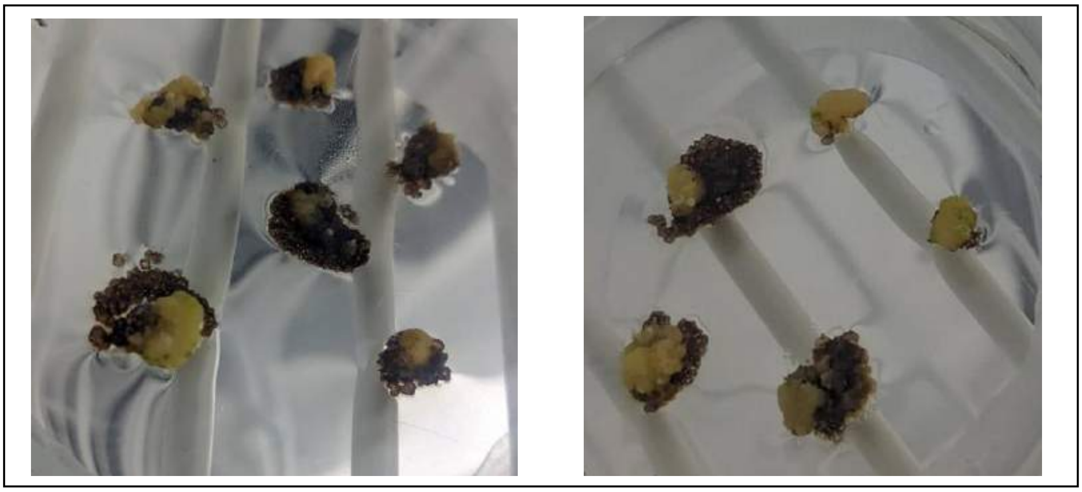


Fig 6: Effect of different doses of EMS for 120 minutes on the callus of BRRIdhan-89.

were shown to result in different callus morphologies. The current study demonstrated that the presence of 2 mg/L 2, 4-D improved callus induction and exhibited varying callus percentages for BRRIdhan-89. This result was consistent with earlier studies that suggested applying 2, 4-D successfully induced calluses in Indica rice. According to Pandey et al. (1994), Thadavong et al. (2002), and Abeyaratne et al. (2004), the ideal concentration of 2, 4-D for inducing callus from ripe rice seeds was 2.0 mg/L. The results of the current investigation were consistent with these findings. Additionally, calli generated on semi-solid

MS medium supplemented with 2.0 mg/L 2, 4-D provided the best desirable traits based on the rice genotypes BRRIdhan-89 [22].

Determination of LD_{50}%: The calli were exposed to various concentrations of EMS for 120 minutes, including 0, 0.05, 0.1, 5.25, 0.35, 0.35, 0.35, and 0.4%. Only 0.05, 0.1, 0.15, 0.2, 0.25, 0.3, 0.35, and 0.4% EMS were used for subsequence mutation. The half-lethal dose (LD_{50}) of EMS was 0.226 % of 120 minutes was observed (Fig 1). The calli's proportion of

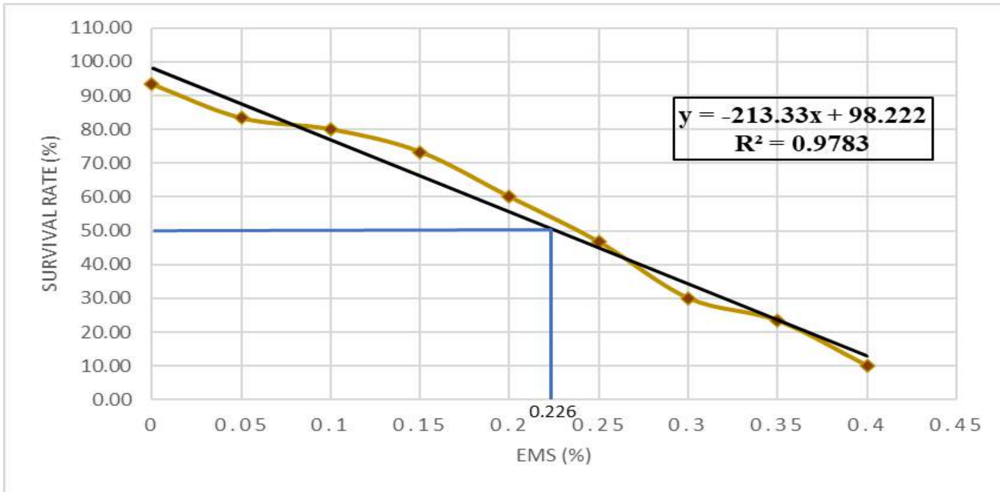


Fig 7: Effect of EMS on survival rate percentage in callus survival.

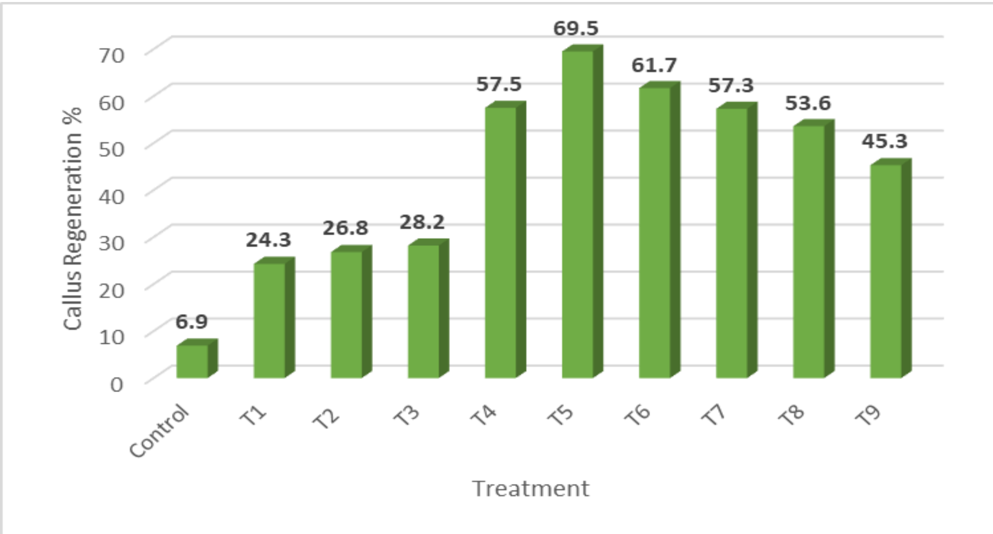


Fig 8: Callus regeneration percentage of different 2,4-D concentration.

survival dropped as EMS concentration rose. The survival rate of the untreated EMS callus was above 90%, whereas the survival rate of the callus at 0.4% EMS was the lowest (Fig 2). According to Datta et al. (2005), the LD_{50} of each plant varies depending on the explant, the explant age, and the amount of mutagen present.

Regeneration: Calli produced on MS media supplemented with 2.0 mg/L 2, 4-D were assessed for their plant regeneration ability after application of EMS mutagen. Significant differences were recorded for plant regeneration ability at different kinetin (0, 1, 2 and 3 mL/L) and NAA (0, 5, 10 and 15 µg/L) concentrations (Table 2). All treatments were found to be significant in the regeneration of plants rather than control. T5 (10 µ/L NAA + 2 mg/L Kinetin) was observed to have the highest regeneration ability. For plant regeneration, the ideal concentration of NAA in combination with 2.0 mg/L kinetin was 10 µg/L, which

Fig 9: Plantlets of BRRIdhan-89 obtained from 0.2% of EMS treatment.

resulted in the maximum plant regeneration frequency, producing both shoots and roots.

The findings of the present study also revealed that as NAA concentrations increased, the frequency of callus-producing shoots and roots reduced. This could be owing to the high concentration of NAA (15 µg/L), which could restrict growth and morphogenesis by inhibiting cytokinin accumulation. The effect of varying NAA concentrations in conjunction with kinetin on root production was the polar opposite of the effect on shoot production. With an increment in NAA concentration, the average number of roots generated per callus was increased. As the concentration of NAA in the medium rises, the ratio of auxin to cytokinin rises as well, resulting in improved root regeneration. Thadavong *et. al.* 2002, described a similar phenomenon. The number of roots generated was reduced when the NAA concentration exceeded 10 µg/L. This NAA severely inhibited growth and morphogenesis at this dose.

Acclimatization: The *in vitro* grown shoots were green and healthy, and they were moved for acclimation (100 percent vermiculate) and kept at a growth chamber at 25°C, 16 h photoperiod, and 30–40 mol/m2s cool white fluorescent light, with about 75 percent survival. The roots sprouted and grew nicely within 3 weeks. After being transferred to large pots and grown in a shaded area for two weeks and then in normal conditions. During acclimatization, rooted shoots grew actively and showed no stress symptoms or morphological abnormalities.

Table 6. Yield and yield contributing character of eight mutant derived from 0.2% EMS for 120 minutes.

SL	Name of the mutant	Plant Height	Total Tiller	Effective Tiller	Panicle length	Yield per plant (g)
1	EM-89-0.2-1-T1	104.2	26	19	26.6	49
2	EM-89-0.2-2-T1	100.8	40	39	26.8	110
3	EM-89-0.2-3-T1	98.4	41	37	25	97
4	EM-89-0.2-4-T1	102.2	47	42	25.8	115
5	EM-89-0.2-5-T1	119.4	31	31	28.4	83
6	EM-89-0.2-6-T1	103	32	30	29.4	85
7	EM-89-0.2-7-T1	118.6	18	18	31.2	53
8	EM-89-0.2-8-T1	113.4	19	19	29.4	45

The regeneration of the genotype of BRRIdhan-89 was successful. We found eight plants from 0.2% EMS treated calli those could successfully complete their life cycle. The mutant EM-89-0.2-7-T1 showed the maximum plant height, whereas the mutant EM-89-0.2-3-T

Fig 10: Acclimatization of Plantlets and Plantlets grown in Field condition.

showed the lowest plant height. The mutant EM-89-0.2-4-T1 produced the most effective tiller. Between 45g and 115g of yield per plant were produced. The highest yield per plant was obtained by the mutant EM-89-0.2-4-T1.

The MS medium supplemented with 2.0 mg/L 2, 4-D produced the maximum frequency of callus induction from matured embryo for the genotype BRRIdhan89, according to the current study. The half-lethal dosage (LD50) of EMS was 0.226% over the duration of 120 minutes. The maximum effective concentration of NAA was 10 μg/L in combination with 2.0 mg/L kinetin for plant regeneration. Eight regenerated mutants of BRRIdhan-89 obtained from 0.2% EMS yielded per plant ranges from 45g to 115g. The genetic variation will be verified with other experiments.

6. MORPHOLOGICAL AND BIOCHEMICAL EVALUATION OF SOME SELECTED TOMATO SOMACLONES UNDER FIELD CONDITION

Morphological evaluation of tomato somaclones

Twenty somaclones from three tomato cultivars with their parents were grown in the field and different morphological characters were evaluated. Mean value of plant height (cm), number of leaves, number of branch, number of cluster per plant, number of fruits per plant, single fruit wt.(g) and yield per plant were presented in Table 13. From the results it is revealed that some somaclones exceeded their parents in one or more characters, while significant decrease was also found.

Among the somaclones and their parents, highest plant height (90.67 cm) was found in SC-3 of BARI Tomato 19 which is statistically similar with parent of BARI Tomato 19 (90.33 cm). Lowest plant height observed in SC-5 (71.17 cm) of Binatomato-11. For the mean value of plant height, most of the somaclones of Binatomato -12 showed superiority compared with their parent except SC-1, SC-6 and SC-10 which mean value decrease with their parent. In case of Binatomato-11, only mean value of SC-4 (74.33 cm) was lowest compare to parent and all other somaclones value increases over their parents. In BARI Tomato 19, SC-3 and parent showed similar result but all other somaclones mean value decreases. Maximum number of leaves (231) was observed in SC-3 of BARI Tomato 19 which is statistically similar with parent of BARI Tomato 19 (220). Minimum number of leaves was found in SC-1 and SC-6 (130) of Binatomato-12. Compare to parent of Binatomato-12 SC-2, SC-4 and SC-8 recorded highest mean value but other somaclones recorded lowest mean value. In Binatomato-11 only SC-1 showed highest mean value (158.67) over their parent. Similar results also observed in BARI tomato 19, only SC-3 showed highest value over the parent The highest mean values of no. of branch per plant were observed in SC-2 of BARI Tomato 19 and parent of BARI Tomato 19 (13). Minimum number of leaves was found in SC-5(5.33) of Binatomato-11. All somaclones except SC-3, SC-4, SC-8 and SC-10 showed superiority over the parent of Binatomato-12. SC-1 and SC-3 of Binatomato-11 also showed superiority over their parents. In BARI Tomato 19, SC-2 and parent showed similar result but all other somaclones mean value decreases.

Maximum cluster per plant (17.67, 17.5, 17.1) were found in SC-4 of BARI Tomato 19, Binatomato-11 and SC-2 of Binatomato-12. Minimum cluster per plant (7.33, 7.5, 7.5) were observed in SC-3, SC-4 and SC-5 of Binatomato-12. From these findings some somaclones showed superiority compared their parents. Highest fruits per plant (44.33) were found in parent of Binatomato-11 which is statistically similar with SC-2 (42.67) and SC-4 (41.67) of Binatomato-12 and Binatomato-11. Lowest fruits per plant (21.17, 21.67, and 21.67) observed in SC-5, SC-6 of Binatomato-12 and SC-3 of BARI Tomato 19. Highest mean values of single fruit wt. (79.32) were recorded in SC-3 of BARI Tomato-19 which is superior to parent of all cultivars. On the other hand, lowest single fruit wt. (25.55) was recorded in SC-4 of Binatomato-11. Maximum yield per plant (1869.4 g) found in SC-2 of Binatomato-12 which is statistically similar with SC-7 (1611.7 g), SC-9 (1639.5 g) of Binatomato-12. Minimum yield per plant (779.7 g) was found in SC-5 of Binatomato-11.

Table 7. Morphological data of different tomato varieties with their somaclones

Variety	Plant height (cm)	No. of Leaves	Branch per plant	no. of cluster per plant	No. of fruits/plant	single fruit weight (g)	Yield/plant (g)
Binatomato-12(parent)	75.00 h-l	150.00 efg	9.33 a-e	9.67 efg	33.00 de	45.21 b-f	1333.7 b-f
SC-1	74.13 j-m	130.00 efg	10.67 a-d	15.00 abc	32.5 def	40.74 b-g	877.0 hi
SC-2	86.93bc	180.00 cd	8.67 a-e	17.10 ab	42.67 ab	47.29 b-f	1869.4 a
SC-3	77.33 f-j	148.00 efg	8.33 a-e	7.33 g	28.07 f-j	46.35 b-f	1371.3 b-e
SC-4	78.67e-h	165.67 cd	8.00 a-e	7.50 g	30.60 d-h	48.37 b-e	1464.7 bcd
SC-5	78.00e-i	158.67 cd	6.67 cde	7.50 g	21.17 m	51.24bc	1180.4 d-h
SC-6	73.33 klm	130.00 efg	9.33 a-e	10.00 efg	21.67 m	47.96 b-f	1005.5 f-i
SC-7	75.67 h-l	150.00 efg	11.33 abc	12.10 def	32.30 def	49.85 bcd	1611.7 ab
SC-8	80.00efg	160.00 cd	5.67 de	10.00 efg	27.20 g-k	45.97 b-f	1259.1 c-g
SC-9	75.67 h-l	150.67 efg	9.67 a-e	14.67 bcd	38.00 bc	49.09 b-e	1639.5 ab
SC-10	72.33 lm	135.00 efg	6.00 de	9.00 g	22.00 lm	38.59 d-g	857.0 hi
Binatomato-11(parent)	75.00 h-l	155.00 ef	7.33 b-e	15.00 abc	44.33 a	37.46 e-h	1587.1 abc
SC-1	76.33 g-k	158.67 cd	10.00 a-e	12.33 cde	25.00 i-m	35.93 fgh	873.3 hi
SC-2	85.13cd	145.33 efg	7.00 b-e	12.00 def	26.67 h-l	43.26 b-g	1097.4 e-i
SC-3	80.33ef	150.67 efg	8.67 a-e	15.33 ab	35.00cd	37.17 e-h	1119.1 e-h
SC-4	74.33 i-m	150.00 efg	6.00 de	17.50 ab	41.67 ab	25.55h	1218.1 d-g
SC-5	71.17 m	153.67 ef	5.33 e	9.33 fg	22.67 klm	32.53 gh	779.7 i
BARI Tomato-19 (parent)	90.33ab	220.00 ab	13.00 a	15.33 ab	31.67d-g	51.43b	1123.3 e-h
SC-1	81.67de	200.00 bc	12.00 ab	9.33 fg	28.67e-i	39.21 c-g	938.3 ghi
SC-2	84.37cd	215.33 ab	13.00 a	15.67 ab	33.00de	47.27 b-f	1111.3 e-i
SC-3	90.67a	231.00 a	10.00 a-e	9.33 fg	21.67m	79.32 a	1558.6 abc
SC-4	84.67cd	210.00 ab	12.00 ab	17.67 a	35.00cd	42.11 b-g	1044.6 e-i
SC-5	79.67efg	180.00 cd	10.00 a-e	9.00 g	23.33 j-m	50.03 bcd	1114.8 e-i
(±) S.E	**0.68**	**3.97**	**0.96**	**0.53**	**0.89**	**2.22**	**61.65**
CV (%)	**1.50**	**4.14**	**18.51**	**7.63**	**5.11**	**8.60**	**8.76**

The same letter in a column didn't differ significantly at 5% level

Table 8. Correlation coefficients between growth and yield parameters of 20 somaclones with 3 parents of tomato cultivar

	Plant height	No. of leaves	Branch/ plant	Cluster/plant	Fruits/ plant	Single fruit wt	Yield/ plant
Plant height	1						
No. of leaves	0.8228**	1					
Branch/plant	0.473*	0.5932**	1				
Cluster/plant	0.2465	0.1853	0.3194	1			
Fruits/plant	0.0626	0.0207	0.1286	0.7711**	1		
Single fruit wt	0.5752**	0.5054*	0.3265	-0.3038	-0.3309	1	
Yield/plant	0.266	0.1263	0.004	0.1461	0.5291**	0.442*	1

Df=21 , *=Significant at 5% level, **= Significant at 1% level

The result of correlation coefficient among the different characters was determined by using pearson's coefficient (Table 14). Number of leaves, plant height and branch per plant were positively correlated with each other. Plant height and number of leaves were highly significant and number of leaves with branch per plant showed strong significant positive correlation. Number of fruits per plant and single fruit weight were significantly correlated with yield per plant. Number of cluster per plant was highly significant with number of fruits per plant.

Biochemical evaluation of tomato somaclones

Some biochemical parameters total soluble solid (TSS), Vit-c, titrable acidity were presented in Table 7. From the data it is found that some somaclones exceeded their parents in one or more characters, while significant decrease was also found.

TSS is a key determinant of shelf life and quality of the crop. Furthermore, TSS levels also contribute strongly to the tomato flavor and consistency (Stevens et al., 1997). TSS ranged from 4.7to 7.2 % (Table 15). The SC-2 of Binatomato-12 gave highest TSS (%) value (7.2%) which is statistically similar with SC-3 and SC-4 of BARI Tomato19 (7.1%, 7.1%). The lowest TSS (%) observed in SC-4(4.7%) of Binatomato-12. SC-3, SC-5, SC-6 and SC-8 mean value of TSS were (6.0, 6.8, 6.7, 6.2) which value were superior compare to their parent of Binatomato-12. In Binatomato-11, SC-1 and SC-3 were superior to their parent. In BARI Tomato-19, all somaclones except SC-1 showed highest TSS (%) value over their parent.

There were significant differences in the amount of ascorbic acid in the different somaclones with their parent of tomatoes studied; it ranges between 17.42mg/100g to 25.68 mg/100g (Table 15). Highest Vit-c content (25.68mg/100 gm) was obtained from SC-2 of Binatomato-11which is statistically similar with SC-8 of Binatomato-12 and lowest Vit-c content (17.42 mg/100 gm) was obtained from SC-4 of Binatomato-12. The level of acidity in tomato fruits is an important parameter associated with sensory attributes like flavor and astringency. Titrable acidity varied significantly between 0.38 to 1.13 per cent (Table 15).The highest TA value (1.13) was recorded in SC-3 of Binatomato-11 and lowest value was obtained from SC-3 and SC-4 (0.38) of Binatomato-12. The observations recorded for pH are presented in table 15. The pH ranged from 3.62 to 4.36 under different somaclones and their parents. The highest pH value (4.36) was recorded in SC-4 of Binatomato-12 and lowest value was obtained from SC-8 (3.62) of Binatomato-12.

Table 9. Biochemical data of different tomato varieties

Variety	TSS (%)	Vit-c (mg/100g)	TA(Titrable Acidity)	pH
Binatomato-12(parent)	5.5gh	23.85 c	0.44 ghi	4.2 ab
SC-1	5.3ghi	18.85 e	0.55 d-g	3.9 c-f
SC-2	7.2 a	25.04 ab	0.66 cd	3.73 efg
SC-3	6.0 f	17.57 ghi	0.38 hi	3.9 d-g
SC-4	4.7k	17.42 i	0.38 hi	4.36 a
SC-5	6.8 bcd	18.83 e	0.56 d-g	3.7fg
SC-6	6.7 bcd	18.37 e-h	0.66 cd	4.06 bcd
SC-7	4.8jk	23.85c	0.51 e-h	3.73 efg
SC-8	6.2ef	25.63a	0.50 e-i	3.63 g
SC-9	4.9ijk	21.28e	0.49e-i	3.8 d-g
SC-10	5.1hij	18.81 ef	0.46 f-i	3.9 d-g
Binatomato-11(parent)	5.6g	17.90 f-i	0.58de	3.73 efg
SC-1	6.8 bcd	18.85 e	0.67cd	4.06 bcd
SC-2	5.2ghi	25.68 a	0.73 c	3.83 defg
SC-3	6.6 cde	24.56 bc	1.13 a	4.2 abc
SC-4	5.3gh	17.57ghi	0.94 b	4.26 ab
SC-5	5.4gh	18.46efg	0.56 d-g	3.7 fg
BARI Tomato19(parent)	6.4de	18.43 efg	0.57 de	3.9 d-g
SC-1	6.0f	17.46 hi	0.60 de	3.86 d-g
SC-2	6.90 abc	18.41 efg	0.60 de	4.0 b-e
SC-3	6.8 bcd	18.73 ef	0.44 ghi	3.83 d-g
SC-4	7.1ab	17.94 e-i	0.53 efg	3.7 fg
SC-5	7.1 ab	18.44 efg	0.60 de	4.26 ab
(±) S.E	**0.07**	**0.17**	**0.02**	**0.07**
CV (%)	**2.01**	**1.47**	**6.96**	**2.33**

The same letter in a column didn't differ significantly at 5% level

7. FUNCTIONAL STUDIES OF OSNHX2 TRANSGENIC TOMATO LINES UNDER SALINITY STRESS

In vitro salinity study

Three OsNHX2 transgenic lines with wild type plants (BARI Tomato 19) of one (1) week seedlings were grown in MS medium containing 0, 100 and 200mM NaCl. After one (1) month total fresh weight (g/plant) was taken from all plants. All the transgenic lines showed better growth than the wild type plants. Transgenic lines had significantly ($p<0.05$) higher fresh weight in stress conditions compared with wild type plants.

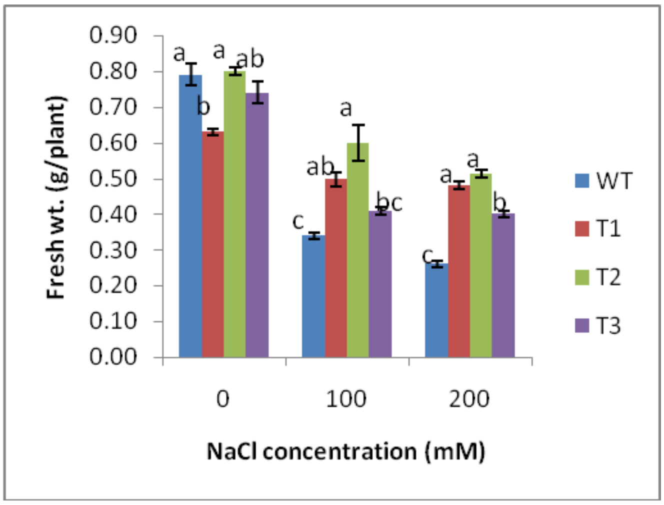


Fig. 11: Effect of *in vitro* salt stress on fresh weight (g/plant) of OsNHX2 transgenic lines T1, T2 and T3 along with wild type (WT) plants grown in MS medium containing 0,100 and 200 mM NaCl. Vertical bars represent the SE of the mean for triplicate determinations.

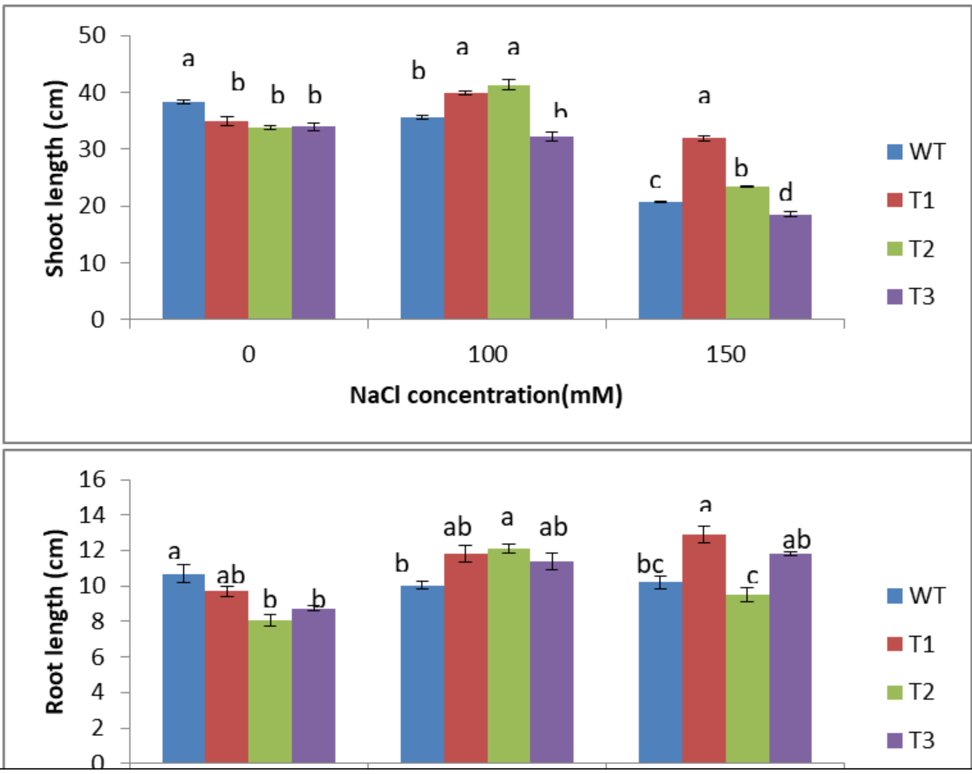


Fig. 12: Effect of shoot and root length (cm) of OsNHX2 transgenic lines T1, T2 and T3 along with wild type (WT) plants grown in hydrophonic culture containing 0,100 and 200 mM NaCl. Vertical bars represent the SE of the mean for triplicate determinations.

Five week old plants both wild type and transgenic plants that were uniform in height were transferred to the hydroponic system with different salt stress condition. After 15 days of salt stress, wild type plants showed higher fresh shoot weight and root weight compared to transgenic plants in control condition. But when salt stress imposed to 100 mM and 150 mM, T1(39.8cm,31.9 cm), T2(41.3cm, 23.5 cm) plants showed higher fresh shoot weight and T1 (11.8 cm), T2(12.1 cm) , T3(11.4 cm) plants showed higher root weight in 100 mM and T1

(12.9 cm), T3(11.8 cm) in 150 mM NaCl concentration compared to wild type plants (Fig. 20).

Five week old plants both wild type and transgenic plants that were uniform in height were transferred to the hydroponic system with different salt stress condition. After 15 days of salt stress some morphological data Shoot fresh weight (g), shoot dry weight (g), root fresh weight (g), and root dry weight (g) were taken.

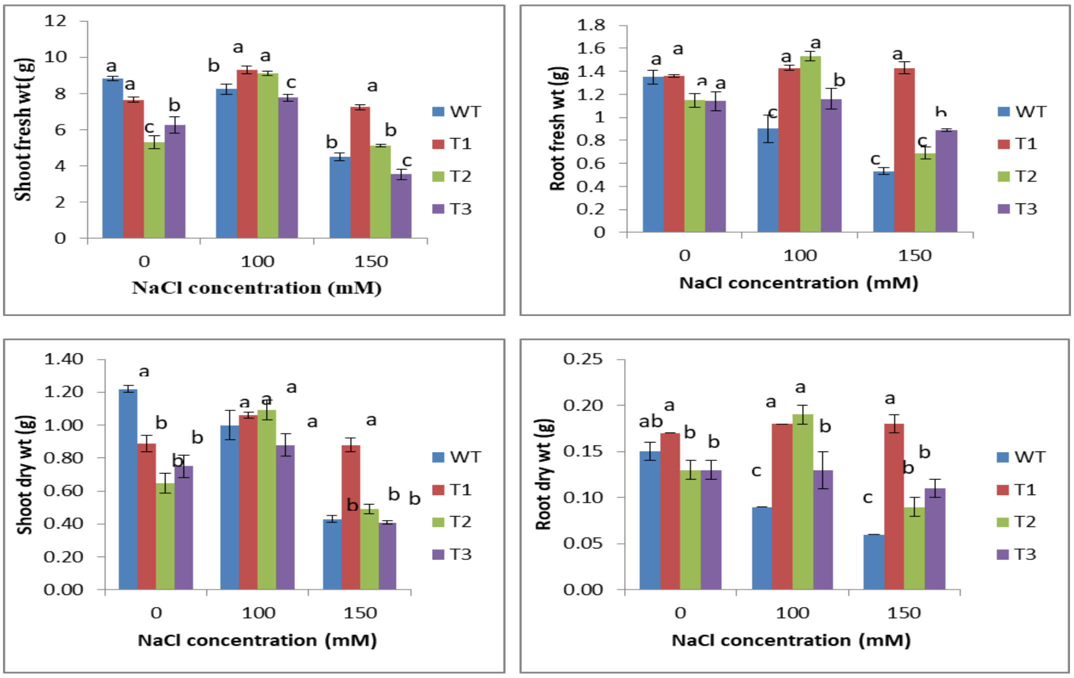


Fig.13. Effect of salinity on shoot fresh weight (g), shoot dry weight (g), root fresh weight (g), and root dry weight (g) of OsNHX2-bar transgenic lines with wild type plants at 0, 100mM and 150 mM NaCl stress condition after 15 days of hydrophonic culture. The data shows the mean ± S.E of three replicates samples and different letters indicate significant difference at $p<0.05$(Tukey HSD All-Pairwise Comparisons Test).

After 15 days of salt stress fresh shoot weight were observed where WT (8.83 g) and T1 (7.66 g) showed higher fresh shoot weight in control condition. When salt stress imposed to 100 mM transgenic plants T1 (9.3 g), T2 (9.09 g) and 150 mM NaCl concentration only T1 (7.24 g) showed higher fresh shoot weight compared to wild type plants. In control and 100 mM salt stress condition no significant variation were found in transgenic and wild type plants but high salt stress condition (150 mM) transgenic plant T1(0.88g) showed significant difference compared to wild type (0.43 g) plants. Like shoot fresh weight, no significant variation observed in root fresh weight in control condition. When salt stress imposed 100 mM and 150 mM all transgenic plants T1 (1.43, 1.43g), T2 (1.53, 0.69 g) and T3 (1.16, .89 g) showed significant difference compared to wild type (0.9, 0.53 g) plants. Highest Root dry weight were observed both in wild type (0.15 g) and T1 (0.17 g) transgenic plant in control condition. 100 mM and 150 mM NaCl salt imposed condition all transgenic plants showed higher root dry weight T1(0.18, 0.18 g), T2(0.19, .09 g), T3(0.13, 0.11 g) with the wild type (0.09, 0.06 g) plants.

Ion estimation (Na^+ and K^+)

Na^+ and K^+ homoestasis is a crucial step in plants for salt tolerance. K^+ accumulation of transgenic plants were higher compared to wild type in control condition in shoot. But the salt stress at 100 mM all transgenic plants showed lower content of K^+ in case of shoot and T1 showed higher K^+ content at high dose of NaCl stress (150 mM). But in case of root all transgenic plants accumulate high K^+ (ppm) compared to wild type plants in all condition (0 mM, 100 mM, 150mM) (Fig.22 A,B). Na^+ accumulation (ppm) was similar in both transgenic and wild type plant in control condition in shoot and root. After salt stress at 100 mM and 150 mM all transgenic plants retained higher Na^+ content (ppm) in than the wild type both in shoot and root (Fig.22 C,D)

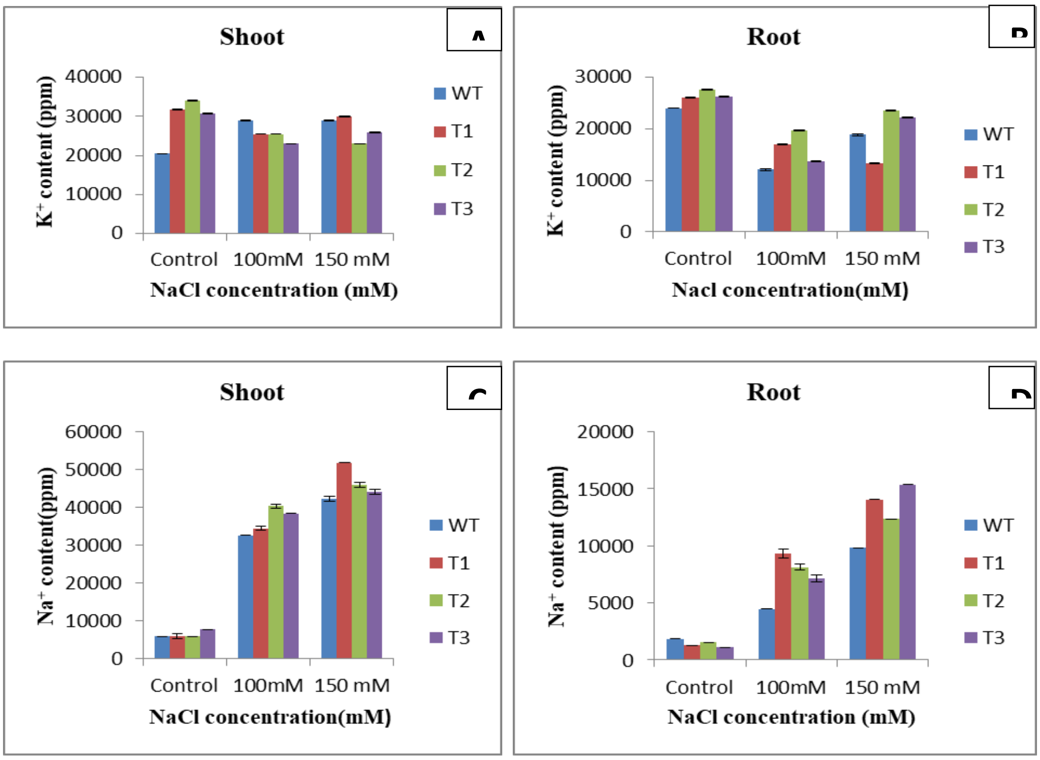


Fig.14: Analysis of K^+ in shoot (A), root (B) and Na^+ in shoot (C), root (D) content of OsNHX2-bar transgenic lines with wild type plants at 0, 100mM and 150 mM NaCl stress condition after 15 days of hydrophonic culture. The data shows the mean ± S.E of three replicates samples.

Chlorophyll measurement

Five weeks old transgenic (T1, T2, T3) and wild type plants that were uniform in height were transferred to the hydroponic system with nutrient solution. After one week, NaCl salt with two concentrations (100 mM and 150 mM) was added with nutrient solution and also control condition (no salt added) was maintained. After 15 days leaf chlorophyll content were taken using chlorophyll SPAD meter (OPTI-Sciences CCM-200 plus). In control condition no significant difference were observed both of transgenic and wild type plant. Increasing salt stress decreasing the chlorophyll content but the rate of decreasing was less compare to wild type. T1 (30.07, and 21.30) and T3 (31.87, 26.63) plants showed higher value at control, 100 mM and 150 mM concentration (Fig. 23).

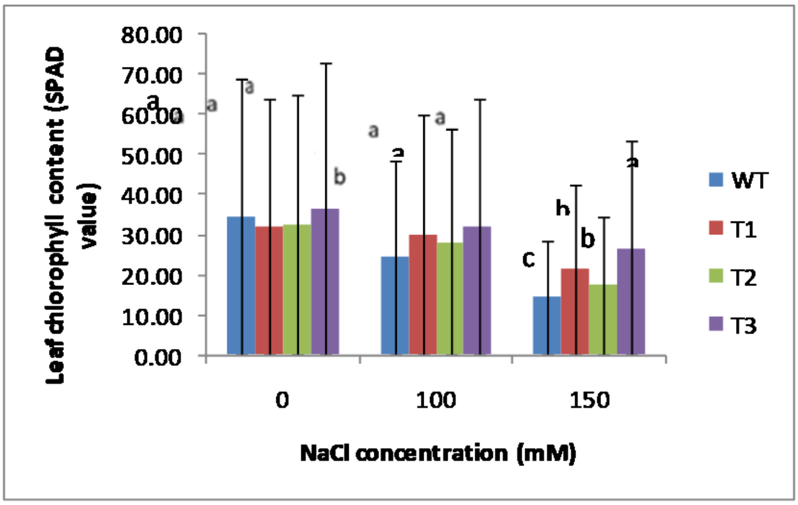


Fig.15: Chlorophyll content in leaves of wild type plants (WT) and transgenic (T1, T2, T3) tomato plants overexpressing OsNHX2 under control (0 mM NaCl) and salt (100 mM, 150 mM NaCl) treatments for 15 days hydrophonic culture. The data shows the mean ± S.E of three replicates samples and different letters indicate significant difference at $p<0.05$(Tukey HSD All-Pairwise Comparisons Test).

8. TRANSFER OF *OsNHX2/OsHKT8* GENES INTO ELITE RAPESEED CULTIVARS THROUGH A*grobacterium* MEDIATED TRANSFORMATION

OsNHX2 and *OsHKT8* high Sodium Potassium ion antiporter gene. Some saline resistance transgenic rapeseed lines will be develope from this research. Rapeseed/ mustard is one of the important crop in Bangladesh. Salinity affects growth and yield attributes of rapeseed. In Bangladesh, more than 30% of the cultivable land is in the coastal area. Out of about 1.689 million hectares of coastal land 1.056 million hectares are affected by various degrees of soil salinity. After harvesting aman rice, a vast area of land remains unused. There is possibility of bringing this vast fallow saline land under cultivation with salt tolerant rapeseed/mustard varieties in rabi season. High saline resistance variety increase mustard production.

For Transfer of *OsNHX2*/*OsHKT8* genes into elite rapeseed cultivars through A*grobacterium* mediated transformation, to establish as in *in vitro* regeneration protocol is required. The experiment was set up at tissue culture laboratory, Biotechnology Division, BINA, Mymensingh. In this study, four rapeseed varieties were used i.e BARI Sharisha 14 and BARI Sharisha 18 from Bangladesh Agricultural Research Institute and other two varieties i.e. Binasharisha-4 and Binasharisha-9 from Bangladesh Institute of Nuclear Agriculture. The seeds of rapeseed varieties were washed with sterilized distilled water. Then the seeds were sterilized with 70% ethanol for 1 min and washed with sterilized distilled water. Then add 3% solution of sodium hypochlorite and one drop of tween-20 in a falcon tube and shaking for 4-5 min. Then the seeds rinsed 5-6 times with sterilized distilled water. After sterilization, seeds were blot dried on sterilized Whatman filter papers and inoculated into the germination medium (1/2 MS medium) in petri plates. pH of the media was adjusted to 5.8.

For callus and shoot initiation, MS media with different concentration growth regulators were used. Hypocotyl from 6-days-old seedlings were cut. Ten formulation of callus and shoot initiation media were prepared with MS media augmented with various concentrations (0.5, 1.0, 1.5, 2.0 and 2.5 mg/L) of 6-Benzyl aminopurine; BAP1 (Stock 10 mg/ml), (0.2 and 0.4 mg/L) of 1-Naphthalene acetic acid (NAA), 0.02 mg/L of Gibberellic acid (GA_3) and 1.0 mg/L of silver nitrate ($AgNO_3$). All media were augmented with 30 mg/L sucrose and solidified with 4g/L gelrite at pH 5.8. Each treatment repeated thrice. Different regeneration medium was formulated by augmenting the MS media with different concentration of (0.00125, 0.00250, 0.00375, 0.0050, 0.00625 and 0.0075 mg/L) BAP2 (Stock 2.5 mg/ml), 40 mg/L adenine hemisulfate and 500 mg/L Polyvinyl pyrrolidone (PVP 40,000). All media were augmented with $30gl^{-1}$ sucrose and solidified with 4g/L gelrite at pH 5.8. The elongated shoots were transferred to rooting media containing half strength MS media (hormone free) or augmented with IBA (1mg/L). All media were augmented with 30g/L sucrose and solidified with 4 g/L gelrite at pH 5.8. Each treatment replicates ten times.

Results:

The seeds of all the rapeseed varieties were germinated on ½ MS medium. Hypocotyls had swollen after 3-4 days of culture, callus and shoot initiate from the cut edges. The hypocotyls cultured on hormone-free MS medium (control), the callus and shoot initiation was 0.0. Among the combinations tested, the highest number of callus and shoot initiation (8.67) observed on MS medium with 1.0 mg/L BAP1 + 0.2 mg/L NAA + 0.02 mg/L GA_3 + 1.0 mg/L $AgNO_3$ in BARI Sharish 18. The lowest number of callus and shoot initiation (3.0) was found from MS medium with 2.5 mg/L BAP1+ 0.4 mg/L NAA + 0.02 mg/L GA_3 + 1.0 mg/L $AgNO_3$ in Binasharisha-9 and BARI Sharish 14.

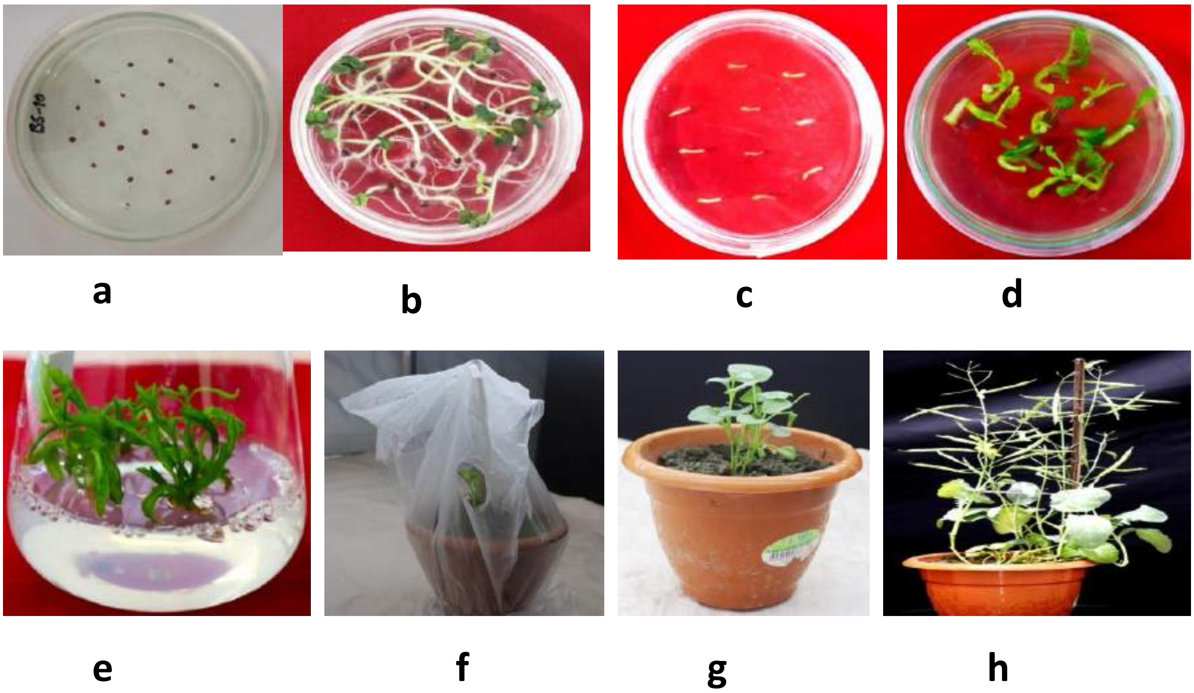


Fig.16: Establishment of rapeseed plant. a) Seed germination, b) 6 days plantlet c) Hypocotyl from plantlet d) Callus and shoot initiation e) Regenerated plant f) Hardening with polythene cover g) Plant inpot h) Plant with siliqua.

Table 10. Mean of Callus and shoot initiation from hypocotyl after 10 days from inoculation

Media combinations (mg/L)	Explant inoculated	Bina Sharisha-4	Bina Sharisha-9	BARI Sharisha 14	BARI Sharisha 18
		Mean number of callus and shoot initiation	Mean number of callus and shoot initiation	Mean number of callus and shoot initiation	Mean number of callus and shoot initiation
MS	10	0.00 g	0.00 e	0.00 f	0 f
MS +BAP1 0.5+ NAA 0.2 +$GA_3$0.02 + $AgNO_3$ 1.0	10	4.00 ef	3.67 d	3.00 e	4 e
MS +BAP1 1.0 + NAA 0.2 +GA_3 0.02 +$AgNO_3$ 1.0	10	8.33 a	7.67 a	6.67 a	8.67 a
MS +BAP 1 1.5+ NAA 0.2 +GA_3 0.02 +$AgNO_3$ 1.0	10	6.67 b	6.00 b	5.67 b	7.33 b
MS +BAP 1 2.0+ NAA 0.2 +GA_3 0.02 +$AgNO_3$ 1.0	10	5.00 cd	4.67 c	4.33 c	6.33 c
MS +BAP1 2.5+ NAA 0.2 +GA_3 0.02 +$AgNO_3$ 1.0	10	4.33 de	3.67 d	3.33 de	4.33 e
MS +BAP1 0.5+ NAA 0.4 +GA_3 0.02 +$AgNO_3$ 1.0	10	3.33 f	3.33 d	3.00 e	3.67 e
MS +BAP1 1.0 + NAA 0.4+GA_3 0.02 +$AgNO_3$ 1.0	10	7.33 b	6.67 b	5.33 b	7.67 b
MS +BAP1 1.5+ NAA 0.4 +GA_3 0.02 +$AgNO_3$ 1.0	10	5.67 c	5.00 c	4.00 cd	6 .00 cd
MS +BAP1 2.0+ NAA 0.4 +GA_3 0.02 +$AgNO_3$ 1.0	10	4.00 ef	3.67 d	3.33 de	5.33 d
MS +BAP1 2.5+ NAA 0.4 +GA_3 0.02 +$AgNO_3$ 1.0	10	3.33 f	3.00 d	3.00 e	4 e
CV		9.74	10.7	11.26	8.84

Table 11. Mean of Shoot regeneration & shoot length (cm) in from hypocotyl after 30 days from inoculation

Media combinations (mg/L)	Explant inoculated	Bina Sharisha-4		Bina Sharisha-9		BARI Sharisha 14		BARI Sharisha 18	
		Mean number of shoots	Mean number of shoot length (cm)	Mean number of shoots	Mean number of shoot length (cm)	Mean number of shoots	Mean number of shoot length (cm)	Mean number of shoots	Mean number of shoot length (cm)
MS	10	0.00 f	0 g	0.00 e	0 g	0.00 f	0 g	0 e	0 g
Ms + 0.00 125 BAP2 + 40 adenine hemisulfate +500 PVP 40,000	10	6.33 a	7 a	6.00 a	6.97 a	5.67 a	6.83 a	6.67 a	7 a
MS + 0.00 250 BAP2 + 40 adenine hemisulfate + 500 PVP 40,000	10	5.67 b	6.83 b	5.33 b	6.77 b	5.00 b	6.63 b	6.00 ab	6.83 b
MS +0.0 0375 BAP2 +40 adenine hemisulfate + 500 PVP 40,000	10	5.00 c	6.57 c	4.00 c	6.6 c	4.00 c	6.43 c	5.33 b	6.63 c
MS + 0.00 5 BAP2 + 40 adenine hemisulfate +500 PVP 40,000	10	4.00 d	6.37 d	3.67 c	6.37 d	3.67 c	6.23 d	4.33 c	6.43 d
MS + 0.00 625 BAP 2 +40 adenine hemisulfate +500 PVP 40,000	10	3.33 e	6.23 e	3.00 d	6.17 e	3.00 d	6.03 e	3.67 cd	6.27 e
MS +BAP2 0.00 75 +40 adenine hemisulfate + 500 PVP 40,000	10	3.00 e	6.03 f	2.67 d	6 f	2.33 e	5.83 f	3.00 d	6.03 f
CV		9.68	0.88	10.73	0.79	11.8	0.98	10.53	0.87

The shoot regeneration observed after 30 days from inoculation. Only MS medium without BAP (2.5g mg/l) do not produce any shoot. The highest (6.67) number of shoot induction was found MS media containing with 0.00125 mg/L BAP 2 + 40 mg/L adenine hemisulfate + 500 mg/L PVP 40,000 in BARI Sharish 18. The lowest (2.33) number of shoot induction was found from MS media with 0.0075 mg/L BAP2 + 40 mg/L adenine hemisulfate + 500 mg/L PVP 40.000 in BARI Sharisha 14. The highest (7) shoot length (cm) was found in Ms media containing with 0.00125 mg L BAP2 + 40 mg/ L adenine hemisulfate + 500 mg/L PVP 40,000 in BARI sharisha 14 and Binasharisha-4. The lowest (5.83) shoot length was found in MS media containing with 0.0075 mg/l BAP2 + 40 mg/l adenine hemisulfate + 500 mg/l + PVP 40,000 in BARI sharisha 14.

The elongated shoots around were transferred to ½ MS media with 1 mg/L IBA and 4g/L gelrite for rooting. After 15-20 days root was developed. The well-rooted plantlets were transferred to pots containing soil and sand and the pots were covered with a polythene bag with pores in it. The plantlets were daily nourished with distilled water.

On the basis of present study it may be concluded that the efficiency of callus and shoot initiation in hypocotyl explant was best achieved in MS medium containing BAP1 1.0 mg/L + NAA 0.2 mg/L + GA_3 0.02 mg/L + $AgNO_3$ 1.0 mg/L. The best shoot regeneration and shoot elongation occurred on MS mediium containg with BAP2 0.00125 mg/L + adenine hemisulfate 40 mg/L + PVP 500 mg/L. The root initiation occurred from elongated shoots on ½ MS (without hormone) or ½ MS+IBA (1 mg/L) rooting medium after 15-18 days and well-developed root found in 15-20 days. The extensive use of high amount of growth regulators reduced shoot initiation and shoot regeneration. *Brassica napus* varieties showed good callus and shoot initiation, shoot regeneration and shoot elongation than *Brassica campestris.*

9. PHENOTYPIC STUDY OF SOME SWEET PEPPER (*CAPSICUM ANNUM* L.) GENOTYPES

Sweet pepper is one of the most important nutritious vegetable and its demand is increasing day by day in Bangladesh indicating need to characterize and assess morphological variability for varietal improvement program. Eleven sweet pepper genotypes (Table 1) from native and exotic sources were characterized for thirty morphological traits using vegetative and reproductive appearances at Bangladesh Institute of Nuclear Agriculture, Mymensingh, Bangladesh from November 2021 to March 2022. Noticeable variation was observed among twenty-three qualitative and seven quantitative traits studied. Twenty-six traits showed undisputable variation among the genotypes. Higher number (9 genotypes) of light purple, purple and dark purple color at node indicated high amount of anthocyanin content. Leaf shape is used as genotypes identifier at vegetative stage and three types of leaves were found with dark green color (6 genotypes) that is highly correlates with yield. In case of flower, 100% white color corolla indicates higher number of fruit set. Entire genotypes exhibited one or more exclusive characters especially fruit shape and color in aspect of Bangladesh which could be used as important breeding materials. Fruit color was observed in various categories at intermediate and mature stage as for instance lemon yellow, orange yellow, orange, red, dark red, red with purple tint etc. as well as higher number of blocky fruit shape (6 genotypes) were observed and these are the consumer catching attributes of sweet pepper. A positive Correlation was observed among the traits and genetic distance value ranged from 0.17 to 0.68 among the selected genotypes However, selection of genotypes with desirable morphological characteristics can be used for their exploitation of future research program.

The experiment was carried out in plastic pots. A total of 165 (11×15) pots were prepared. Each pot size was 10 L and hosted one plant. Seeds were soaked in water for 24 hours in order to facilitate germination and subsequently sown on plastic trays in lines. Sowing of seeds on the tray was done at a depth of one centimeter for easy emergence. Sowing was done on 17 November 2021. Six to seven days were required to start germination. When the seedlings attained 3 leaf stages, they were transferred under the polyethylene shade covering with fine net to prevent from scorching sunlight as well as unexpected storm or heavy rainfall and insect infestation. The seedlings were watered thoroughly every day as per on the requirement. Thirty days old seedlings were transplanted on 22 December, 2021, in well prepared experimental pots comprising of soil, compost and sand (3:1:1).One teaspoon of urea, half teaspoon of MoP and gypsum were applied 25 and 50 days after transplanting of seedlings in the pots. During the crop cycle, appropriate intercultural operations were performed for proper plant growth and development, such as irrigation at different growth stages, weeding, soil mulching and staking as and when needed. Different types of insect infestation were occurred during the experimental period such as mites, aphids, and yellow strip armyworm. To control these karishma, zero mite and mukti @ 1 ml/l L of water were sprayed at 7 days interval.

Observations of different characters were recorded from eleven sweet pepper genotypes at specified stages of crop growth period when the characters under study had full expression. Five plants from each genotype were randomly selected and tagged for recording the observations. The data was taken in the form of descriptor codes assigned by IPGRI, AVRDC and CATIE (1995) for the crop capsicum (*Capsicum spp*.). Fruit parameters were recorded by observing 10 fruits from different plants on mature fruits in the first harvest unless specified. Correlation and dissimilarity study was done by Past 4.10 software.

Plant Growth Characteristics: Diverse variation was found regarding eleven morphological traits of capsicum observed at appropriate stage of each genotype and displayed in Table 2. Two types of stem color were observed such as, dominant green (7 genotypes) and green with purple streak (4 genotypes). Most of the genotypes (10) exhibited cylindrical or round stem shape with strong intensity of anthocyanin coloration i.e., light purple color on nodes (5 genotypes) while angled stem shape were found in case of one genotypes as well as equally two genotypes showed green and purple color at nodes. Purple color or purple color streak on chilli plants indicates the presence of high amount of anthocyanin content, which is an effective antioxidant for human body. Plant growth habit was characterized as prostate, intermediate and erect, where intermediate (8 genotypes) was found dominant compared to prostate (3 genotypes). The branching habit was intermediate in all the genotypes except one sparse and only two genotypes were dense.

Leaf Characteristics: Leaf shape was mainly lanceolate (5 genotypes); some genotypes had deltoid (3) and ovate (3) shape leaves. In the present investigation dark green leaf color was more (6 genotypes) than green (4 genotypes) and light green (1 genotype) color. The dark green color of leaves is generally due to presence of high chlorophyll content in the leaves which ultimately leads to increased yield. Hence, it becomes a good criterion for selection of elite cultivars group. All the genotypes in the present study had entire leaf margin but leaf pubescence were sparse (4 genotypes), intermediate (3 genotypes) and dense (4 genotypes). The leaf density was equally dense (5 genotypes) and intermediate (5 genotypes) as well as sparse in case of one genotype.

Characterization of Reproductive Plant Parts: The most important advances obtained in the genetic improvement of plants are associated with the knowledge of their reproductive system and thirteen morphological traits of reproductive organ of sweet pepper genotypes are arrayed in Table 3. Flower position highly influences the degree and mode of pollination. All of the germplasm showed intermediate flower position and were found having attractive white corolla color which is a desirable trait as it helps in attracting pollinators during the pollination process. Fruit color of sweet pepper genotypes at different stages is one of the most desirable traits for selecting a suitable inbred line. Attractive fruit color, lesser fruit pubescence and smooth fruit texture are the factors which determine consumer acceptability of the product. Hence, these traits become good selection criterion for a breeder. In the present study it was found that fruit color at intermediate stage was green (8 genotypes) and more prominent than lemon green and deep green. Diversified fruit color was observed at mature stage such as Lemon yellow, Orange yellow, Orange, Red, Dark red and Red with purple tint. Among these, red color (4 genotypes) was more dominant (Table 3). Wider variation was found for fruit shape. As per consumer's preference blocky fruits are more preferable and higher number of blocky fruits were observed (6 genotypes) than triangular (4 genotypes) and elongate (1 genotype) shape. Fruits are categorized into four categories based on fruit shape at blossom end as like sunken (5 genotypes), pointed (3 genotypes), blunt (2 genotypes) as well as sunken and pointed (1 genotype). Fruit shape at pedicel attachment was found obtuse (1 genotype), cordate (3 genotypes) and lobate (7 genotypes). Blocky fruit shape, lobate pedicel attachment, sunken blossom end, pendent fruit position and dark green fruit color at maturity are desirable attributes. Perfect fruit shape, size and color along with mild taste are the main quality parameters that make the task of developing new genotypes/variety/hybrids very sticking. All the genotypes were devoid of blossom end fruit appendages except CKN-8 and CKN- 11. As most of the genotypes were blocky, so intermediate corrugation (5 genotypes) found dominant over slightly corrugated (4 genotypes) and corrugated (2 genotypes) at cross section. All the genotypes had straw color seed and most of the genotypes (6 genotypes) contained more than fifty (>50) seeds which were measured from ten fruits in each replication and the average was considered to the number of seed per fruits.

Correlation among the selected traits of the genotypes: Correlation study indicated that there were a significant positive correlation among fruit length, fruit weight and yield per plant. There were also positive correlation between fruit diameter and fruit weight along with no. of fruit per plant and yield per plant. But plant height had a negative correlation with fruit weight and yield per plant.

Genetic Dissimilarity Analysis: Green colored point showed lowest genetic dissimilar pair while red colored point indicated maximum genetic dissimilarity. In Gower's matrix the genotype CKN-3 was found to be the most dissimilar accession with others followed by CKN-11, CKN-12. The genotype CKN-13 showed higher amount of similarity with another genotypes followed by CKN-9, CKN-7 and CKN-6 . In this study, genetic distance among eleven sweet pepper genotypes ranged from 0.17 to 0.68.

Table 12. List of Sweet pepper genotypes used in this study

Sl. No.	Sweet pepper genotypes ID used in this study	Source organization of collection
1	CKN-1	AVRDC, Taiwan
2	CKN-2	AVRDC, Taiwan
3	CKN-3	AVRDC, Taiwan
4	CKN-6	AVRDC, Taiwan
5	CKN-7	AVRDC, Taiwan
6	CKN-8	AVRDC, Taiwan
7	CKN-9	AVRDC, Taiwan
8	CKN-10	AVRDC, Taiwan
9	CKN-11	AVRDC, Taiwan
10	CKN-12	BARI, Gazipur
11	CKN-13	BARI, Gazipur

Table 13. Different plant growth characteristics of Sweet pepper genotypes

Genotypes	Stem color	Nodal antho-cyanin	Stem shape	Stem Pube-scence	Plant growth habit	Branc-hing habit	Leaf Density	Leaf color	Leaf shape	Lamina margin	Leaf Pube-scence
CKN-1	Green with purple streak	Dark purple	Cylindrical	Dense	Prostrate	Sparse	Intermediate	Green	Ovate	Entire	Sparse
CKN-2	Green with purple streak	Dark purple	Cylindrical	Sparse	Intermediate	Intermediate	Intermediate	Dark green	Lanceolate	Entire	Dense
CKN-3	Green	Light purple	Cylindrical	Intermediate	Intermediate	Intermediate	Sparse	Green	Lanceolate	Entire	Intermediate
CKN-6	Green	Light purple	Cylindrical	Intermediate	Intermediate	Intermediate	Intermediate	Green	Lanceolate	Entire	Dense
CKN-7	Green	Light purple	Cylindrical	Sparse	Intermediate	Dense	Dense	Dark green	Ovate	Entire	Dense
CKN-8	Green with purple streak	Light purple	Cylindrical	Sparse	Intermediate	Intermediate	Dense	Green	Lanceolate	Entire	Intermediate
CKN-9	Green	purple	Cylindrical	Intermediate	Prostrate	Intermediate	Dense	Dark green	Deltoid	Entire	Dense
CKN-10	Green	purple	Angled	Sparse	Intermediate	Intermediate	Intermediate	Dark green	Ovate	Entire	Sparse
CKN-11	Green with purple streak	Light purple	Cylindrical	Sparse	Intermediate	Dense	Dense	Dark green	Lanceolate	Entire	Intermediate
CKN-12	Green	Green	Cylindrical	Intermediate	Intermediate	Intermediate	Dense	Light green	Deltoid	Entire	Sparse
CKN-13	Green	Green	Cylindrical	Dense	Prostrate	Intermediate	Intermediate	Dark green	Deltoid	Entire	Sparse

Table 14. Morphological characterization of reproductive plant parts of sweet pepper genotypes

Genotypes	Flower position	Corolla color	Fruit set	Fruit color at interm-ediate stage	Fruit color at mature stage	Fruit shape	Fruit shape at blossom end	Fruit shape at pedicel attachment	Fruit blossom end appendage	Fruit surface	Fruit cross sectional corrugation	Seed color	No. of seeds per fruit
CKN-1	Intermediate	White	Intermediate	Lemon green	Lemon yellow	Blocky	Sunken	Lobate	Absent	Smooth	Slightly corrugated	Straw (Deep yellow)	>50
CKN-2	Intermediate	White	High	Green	Dark red	Blocky	Sunken and pointed	Lobate	Absent	Smooth	Intermediate	Straw (Deep yellow)	>50
CKN-3	Intermediate	White	Low	Green	Red	Elongate	Pointed	Obtuse	Absent	Semi-wrinkled	Slightly corrugated	Straw (Deep yellow)	<20
CKN-6	Intermediate	White	Low	Green	Orange	Triangular	Blunt	Lobate	Absent	Semi-wrinkled	Intermediate	Straw (Deep yellow)	20-50
CKN-7	Intermediate	White	Intermediate	Deep green	Red with purple tint	Triangular	Pointed	Cordate	Absent	Semi-wrinkled	Corrugated	Straw (Deep yellow)	20-50
CKN-8	Intermediate	White	High	Green	Red	Triangular	Blunt	Cordate	Present	Smooth	Slightly corrugated	Straw (Deep yellow)	>50
CKN-9	Intermediate	White	Intermediate	Deep green	Orange yellow	Blocky	Sunken	Lobate	Absent	Smooth	Intermediate	Straw (Deep yellow)	20-50
CKN-10	Intermediate	White	Low	Green	Red	Blocky	Sunken	Lobate	Absent	Smooth	Intermediate	Straw (Deep yellow)	20-50
CKN-11	Intermediate	White	Intermediate	Green	Red	Triangular	Pointed	Cordate	Present	Semi-wrinkled	Slightly corrugated	Straw (Deep yellow)	>50
CKN-12	Intermediate	White	Intermediate	Green	Dark red	Blocky	Sunken	Lobate	Absent	Smooth	Corrugated	Straw (Deep yellow)	>50
CKN-13	Intermediate	White	Intermediate	Green	Orange	Blocky	Sunken	Lobate	Absent	Smooth	Intermediate	Straw (Deep yellow)	>50

Table 15. Yield contributing characters of sweet pepper genotypes

Genotype	Plant height (cm)	No. of fruit/plant	Fruit wt. (gm)	Fruit length (cm)	Fruit diameter (cm)	Yield/plant (gm)
CKN-1	38.5 bc	5 ab	73.52 ab	7.5 cd	6.4 a	367.6 a
CKN-2	50.9 a	7 a	38.45 d	9.1 b	4.2 d	269.15 bc
CKN-3	41.2 b	2 c	14.16 e	5.3 g	1.2 e	28.32 f
CKN-6	53.5 a	3 bc	34.36 d	5.7 fg	4.5 bcd	103.08 e
CKN-7	51.6 a	5 ab	43.76 d	7.9 c	5 bcd	218.8 cd
CKN-8	33.4 de	6 ab	60.34 bc	9.3 b	4.2 d	362.04 a
CKN-9	36.6 bcd	4 bc	39.6 d	5.2 g	5 bcd	158.4 de
CKN-10	30.1 e	3 bc	39.64 d	5.1 g	5.3 b	118.92 e
CKN-11	34.9 cd	4 bc	76.22 a	12.1 a	4.3 cd	304.88 ab
CKN-12	34.3 cde	5 ab	72.94 ab	6.8 de	6.3 a	364.7 a
CKN-13	37.8 bcd	4 bc	49.34 cd	6.5 ef	5.2 bc	197.36 d
CV (%)	6.93	21.15	18.83	7.23	12.24	17.28
$LSD_{0.05}$	4.72	2.97	15.71	0.89	0.97	66.306

Based on the above discussion it can be concluded that a distinct morphological variation was observed among eleven sweet pepper genotypes. Among different morphological traits studied, a higher frequency was observed for plant height, nodal anthocyanin, dark green leaves, intermediate branching habit and flower position, blocky fruit shape, green and red color fruit, sunken blossom end shape, fruit length and diameter, fruit weight, yield etc. indicating fitness of genotypes. The study suggested that the genotypes like CKN- 1, CKN- 2, CKN- 8 and CKN- 9 exhibited desirable characters in various aspects. So, the four genotypes can be selected for the further sequence of the research programs i.e., genetic engineering and tissue culture for higher yield and quality improvement of sweet pepper in Bangladesh.

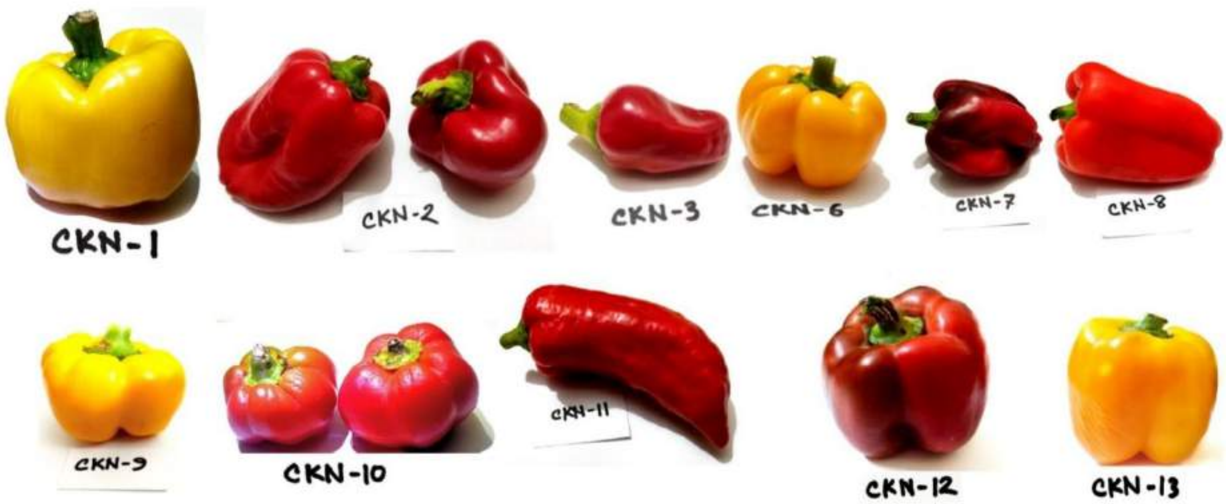
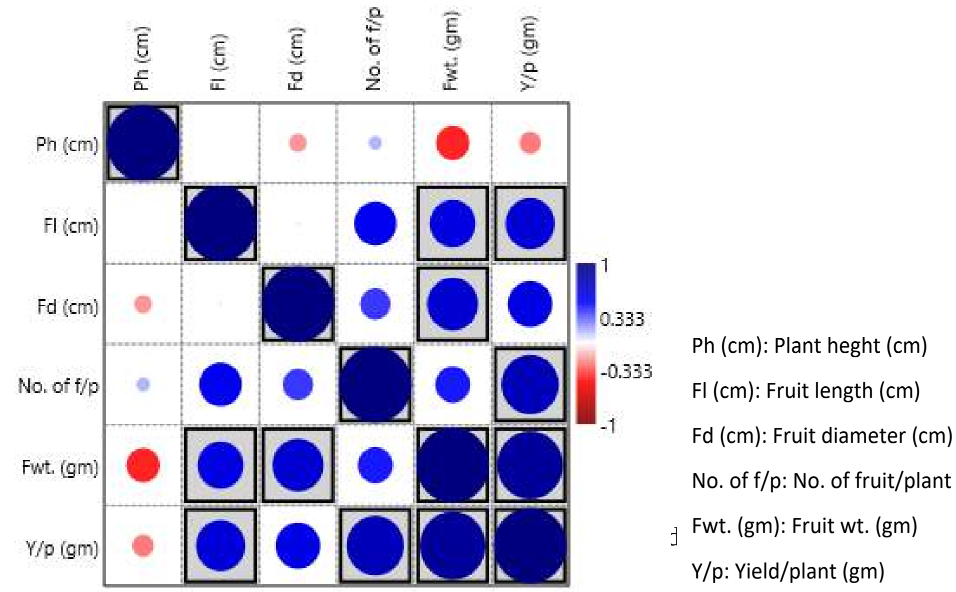


Fig 17: Variation in fruit color, shape and size of eleven genotypes of *Capsicum annuum* L. at mature stage.



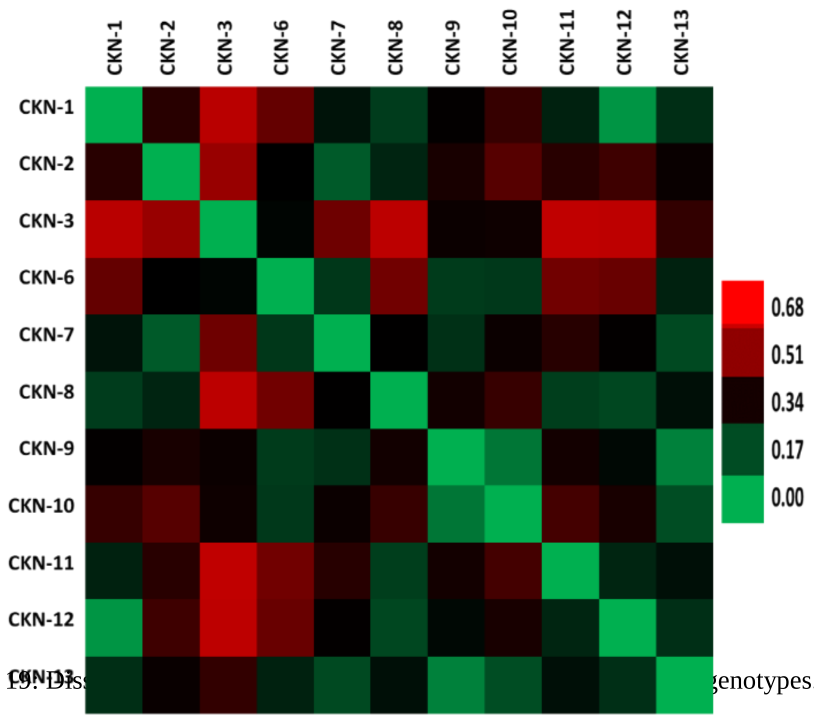


Fig 19: Dis ... genotypes.

PROGRAMME AREA II: MARKER ASSISTED SELECTION/MARKER ASSISTED BACKCROSS BREEDING

10. SCREENING OF SOME SELECTED TIDAL TOLERANT RICE LINE

Bangladesh is the largest deltaic country in the world. Its ecology and climatic conditions offer fertile land for agricultural production. However, the land is also vulnerable to water submergence, sea-level rise (SLR) and intense storm surge events. By the year 2030, global climate models estimate that Bangladesh's annual mean temperature will increase by 10°C, accompanied by a 5% increase in annual precipitation and a 14cm rise in sea level.
Farmers in tidal floodplain of Jhalakati and adjoining areas of Pirojpur, Barguna and Patuakhali districts covering substantial area of Southern Delta Region grow traditional aman rice cultivars. Most traditional aman rice cultivars are tall, long duration, and photoperiod-sensitive with low

yield potential. So the study was undertaken to developed suitable advanced line to cultivate in tidal situation have similar plant and better yielding capacity than indigenous rice cultivar through irradiation and other advanced techniques.

In T. aman 2021 for tidal submerged tolerant rice variety development twenty-one F_4 lines, seventeen F_3 lines and 23 M_3 mutant lines were planted in BINA head quarter, Mymensingh. In T. Aman 2021, three F_5 line were selected from 21 F_4 lines from their better performance. A total of 56 F_4 plant were selected from 17 F_3 lines. The collected samples were bulked and dried, stored for the next season further evaluation. On the other hand, a total of 12 M_4 mutant lines were selected from 23 M_3 mutant lines. The selected seeds were collected, dried and stored for further evaluation. Each progeny was grown in a 0.5m squares meter with line to line distance 20cm and plant to plant distance 15cm using single seedling/hill. Fertilizer was applied at 90:15:30:5:2 of NPKSZn kg/ha and standard agronomic practices were followed.

11. ADVANCE YIELD TRIALS OF SOME SELECTED HIGH YIELDING RICE LINE

Recent studies by several groups have shown that despite its inferior agronomic performance, a wild rice, an accession of *Oryza rufipogon*, is likely to contain genetic factors that can increase the yield of modern varieties. It was reported that *Oryza rufipogon* allele at two QTL loci on chromosome 1 and 2 were associated with an 18 and 17% increase in grain yield per plant, respectively, without delaying maturity or increasing plant height. This discovery suggested the innovative use of wild and exotic germplasm for rice crop improvement through molecular markers. Therefore, the proposed study is set to increase yield of modern Bangladeshi rice varieties through selectively introgressing useful genes from accessions of *O. rufipogon*.

A total of thirteen advance breeding materials were grown in Boro, 2021-22 with three standard checks viz Binadhan-16, BRRI dhan96 and BRRI dhan100. The design of the experiment was RCBD with three replication at BINA head quarter, Mymensingh. Each progeny was grown in a 4.0 (2.0 m x 2.0 m) squares meter with line to line distance 20cm and plant to plant distance 15cm using single seedling/hill. Fertilizer was applied at 120:25:40:10:4 of NPKSZn kg/ha and standard agronomic practices were followed.

During the Boro, 2021-22 thirteen materials were grown with three standard checks at BINA HQs, Mymensingh. Out of these only six materials (Table--) were selected depending on the duration and comparable yield with the checks for further evaluation. The tested lines and the check differed significantly for grain yield and maturity. The line Bina(bio)-BC2-5-2-3-14 produced the higher yield (9.05 t/ha) followed by line Bina(bio)-BC2-5-2-11-2-33 (8.82 t/ha) and line Bina(bio)-BC2-5-2-3-50 (8.65 t/ha). The check variety BRRI dhan96 also produced the higher yield and it was 9.0 t/ha. Highest plant height were found line Bina(bio)-BC2-5-2-3-31 (151cm) followed by line Bina(bio)-BC2-5-2-3-20 (135cm) and the lowest was BRRI dhan96 (110cm) followed by Bina(bio)-BC2-5-2-3-49 (111cm). The yield of the selected lines other agronomic characters further evaluation is needed. So, next season selected lines will be transplanted in the fields.

Table 16. Average yield and days to maturity of some selected materials in Boro, 2021-22 at BINA HQs, Mymensingh

Sl. No.	Line Name	Maturity	Plant height	Yield (ton/ha)
1	Bina(bio)-BC2-5-2-3-14	140- 145	112	**9.05**
2	Bina(bio)-BC2-5-2-11-27	148-150	133	**8.24**
3	Bina(bio)-BC2-5-2-11-2-33	148-150	134	**8.82**
4	Bina(bio)-BC2-5-2-3-42	145-147	125	**8.61**
5	Bina(bio)-BC2-5-2-7-32	142-145	133	7.82
6	Bina(bio)-BC2-5-3-3-47	144-146	120	7.91
7	Bina(bio)-BC2-5-2-3-49	140-145	111	**8.25**
8	Bina(bio)-BC2-5-2-3-50	144-148	115	**8.65**
9	Bina(bio)-BC2-5-2-3-20	152-155	135	7.76
10	Bina(bio)-BC2-5-2-3-31	146-148	151	7.54
11	Bina(bio)-BC2-5-2-3-48	150-155	134	7.86
12	Bina(bio)-BC2-5-2-3-28	148-152	125	7.82
13	Bina(bio)-BC2-5-2-3-41	140-144	128	7.72
14	Binadhan-16	150-153	113	7.77
15	BRRI dhan96	140-145	110	9.00
16	BRRI dhan100	148-150	112	7.1

12. SCREENING OF SOME SELECTED SALT TOLERANT HIGH YIELDING RICE LINE

Salinity is one of the major obstacles to increasing production in rice growing areas worldwide. Therefore, development of salt tolerant varieties has been considered as one of the strategies to increase rice production in saline prone coastal areas. In Bangladesh, out of 2.8 million hectares of the coastal area, around 1.0 million ha has become saline due to heavy withdrawal of surface and groundwater for irrigation and intrusion of seawater. The total coastal saline area covers one third of the 9 million hectares of total cultivated area in Bangladesh. Thus, the objective of this study was to identify salt tolerant rice genotypes using molecular markers and to introgress *saltol* gene from IR4630 into BRRI dhan28 with marker assisted selection technique.

This experiment was carried out to select desirable lines or plants having high yield with salt tolerant. A total of five advance breeding materials were grown in Boro, 2021-22 with one standard checks viz BRRI dhan28. The size of unit plots was 2.0m x 2.0m. Plant to plant distance was 15cm and row to row distance was 20cm using single seedling/hill. The experiment followed RCBD with three replications. On the other hand, a total of 92 F_3 lines were grown during the season for selecting better lines or plant selection. Fertilizer was applied at 120:25:40:10:4 of NPKSZn kg/ha and standard agronomic practices were followed.

The following table revealed the mean data of three replication of the advanced yield trial. Among the tested lines and compared with check three advanced lines were selected for further evaluation. The highest yield were found Bina(bio)-Sl-bc2-5-2-4-15 (8.67 t/ha) line followed by Bina(bio)-Sl-bc2-5-2-5-17 (7.30 t/ha) and Bina(bio)-Sl-bc2-5-2-1-11 (7.06 t/ha) line. The highest plant height were found line Bina(bio)-Sl-bc2-5-2-5-17 (124cm) followed by Bina(bio)-Sl-bc2-5-2-3-6 (123cm) and the lowest was BRRIdhan28 (105cm).

Table 17. Agronomic characteristics of selected materials tested as advanced yield trial, Boro, 2021-22

Sl. No.	Line Name	Maturity	Plant height	Yield
1	Bina(bio)-Sl-bc2-5-2-3-6	145-146	123	6.17
2	Bina(bio)-Sl-bc2-5-2-2-9	145-146	109	6.47
3	Bina(bio)-Sl-bc2-5-2-1-11	144-147	119	**7.06**
4	Bina(bio)-Sl-bc2-5-2-4-15	144-147	114	**8.67**
5	Bina(bio)-Sl-bc2-5-2-5-17	145-146	124	**7.30**
6	BRRIdhan28	140-145	105	5.33

13. DEVELOPMENT OF LODGING RESISTANCE AND HIGH YIELD PREMIUM QUALITY RICE VARIETY THROUGH MARKER ASSISTED SELECTION

Aromatic or scented rice have long been highly regarded in our society not only because of their excellent quality but also because they had been considered auspicious. The aromatic rice variety Kataribhog in the district of Dinajpur, are medium long type, fine grained and highly scented. The cultivar is highly priced in the locality where they are grown. These varieties are characterized by weak stem, highly lodging tendency, very long growth duration, low grain weight and poor yield. Binadhan-13 is another aromatic rice variety in our country, but the variety same problem. Farmers mainly grow these varieties for their own consumption and ceremonial purposes. Under this circumstance a program were taken the two aromatic varieties improved as yield potential and lodging resistance through hybridization with *oryza rufipogon* and BR5.

This experiment was carried out to select desirable lines or plants having high yield with fine grains and aroma. A total of 38 F_2 materials (Binadhan-13x BR5) were grown in T. aman, 2021. On the other hand, Twenty five F_3 (Kataribhog x *Oryza rufipogon)* lines were grown in Boro 2021-22. The size of unit plots was 0.50m x 1.0m. Plant to plant distance was 15cm and row to row distance was 20cm using single seedling/hill. Fertilizer was applied at 120:25:40:10:4 of NPKSZn kg/ha and standard agronomic practices were followed.

In T. aman 2021 about 100 F_3 plants were selected from 25 segregating F_3 populations. Sub sequentially population improvement the previous materials were grown in Boro, 2021-22 and twenty nine F_4 (Kataribhog x *Oryza rufipogon*) lines/plants were selected on the basis of better plant types compare to the parents. On the other hand 107 F_3 plants/lines were selected in T. aman 2021 from the 38 (Binadhan-13x BR5) F_2 populations. The seeds of selected plants were harvested and store for the next season further evaluation.

PROGRAMME AREA III: MICROBIAL BIOTECHNOLOGY

14. COMPERISON OF THE EFFECTIVENESS OF COMMON BIOFERTILIZERS FOR PEA, LENTIL AND LATHYRUS

Rhizobia, the gram-negative soil bacteria, forms root nodules with legume crops and influences their growth and yield. We evaluated the ability of the selected rhizobial strains to affect the growth and yield of pea, lentil, and lathyrus on the high Ganges River floodplain soils of Bangladesh under field conditions. The field experiment included five treatments- three indigenous rhizobial strains (BL129, BL153, and BL460), one mixed culture, and a control. Pea, lentil, and lathyrus seeds were inoculated with rhizobial strains as per the treatments and planted. In this study, we assessed the growth and production of pea, lentil, and lathyrus in Bangladesh's Gangetic flood plain soils using three native strains (BL129, BL153, and BL460). Inoculation of pea with indigenous strain BL460, inoculation of lentil with strain BL129 and inoculation of lathyrus with strain BL460 recorded higher grain yields than all other treatments. Inoculation of indigenous mixed strains also resulted in significantly higher pea, lentil, and lathyrus grain yields than control. Thus, indigenous strains BL129 can be used for lentil and BL460 for pea and lathyrus cultivation to improve nodulation, growth and yield of pea, lentil, and lathyrus on the high Ganges River floodplain soils of Bangladesh.

Significant variation was observed for plant height at different treatment but there was no significant variation in case of branch per plant. Maximum plant height was observed for the treatment T_4 and maximum branch per plant was observed for the treatment T_1. Maximum hundred seed weight, dry weight per plant and plot yield was observed for the treatment T_3 in pea. Significant variation of nodule per plant and nodule weight was observed for different treatment of lentil. For lentil maximum noudule per plant and nodule weight was observed for the treatment T_1.

Table 18. Effect of rhizobial strain on growth, yield and yield contributing character of pea

Treatment	At 50% flowering stage			At harvest					
	Nodule per plant	Nodule weight (g plant^{-1})	Dry weight per plant	Plant height	Branch per plant	Pods per plant	Seed per pod	Hundred seed weight	Plot yield
T_1 (BL129)	20.07c	0.0473a	11.43ab	160.67a	3.93a	37.2b	5.31a	10.33a	960c
T_2 (BL153)	22.4b	0.0636a	10.71bc	155.67b	3.53a	40.27b	4.76b	10.31a	1243.3a
T_3 (BL460)	19.67c	0.058a	12.42a	163.33a	3.47a	48.67a	4.80b	10.37a	1276.3a
T_4 (BL129, BL153 and BL460)	28.13a	0.0597a	9.65c	163.67a	3.87a	34.47b	4.31c	9.49b	1052b
T_5 (Control)	15.2d	0.0536a	9.7c	151.67b	3.4a	33.27b	3.71d	9.32b	926.3c
CV%	3.97	15.75	8.12	1.48	11.2	9.61	4.5	3.73	2.46

Significant variation in the yield contributing character of lentils was observed across treatments. For lentil treatment T1, it was observed that maximum pods per plant, hundred seed weight and plot yield were. There was a significant variation in nodule per plant and nodule weight for several treatments in lathyrus. Maximum noudule per plant and nodule weight for lathyrus were observed for treatments T_2 and T_3.

Table 19. Effect of rhizobial strain on *growth,* yield and yield contributing character of lentil.

Treatment	At 50% flowering stage			At harvest					
	Nodule per plant	Nodule weight (g plant^{-1})	Dry weight per plant	Plant height	Branch per plant	Pods per plant	Seed per pod	Hundred seed weight	Plot yield
T_1 (BL129)	67.73a	0.103a	4.88ab	38.40ab	2.33b	277.0a	1.6ab	3.58a	1300.7a
T_2 (BL153)	52.33b	0.015bc	5.55a	37.73bc	2.07b	217.4c	1.52b	3.52a	1131b
T_3 (BL460)	39.33c	0.017bc	4.81ab	40.07a	3.07a	234.9b	1.53b	3.49a	1132.3b
T_4 (BL129, BL153 and BL460)	24.00d	0.038b	4.74b	38.20ab	2.00b	224.1c	1.67a	3.56a	1139.3b
T_5 (Control)	43.63c	0.012c	4.21b	36.07c	2.20b	185.2d	1.30c	3.31a	1051.3c
CV%	8.32	16.78	8.67	2.74	12.52	1.74	3.39	7.12	0.91

The traits plant height, branch per plant, pods per plant, hundred seed weight, dry weight per plant, and plot yield significantly varied among treatments. For the traits branch per pod, seed per pod, hundred seeds per pod, dry weight per plant and plot yield, T_1 was the most necessary feature treatment. T_3 was found to have the highest plant height, seed weight per hundred seeds, and plot yield. Between T_1 and T_3, there was no significant difference in the trait plot yield.

Table 20. Effect of rhizobial strain on growth, yield and yield contributing character of lathyrus.

Treatment	At 50% flowering stage			At harvest					
	Nodule per plant	Nodule weight (g plant^{-1})	Dry weight per plant	Plant height	Branch per plant	Pods per plant	Seed per pod	Hundred seed weight	Plot yield
T_1 (BL129)	16.13a	0.085b	11.66a	85.67b	5.30a	82.68b	4.49a	6.37a	2039a
T_2 (BL153)	17.67a	0.116a	9.81c	97.33a	4.27c	97.73a	4.36a	5.36bc	1994b
T_3 (BL460)	17.27a	0.117a	10.42b	99.33a	5.07ab	83.40b	4.37a	5.75b	2072.3a
T_4 (BL129, BL153 and BL460)	16.33a	0.050c	9.95c	99.33a	4.73b	84.27b	4.36a	6.59a	1769c
T_5 (Control)	10.80b	0.056c	9.39d	78.33c	3.47d	78.93c	3.97b	5.26c	1741c
CV%	5.93	14.17	2.03	1.96	5.39	1.75	2.82	3.85	0.97

The performance of indigenous rhizobial strains was better than mixed strain and control in producing pea, lentil and lathyrus yield. Compared to all other treatments, the inoculation of pea with the native strain BL460, lentil with strain BL129, and lathyrus with strain BL460 resulted in greater grain yields.

15. GENETIC DIVERSITY OF FABA BEAN Rhizobia FROM DIFFERENT LOCATION OF BANGLADESH

Faba bean (*Vicia faba* L) is a protein rich legume crop which enable to fix atmosphereic nitrogen in association with Rhizobim bacteria. This association provides environment friendly substitution of industrial N- fertilizers with associated improvement in resource efficiency and production costs. Twenty five (25) rhizobial strains were isolated from root nodules of faba bean. To understand morpho-physiological characteristics of the isolated strains, they were evaluated by different morpho-physiological tests. Results revealed that colony size of the strains was ranged from 1.2 to 2.00 mm. All strains showed positive result in nodulation test and also showed acid producing fast growing nature in bromothymol blue (blue) test. In salt tolerance test, four strains (faba-1, faba-2, FM-4c and FM-4f) showed better performance at 1.7% NaCl and nine strains (Faba -1, Faba -2, Faba -6, Faba -10, FM-1a, FM-4c, BL-129, BL-153 and 640) able to grow at PH 5.7. Two strains (faba- 1 and faba- 2) able to sustain in high temperature (40^0C) and high phosphate solubilization index was obtained in Faba-2 (2.75). Symbiotic effectiveness of these isolates was evaluated by conducting pot experiment. The highest seed yield (7.33 gplant-1) and protein content (33.63%) were found from inoculation with faba-2 followed by FM- 1a and faba-10. With that in case of all parameters related to growth and yield viz. plant height, chlorophyll content, number of branches plant-1 , number of nodules plant1 , nodule dry weight, number of pods plant-1 , number of seeds pod-1 and 100-seed weight Faba-2 showed the best result compared to others. Among the strains 66.67% strains showed better performance over control-1 (absolute control) while 44.4% strains showed high performance than control-2 (nitrogenous control) and only 27.74% showed lower performance due to “cheating behavior” or “selfish character”. So, it could be concluded that strain Faba-2 , FM-1a and Faba-10 appears as the promising strains to produce bio-fertilizer as the means of restoring soil fertility and reduction of chemical nitrogenous fertilizers in faba bean. Genetic diversity analysis by DNA fingerprint analysis showed four different groups of rhizobia in faba nodules. Among the strains, faba-20, faba- 21 and faba-22 are more diverse than other strains. Taxonomic status analysis by housekeeping gene analysis showed that the strains are belonging to the species *Rhizobium binae*. Although Rhozbium etli is the main symbiont of faba bean in the rest of the world but in Bangladesh we did not find any strain belong to this species.

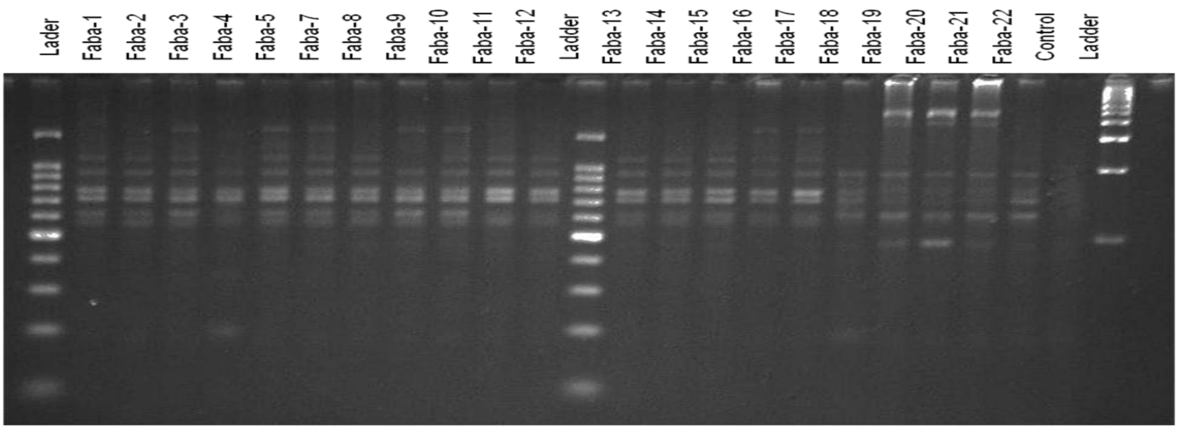


Fig 20: DNA fingerprint of rhizobial strains from faba bean nodule.

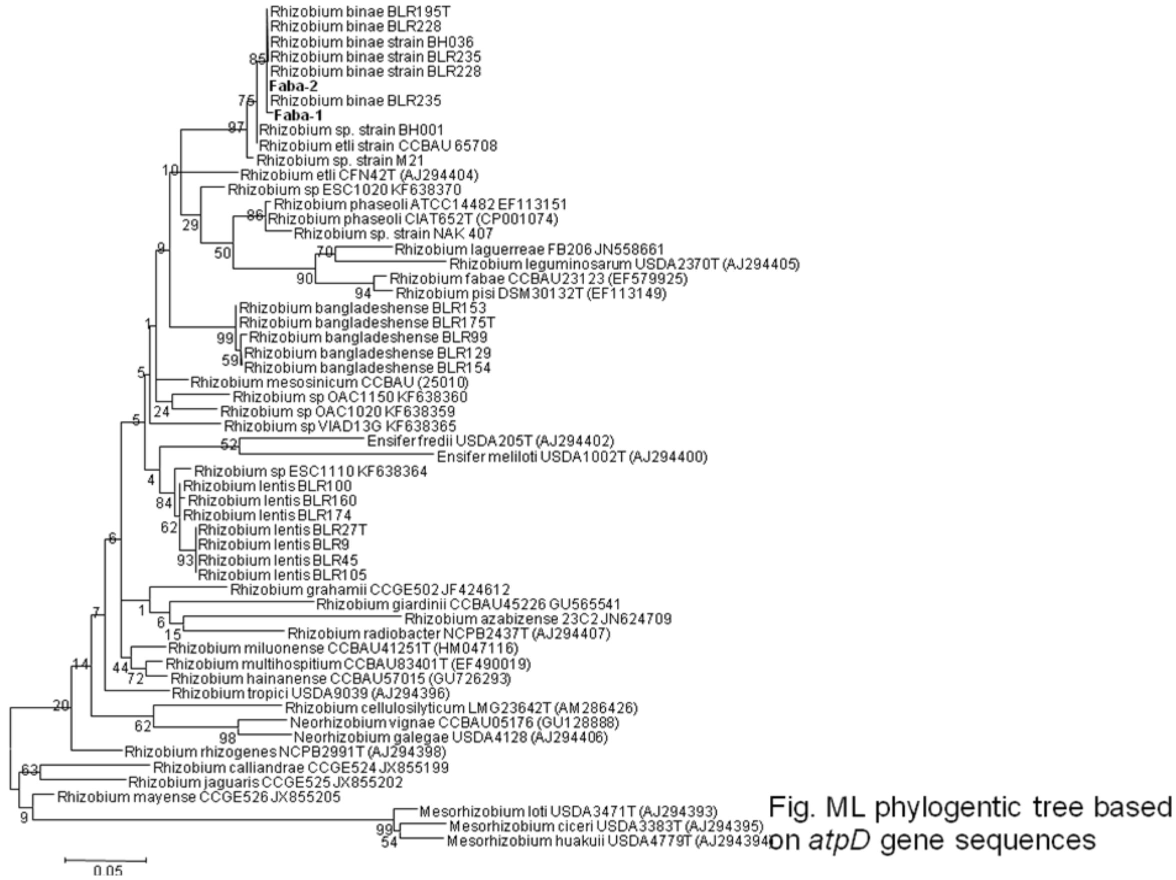


Fig 21: ML phylogenetic tree based on *atpD* gene sequences

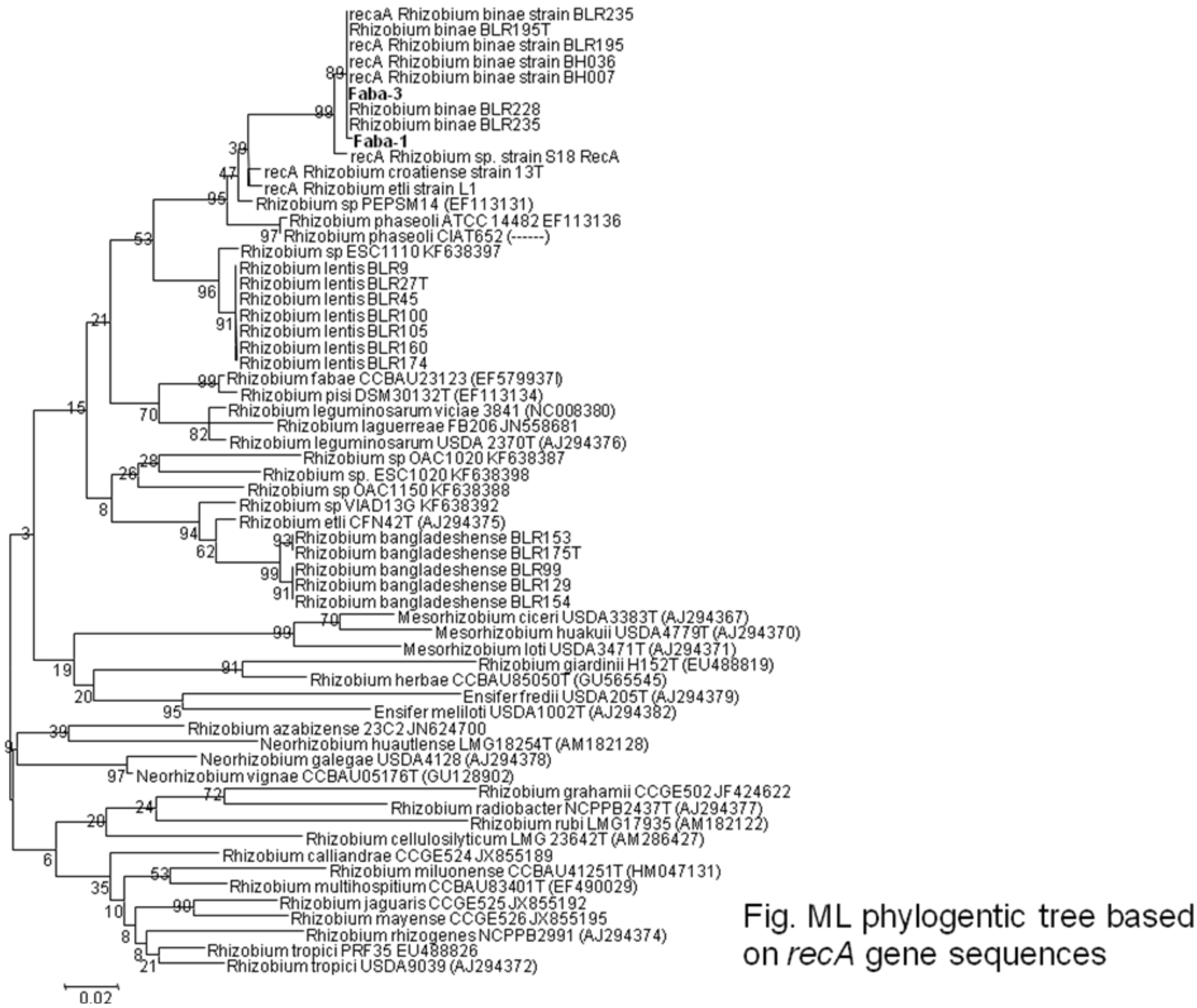


Fig 22: ML phylogenetic tree tree based on racA gene sequences

16. EVALUATION OF PLANT GROWTH-PROMOTING RHIZOBACTERIA (PGPR) FOR THE ENHANCEMENT OF RICE GROWTH AND YIELD UNDER POT CONDITION

Plant growth-promoting rhizobacteria (PGPR) are beneficial bacteria that colonize plant roots and enhance plant growth by a wide variety of mechanisms. Therefore, the use of PGPR is steadily increasing in agriculture and offers an attractive way to replace chemical fertilizers. Here, we have isolated the PGPR from the cow dung for the enhancement of growth of rice. Cowdung were collected from different cattle shed/house of Mymensingh, Bangladesh and twenty bacterial strains were selected based on colony morphology. Three bacterial isolates designated as CD1A, CD2A and CD3 were used with 50% recommended dose of fertilizer in this experiment as treatments to investigate their effects on the growth and yield of rice by pot culture experiment at field condition. Prior to transplantation, seedlings were inoculated with bacterial strains as per treatment. Most of the treatments significantly increased plant height, total tiller per hill, effective tiller per hill, filled grain per panicle and grain weight per plant. Among the treatments, treatments T_1 (CD1A+50% fertilizer), T_2 (CD2A+50% fertilizer) and T_3 (CD3+50% fertilizer) were found better in producing effective tillers per hill, filled grain per panicle and grain yield per plant. The present study, therefore, suggests that the bacterial isolates CD1A, CD2A and CD3 could be used as bio-fertilizers for reducing the use of chemical fertilizers, enhancing growth and yield of rice at field conditions. Further evaluation is needed for confirm their beneficial effects on rice cultivation.

Isolation of PGPR: Twenty bacterial isolates were successfully isolated from the cow dung. They were designated as CD1A, CD2A and CD3 were used in this experiment.

Days to maturity: Significant difference was observed for the trait days to maturity for different treatments. Early maturity was observed in the treatments T_1, T_2, T_3 and T_4 where T_6 took maximum days to mature. Both T8 and control needed more days to mature than the other inoculated treatment.

Plant height: The PGPR isolates significantly affected the height of rice seedlings. Results reveal that plant height increased in bacterial treated plants over uninoculated control. The highest plant height (92.67cm) was recorded in T_2 followed by T_4 (92cm) and T_1 (91.67cm). Phosphorus is one of the major nutrients, second only to nitrogen in requirement for plants. Most of phosphorus in soil is present in the form of insoluble phosphates and cannot be utilized by the plants (Pradhan and Sukla, 2006).

Table 21. Effect of PGPR bacterial strains on growth of rice

Treatment	Days to maturity (days)	Plant height (cm)	Total tiller per hill	Effective tiller per hill	Panicle length (cm)	Filled grain per panicle	Grain weight per hill (gm)
T_1	124.33d	91.67ab	35.67bc	33.67cd	25.47ab	156.00a	81.42a
T_2	124.00d	92.67a	32.67cd	30.00de	24.67abc	105.27cde	72.79b
T_3	124.67d	88.33bc	28.67d	28.00e	24.87abc	133.33abc	58.61c
T_4	124.33d	92.00ab	33.00bc	30.33de	25.60a	138.07ab	55.43cd
T_5	128.67bc	79.00de	41.33a	37.67ab	24.27bc	97.47de	52.86de
T_6	132.00a	84.67c	43.67a	39.33a	24.73abc	107.13bcde	33.94f
T_7	128.33c	75.33ef	22.67e	20.00f	24.07c	85.27e	31.10f
T_8	131.67ab	72.33f	37.00b	34.67bc	24.92abc	99.73de	50.67e
Control	131.67ab	80.67d	9.33f	8.67g	24.63abc	125.53abcd	20.37g
CV%	1.39	2.72	7.39	7.55	2.94	15.78	5.15

Abbreviations: T_1= (CD1A+50% fertilizer), T_2= (CD2A+50% fertilizer), T_3= (CD3+50% fertilizer), T_4= (MIX+50% fertilizer), T_5= (CD1A+100% fertilizer), T_6= (CD2A+100% fertilizer), T_7= (MIX+100% fertilizer), T_8 (100% fertilizer) and Control (No fertilizer)

Total tiller per plant: Among the eight treatments, treatment T6 produced the highest tiller per plant followed by T5 but they were statistically non-significant. The ability of bacteria to solubilize mineral phosphates has been of interest to agricultural microbiologists as it can enhance the availability of phosphorus and iron for plant growth. PGPR have been shown to solubilize precipitated phosphates and enhance phosphate availability to rice that represent a possible mechanism of plant growth promotion under field conditions (Verma et al., 2001).

Fig 23: Effect of different PGPR treatment on growth of rice.

Panicle length: For the parameter of panicle length, there was a significant variation across treatments. The greatest panicle length was measured for the treatment T4 (25.60 cm) then for T8.

Filled grain per panicle: The grain with the maximum filling was observed in T1 (156) treatment which was followed by T4 (138.07) and T3 (133.33).

Grain yield per hill: For the various treatments, a significant variance in grain yield per hill was observed. The largest grain yield per hill was observed at the treatment T_1 followed by T_2 and T_3. The control, which received no fertilizer or bacterial inoculation had the lowest grain production per panicle.

The experimental results suggest that used PGPR bacterial strains can reduce the use of chemical fertilizers, improve the growth and yield of rice plants. There for use of PGPR as bio-fertilizers is an efficient approach to replace chemical fertilizers for sustainable rice cultivation in Bangladesh. Further investigations are needed to clarify the role of these PGPR strains as bio-fertilizers that exert beneficial effects on plant growth and development.

17. EVALUATION OF ARSENIC TOLERENT BACTERIA FOR REDUCTION OF ARSENIC UPTAKE IN RICE IN ARSENIC CONTAMINATED SOIL

The study was undertaken to test the effects of isolated arsenic tolerant bacterial strains from arsenic contaminated areas of Bangladesh on growth and yield of rice. Isolated strains were characterized by morphological, biochemical, functional properties and, identified by 16S-rRNA gene sequencing. Isolated strains were able to grow at higher concentration of arsenic at laboratory conditions. After complete characterization, a pot experiment was conducted during 2021-2022 to scrutinize the role of isolated bacterial strains on rice growth, yield and uptake of arsenic in arsenic contaminated soil. The objective of the present study was to evaluate arsenic tolerant bacteria for reduction of arsenic uptake in rice in arsenic contaminated soil. It was observed that three strains combat the As toxicity in plants and significantly increases plant growth and yield of rice in comparison to control treatment. Among the strains, the strain TAN-2 showed maximum efficiency on growth, yield and yield contributing characters of rice followed by the strain TAN-8. Thus, these results clearly show that the strain TAN-2 showing to its intrinsic abilities of rice growth promotion and could be used for phytostabilization of rice in arsenic contaminated soil.

Days to maturity: Arsenic creates adverse condition in rice rhizophere and influence on growth duration of crops. Different treatments showed significant effect on growth duration of rice (Table-1). The maximum growth duration was observed in the control treatment and minimum was in the treatment two. Pots that were not treated with any arsenic tolerant bacteria took longer time to mature.

Plant height: There was no significant effects were observed on plant height due to the application of different treatments (Table-1).

Total tiller per hill: Different treatments showed significant influence for producing tiller per plant (Table-1). Among the treatments, T_1 produced the maximum total tiller per hill from a single tiller which was followed by the treatments T_2, T_3, and T_4. The treatments T_2, T_3, and T_4 showed significant effects on tiller/hill over the control treatments. Control treatment, T_5 produced the lowest total tiller per plants.

Effective tiller per hill: Effective tiller produced by different treatments showed significant variations (Table-1). The treatments T_1 showed maximum potentiality for producing effective tiller per hill among the five treatments which was followed by the treatment T_2. The lowest effective tiller per plant was recorded in control treatment which was statistically similar to the treatment T_4.

Panicle length: Panicle length was not significantly influenced by different treatments (Table-1). The panicle length was between 23.6 and 24.73 cm among different treatments. Maximum panicle length was observed in treatment T_2 and minimum in control treatment.

Filled grain per panicle: Filled grains per panicle produced by different treatments showed significant differences (Table-1). The maximum filled grains found in the treatment T1 followed by the treatment T_2. T_1 and T_2 had the most grains per panicle, respectively. The least amount of grain was obtained per panicle in the control group, where no bacterial strain was injected.

Unfilled grain per panicle: The treatment T_5 had the most unfilled grains per panicle, followed by T_2 and T_1 (Table-1). The lowest number of unfilled grains per panicle was observed in T_3. Treatments T_1, T_2, T_3, and T_4 showed no significant change for producing unfilled grains per panicle.

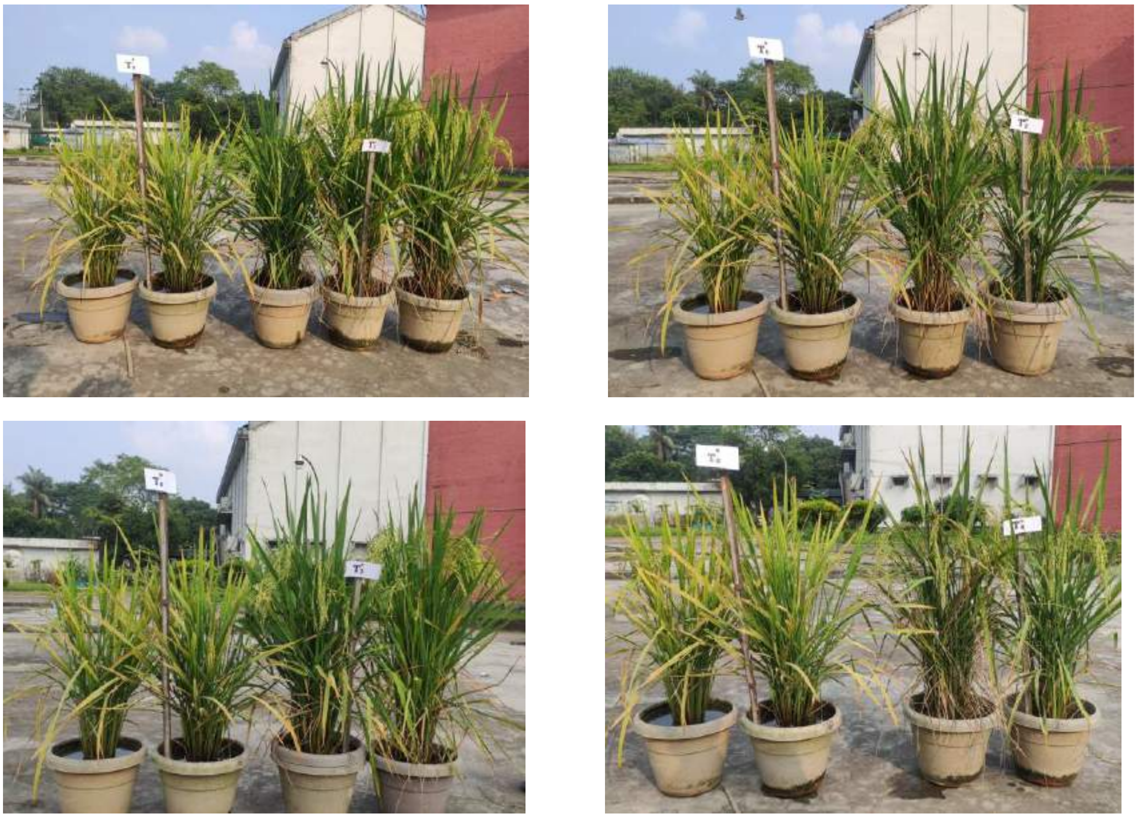


Fig 24: Effect of arsenic tolerant bacteria on growth and yield of rice at arsenic contaminated soils

Table 21: Effect of arsenic tolerant bacteria on growth and yield of rice at arsenic contaminated soils

Treatment	Days to maturity (days)	Plant height (cm)	Total Tiller per hill	Effective tiller per hill	Panicle length (cm)	Filled grain per panicle	Unfilled grain per panicle
T_1	131bc	84.4a	10.53a	9.93a	24.47a	136.6a	25.33b
T_2	128c	81a	7.33ab	7.6ab	24.73a	131.4a	26.73b
T_3	128.33c	81.33a	8.8ab	7.27b	24.2a	95.8b	14.73b
T_4	133.33b	79.73a	8.6ab	4.6c	23.87a	93.87b	20.4b
T_5	138.67a	74.33a	6.2b	4.33c	23.6a	43.33c	53a
CV%	0.75	8.22	10.7	9.67	3.69	6.6	9.46

Treatments details: T_1 (TAN-2), T_2 (TAN-8), T_3 (TAN-10), T_4 (MIX=TAN-2, TAN-8, TAN-10) and T_5 (Control)

Grain yield per pot: Grain yield was significantly influenced by different treatments The treatment T_1 produced maximum yield (89g/pot) which was followed by the treatment $T_{2.}$ $_T$he treatments T_3 and T_4 produced statistically similar yield but significantly different over control treatment. The lowest grain yield was found in control treatment.

Chemical analysis: Chemical analysis for arsenic content in rice grain and straw are under process.

Arsenic tolerant strain TAN-2 and TAN-8 could be used as bacterial inoculants for mitigation of arsenic uptake by rice in arsenic contaminated soil. Further experiment is needed for validation of the pot experiment data.