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ANNUAL REPORT

2022-23

BANGLADESH INSTITUTE OF NUCLEAR AGRICULTURE

September 2023

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BANGLADESH INSTITUTE OF NUCLEAR AGRICULTURE
BAU CAMPUS, MYMENSINGH-2202, BANGLADESH

September 2023

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PREFACE

Bangladesh Institute of Nuclear Agriculture (BINA) Annual Research Report 2022-23 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.

Plant Breeding Division

RESEARCH HIGHLIGHTS

Rice

Three rice lines viz. BLB-P-19, MEF-27 and BN-P-318 have been sent to SCA for DUS test. The line BLB-P-19 is Bacterial leaf blight (BLB) resistant and selected for the cultivation in T. *Aman* season. It matures within 115-120 days and produces grain yield of 6.0-6.5 tha^{-1}. Another Blast resistant rice line BN-P-318 was selected for the cultivation in T. *Aman* Season. The growth duration of BN-P-318 is 110-115 days and produces 6.50-7.00 tha^{-1} of grain yield. The line MEF-27 was selected for the growth duration of this line is 140-145 days and produces grain yield of 7.0-7.5 tha^{-1}. MEF-27 is suitable for the cultivation at haor areas. Apart from this three lines and Fe and zn enriched rice line IZSD-26 was selected for T. *Aman* season which matures within 110-115 days and produces 5.5-6.0 tha^{-1} of grain yield.

Wheat

One promising line BWM-M-1-2-1 had produced higher yield (4.01tha^{-1}) than the check variety BARI Gom-28 (3.91 tha^{-1}) will be evaluated for the next trial.

Rapeseed

One rapeseed variety has been released named as **BINA Sarisha12** having low erucic acid (26%) content, early maturing (82-86 days) with higher (2.0 tha^{-1}) seed yield. Two promising rapeseed mutants (RT-38 and RT-39) were selected for further trials on the basis of their yield stability and other agronomic traits. Twenty mutants and eight advanced rapeseed lines from different trials also been selected in respect of maturity period along with some others improved yield components.

Sesame

Two promising white seed coat color sesame mutants (SM-25 and SM-26) has been selected in respect to higher seed yield potential and improve agronomic characters. From these two mutants one mutant will be applied to the NSB for releasing as a new variety. Nine advance sesame mutants were selected from different trials and on the basis of their agronomic performances.

Soybean

Two advanced soybean mutants (SBM-22 and SBM-25) were selected as promising mutants and fifteen advanced soybean mutants were selected regarding early maturing period along with higher seed yield.

Sunflower

Nine promising sunflower mutants were found early maturing along with higher seed yield potential from different generations.

Groundnut

Yield of the mutants, B6/282/80 was 2.04 tha^{-1} which was higher than the check variety Binachinabadam-4 (1.96tha^{-1}). The mutant line B6/282/80 which has higher shelling percentage and bigger kernel sizes. NSB released a new groundnut variety as BINA Chinabadam11 for Rabi and Kharif season all the groundnut growing areas of Bangladesh.

Five promising mutants of groundnuts were selected for advanced yield trial (AYT) on the basis of early maturity and higher seed yield.

Mungbean

Two promising mutants MB-03 and MB-07 were selected for earliness, synchronous pod maturity, disease tolerant and higher yield from preliminary yield trial.

Jute

Two mutants BJM-10-1-3 and BJM-10-1-5 with taller plant height and higher fiber yield than the parent, JRO-524 have been selected for Zonal Yield Trial in the next season.

On-farm and on-station trials of premium quality rice lines for earliness and higher grain yield

For this experiment, 2 lines MPQR-12, MPQR-62 with two check varieties BRRI dhan49 & BRRI dhan75 were used during *T.Aman* season 2022-23 at different location under the supervision of BINA HQS and BINA Sub-stations. The experiment was followed RCB design with three replications. The size of unit plot was 4.0m × 5.0m. Plant to plant distance was 15cm and row to row distance was 20cm. Data on days to flowering, days to maturity, plant height, total number of tillers $hill^{-1}$, number of effective tillers $hill^{-1}$, panicle length, filled grain and unfilled grains $panicle^{-1}$ and grain yield (t ha^{-1}) were recorded at harvest from five randomly selected competitive plants $plot^{-1}$. The collected data were analyzed. Significant variations were observed among the lines and check varieties for most of the characters in both of individual location and combined over location (Table 1).

Results from combined mean over locations, it was revealed that MPQR-12 performed better in term of earliness (108 days), higher filled grains $panicle^{-1}$ (125) than the two checks. The highest grain yield of MPQR-12 was found in BINA HQS farm, Mymensingh (4.57 tha^{-1}) and lowest was found at BINA Sub-station Ishwardi (4.27 tha^{-1}). Yield performance of 2 rice lines are not satisfactory comparing to the checks. Further yield trial should be carried out in next season for confirmation of the results.

On-farm and on-station yield trial of bacterial leaf blight resistant rice lines during*Aman* season

This experiment was carried out to assess high yield attributes of two BLB resistant rice lines along with check variety BRRI dhan75 tested in *Aman* season during 2022 at BINA HQSs farm, Mymensingh and BINA Sub-station farm Rangpur, Ishwardi & Nalitabari and farmers field of Mymensingh and Netrokona. The size of unit plot was 4.0m × 5.0m. Plant to plant distance was 15cm and row to row distance was 20cm. Data on days to flowering, days to maturity, plant height , total number of tillers plant^{-1}, number of effective tillers plant^{-1}, panicle length, number of filled and unfilled grains panicle^{-1}, 1000-grain weight and grain yield/plot were recorded at harvest from five randomly selected competitive plants/plots. Maturity was assessed by plot basis. Plot yield was converted to tha^{-1}. Recorded data were finally subjected to proper statistical analyses.

The results obtained from these trials of individual location and mean over locations for all characters. 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-19 produced the highest grain yield (6.24 tha^{-1}) followed by BLB-P-26 (5.83 tha^{-1}). The higher yield is contributed by the higher number of filled grains panicle^{-1} than the check variety at all the locations. It also produced the higher thousand grain weight than the check variety. There was no significant difference among the test lines and check for the number of total tillers and effective tillers. Both 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, respectively where the BRRI dhan75 was medium. Considering BLB resistance and high yield performance, BLB-P-19 could be selected for further evaluation to release it as a BLB resistant variety.

On-farm and on-station yield trial of bacterial leaf blight resistant rice lines at *Boro* season

This experiment was carried out to assess high yield attributes of one BLB resistant rice line along with one check BRRI dhan28 in *Boro* season during 2022-23 at BINA HQSs farm, Mymensingh and BINA Sub-station farm at Ishwardi, Sunamgonj, Nalitabari, Cumilla andfarmers field of Mymensingh. The size of unit plot was 5.0m × 4.0m. Plant to plant distance was 15cm and row to row distance was 20cm. Data on days to flowering, days to maturity, plant height , total number of tillers hill^{-1} number of effective tillers hill^{-1}, panicle length, filled and unfilled grains panicle^{-1}, 1000-grain weight and grain yield/plot were recorded at harvest from five randomly selected competitive plants/plots. Maturity was assessed by plot basis. Plot seed yield was converted in tha^{-1}.Recorded data were finally subjected to proper statistical analyses.

The results revealed from on-farm and on-station yield trials of individual location and mean over locations for all the characters are presented in Table 4. Results mean over three locations, on an average, some characters showed significant differences and some other shows non-significant 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. The highest number of total tillers hill^{-1} and number of effective tillers hill^{-1} were observed at almost all the locations but not significantly difference with the check. It also had the longest panicle and the highest number of filled grains panicle^{-1} at almost all the locations (Table 4). BLB-P-44 (7.01t/ha) produced significantly highest yield at mean over locations than the check variety (6.26 tha^{-1}).BLB-P-42 had almost same duration with check BRRIdhan58. BLB-P-42 had the lowest thousand grain weight (21.21 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 where the BRRI dhan58 was medium (Table 5). Considering BLB resistance and high yield performance, BLB-P-42 could be selected for further evaluation to release it as a BLB resistant variety.

On-farm and on-station yield trial of of blast resistant rice lines in *Aman* season

This experiment was carried out to assess the yield and yield attributes of one blast resistant rice lines along with one check variety BRRI dhan49 in *Aman* season during 2022 at BINA HQS farm, Mymensingh, BINA sub-station farm Rangpur, Cumilla, Magura & Nalitabari and farmer's field of Mymensingh and Rangpur. Seeds were sown on 2-10th July 2022 and transplanted on 25-31 July 2022 at different locations. The experiment followed RCB design with three replications. The size of unit plot was 4.0m × 5.0m. Plant to plant distance was 15cm and row to row distance was 20cm. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Intercultural practices were followed as and when necessitated. Data on days to maturity, plant height, total number of tillers hill^{-1}, number of effective tillers hill^{-1}, panicle length, filled and unfilled grains panicle^{-1} and 1000-grain weight were recorded after harvesting from five randomly selected competitive hills. Maturity and yield data were recorded plot basis. Plot seed yield was converted to tha^{-1}. Finally, the yield data were converted to tha^{-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**.** Results mean over three locations, on an average, all characters showed significant differences among the lines and check for both individual locations and mean over locations. Among the lin and check varietiy, BRRI dhan49 had produced the longest duration (126 days) at all the locations. Longer panical length and highest number of filled grains were observed at Rangpur, Nalitabari and Mymensingh, Nalitabari and Rangpur, respectively by line BN-P-318 (Table 6)**.** Higher grain yield was observed in BN-P-318 at most locations except Magura, Rangpur and Cumilla. This line matured 10-12 days earlier than the check variety BRRI dhan49 at all locatios. Quality assessment was done based on kernel length and L/B ratio. The kernel shape and size of BN-P-318 is long-slender where the BRRI dhan49 is medium. Based on the yield performance, earliness and resistance against blast and grain quality, BN-P-318 could be selected for further evaluation to release it as a blast resistant variety.

On-farm and on-station yield trial with blast resistant rice lines in *Boro* season

On-farm and on-station trials were carried out with two lines along with two check varieties (BRRI dhan58 & BRRI dhan86) at BINA HQSs farm Mymensingh and sub-station farm at Nalitabari, Magura, Sunamganj and farmer's field at Mymensingh and Netrokona during *Boro* season of 2022.

Seedlings were planted in RCB design with three replications. Unit plot size was 5.0m × 6.0m. Plant to plant and row to row distance were 15cm was 20cm, respectively. Data on days to flowering, days to maturity, plant height, total number of tillers plant^{-1} number of effective tillers plant^{-1}, panicle length , filled and unfilled grains panicle^{-1}, 1000-grain weight and grain yield were recorded from five randomly selected plants of each plot. Plot seed yield was converted to t/ha. Recorded data were finally subjected to proper statistical analyses and are presented.

The results obtained from the on-farm and on-station trials of individual locations and mean over locations for all the characters are presented. Significant differences were observed among the lines and the check variety for yield and yield attributing character. BN-P-114 performed better among the lines and check variety in terms of yield. It produced the highest grain at all the locations except Nalitabari & Sunamganj. Highest grain yield was found at BINA HQS farm Mymensingh (8.43 tha^{-1}) followed by Magura (8.27 tha^{-1}). The higher grain yield of BN-P-114 is attributed by the higher number of effective tillers hill^{-1} and number of filled grains panicle^{-1}. The duration of BN-P-114 was higher than the check variety BRRI dhan86 at all locations.

On-farm and on-station trial with iron and zinc enriched rice mutant

The experiment was carried out to assess overall performance for better grain quality and higher grain yield of two iron and zinc enriched rice lines along with one check variety BRRIdhan62 during *Aman* season 2022 at BINA HQS farm Mymensingh, BINA Sub-station farm at Nalitabari, Jamalpur and farmer's field at Mymensingh. The experiment followed RCB design with three replications. The size of unit plot was 4.0m × 5.0m. Plant to plant distance was 15cm and row to row distance was 20cm. Data on days to flowering, days to maturity, plant height, total number of tillers and effective tillers hill^{-1}, panicle length , filled and unfilled grains panicle^{-1}, 1000 grain weight and grain yieldplot^{-1} were recorded at harvest from five randomly selected competitive hill. Maturity was assessed plot basis. Plot seed yield was converted to tha^{-1}. Recorded data were finally subjected to proper statistical analyses and are presented.

It is observed that the results obtained from regional yield trials of individual location and mean over locations for all characters presented in Table 8. 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 had significantly higher number of total tillers hill^{-1} (12.57), number of effective tillers hill^{-1} (11.86) and higher number of filled grains (164.95) at locations than the check variety, BRRIdhan62. There was no significant difference between the test line and check for the number of unfilled grain and 1000-grain weight. Grain yield of IZSD-26 was significantly higher (6.49 t/ha) at mean over locations than the check variety BRRIdhan62. But the check variety BRRI dhan62 was matured (105 days) earlier than the both lines, IZSD-26 (111 days) and IZSD-10 (114 days). The mean grain Fe concentration of rice lines IZSD-26 and IZSD-10 were 19 & 14 mg/kg and 6 & 4 mg/kg in unpolished & polished rice, respectively. The mean zinc concentration of rice lines were 45 & 51 mg/kg and 26 & 29 mg/kg in unpolished & polished rice, respectively (Fig. 1& 2). Considering Fe, Zn content and higher yields, the lines IZSD-26 could be selected for further evaluation.

On-farm and on-station yield trial of two rice lines for earliness and higher grain yield in haor areas

One early maturing *Boro* rice line MEF-27 was evaluated over locations along with two check varieties BRRI dhan86 and BRRI dhan28. The experiment was conducted atBINA HQSs farm Mymensingh, BINA Sub-station farm at Sunamgonj including haor regions farmer's field at Bishunbar pur, Hasin nagar, Netrokona and Bijoynagar. The experiment followed RCB design with three replications. The size of unit plot was 5.0 m × 4.0 m. Plant to plant distance was 15cm and row to row distance was 20cm. Data on days to flowering, days to maturity, plant height, total number of tillers and effective tillers plant^{-1}, panicle length, filled and unfilled grains panicle^{-1}, 1000-grain weight and grain yield/plot were recorded after harvesting from five randomly selected competitive plants. Maturity was assessed plot basis. Plot seed yield was converted to tha^{-1}. The data were statistically analyzed.

From the results, significant variations were observed for all the characters at all the locations. It was observed that MEF-27 matured 5-7 days delayed (147 days) than the check variety BRRI dhan28 (142 days) and BRRI dhan86 (141 days). MEF-27 produced highest grain yield (7.00 tha^{-1}) followed by BRRI dhan86 (6.27 tha^{-1}) and BRRI dhan28 (5.68 tha^{-1}). At farmer's field, the highest grain yield was found in MEF-27 (7.56 tha^{-1}) at Bishombopur farmer's field followed by BRRI dhan86 (5.75 tha^{-1}). MEF-27 produced the highest grain yield and filled grain (7.87 tha^{-1}& 186.53) at BINA sub-station Sunamgonj (Table 9). 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* rice at Haor areas. The line MEF-27 is matured 142-147days, it could escape early flash flood at haor areas. Considering short duration and higher yield, the line MEF-27 could be selected for further evaluation to release it as a variety.

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

Regional yield trial were carried out with two lines along with one check variety (BRRI dhan75) at BINA HQS farm Mymensingh and sub-station farm at Nalitabari, and farmer's field at Ishwardi, during T. *Aman* season of 2022. Seedlings were planted in RCB design with three replications. Unit plot size was 5.0m × 4.0m. Plant to plant and row to row distance were 15cm and 20cm, respectively. Data on days to flowering, days to maturity, plant height , total number of tillers and effective tillers plant^{-1}, panicle length, filled and unfilled grains panicle^{-1}, 1000 grain weight and grain yield/plot were recorded from five randomly selected plants of each plot. Plot seed yield was converted to t/ha. Recorded data were finally subjected to proper statistical analyses and are presented.

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 10. Significant differences were observed among the lines and the check variety for yield and yield attributing characters. EFSD-58 performed better among the lines and check variety in terms of yield. EFSD-58 produced the highest grain yield among the lines and the check variety at all the locations. The highest grain yield was found at Nalitabari (5.69 tha^{-1}) followed by Mymensingh, (5.64 tha^{-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 EFSD-58 almost same (103-107 days) compare to the check variety BRRI dhan75 at all locations. The lines EFSD-58 and EFSD-21 had the head rice recovery % of 69.78 and 66.36, respectively. The line EFSD-58 had the longest grain (6.54mm) and the highest L/B ratio (3.17) indicating that the line produced medium slender grain. 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 variety.

Regional yield trial of Brown Plant Hopper (BPH) resistant rice lines in *Boro* season 2022-2023

For this experiment, 3 lines BPH-P-020, BPH-P-034, BPH-P-065 with the check variety BRRI dhan58 were used during *Boro* season 2022-23 at different locations. The experiment was followed RCB design with three replications. The size of unit plot was 4.0m × 5.0m. Plant to plant distance was 15cm and row to row distance was 20cm. Data on days to flowering, days to maturity, plant height, total number of tillers hill^{-1}, number of effective tillers hill^{-1}, panicle length, filled grains and unfilled grains panicle^{-1} and grain yield were recorded after harvesting from five randomly selected competitive plants hill^{-1}. The collected data analyzed wherever applicable. Data were analyzed.

Significant variations were observed among the lines and check varieties for plant height, panicle length no. of filled and unfilled grains in both of individual location and combined over location. Results from combined mean over locations, it is revealed that BPH-P-034 performed better in term of yield (6.90t/ha) than the check variety BRRI dhan58 (6.80 t ha^{-1}) followed by BPH-P-020 (6.24 t ha^{-1}) and BPH-P-065 (6.14 t ha^{-1}). The highest field grains was observed in BPH-P-034 (119) followed by BPH-P-065 (108) and BPH-P-020 (104). Maturity duration, no. of total tillers hill^{-1}, no. of effective tillers hill^{-1} and unfilled grains were not significantly different among the lines and check variety.

Regional yield trial of Brown Plant Hopper (BPH) resistant rice lines in *T. Aman* season 2022

For this experiment, 3 lines BPH-P-034, BPH-P-043, BPH-P-065 with the check variety BRRI dhan49 were used during *T. Aman* season 2022 at different locations under the supervision of BINA HQS and BINA Sub-stations. The experiment was followed RCB design with three replications. The size of unit plot was 4.0m × 5.0m. Plant to plant distance was 15cm and row to row distance was 20cm. Data on days to flowering, days to maturity, plant height, total number of tillers hill^{-1}, number of effective tillers hill^{-1}, panicle length, filled grain and unfilled grains panicle^{-1} and grain yield were recorded at harvest from five randomly selected competitive plants plot^{-1}. Maturity was assessed plot basis. The data for the characters under study were statistically analyzed wherever applicable. Data were analyzed using Statistix 10 package.

Significant variations were observed among the lines and check varieties for plant height, panicle length and unfilled grains in both of individual location and combined over location. Results from combined mean over locations, it was revealed that BPH-P-065performed better in term of yield (6.24t ha^{-1}) than the other 2 lines BPH-P-034 (5.56t ha^{-1}), BPH-P-043 (5.70t ha^{-1}) andcheck variety BRRI dhan49 (5.45t ha^{-1}). BPH-P-034, BPH-P-043, BPH-P-065 all the three lines mature nearly

10-12 days (114-115 days) earlier than the check variety (126-127days). Number of total tillers hill^{-1}, no. of effective tillers hill^{-1} and filled grains panicle^{-1} were not significantly different among the lines and check variety.

Regional yield trial of high yielding NIRICA mutants

Two promising M_8 mutants [RM-16(N)-8-1 and RM-16(N)-10-1] of rice derived from heavy ion (nitrogen) beam irradiation were evaluated at six locations, three at different research stations and three at farmer's field. These were BINA Headquarters farm, Rangpur and Chapinawabganj substations & farmer's fields as well. This trial was carried out with the objectives of short duration, high yielding with non- shattering grains as well as to assess the yield potential over locations. The experiment was conducted by following RCB design with three replications. The size of the unit plots were 4.0 m × 5.0 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. Intercultural practices were followed as and when necessitated. Data on days to 50% of flowering, days to maturity, plant height, number of effective tillers hill^{-1}, panicle length, number of filled and unfilled grains panicle^{-1}, yield tha^{-1} were recorded after harvest from five randomly selected competitive hills. Finally, all the recorded data were subjected to proper statistical analyses as per design used.

Results showed significant variation among the mutants and check for most of the characters at all locations. It was observed that plant height of two mutants lines RM-16(N)-8-1 and RM-16(N)-10-1 was shorter (113.61 cm and 116.17 cm) than the check variety BRRI dhan58 (118.33 cm).RM-16(N)-8-1 and RM-16(N)-10-1 had statistically higher number of effective tillers(11.27 and 11.60 respectively) comparing to BRRI dhan58 (9.35). Panicle length of RM-16(N)-8-1 and RM-16(N)-10-1 were recorded as 22.9 and 24.45 cm respectively. The highest number of filled grains panicle^{-1} were observed in RM-16(N)-10-1 (147.75) followed by RM-16(N)-8-1 (138.42). The lowest was recorded in BRRI dhan58 (143.2). The mutants RM-16(N)-8-1 and RM-16(N)-10-1 had produced higher yield (6.85 & 7.24 tha^{-1} respectively) than the BRRI dhan58 (6.80) (Table 14).Considering the 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.

Advanced yield trial of high-yielding rice lines

This trial was carried out with two rice lines derived from Binadhan-16×NERICA-4 along with a check BRRI dhan87 to assess the yield performance over locations. The experiment was conducted at BINA HQSs farm Mymensingh, BINA sub-stations' farm Ishurdi and Magura during the T. *Aman* season of 2022. 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 are summarized in table 15. The two tested lines are intermediate in plant height which is shorter than the check BRRI dhan87. The line B-32-2-3 produced 5.49 t/ha of grain yield which is higher than the check variety.

Estimation of the heritability% depicted that the plant height (0.90) and growth duration (0.93) were highly heritable traits in the studied lines while heritability in the case of yield (0.61) was lower. The line B-32-2-3 was selected for further trial.

Advanced yield trial of blast nursery rice lines (IRBN) in *Boro* season

This experiment was conducted with four 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 BRRI dhan74 and BAU dhan-3 were used as check variety at BINA HQS farm, Mymensingh. The seeds were sown on 5th December 2022 and transplanted the field on 7th January 2023. The experiment was laid out in RCBD with three replications. Unit plot size was 4m x 3m and spacing between hills and rows were 15 cm and 20 cm, respectively. Data on plant height, effective tillers hill^{-1} no. of filled grains panicle $^{-1}$ and panicle length 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.

From the Table 16, it is observed that two lines (IRBN-9, IRBN-18) had taller plant height 102.89cm and 101.11cm, respectively than check variety. BAU dhan-3 had the highest plant height (115 cm) whereas IRBN-34 had the lowest (89.11cm). The highest number of effective tillers plant^{-1} (10) was observed in IRBN-34. The lowest number of effective tillers plant^{-1} (7.22) was found in IRBN-14 and IRBN-18. The panicle length ranged 22.67cm to 26.6cm. The longest panicle length (26.6 cm) was observed in BAU dhan-3 followed by IRBN-9, IRBN-14, &IRBN-18, while shortest panicle length (22.67cm) observed in IRBN-34. The number of filled grains panicle^{-1} ranged from 127 to 150. IRBN-14 and BAU dhan-3 had produced significantly higher number of filled grains 149 & 150, respectively while IRBN-34 had the lowest (127). Comparing all IRBN lines, IRBN-18 matured in the shortest period of time (142 days), while IRBN-14 took maximum 152 days for maturity. Grain yield (t ha^{-1}) ranged from 7.01 to 8.90 t ha^{-1}. IRBN-34, IRBN-14 and one check BRRI dhan74 had maximum statistically same yield 8.90, 8.87 and 8.18 tha^{-1}, respectively. Two lines IRBN-9 & IRBN-18 produced comparatively less grain yield7.01t ha^{-1} and 7.47t ha^{-1} thanthe two check varieties BRRI dhan74 & BAU dhan-3.

Based on higher grain yield two lines (IRBN-14 and IRBN-34) have been selected that will be evaluated in next *Boro* season.

Advanced Yield Trial of brown plant hopper resistant rice lines in *Aman* season 2022

This experiment was carried out to assess insect resistant with high yield attributes of six rice lines along with one check variety Binadhan-17 tested in *Aman* season at BINA Headquarter farm, Mymensingh and BINA Substation, Cumilla. Seeds were sown on 29th June 2022 and transplanted to the field on 26 July 2022 at Mymensingh and Cumilla. The experiment followed RCB design with three replications. The size of a unit plot was 4.0 m × 3.0 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. Intercultural practices were followed as and when necessitated. Data on plant height (cm), number of effective tillers 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**.**

From the Table 17,it is observed that the plant height of the lines were ranged from 103.11 cm to 128.49cm. IRBPH-35 was the tallest (128.49 cm) and IRBPH-5 had the shortest (103.11 cm). The panicle length ranged 23.99 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 varietyBinadhan-17 was 24.19cm . There were 3 lines had longer panicle length than check varieties. The number of filled grains per panicle ranged from 199 to 253. The highest number of filled grains (253) was observed in IRBPH-5, while lowest number of filled grains was observed in check variety.

Grain yield ranged from 4.90 to 6.30 tha^{-1}in BINA HQS Mymensingh and 5.51 to 7.37 tha^{-1} in BINA Sub-station Comilla. In combined mean over location grain yield ranged from 5.35 to 6.82 t/ha. IBPHN- 35 had maximum yield which was followed by IBPHN- 44, IBPHN-38. and Binadhan-17 had comparatively lower yield (5.44 t/ha).

IRBPH-35, IRBPH-38, IRBPH-44 had higher yield at both location then the check variety but IRBPH-21performed better than the check variety in BINA HQS but not at BINA Sub-station farm Comilla. Based on Grain yield four 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 bacterial blight nursery rice lines (IRBBN) in *Aman* season 2022

This experiment was carried out to assess disease tolerant, short duration with high yield attributes of four rice lines along with check variety and Binadhan-17 tested in *Aman*' 2022 at BINA HQS farm, Mymensingh and BINA sub-station, Cumilla . Seeds were sown on 28th June 2022 and transplanted to the field on 26th July 2022. The experiment was followed by RCB design with three replications. The size of a unit plot was 4.0 m × 3.0 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. Intercultural practices were followed as and when necessitated. Data on plant height (cm), number of effective tillers plant^{-1}, panicle length (cm) and number of filled grains panicle^{-1} were recorded after harvesting from five randomly selected competitive hills. Days to 50% flowering and days to maturity were assessed plot basis. Recorded data were finally subjected to proper statistical.

From the Table18, days to maturity of IRBBN-31 and check variety Binadhan-17 took longest time (110 days) and IRBBN-9, IRBBN-17 took shortest time (105-107 days) to mature at both locations. All the lines produced taller plant than check varieties. The shortest plant height (101.42 cm) was found in check variety Binadhan-17. Total tillers were found the highest in check variety Binadhan-17 and IRBBN-9 at both locations and combined mean over locations.. Binadhan-17 produced highest number of effective tillers (12) at Cumilla and it was similar with another line IRBBN-9. All lines had produced taller panicle length than check variety. IRBBN-9 had produced tallest panicle length(29.20 and 28.22 cm) at both locations. IRBBN-17 and IRBBN-31 had produced highest 1000 seed weight(25gm) at both locations. From combined mean over location it was observed that the check variety Binadhan-17 had produced highest yield (5.85kg/plot) than other lines. The yield ranged from 4.99-5.19 tha^{-1} those are not satisfactory. IRBBN-9, IRBBN-31 performed comparatively better at BINA sub-station Comilla that can be selected for next evaluation during *Aman* season-2023.

Advanced yield trial of one mutant derived from Kasalath

Seeds of the mutant RM-Kas-80(C)-1derived from Kasalath and the check variety BRRI dhan49 were sown at five locations viz. BINA Headquarters, Mymensingh, and Substation at Rangpur, Ishwardi, Chapainawabganj and Sunamganj. The experiment was followed by Randomized Complete Block Design (RCBD) with three replications. The size of the unit plots were 4.0 m × 5.0 m. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Intercultural practices were followed for normal plant growth and development. Data on plant height, Days required for 50% flowering, days to maturity, number of effective tillers, panicle length, filled and unfilled grains $panicle^{-1}$ and 1000 seed weight were recorded at harvest from 5 randomly selected competitive plants. Finally, all the recorded data were subjected to proper statistical analyses as per design.

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 RM-Kas-80(C)-1 mutant line was 117.09 cm and was statistically taller than the check variety BRRI dhan49 (103.45 cm). RM-Kas-80(C)-1 had statistically lower number of effective tillers (10.50) contrasting to BRRI dhan49 (11.43). Panicle length of RM-Kas-80(C)-1 was recorded as 26.85cm comparing to BRRI dhan49 (22.90 cm). The highest number of filled grain $panicle^{-1}$ was observed in the check BRRI dhan49 (158.17) while lower filled grain $panicle^{-1}$ was found in RM-Kas-80(C)-1 mutant (134.35). The mutant RM-Kas-80(C)-1 had produced lower yield (5.52 tha^{-1}) than the BRRI dhan49 (5.59 tha^{-1}).

Advanced Yield Trial of 18 mutants for salinity and high temperature

The seeds of selected lines for salinity and high temperature were sown at BINA Headquarter field, BINA Substation Ishwardi, BINA Substation Chapainawabganj and BINA Substation Satkhira at 29^{th} November, 2022 by maintaining plant to plant and row to row distance 20cm and 15cm respectively. The lines BNDR are the mutants derived from gamma irradiation of local improved germplasms (LIRG-2 & LIRG-4) collected from the Southern part of Bangladesh. This research is continuing since 2018 onward. Two checks (viz. Binadhan-10 and BRRI dhan86) were also included in this experiment. The experiment was followed by Randomized Complete Block (RCB) design with 2 replications. A unit plot size was 3m × 2m. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Intercultural practices were followed as and when necessitated. Data on plant height, effective tillers hill^{-1}, panicle length, filled and unfilled grains panicle^{-1} and grain yield tha^{-1} was recorded.Finally, all the recorded data were subjected to proper statistical analyses as per design used.

In BINA Headquarter, Mymensingh, all the selected lines had statistically significant variation in plant height (Table 20). The line BNDR-27 showed a higher plant height that was 119.13 cm Significant statistical variation was observed in effective tillers among the selected lines. Higher tillers was found in line BNDR-51 (7.47) whereas lowest observed in BNDR-28 (3.53). The line BNDR-49 exhibited longer panicle length (28.73 cm) comparing to the other lines. Maximum field grains panicle^{-1} was found in the line BNDR-57 (296.2). The line BNDR-11 showed significantly maximum unfilled grains/panicle (136.67) comparing to the other lines. The line BNDR-17 had higher yield (8.48t/ha) comparing to the checks Binadhan-10 (7.10 tha^{-1}), and BRRI dhan86 (6.01 tha^{-1}).

In BINA Substation, Ishwardi, all the selected lines had statistically significant variation in plant height. Among the lines, BNDR-28 showed the tallest plant (106.80 cm). Significant statistical variation was observed in effective tillers among the studied lines. Higher tillers was found in line BNDR-51 (12.93) whereas the lowest observed in BNDR-16 (6.33). The line BNDR-28 exhibited longer panicle length (27.87 cm) comparing to the other lines. Maximum filled grains panicle^{-1} was found in the line BNDR-9 (265.4). The line BNDR-57 showed significantly maximum unfilled grainspanicle^{-1} (81.33) comparing to the other lines. The line BNDR-26 had higher yield (8.38 tha^{-1}) comparing to the checks Binadhan-10 (8.24 tha^{-1}), and BRRI dhan86 (5.79 tha^{-1}).

In BINA Substation, Chapainawabganj, all the selected lines had statistically significant variation in plant height. Among the lines, BNDR-55 showed a higher plant height that was 119.80 cm. Significant statistical variation was observed in effective tillers among the studied lines. Higher no of tillers was found in line BNDR-16 (12.73) whereas lowest in BNDR-28 (5.67). The line BNDR-55 exhibited longer panicle length (27.87 cm) comparing to the other lines. Maximum field grains panicle^{-1} was found in the line BNDR-11 (163.9). The line BNDR-28 showed significantly maximum unfilled grains/panicle (72.33) comparing to the other lines. The line BNDR-55 had higher grain yield (6.78t/ha) comparing to the checks variety Binadhan-10 (5.09 tha^{-1}), and BRRI dhan86 (3.5 tha^{-1}).

In BINA Substation, Satkhira, all the selected lines had statistically significant variation in plant height. Among the lines, BNDR-41 showed a higher plant height that was 124 cm. Significant statistical variation was observed in effective tillers among the selected lines. Higher tillers was found in line BNDR-31 (11.4) whereas lowest observed in BNDR-5 (3.4). The line BNDR-34 exhibited longer panicle length (33.40 cm) comparing to the other lines. Maximum filled grains panicle^{-1} was found in the line BNDR-34 (518). The line BNDR-43 showed significantly maximum unfilled grains/panicle (147.4) comparing to the other lines. The line BNDR-49 had higher yield (9.42t/ha) comparing to the checks Binadhan-10 (6.91 tha^{-1}), and BRRI dhan86 (6.32 tha^{-1}).

Preliminary yield trial of submergence tolerant rice lines

This experiment was conducted to evaluate rice lines for submergence tolerance with high yield attributes. Eleven rice lines along with two checks Binadhan-11 and BRRI dhan52 were tested in *Aman* season at BINA HQSs farm, Mymensingh. Seeds were sown on 04 July 2022 and transplanted on 07 August 2022. The experiment followed RCB design with three replications. The size of the plot was 2m × 1m. Plant to plant distance was 15cm and row to row distance was 20cm. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Necessary intercultural practices were followed as and when necessitated. Data on plant height, number of effective tillers/hill, panicle length and filled grains panicle^{-1} (no.) were recorded at harvest from five randomly selected competitive hills plot^{-1}. Days to flowering and maturity were assessed plot basis. Recorded data were finally subjected to proper statistical analyses and are presented in Table 24.

From the study, it was observed that the average range of plant height among the lines and check variety were 95cm to 153cm. The line IRSSTN-FP-6 had the highest plant height whereas IRSSTN 3 had the lowest. There all the parameters showed significant differences among genotypes. The highest number of effective tillers/plant (9.73) was found in IRSSTN-FP-8. The filled grains panicle^{-1} and unfilled grains panicle^{-1} ranged from 90.50gm to 157.73gm and 20.93 to 57.60 respectively. Grain yield plot^{-1} ranged from 5.17 tha^{-1} to 7 tha^{-1}. IRSSTN-FP-12 had maximum yield (7 tha^{-1}) whereas IRSSTN 6 had minimum yield (5.17 tha^{-1}). There are three lines (IRSSTN-FP-8, IRSSTN-FP-9 and IRSSTN-FP-12) produced higher grain yield (tha^{-1}) than both check variety BRRI dhan52 and Binadhan-11 where IRSSTN-FP-2 and IRSSTN-FP-5 produced higher grain yield (tha^{-1}) only than the Binadhan-11. Based on higher grain yield IRSSTN-FP-8, IRSSTN-FP-9,

IRSSTN-FP-12, IRSSTN-FP-2 and IRSSTN-FP-5 have been selected for further evaluated in next season.

Preliminary yield trial of some blast resistant rice lines

This experiment was carried out with four blast introgressed rice lines (BINA-BR-4-10-18, BINA-BR-4-10-12, BINA-BR-4-10-15 and BINA-BR-4-10-19),BRRI dhan87 as a check to assess the yield potential in T. *Aman* season. Seeds were sown on 7 July 2022 and transplanted on 28 August 2022. This experiment was conducted at BINA HQS farm, Mymensingh,The experiment was followed RCB design with three replications. The size of the unit plot was 3.0 m × 2.0 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. Necessary and intercultural practices were followed as and when needed. Data on plant height, number of total tillersplant^{-1}, effective tillersplant^{-1}, panicle length, filled and unfilled grains panicle-^{1} and thousand seed weight were recorded at harvest from 5 randomly selected competitive plants of each plot. Maturity was assessed plot basis. Grain yield was recorded from an area of 6 m^{2} which was later converted to t ha-^{1}. Finally, all the recorded data were subjected to proper statistical analyses.

The results revealed from preliminary yield trials for all characters are presented in Table 25. Results of all characters showed that there is no significant difference among the lines and checks except BINA-BR-4-10-19 in respect of days to maturity (103days) and plant height (98cm). That means BINA-BR-4-10-19 matures 15-20 days earlier than all lines and check. On the other hand, amongst the lines and check variety, BINA-BR-4-10-12performed the best in terms of filled grains panicle^{-1} (176) and grain yield (6.79) followed by BINA-BR-4-10-19. From the above results, considering effective days to maturity, plant height, no. of filled grain panicle^{-1}, grain quality and yield performance, BINA-BR-4-10-19 and BINA-BR-4-10-12are recommended for advanced trial in next *Aman* season.

Preliminary yield trial for high yielding, short duration and cold tolerant rice lines

The seeds of selected lines for cold tolerance were sown at BINA Headquarter field, Sunamganj Substation field and Farmer's field at Sunamganj on 20th November, 2022 by maintaining plant to plant and row to row distance 20cm and 15cm respectively. The lines BNCR were developed from the crossing between Nepalese dhan and Binadhan-17. This research is continuing since 2018 onward. Three checks (viz. BRRIdhan67, BINA dhan25 and Binadhan-17) were also includeds in this experiment. The experiment was followed by Randomized Complete Block (RCB) design with 2 replications. A unit plot size was 3m × 2m. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Intercultural practices were followed as and when necessitated. Data on plant height, effective tillers hill^{-1}, panicle length, no of filled and unfilled grains panicle^{-1} and grain yield tha^{-1} was recorded. Finally, all the recorded data were subjected to proper statistical analyses as per design used and are presented in Table 29.

In Farmer's field, Tahirpur, Sunamganj, all the selected lines had statistically significant variation in plant height (Table 29). The line BNCR-68 and the check BINA dhan25 showed higher plant heights that were 115.33 cm and 116cm, respectively. Significant statistical variation was observed in effective tillers among the selected lines. Higher tillers was found in line BNCR-32 (11.50) whereas lowest observed in BNCR-20 (7.08). The line BNCR-37 exhibited longer panicle length (27.41 cm) comparing to the check varieties. The line BNCR-90 showed significantly maximum unfilled grains/panicle (40.83) comparing to the other lines. The line BNCR-27 had higher yield (8.53t/ha) comparing to the checks BINA dhan25 (7.79 tha^{-1}), Binadhan-17 (6.5 tha^{-1}) and BRRI dhan67 (5.94 tha^{-1}) (Table 30).

In BINA substation Sunamganj, all the selected lines had statistically significant variation in plant height (Table 30). The line BNCR-32 and the check BINA dhan25 showed higher plant heights that were 106.91 cm and 117.50 cm respectively. Significant statistical variation was observed in effective tillers among the selected lines. Higher tillers was found in line BNCR-32 (11.50) whereas lowest observed in BNCR-20 (7.70). The line BNCR-37 exhibited longer panicle length (26.41 cm) comparing to the check varieties BINA dhan25 (25.84 cm), Binadhan-17 (22.50 cm) and BRRI dhan67 (23.00 cm). The line BNCR-90 showed significantly maximum unfilled grains/panicle (40.83) comparing to the other lines. The line BNCR-68 had higher yield (8.34t/ha^{-1}) comparing to the checks BINA dhan25 (7.27 tha^{-1}), Binadhan-17 (6.63 tha^{-1}) and BRRI dhan67 (6.36 tha^{-1}) (Table 31).

In BINA Headquarter, Mymensingh, all the selected lines had statistically significant variation in plant height (Table 31). The line BNCR-60 and the check BINA dhan25 showed higher plant heights that were 117.75 cm and 114.55 cm respectively. Significant statistical variation was observed in effective tillers among the selected lines. Higher tillers was found in line BNCR-1 (11.70) whereas lowest observed in BNCR-60 (6.30). The check BINA dhan25 exhibited longer panicle length (28.05 cm) comparing to the other lines. Maximum field grains panicle^{-1} was found in the line BNCR-60 (259.90). The line BNCR-109 showed significantly maximum unfilled grains/panicle (66) comparing to the other lines. The line BNCR-60 had higher yield (8.76t/ha) comparing to the checks BINA dhan25 (6.86 tha^{-1}), Binadhan-17 (6.60 tha^{-1}) and BRRI dhan67 (7.30 tha^{-1}) (Table 32).

In Jamalganj, Sunamganj, all the selected lines had statistically significant variation in plant height (Table 32). The line BNCR-120 and the check BINA dhan25 showed higher plant heights that were 115.20 cm and 122.00 cm respectively. Significant statistical variation was observed in effective tillers among the selected lines. Higher tillers number was found in check BNCR-90 (11.62) whereas lowest observed in BNCR-120 (8.66). The check BINA dhan25 exhibited longer panicle length (27.99 cm) comparing to the other lines.Maximum field grains panicle^{-1} was found in the line BNCR-30 (162.7).The line BNCR-123 showed significantly maximum unfilled grains/panicle (82.83) comparing to the other lines. The line BNCR-20 had higher yield (8.80t/ha^{-1}) comparing to the checks BINA dhan25 (7.40 tha^{-1}), Binadhan-17 (6.71 tha^{-1}) (Table 33)

In Panchagargh Sadar farmer's field,all the selected lines had statistically significant variation in plant height (Table 33). The line BNCR-67 showed a higher plant height that was 135.40 cm. Significant statistical variation was observed in effective tillers among the selected lines. Higher effective tillers number was found in BNCR-1 (18.30) hill^{-1} whereas lowest observed in BNCR-8 (9.50) hill^{-1}. The check BINA dhan25 exhibited longer panicle length (26.01 cm) comparing to the other lines.Maximum field grains panicle^{-1} was found in the line BNCR-8 (242.85).The check BINA dhan25 showed significantly maximum unfilled grains/panicle (63.80) comparing to the other lines. The line BNCR-39 had higher yield (8.53t/ha) comparing to the checks BINA dhan25 (7.9 tha^{-1}), Binadhan-17 (8.2 tha^{-1}), BRRI dhan67 (6.1tha^{-1}) and BRRI dhan28 (6.0tha^{-1} (Table 34)

Preliminary yield trial for high yielding and non-shattering rice lines

The seeds of backcross populations were grown at BINA Headquarters, Mymensingh by maintaining plant to plant and row to row distance 20cm and 15cm respectively. The two parents

(Binadhan-14 and BRRI dhan28) and one check (BRRI dhan81) 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. Intercultural practices were followed when necessary. Data on plant height, Days required for 50% flowering, days required for maturity, number of effective tillers, panicle length, and no. of filled and unfilled grains panicle^{-1} and 1000seed weight and yield converted to tha^{-1} were recorded at harvest from 5 randomly selected competitive plants per plot.

Significant variation was observed for yield contributing characters of the tested lines. The line BN-RM-P-5-1-4 required one day less times for 50% flowering (112.3 days) and grain yield comparing to the parent BRRI dhan28 (111.3 days) (Table 33). It was observed that the similar maturity period between BN-RM-P-5-1-4 (144 days) and BRRI dhan81 (144 days). Higher effective tillers plant^{-1} was observed in two mutants BN-RM-P-2-2-3 (11.5) and BN-RM-P-2-2-4 (11.5). Highest panicle length (26.6 cm) was observed in BN-RM-P-2-1-3 mutant that was significant difference from others. Maximum filled grain (145.7) was found in the BN-RM-P-3-3-1 mutant line while minimum filled grain (127.6) was observed in BN-RM-P-2-2-3 mutant line. Lowest unfilled grain (20.35) per panicle was found in check variety BRRI dhan81 but maximum unfilled grain (24.53) found in line BN-RM-P-2-2-2. The highest grain yield (7.34 t/ha^{-1}) was obtained in BN-RM-P-5-1-4 mutant whereas lowest yield was found in the parent BRRI dhan28 (6.30 t/ha^{-1}) (Table 35)

Observation yield trial of International RiceTungro Nursery (IRTN) rice lines

Total 15 International Tungro Rice Nursery Lines (IRTN) were evaluated for grain yield along with yield check BRRI dhan87. The experiment was conducted during *Aman* season 2022 at BINA HQS farm, Mymensingh and it was non-replicated. The unit plot size was 2.0m × 2.0m with a plant-to-plant distance of 15cm and row-to-row distance of 20cm. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Intercultural practices were followed as and when necessitated.

The agronomic performances of the selected lines are presented in Table 35. The lines were selected based on grain yield. The growth duration of the tested lines varied between 124 days (BN-R-21-2) to 137 days (BN-R-21-6) while the check matured in 133 days. The plant height ranged from 102cm (BN-R-21-2 and BN-R-21-4) to 111cm (BN-R-21-3). The highest yield was produced by line BN-R-21-1 which was 7.01 tha^{-1} while the check produced 6.26 tha^{-1} yield. The selected lines will be used for further evaluation.

Observation yield trial of International Rice Stem Borer Nursery (IRSBN) rice lines

Total 10 IRRI Stem borer Rice Nursery Lines were used for the yield trial including yield check BRRI dhan87 and TN1. The experiment was conducted during *Aman* season 2022-23 at BINA HQS farm, Mymensingh and BINA sub-station farm at Cumilla. The unit plot size was 2.0m × 2.0m with a plant-to-plant distance of 15cm and row-to-row distance of 20cm. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Intercultural practices were followed as and when necessitated.

The data obtained from Cumilla was excluded as yield was heavily hampered due to water logging and bird infestation. The agronomic performances of the selected lines at BINA HQS, Mymensingh are presented in Table 36. The lines were selected based on yield and the line which produced more than 6.35 tha^{-1} yield were selected. The growth duration varied between 122 days (BN-R-22-1) to 130 days (BN-R-22-3) while the check BRRI dhan87 and TN1 matured in 133 and 118 days, respectively. The plant height ranged from 101cm (BN-R-22-3) to 116cm (BN-R-22-2). The highest yield was produced by the line BN-R-22-3 which was 7.36 tha^{-1} while the check produced 6.26 tha^{-1} yield.

Observation yield trial of International Low Land Rice Nursery (IRLON) rice lines

Total 30 International Low Land Rice Nursery Lines (IRLON) were evaluated for grain yield along with yield check Binadhan-11. The experiment was conducted during *Aman* season 2022-23 at BINA HQS farm, Mymensingh with two replication. The unit plot size was 2.0m × 2.0m with a plant-to-plant distance of 15cm and row-to-row distance of 20cm. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Intercultural practices were followed as and when necessitated.

The agronomic performances of the selected lines are presented in Table 37. Twelve (12) lines were selected based on grain yield. The growth duration of the tested lines varied from 101 days (IRLON-11) to 127 days (9008) while the check matured in 117 days. The plant height ranged from 98cm (IRLON-16) to 117cm (9008). The highest yield was produced by line IRLON-21 which was 6.57 tha^{-1} while the check produced 5.69 tha^{-1} yield. The selected lines will be used for further evaluation at low land areas.

Observation yield trial of nine advanced salt tolerant rice lines

This trial was carried out with 09 advanced salt tolerant rice lines with 3 checks (Binadhan-10, BRRIdhan97 and Binadhan-17). The experiment was conducted at Sathkhira region. 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.

Nine lines were selected from the trial based on their agronomic performance. The mutants matured in between 146 and 147 days. The plant height ranged from 80 (SAL-52) to 97cm (Binadhan-10). Four lines produced higher number of filled grain per panicle ranged from 81.95 to 98.33 than check Binadhan-10. But, interestingly Binadhan-17 produced highest no. of filled grain per panicle. SAL-52, 15021, SAL-73, 15011 had aparently same duration (143-146) with check Binadhan-10. SAL-52, SAL-44 had the lowest hundred grain weight (2.44g). Based on yield contributing characters, SAL-52, IRSSTN-21, SAL-73, IRSSTN-11 and IRSSTN-10 lines were selected for further evaluation in next *Boro* season.

Observation yield trial International Irrigated Rice Nursery (IIRON) lines

Total 39 International Irrigated Rice Nursery Lines were used for the yield trial including yield check BRRI dhan87 during *Aman* 2022-23. Seventeen selected rice lines from the 38 lines were evaluated during *Boro* 2022-23. The experiment was conducted following RCB design with two replications at BINA HQS farm, Mymensingh. The unit plot size was 2.0m × 2.0m with a plant-to-plant distance of 15cm and row-to-row distance of 20cm. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Intercultural practices were followed as and when necessitated.

The agronomic performances of the top eight selected lines in *Aman* season are presented in Table 39. The lines were selected based on yield and the lines which produced more than 6.20 tha^{-1} yield were selected. The growth duration varied between 119 days (BN-R-18-14) to 133 days (BN-R-18-12) while the check matured in 138 days. The plant height ranged from 102cm (BN-R-18-12) to 127cm (BN-R-18-10). The highest yield was produced by line BN-R-18-16 which was 7.45 tha^{-1} followed by BN-R-18-11 and BN-R-18-12 (7.22 tha^{-1}) while the check produced 6.88 tha^{-1} yield.

The agronomic performances of the selected lines in *Boro* season are presented in Table 40 The lines were selected based on yield and the line which produced more than 7.90 tha^{-1} yield were selected. The growth duration varied between 142 days (BN-R-18-13 and BN-R-18-16) and 145 days (BN-R-18-5) while the check BRRI dhan89 matured in 142 days and BRRI dhan88 matured in 145 days. The plant height ranged from 90cm to 100cm. The highest yield was produced by line BN-R-18-12 which was 8.04 tha^{-1} followed by BN-R-18-5 (7.93 tha^{-1}) while the check BRRI dhan88 and BRRI dhan89 produced 7.68 tha^{-1} and 7.92 tha^{-1} yield, respectively.

Observation yield trial of 9 mutants for premium quality and higher yield

Seeds of selected lines for premium quality and higher yield were sown on 30th June, 2022 at BINA Headquarters, Mymensingh and BINA substation, Rangpur by maintaining plant to plant and row to row distance 15cm and 20cm respectively. The parent Binadhan-7 was used in this experiment. The experiment was followed by Randomized Complete Block (RCB) design with 3 replications. The size of the unit plots were 1.0 m × 2.0 m. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Intercultural practices were followed according to the necessity. Data on plant height, Days required for 50% flowering, days required for maturity, number of effective tillers, panicle length, and filled and unfilled grains $panicle^{-1}$, 1000-seed weight and yield (t/ha^{-1}) were recorded after harvest from 5 randomly selected competitive plants $plot^{-1}$. Finally, all the recorded data were subjected to proper statistical analyses as per design used and are presented in Table 41.

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, significant variation was observed for yield and contributing characters of the selected lines. The line P-3-3 showed lowest plant height (79.67) comparing to check Binadhan-7 (84.33 cm). The check Binadhan-7 produced higher tillers number (12.80) whereas the line P-3-3 had greater tillers number (5.83) among all the lines. Maximum filled grain (133.55) was found in the P-3-4 line while minimum grain (95.72) was observed in P-2-1 line. Lowest unfilled grain (21.13) per panicle was found in P-6-1line but maximum unfilled grain found in check Binadhan-7 (23.57). Maximum yield (5.98 t/ha) was obtained in the line P-3-4 contrasting to the check Binadhan-7 (5.16 t/ha) (Table 41)

Observation yield trial of short duration and cold tolerant 63 rice lines suitable for Northern areas

Seeds of selected lines for short duration and cold tolerance were sown on 20th November, 2022 at BINA substation, Rangpur by maintaining plant to plant and row to row distance 15cm and 20cm respectively. The parent Binadhan-7 was used in this experiment. The experiment was followed by Randomized Complete Block (RCB) design with two replications. The size of the unit plots were 2.0 m × 1.0 m. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Intercultural practices were followed according to the necessity. Data on plant height, number of effective tillers, panicle length, and filled and unfilled grains panicle^{-1}, and yield (t/ha^{-1}) were recorded after harvest from 5 randomly selected competitive plants plot^{-1}. Finally, all the recorded data were subjected to proper statistical analyses as per design used and are presented in Table 42.

In BINA Substation, Rangpur, the line BNCR-105 had shorter duration (135 days) comparing to the check varieties *viz*. Binadhan-17 (167 days), BINA dhan25 (169 days) and BRRI dhan67 (157 days). All the selected lines had statistically significant variation in plant height (Table 42). Among the lines, the highest plant height was found in BNCR-67 (140 cm). Significant statistical variation was observed in effective tillers among the selected lines. Higher effective tillers number was found in line BNCR-64 (22.2) whereas lowest was observed in BNCR-105 (7.6). The line BINA dhan25 exhibited longer panicle length (27.2 cm) comparing to the other lines. Maximum field grains panicle^{-1} was found in the line BNCR-54 (309.6). The line BNDR-46 showed significantly maximum unfilled grains panicle^{-1} (86) comparing to the other lines. The line BNCR-45 had higher grain yield (9.42t/ha) than the checks Binadhan-17 (8.5 tha^{-1}), BINA dhan25 (8.0 tha^{-1}) and BRRI dhan67 (7.4 tha^{-1}) (Table 43).

Observation yield trial of 22 mutants for premium quality and higher yield

The seeds of selected lines for premium quality and higher yield were sown on 30th June, 2022 at BINA Substation, Ishwardi and Magura by maintaining Plant to plant and row to row distance 20cm and 15cm respectively. Two checks (viz. BRRI dhan49 and Binadhan-17) were also included in this experiment. The experiment was followed by Randomized Complete Block

(RCB) design with 2 replications. 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. Intercultural practices were followed according to the necessity. At harvest data on plant height, effective tillers hill^{-1}, panicle length, filled and unfilled grains panicle^{-1} and grain yield tha^{-1} was recorded. The collected data were analyzed statistically.

Significant variation was observed in term of duration among the mutants. Mutant line L4-250-5(1)-P-1 had shorter duration (103 days) compare yield attributes and grain yield (Table 43) to the check variety BRRI dhan49 (124 days) and Binadhan-17 (123 days) (Table 42). All the mutants had lower effective tillers comparing to the check variety Binadhan-17 (11.13). Longest panicle length (29.13 cm) was observed in mutant line L4-250-2(4)-P-2. The mutant L4-250-P-1-2 had the highest number (183.53) of filled grains panicle^{-1}. Lowest unfilled grains paicle^{-1} (21.33) was observed in the mutant L4-250-4-10-2. The mutants L4-250-4-10-2, L4-250-P-3(2)-4, and L2-250-17-P-1 were exhibited higher yield (8.60, 7.81, and 7.81 tha^{-1} respectively) than the other mutants and the check variety BRRI dhan49 (6.83) and Binadhan-17 (7.37 tha^{-1} respectively) (Table 44).

Significant variation was observed in term of duration among the mutants. Mutant line L2-250-17-P-1 had shorter duration (106 days) comparing to the yield attributes and grain yield check variety BRRI dhan49 (127 days) and Binadhan-17 (122 days) (Table 43). The mutant L4-250-5(1)-P-1 had higher effective tillers number (9.0) similar to BRRI dhan49 (9.0). Longest Panicle length (28.97 cm) was observed in mutant line L4-250-4(1)-P-2. The mutant L4-250-2(4)-P-2 had highest number (234) of filled grains panicle^{-1} contrasting to other mutants and the check variety BRRI dhan49 (80.5) and Binadhan-17 (130.90). Lowest unfilled grains paicle^{-1} (15.83) was observed in the mutant L2-250-2-P-2. The mutants L4-250-4-10-2, L4-250-5(1)-P-1, and L2-250-17-P-1 were exhibited higher yield (8.36, 8.23, and 7.90 tha^{-1} respectively) than the other mutants and the check variety BRRI dhan49 (6.23) and Binadhan-17 (7.27 tha^{-1} respectively) (Table 44).

Accelerating the Genetic Gains in Rice (AGGRi)-IRRI Project: Breeding Zone trials

This trial is composed of 190 advanced breeding lines developed at IRRI-HQS with 6 global (IRRI 147, IRRI 240, IRRI 241, IRRI 242, IRRI 154 and A69-1) and 4 local (BRRI dhan28, BRRI dhan67, BRRI dhan99 and Binadhan-10) check varieties. The germinated seeds were sown on 15 December, 2022 in the seedbed. Thirty-nine days old seedlings were transplanted on 23 January, 2023 following the alpha lattice design. The unit experimental plot size was 4.32 m^2 (27 hills × 4 rows). Two-three seedlings per hill were transplanted, maintaining a 15 cm distance between plant to plant and 20 cm between rows. Intercultural operations were performed to ensure proper growth of the rice plants following BRRI guidelines. All the rice plants were harvested from each plot separately, and data were collected on days to 50% flowering (DF), days to 80% maturity (DM), plant height (PH), number of harvested hills per plot, plot yield (g), and grain moisture content (%). Plant height was recorded from randomly selected 3 hills of each plot. Grain yield (GY) data were adjusted to Kg/ha. Finally, the collected data were tabulated and analyzed using single-environment analysis following Alpha-Lattice Design using RStudio version 4.1.1.

Population distribution and variation among the measured traits

The populations randomly distributed as shown in Figure 1 for growth duration, plant height and grain yield. The majority of the traits were within the value of a normal distribution.

Significant differences were found among the genotypes for growth duration (days), plant height (cm) and grain yield (Kgha^{-1}) (Table 45). Average grain yield of the genotypes was 4976.33 Kgha^{-1} with an average plant height of 93 cm and average growth duration of 142 days.

In addition, heritability is important to quantify the precision of field trials and determine the response to selection. Therefore, the heritability for growth duration (days), plant height (cm) and grain yield (Kgha^{-1}) were calculated as 0.44, 0.49and 0.24, respectively (Table 45).

Selection of best performing genotypes based on adjusted mean

Among the 190 lines the top 20 lines based on grain yield (Kgha^{-1}) are presented in Table 46. The line IR21LT1178 produced the highest grain yield (7001.143 Kgha^{-1}) followed by IR21LT1339 (6756.401 Kgha^{-1}), IR21LT1026 (6734.63 Kgha^{-1}) and IR21LT1184 (6714.993 Kgha^{-1}). The line IR21LT1178 was 82 cm tall and required 140 days to mature. The selected lines will be evaluated in stage 2 trial.

Screening of direct seeded upland rice lines under field conditions for drought tolerance (AFACI project)

Experimental site and plant materials

The field trials for the identification of drought-tolerant direct-seeded upland rice genotypes were conducted in June, 2022 at the drought hotspots of Bangladesh located at Kantinagar, Kushtia Sadar, Kushtia. The trial comprises two sets and is conducted under stress and non-stress conditions following an augmented RCB design. Total plant materials were 140. The plant material comprises 130 test entries including 30 local entries. There were five global checks *viz.* Vandana, SAHBHAGI DHAN, IR 87707-445-B-B-B, IRRI 154 and IRRI 163 and 5 local checks *viz.* Binadhan-19, Binadhan-21, BR-24, BRRI dhan65 and BRRI dhan83 were included in the trial. The seeds were sown on 26 June 2022 directly into the soil in a four-meter-long plot with four grams of seeds for each line. The non-stress condition plots comprised two lines for each entry while the stress condition plots had three lines for each entry. Line-to-line distance was 25 cm and 20 cm for the stress and non-stresstrials, respectively. The nutrient N, P, K, S and Zn were applied as urea, triple super phosphate, Muriate of potash, gypsum and zinc sulfate were applied @ 60, 10, 40, 10 and 4 kg N, P, K, S and Zn ha^{-1}, respectively. All the fertilizers except urea were applied as basal and urea was applied in three equal splits at 20, 35 and 45 days after seeding (DAS). Recommended and uniform crop management practices were followed in all cases. Appropriate measures were taken to manage insects and diseases.

Meteorological conditions and imposing of drought stress

The soil type of the experimental plot is silty loam. The depth-wise (10 cm interval) percent sand, silt and clay particle are presented in Table 47. The field capacity and wilting point of this field were approximately 30-33% and 14-16% (VWC), respectively.

The experimental site encountered a maximum temperature of 36^{0}C during the seedling stage, while the rainfall during the reproductive phase c*Aus*ed a reduction in temperature. During the entire experiment, rainfall occurred in 47 days accumulating 1178.3 mm of rainfall. As the experiment was delayed for three months, the plants encountered massive rainfall in the latter phase.

Drought was imposed 45 days after seeding in the stress trial by withdrawing irrigation water. As the experiment was delayed, the plants encountered rainfall throughout the whole life cycle with massive rainfallin the flowering stage (Table 48). The drought symptom occurred two times at 58 DAS and 74 DAS. Volumetric soil moistures were 17-18% at this wilting point.

Data collection and analysis

Data were recorded on three visually scored and three quantitatively scored traits. Visually scored traits were germination (GER) score, early vegetative vigor (EVV) score, plant phenotypic acceptability (PACP). The GER and EVV were recorded at 10 DAS and PACP was recorded during maturity following the Table 49. Three quantitatively measured traits *viz.* plant height (PH), Growth duration (GD) and plot yield were recorded. Randomly three plants were measured and averaged per plot to get plant height (PH) data. Plot yield was converted to grain yield tha^{-1} (GY). All the data were analyzed statistically and presented graphically using RStudio version 4.1.1.

Visually scored traits

There was a wide range of variation among the genotypes for three visually scored traits *viz.* GER, EVV and PACP. The GER score varied from 3 to 9 in both stress and non-stress condition. In non-stress condition most of the genotypes have score 5 for GER. But under stress majority have score 7 followed by score 5 and score 9. For EVV score it ranged from 1 to 9 under stress with a maximum frequency of score 5, followed by score 3 and score 7. On the other hand, the genotypes scored 3 to 9 under non-stress condition. The PACP score ranged from 3 to 9 in stress and 3 to 7 in non-stress condition with the highest frequency in score 7 in both stress and non-stress condition.

Plant height, growth duration and grain yield

The results of the statistical analysis of the effects of treatments, genotypes, and checks on plant height, growth duration and grain yield under stress and non-stress condition are summarized in Table 50 and Table 50. In stress condition significant differences were observed for all the effects for growth duration except for block. For plant height only the checks showed significant differences. Block (ignoring treatments) and check effect significantly differed for grain yield. Under non-stress condition block (ignoring treatments) check and block (eliminating treatments) effects significantly differed for plant height. For growth duration check was significantly differed and significant genotype vs. check interaction was found. Significant differences were observed for all the effects except block (eliminating treatments) and genotype vs. check in grain yield under non-stress.

Under stress condition PH ranged from 57 cm to 117 cm (Table 51) while this range was 76 cm to 116 cm for the checks (Table 52). Among the checks Binadhan-19 and BRRI dhan83 had the shortest (76 cm) and longest (116 cm) plant height, respectively. GD ranged from 104 to 136 days while this range was 107 to 127 days for the checks. Among the checks BRRI dhan83 (107 days) and IRRI 163 (126 days) had the shortest and longest growth duration, respectively. GY ranged from 0.27 tha^{-1} to 5.69 tha^{-1} while this range was 0.9 tha^{-1} to 3.2 tha^{-1} for the checks. Among the checks Binadhan-19 (0.9 tha^{-1}) and Vandana (3.2 tha^{-1}) produced the lowest and highest yield, respectively.

Under non-stress condition PH ranged from 62 cm to 128 cm (Table 51) while this range was 76 cm to 113 cm for the checks (Table 51). Among the checks Binadhan-19 and Vandana had the shortest and longest plant height, respectively. GD ranged from 107 to 137days while this range was 111 to 127 days for the checks. Among the checks BRRI dhan83 and CIHERANG had the shortest and longest growth duration, respectively. GY ranged from 0.07 tha^{-1} to 4.74 tha^{-1} while this range was 0.7 tha^{-1} to 3.8 tha^{-1} for the checks. Among the checks Binadhan-19 and SAHBHAGI DHAN produced the lowest and highest yield, respectively.

Infestation data for bacterial leaf blight (BLB), blast, tungro, stemborer, and rodents were collected for each genotype and the corresponding data for the checks are shown in Table 53. Every single check had some degree of BLB, blast, and stemborer infestation. Among the varieties tested, BRRI dhan65 and Vandana fared the worst against all three pests. Binadhan-19 (Score 1), BRRI dhan65 (Score 5), BRRI dhan83 (Score 3), and IR13LT799 (score 3) all screened positive for Tungro disease. SAHBHAGI DHAN was reported to have a rat infestation (score 3).

Selection of promising genotypes for the stage 2 trial

As the trial was set 3 months late, drought condition was not imposed properly. In addition, due to the late sowing, disease incidence and pest infestation were high compared to the normal crop cultivation. Moreover, top 10% genotypes were selected for stage 2 trial from the stress condition based on grain yield. The selected genotypes are IR 127165-1-27-9-1-B-B, BN-UR1012, IR 127153-2-3-5-1-B-B, BN-B17/P-3-4 (3), BN-UR1021, IR 132084-B-224-1-1-B-4, BN-N4/M6/P-12, BN-UR1006, IR 127165-1-27-2-1-B-B, BN-UR1023, IR 132084-B-1327-2-1-B-18, IR 132084-B-437-1-5-B-14, IR 127153-2-3-14-1-B-B, BN-UR1022, and BN-UR1003. Among the selected genotypes 7 are IRRI test material and 8 are local test materials. Grain yield of the selected genotypes ranged from 3.3 tha^{-1} to 5.7 tha^{-1}. The highest yield was observed by IR 127165-1-27-9-1-B-B which required 136 days to mature while BN-UR1003 had the shortest growth duration (109 days) and produced 3.3 tha^{-1} yield.

Pest reaction of the selected genotypes under stress condition

Infestation data for bacterial leaf blight (BLB), blast, tungro, stemborer, and rodents were collected for each genotype and the corresponding data for the selected genotypes are shown in Table 54. Every single selected genotype had some degree of BLB and blast infestation. Stemborer infestation was observed in IR 127153-2-3-14-1-B-B, IR 127165-1-27-2-1-B-B, BN-UR1003, BN-UR1012, BN-UR1023 and BN-N4/M6/P-12. There was no tungro disease and rodents' infestation in any of the selected genotypes.

Yield advantages of the selected genotypes over best global and local check

The selected genotypes provided yield advantage up to 77.92% and 118.98 % against the highest global check (Vandana- yield 3.2 t/ha) and highest local check (BRRI dhan83- yield 2.6 t/ha), respectively (Table 55). Ten selected genotypes delivered more than 10% yield advantage over the best global check meanwhile all the genotypes provided at least 25% yield advantage over the local best check.

Screening of rice lines against blast disease

This experiment was conducted at BINA HQS farm in a protected blast screening house by spraying four different isolates of the blast pathogen *Magnaporthe oryzae* on to the four introgressed rice lines and two checks (1 BRRI dhan74, Moderately Blast resistant, 1 USV2, Universal susceptible variety) to observe the response of the rice blast disease and to assess the resistance of different genotypes against the four specific isolates followed randomized complete block design (RCBD) with 3 replications and every replication had 4 plants. Each replication had 6 rows for the 6 genotypes. Total 6 × 3 × 4 = 72 plants were sown in each Isolate specific plot. So total plants were sown 72 ×4 = 288 for 4 Isolates specific areas. Sporulation, inoculation and disease scoring was followed by (JIRCAS) protocol.

Scoring of rice blast fungus infection

The reaction of each blast isolates was evaluated 7 days, 14 days and 21 days after inoculation respectively following 0–5 scoring scale by JIRCA protocol developed by Hayashi and Fukuta, 2009 (Table 56). Based on the chart there were 3categories made that classified the genotypes according to resistance. The three categories were i) Resistant (R), ii) Moderately resistant (MR) and iii) Susceptible. Those plant that was in the range of 0 - 2, were classified as resistant; and if the score was 3 then it was counted as moderately resistant andfinallyifthescorewasinbetween4-5,itwasinthesusceptible category(Figure) below is showing the scale of scores that were followed to score the genotypes. The plants were scored with three readings, 7 days after inoculation and at 7 daysintervalsuntil21 days after inoculation.

Observation of the genotypes after inoculation

After 21days of inoculation the final scoring was done and showing in the (Table 57). Among genotypes, BINA-BR-4-10-12 showed the best resistance against all isolates followed byBINA-BR-4-10-15 and BINA-BR-4-10-19 in case of Isolate 1 and Isolate 4, respectively. All ckecks and all introgressed lines showed susceptibility against isolate 3 except BINA-BR-4-10-12 and BINA-BR-4-10-15. It means that isolate 3 was the most virulent among four isolates.

Screening was done after 7, 14 and 21 days interval to observe the resistance of6 rice genotypes against selected four isolates. Disease scale of (0 - 5) developed by Hayashi *et al.* (2009) was used to score the response of rice genotypes against blast disease (*Magnaporthe oryzae*).

Disease severity (%)

Different disease severity of the four blast resistant introgressed lines and two checks varied in their disease reaction to four isolates. Highest disease severity (20, 68 & 94%) was observed 7, 14 and 21 days after inoculation in USV2, Universal susceptible variety in case of isolate 3 followed by other isolates (Figure 9). Lowest disease severity (0, 3 & 6%) was observed in respect of BINA-BR-4-10-12 followed by BRRI Dhan 74 and other introgressed lines except line BINA-BR-4-10-19.

Handling of segregating materials

Growing M_4 population of Chinigura and Kataribhog

This experiment was carried out with 43 M_4 rice mutants derived from aromatic rice landraces Chinigura (22 mutants) and Kataribhog (21 mutants) to assess the homogeneity, grain quality and yield performance. The experiment was conducted at BINA HQ farm, Mymensingh during *Aman* 2022-23. Each mutant was grown in 5 rows and each row contained 14 hills. The row-to-row and plant-to-plant distances were 20cm and 15cm, respectively. Parental lines were grown at every 10 mutants. Standard production practices for water and nutrition management, and disease and pest control were followed. Growth duration was calculated plot wise and plant height was measured from 5 randomly selected competitive plants. Grain yield was calculated from 1m^2 plot and was converted to t/ha. Grain physical parameters such as length, breadth and length-breadth ratio were measured from 3 randomly selected decorticated grains. For the sensory test of decorticated grains, 1.7% KOH solution was used. One gram of stored decorticated grain was put into Petri dishes with 5 mL of 1.7% KOH solution at room temperature. After 30 minutes, the dishes were opened and immediately smelled. The presence or absence of aroma was scored.

Wide range of variation was observed among the mutants of Chinigura for grain yield and quality related parameters (Fig 1). The Chinigura mutants took 95 to 120 days to mature with average growth duration of 109 days. The Chinigura required 119 days to complete its life cycle. The Chinigura was 155 cm in height while the mutants' plant height ranged between 80 to 180 cm with an average of 111 cm. The average grain yield of the Chinigura mutants was 468 gm/m^2. The grain of Chinigura was 4.57 mm long with a length-breadth ratio of 2.8 mm. Grain length and length-breadth ratio ranged from 3.97 mm to 7.63 mm and 2.23 mm to 4.25 mm, respectively. Among the 22 Chinigura mutants only 3 mutants *viz.* BN-R-2-250-3-1, BN-R-2-250-30-1 and BN-R-2-250-10-1 retained grain aroma (Table 58). Moreover, the mutant BN-R-2-300-3-2 had red pericarp. Finally, based on grain yield (> 500 gm/m^2), decorticated grain length-breadth ratio (> 3.5), grain aroma and pericarp color 10 mutants were selected for further

The Kataribhog mutants also showed wide range of variation for grain yield and quality related parameters (Fig 2). The Kataribhog mutants took 100 to 122 days to mature with an average growth duration of 110 days. The parent Kataribhog was 146 cm in height while the mutants' plant height ranged between 80 to 180 cm with an average of 123 cm. The average grain yield of the Kataribhog mutants was 478 gm/m^2. The grain of Kataribhog was 5.67 mm long with a length-breadth ratio of 1.77 mm. Grain length and length-breadth ratio ranged from 4.7 mm to 7.53 mm and 2.3 mm to 3.65 mm, respectively for the mutants. Among the 21 Kataribhog mutants only 2 mutants *viz.* BN-R-3-250-4-1 and BN-R-3-250-7-1 retained grain aroma (Table 59). Moreover, the mutant BN-R-3-400-2-2 and BN-R-3-400-4-1 had red pericarp. Finally, based on grain yield (> 500 gm/m^2), grain aroma and pericarp color 11 mutants were selected for further evaluation in replicated trial.

Growing M_5 population of Black rice

Five M_5 populations of black rice were grown during *Aman* 2022-23 at BINA HQS, Mymensingh. Individual plants were selected based on plant height and grain filling rate.

Growing M_3 Generation of Nepali Swarna

Seeds of Nepali Swarna were irradiated with ^{60}Co gamma rays. Irradiation doses were 100, 150,200, 250, 300, 350, 400 and 450Gy. 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 2022. From them a total of 40 plants have been selected primarily for future selection in M_4 generation.

Growing F_4, F_5, M_5 population of rice through field RGA

A total of 740 F_4, 620 F_5 of different crosses and 5 M_5 plants were advanced following field RGA method at BINA HQS, Mymensingh.

Growing F_3 population of aromatic rice

A total of 10 F_3 families of Kataribhog× Binadhan-17 were grown in *Aman* 2022-23 at BINA HQs, Mymensingh. The F_3 plants were evaluated for plant height, leaf and grain aroma. A total of 22 plants were selected based on semi-dwarf (90-110cm) plant stature, leaf and grain aroma.

Growing F_2 & F_3 population rice through Field RGA

A total of 450 F_3 and 570 F_2 lines were advanced through field RGA.

Screening of F_6 population of Binadhan-7 × Biroi crosses for higher yield and Biroi grain type

Seeds of F_6 population of Binadhan-7 × Biroi were sown at BINA Headquarter, Mymensingh by maintaining plant to plant and row to row distance of 15cm and 20cm respectively. The experiment was followed by non- replicated design. The size of the unit plots were 1.0 m × 2.0 m. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Intercultural practices were followed according to the necessity. Data on plant height, Days required for 50% flowering, days required for maturity, number of effective tillers, panicle length, and filled and unfilled grains panicle^{-1} and 1000 seed weight were recorded after harvest from 5 randomly selected competitive plants. Finally, all the recorded data were subjected to proper statistical analyses as per design used and are presented in Table 60.

Significant variation was observed for yield contributing characters of the selected lines. The line P-2-38-1-1 required less times for 50% flowering (94 days) comparing to the parent Biroi (110 days) (Table5). It was observed that the Biroi tooks higher time for maturity (140 days) while less time required for the P-2-38-1-4 line (127 days). The line P-2-38-1-7 showed lowest plant height (71.4 cm) in contrast higher plant height was obtained in Biroi (128.8 cm). Maximum effective tillers/plant (16) was found in P-2-38-1-14 line (16) whereas lowest effective tillers $plant^{-1}$ was observed in P-1-40-1 line (10.4). Higher panicle length (27.2 cm) was observed in P-1-50-1 line comparing to the parent Biroi (23 cm). Highest filled grain (135) was found in the P-2-38-1-14 line while minimum filled grain (59) was observed in P-2-38-1-7 line. Lowest unfilled grain (9) per panicle was found in P-2-38-1-9 line but maximum unfilled grain (45) found in line P-2-38-1-10. Highest 100 grain weight (23.6) was obtained in Biroi whereas lowest yield was found in P-2-38-1-6 line (20) (Table 57).

Screening of M_4 lines derived from Tulsimala for higher yield

Seeds of selected lines derived from Tulshimala were sown at BINA Headquarter, Mymensingh by maintaining plant to plant and row to row distance of 15cm and 20cm respectively. The parent Tulsimala was used in this experiment. The experiment was followed by non- replicated design. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Intercultural practices were followed according to the necessity. Data on plant height, days required for 50% flowering, days required for maturity, number of effective tillers, panicle length, and filled and unfilled grains $panicle^{-1}$, 1000 seed weight were recorded after harvest from 5 randomly selected competitive plants. Finally, all the recorded data were subjected to proper statistical analyses as per design used and are presented in Table 61.

Significant variation was observed for yield contributing characters of the selected lines. The line T/250/P-5(1)-2 and T/150/P-2(1)-3 showed lowest plant height (103 cm) comparing to the parent Tulsimala (121 cm). Tulshimala produced comparatively lower tillers number (6.80) whereas the line T/150/P-5(1)-5 had greater tillers number (12.75) among all the lines. Maximum filled grain $panicle^{-1}$ (152) was found in the T/150/P-2(1)-11 line while minimum filled grain (101.70) was observed in Tulsimala parent. Lowest unfilled grain (25) per panicle was found in Tulshimala but maximum unfilled grain (45) found in line T/150/P-2(1)-3 (Table 58).

Screening of rice mutants derived from deepwater rice

A total of 6 M_5 lines of Sarsaria were selected in term of high yielding and deep water characteristics that was irradiated with 150, 200, 250, 300 and 350Gy of gamma ray. This experiment was conducted in *Aman* season, 2022 at Deep Water Rice Screeing (DWRS) Tank, BINA Headquarter farm, Mymensingh.

Growing of BC_1F_6population to find out deepwater characteristics

The seeds of 8 BC_1F_6 populations derived from crossing between Laksmi digha and Binadhan-18 were sown at BINA HQSs 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. Intercultural practices were followed as and when necessitated. Data on plant height, effective tillers, 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 62.

Most of the lines had significantly shorter plant height than the parent Laksmi digha (Table 59). The lineRC-4-1-15-2-11had the highest plant height (173 cm) comparing to the other progenies. Number of effective tillers was highest in the line RC-4-1-15-2-11(7.9) than the check variety Luxmidigha (7.5) (Table 59). The line RC-2-6-3-1-8-4had significantly higher number of filled grains panicle^{-1} (135) than other lines. The line RC-4-1-15-2-11had highest grain yield (22.6 g plant $^{-1}$)than the other lines and parents. All these high yielding cross populations with Luxmidigha (parent) will be screened in Deep water Rice Screening Tank (DWRST) to check the floatability, stem elongation ability in the next growing season (Table 59).

Screening M_3 generation for high yielding *Boro* Rice

A total of 20 M_3mutantlines were selected according to the short duration high yielding characters. This experiment was conducted in*Boro* season, 2022 at BINA Headquarters farm, Mymensingh. Selected M_4seeds will be evaluated and selected at *Boro* season, 2023 further to develop M_4 lines.

Growing M_1 Generation of Binni Dhan

To create genetic variability, seeds of Binni dhan were irradiated with 100, 150, 200, 250, 300 and 350 Gy of gamma rays. Seeds of M_2 generation were colletced at BINA Headquarters farm, Mymensingh during *Aman* season 2022.

Introgression of blast resistant genes (*Pi9, Pish, Pb1)*derived from IRRI blast resistant rice lines into Binadhan-17, BRRI Dhan 89 and BRRI Dhan 92 throughmarker-assisted backcrossing.

Khan *et al.* (2016) has shown in their research paper that total 1280 isolates were collected and 331 isolates tested against 23 differential varieties (DV). Isolates of low virulence frequencies were observed in monogenic lines (MLs) having *Pish, Pi9, Pita2 and Pb1* genes. These genes were more compatible and widely distributed in Bangladesh. They suggested that these genes are useful for developing durable blast resistant variety. So, our present study was to produce F_1 seed derived from cross between recipient parents and resistant donor lines,

SN	Activities to achieve the objective(s)	Findings/ Output
1	Hybridization	9 cross combinations were made using 3 recipient parents with 4 blast resistant (*Pish, Pi9, Pita2 and Pb1*) donor lines 423 F_1 seed were produced derived from following cross combination 1. BRRI Dhan 89 (recurrent) x blast resistant line (*Pi9*) 2. BRRI Dhan 89 (recurrent) x blast resistant line (*Pita2*) 3. BRRI Dhan 89 (recurrent) x blast resistant line (*Pb*1) 4. BRRI Dhan 92 (recurrent) x blast resistant line (*Pi9*) 5. BRRI Dhan 92 (recurrent) x blast resistant line (*Pita2*) 6. BRRI Dhan 92 (recurrent) x blast resistant line (*Pib*1) 7. Binadhan-17(recurrent) x blast resistant line (*Pi9*) 8. Binadhan-17 (recurrent) x blast resistant line (*Pish*) 9. 9.BRRI Dhan 89 (recurrent) x blast resistant line (*Pish*)

Introgression of long slender grain trait in Binadhan-10

Binadhan-10 was crossed with a restorer line having long slender grain and crossed seeds were harvested.

Hybridization of Binadhan-17 with Binni Dhan

Binadhan-17 was crossed with Binni dhan and crossed F_1seeds were harvested

Hybridization of Binadhan-10 with SAL-52 and Binadhan-10 with SAL-73

Binadhan-10 was crossed with advanced line **SAL-52** and **SAL-73** having slender grain and short duration and crossed seeds were harvested.

Growing of M_1 Generation of salt tolerant rice variety Binadhan-10

To create genetic variability, seeds of Binadhan-10were irradiated with 100, 150, 200, 250, 300 350 and 400 Gy of gamma rays. Seeds of M_2 generation were colletced at BINA Headquarters farm, Mymensingh during *Boro* season 2022-23.

Growing M_1 Generation of premium quality advanced line EFSD-59

To create genetic variability, seeds of EFSD-59 were irradiated with 100, 150, 200, 250, 300 350 and 400 Gy of gamma rays. Seeds of M_2 generation were colletced at BINA Headquarters farm, Mymensingh during *Boro* season 2022-23.

Screening of Advanced Rice lines for salinity stress tolerance at the reproductive stage

Salinity screening salt-tolerant rice genotype is important to develop salt-tolerant high-yielding varieties. In this research, eighteen better-performing salt-tolerant rice genotypes were further screened to assess the effects of salt by analyzing biomolecular and morphological responses compared with established checks (tolerant rice genotypes: Binadhan-10, BRRI dhan97, BRRI dhan99, and susceptible rice variety: BRRI dhan29).Standard protocols were followed for salinity tolerance screening of rice developed by the International Rice Research Institute (IRRI) at reproductive stages. The experiment was conducted with a completely randomized design (CRD) with three replications. When flag leaves appeared or were at the booting stage, rice genotypes were imposed under different levels of salt treatments (electrical conductivity: 6 dS m^{-1} and 10 dS m^{-1}) and control set up to fourteen days. Afterward, the genotypes were grown with regular water until harvesting. Most of the genotypes showed better performance (tolerant and moderately tolerant) at the reproductive stage under EC: 6-10 dS m-1. At 6 dSm^{-1} salinity, eight (8) genotypes (SALN-38, SALN-54, SALN-52, SL-23, SAL-52, BRRI dhan99, BRRI dhan97 and Binadhan-10) showed tolerance but four (4) of them (SALN-54, SALN-52, BRRI dhan97 and Binadhan-10) could show tolerance upto 10 dSm^{-1} salinity. Similarly ten (10) genotypes (SALN-40, SALN-25, SALN-44, SALN-05, SL-44, SL-21, SL-10, SAL-73, SAL-44 and BRRI dhan29) were moderately tolerant at 6 dSm^{-1} salinity but became susceptible at 10 dSm^{-1}. The rest of the genotypes were susceptible at both the conditions (Table 63) based on salt injury with significant variation.

The genotypes were also grouped into four major clusters for ten microsatellite markers (RM336, RM493, RM472, RM562, RM152, RM25, RM10793, RM10694, RM10825, and RM2412b) based on the method Unweighted Pair Group Method of Arithmetic Means (UPGMA) is linked to *saltol* QTL and identified as salt tolerant. The SSR analysis found an average number of 9.8 alleles per locus was detected with polymorphism information content (PIC) values ranging from 0.7531 (RM10825) to 0.9140 (RM493). The highest gene diversity was observed in loci RM493 and the lowest in loci RM10825 with a mean diversity of 0.8483. Therefore, the present study revealed some lines of rice that showed salinity tolerance; these were: SALN-54, SALN-52, and SL-21, and moderately tolerant were: SAL-52 and SL-23 for both the morphological and molecular screening.

Based on a modified standard evaluation system (SES)(1-9 scale scoring), morphological characters, biochemical responses, and molecular characterization revealed that SALN-54, SALN-52, SALN-38, SL-21, SL-23, SAL-52, BRRI dhan99, BRRI dhan97, and Binadhan-10 were identified as salt-tolerant rice genotypes at 10 dSm^{-1} at the reproductive stage. These lines could help to improve future rice breeding programs and a potential germplasm source of *saltol* QTL for developing salt-tolerant high-yielding rice genotypes.

Crossing of Binadhan-11 × Binadhan-12and Binadhan-11 × BRRIdhan-87

All F_1 seeds are collected crossing between Binadhan-11 × Binadhan-12 and Binadhan-11 × BRRIdhan-87. This experiment was conducted in*Aman* season, 2022 at BINA Headquarters farm, Mymensingh

Introgression of Biroi type trait to produce short duration, lodging resistant rice lines through hybridization

All F_1 seeds are collected crossing between Biroi-250-2-6 line and Binadhan-17. This experiment was conducted in *Aman* season, 2022 at BINA Headquarters farm, Mymensingh.

Screening M_2 population derived from Baishmuri local landrace rice

Bulked seed collected from M_3 generation of Baishmuri that was irradiated with 200, 250, 300, 350 and 400 Gy of gamma ray. This experiment was conducted in *Aman* season, 2022 at BINA Headquarter farm, Mymensingh

Accelerating Genetic Gains in Rice: (AGGRi): using rapid cycle genomic selection to deliver annual genetic gains of 2% in rice

A total of 62 IRRI breeding lines along with six international check varieties and five national check varieties were evaluated at Rangpur Substation of BINA during *Aman* 2022 to understand and select the best performing breeding lines with highest genetic merits. The entries showed a wide range of variations in grain yield in this site. Yield range of the lines with check was 1.63 to 5.11 t/ha with growth duration ranges from 106-128 days at BINA substation, Rangpur. These lines could be used in the advanced yield trials prior to select candidates for variety release or use as parents in the breeding program.

Accelerating Genetic Gains in Rice: (AGGRi): using rapid cycle genomic selection to deliver annual genetic gains of 2% in rice

A total of 64 IRRI breeding lines along with six international check varieties and five national check varieties were evaluated in Alfa lattice design at Rangpur Substation of BINA during *Boro* 2022-23 to understand and select the best performing breeding lines with highest genetic merits. The entries showed a wide range of variations in grain yield in this site. Yield range of the lines with check was 3.18 to 7.35 t/ha with growth duration ranges from 142-162 days at BINA substation, Rangpur. These lines could be used in the advanced yield trials prior to select candidates for variety release or use as parents in the breeding program.

Screening M_2 population derived from local landrace Kajalsail

Bulked seeds were collected from M_2 generation of Kajalsail mutants. This experiment was conducted in T. *Aman* season, 2022 at BINA Headquarter farm, Mymensingh

Improvement of aromatic rice through hybridization

All F_1 seeds were collected from crossing Binadhan-17 as a recipient with BRRI dhan34 and BRRI dhan50 as donors; BINA dhan-25 as a recipient with BRRI dhan34 and BRRI dhan50 as donors. This experiment was conducted in T. *Aman* season, 2022 at BINA Headquarters farm, Mymensingh

Screening of F_2 generation for earliness with high yielding characters

Fifty F_2populations were evolved from crossing between Binadhan-5 and Binadhan-17 and Binadhan-24 to select high yielding, short duration, and lodging resistant plant/progenies. This experiment was conducted *Boro* season, 2022 at BINA Headquarters farm, Mymensingh. The F_2 population was put at Rapid Generation Advance (RGA) trail to develop $F_3$and F_4 populations.

Induced mutation of *Boro* rice through physical & chemical mutagens

All M_1 seeds were collected from irradiation of selected genotypes with 150, 200, 250, 300 and 350 Gy and through chemical mutagen @ 0.5, 1.0, 1.5 & 2.0% EMS. This experiment was conducted in *Boro*season, 2022 at BINA Headquarter farm, Mymensingh

Induced mutation of *Aus* rice through physical & chemical mutagens

The genotypes BR26 and BRRI dhan55 was irradiated with 150, 200, 250, 300 and 350 Gy and through chemical mutagen @ 0.5, 1.0, 1.5 & 2.0% EMS. This experiment was conducted in*Aman* season, 2022 at BINA Headquarter farm, Mymensingh

Field RGA of some crossing population growing at *Boro* Season

Seventy five F_4populations were evolved from crossing between Binadhan-5 and Binadhan-17 and Binadhan-24 to select high yielding, short duration, and lodging resistant plant/progenies. This experiment was conducted *Boro* season, 2022 at BINA Headquarters farm, Mymensingh. The F_4 population was put at Rapid Generation Advance (RGA) trail to develop F_5 and F_6 population

Source Nursery

The source nursery was constructed with two CMS lines along with 25 restorers. A total of 33 test crosses were made. The test cross hybrids will be evaluated in the next *Aman* season.

Generation advancement of parental lines having multi-stress genes (HRDC materials) with Restorer (R) and Maintainer (B) background

Six F_2 having multi-stress genes with restorer (R) and maintainer (B) backgrounds were grown at BINA HQS farm, Mymensingh. A total of 106 plants were selected from the six populations based on growth duration and plant architechture.

Growing M_2 generation of Binadhan-16 and Binadhan-17

The M_2 generation of Binadhan-16 and Binadhan-17 were grown at BINA HQS farm, Mymensingh. At maturity, a single panicle from each genotype was collected and will be grown in the next *Aman* season.

Preliminary yield trial of promising hybrids

This trial was carried out with five rice hybrids (HRDC materials) along with two yield check Suborna-3 and Mitali-4 to assess the yield performance at BINA HQS, Mymensingh during the *Boro* season of 2022-23. 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 agronomic performances are summarized in the Table 68, days to maturity ranged from 141 days (Suborna-3) to 154 days (IR139526H and Mitali-4). Mitali-4 had the shortest plants with an average plant height of 90 cm while the highest plant height was observed in case of the hybrid IR139526H (104 cm). Yield ranged from 6.68 t/ha (Suborna-3) to 8.02 t/ha (IR139526H). The heritability for days to maturity, plant height and yield was 0.98, 0.85 and 0.69, respectively.

Project 3: Diversity of rice blast pathogen (*Magnaporthe oryzae*) in Bangladesh

Collection, isolation, identification, purification and preservation of different isolates of rice blast

In total, 80 neck blast samples (*Magnaporthe oryzae*) were collected from Barishal and Rajshahi Division 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 10 isolates were stored aseptically in filter paper at −20°C after the necessary drying for the study of morphological, molecular and pathogenocity test.

Morphological characterization of blast isolates in Bangladesh

In this study, morphological differentiation of 19 *Magnaporthe oryzae* isolates was done based on the colony morphology, such as colony color and margin of the colony of different *Magnaporthe oryzae* isolates on PSA plates. A range of color variation was observed among the 19 isolates. Some isolates have blackish grey with a concentric ring, whereas some isolates have dark brownish with a black margin, ashy with a concentric ring (Figure & Table 69). In terms of colony shape, most of the isolates of 19 *Magnaporthe oryzae* showed irregular, wavy margin, whereas the others had regular margins (Figure 15 & Table 69). In this study, isolates were also differentiated based on colony growth variation Figure 15. The radial mycelial growth of 19 *Magnaporthe oryzae* isolates was measured in cm until 13 DAI (Figure 16). Radial mycelial growth variation was distinct for 19 isolates at 3, 6, 9, and 13 DAI. However, the highest radial mycelial growth was observed at 13 DAI for the isolates Po-17, Po-6, Po-16, Po-18, and Po-11, and their respective radial mycelial growth were 8.0 cm and 8.0, 7.9 cm, 7.8 cm, and 7.7cm (Figure 15). On the other hand, the lowest radial mycelial growth was observed at 13 DAI for the isolates Po-5, Po-15, and Po-1, and their respective vegetative growth was 5.2 cm, 6.2 cm, and 6.6 cm (Figure 16).

Moreover, the *Magnaporthe oryzae* isolates were differentiated based on their conidial shape. Five different types of conidial shapes, such as Fusoid with thickened wall at ends, Pyriform, Ovoid with acute ends, Ovoid conidium of *Hirsutella*-like synanamorph, and Fusoid, were observed among the isolates (Table 67). Moreover, based on their degree of sporulation (no. of conidia per ml), the highest sporulation rate (5.12×10^5spores/ml) was observed in the Po-17 isolate, whereas the lowest sporulation rate (1.12×10^5spores/ml) was observed in the Po-5 isolate (Table 70).

Wheat

Advanced yield trial of 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-1-2-1 and the check variety BARI Gom-28 were sown at at BINA Headquarter, Mymensingh, BINA Sub-station Rangpur, BINA Sub-station Ishwardi, BINA Sub-station Chapainawabganj, farmer's field Sadar Chapainawabganj and farmer's field Godagari, Rajshahi by maintaining plant to plant and row to row distance 15cm and 20cm respectively. The experiment was followed by RCBD with 3 replications. The size of the unit plots were 4.0 m × 5.0 m. Recommended doses of nitrogen, phosphorus, potassium, sulphur, zinc and *Boro*n were applied in the form of Urea, T.S.P, MOP, Gypsum, Zinc sulphate and Boric acid. 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 10 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 71.

Results showed significant variation among the mutant 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-1-2-1 were 87.84 cm which is shorter than the check variety BRRI Gom-28 (89.23 cm). The line BWM-M-1-2-1 had higher number of effective tillers 10.17 comparing to BARI Gom-28 (7.72). Spike length of BWM-M-1-2-1 was recorded as 10.20 which are statistically higher than check variety BARI Gom-28 (9.36). The highest number of filled grains spikelet^{-1} was observed BWM-M-1-1 (47.01) followed by BARI Gom-28 (44.50). Check variety BRRI Gom-28 had higher number of 1000 grain weight (46.74 g.) to the BWM-M-1-1 line (43.06 g.). BRRI Gom-28 had statistically early maturity 105 days than the line BWM-M-1-1 of 114 days. The line BWM-M-1-1 had produced higher yield (4.0tha^{-1}) than the check variety BARI Gom-28 (3.91tha^{-1}) (Table 72).Considering the duration, yield & yield attributes, the promising line BWM-M-1-1 will be evaluated in the next trial at the Barind region.

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Screening of BC_1F_3 generation for earliness and high yielding

To select early maturing lines with desirable yield attributes of BC_1F_3 generation developed from the cross between BARI Gom-33 × Bina-800-1-3 and Bina-800-1-3 × BARI Gom-33 were grown at BINA Headquarters farm, Mymensingh. From the crosses, 40 lines were selected primarily for further selection in BC_1F_4 population.

Induced mutation of wheat through physical mutagen

To create genetic variability for high yield and heat tolerance, seeds of 28 germplasm including four popular wheat varieties BARI gom-33, BWMRI gom-1, BWMRI gom-2 and Sonalika were irradiated with 150, 200, 300 and 400 Gy of gamma rays. Seeds were sown on 22 November 2022 at BINA Headquarters farm, Mymensingh. This experiment was followed by non-replicated design and sown separately (variety and dose wise). Finally, the survived plants produced seeds were harvested separately for growing M_2 population.

Hybridization of wheat for earliness and heat tolerance

The aim of this study is to create genetic variability for earliness and heat tolerance of wheat. The seeds were sown on 10 days interval of November 2022. In early morning the recipient parent was emasculated and pollinated by the respective donor parents followed by bagging and tagging. After few days seed setting spike was considered a success of cross.

Maximum cross was conducted between BARI Gom-33× Sonalika followed by BARI Gom-33× BWMRI-1 and success rate was higher in BARI Gom-33× BWMRI-2 65%. F_1 seeds were harvest separately for growing F_2 population.

Progrm Area-II: Varietal Improvement of oilseeds

Rapeseed-Mustard

Project-1: Varietal improvement of rapeseed-mustard through induced mutation and other advanced breeding techniques

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

Three rapeseed (*B. rapa* var. *toria*) mutants (RT-35, RT-38 and RT-39) along with two check varieties Tori-7 and BARI Sarisha-15 were evaluated to assess overall performance for earliness and yield attributes. The trial was conducted at BINA Head quarters farm, Mymensingh and BINA Sub-station farms at Rangpur, Ishwardi and Magura. The experiment was laid out in a randomized complete block design with three replications. Seeds were sown on 3 November 2022 at all the locations. Unit plot size was $16m^2$ ($4m \times 4m$) 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 73. Significant variation was observed among the lines and check varieties for most of the characters in each location and combined over all locations. Average maturity period ranged from 80 to 86 days. BARI sarisha-17 required longest maturity period of 86 days and RT-38 required the earliest 80 days, whereas Tori-7 required 85 days. In case of plant height, RT-38 produced the tallest plant (110.17cm) followed by RT-35 (104.83cm) and RT-39 (100.61cm). RT-35 and RT-38 produced the highest number of branches plant^{-1} (6) and other genotypes had similar number of branches plant^{-1} (4-5). RT-38 produced the highest number of siliquae plant^{-1} (146) followed by RT-39 (142). 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 RT-35 (5.17cm) whereas; the shortest (3.42cm) was in Tori-7.

Among the genotypes, line RT-39 produced highest seed yield 1311 kg ha^{-1} followed by RT-38 (1301 kg ha^{-1}) which was statistically different from seed yield of check variety Tori-7 (1163 kg ha^{-1}). Higher seed yielded lines RT-38 and RT-39 was selected for future trial on the basis of their yield stability and other agronomic traits.

Preliminary yield trial with rapeseed (*B. napus*) mutants in drought and saline prone areas

Seven rapeseed mutants (RM-27, RM-28, RM-32, RM-33, RM-34, RM-35 and RM-39) along with the two check varieties Binasharisha-4 and Binasharisha-9 were taken in the present investigation. This trial was conducted at BINA HQS farm, Mymensingh and BINA substation farms at Satkhira, Noakhali and Ishwardi. The experiment was laid out in a randomized complete block design with three replications. Seeds were sown on 3 November 2022 at all locations. Unit plot size was 4m2 (2m×2m) 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 the mean of each character.

Results obtained from the trial of individual location and combined over location for all the characters are presented in Table 74. Significant variation was observed among the lines and checks variety for most of the characters in both of the three individual locations and combined over all locations. On average, the maturity period ranged from 79 to 96 days. Check variety Binasharisha-4 required the longest maturity period of 96 days and RM-27 required the shortest maturity period of 79 days. RM-34 (93cm) and Binasharisha-4 (92cm) had the tallest plant height followed by RM-32 (89cm). Check variety Binasharisha-9 (80cm) was a comparatively dwarfed plant. The mutants RM-28, RM-35 and RM-39 produced a similar number of branches (5) which is higher than all other genotypes and check varieties. RM-39 produced the highest number of siliquae plant^{-1} (67) followed by RM-34 and RM-32 which produced 63 and 62 siliqua plant^{-1}, respectively. Number of seeds siliquae^{-1} and siliquae length is a good indicator contributing to seed yields.

Screening mustard mutants for salinity tolerance at reproductive stage in hydroponic culture

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 technique. Uniform seeds of RL-13, RL-14, RL-17 and Tori-7 were used in the present investigation. Salinity treatment (6, 8 and 10 dSm^{-1}) was applied after every seven days when the entire seedling was established in hydroponic culture. Data on various characters such as plant height, leaf number, leaf area, shoot and root dry weight were 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 72 and visual injury at reproductive stage presented in Table 75. 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 dSm^{-1} 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^{-1} 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.

Molecular marker based selection of rapeseed mutants for low erucic acid content against *FAE1* gene

Seven mutants (RM-12, RM-13, RM-14, RM-15, RM-17, RM-18 &RM-19) and one check (BARI sarisha-18) were observed in this trial. The trial was conducted at BINA Head quarter farm, Mymeningh and BINA Sub-station farm at Nalitabari. This experiment was laid out in a randomized complete block design with three replications. Seeds were sown on 3 November 2022. 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 77. 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 79 to 110 days. Check variety BARI sharisha-18 required the longest maturity period of 110 days and RM-12 required the shortest maturity period of 79 days. RM-17 (93cm) and BARI sharisha-18 (126cm) produced the tallest plant followed by RM-14 (89cm). The mutants RM-13, RM-18 and RM-19 produced a similar number of branches (5) which is higher than all other genotypes and check varieties. RM-19 produced the highest number of siliquae plant^{-1} (67) followed by RM-17 and RM-14 which produced 63 and 62 siliqua plant^{-1}, respectively. Number of seeds siliquae^{-1} and siliquae length is a good indicator contributing to seed yields.

Seeds siliqua^{-1} and siliquae lengths were also contributing indicator for higher seed yield of rapeseed. Both of these characters were showed significant variation of all the genotypes. BARI sharisha-18 produced the highest seed yield (2030 kg ha^{-1}) which was significantly different compared to the mutants with 100 days for maturity. Considering with growth duration, agronomic performances and yield RM-14 and RM-18 was selected as a promising mutants for further breeding program of rapeseed.

Screening of segregating population of rapeseed mutant RM-005

Mutant RM-005 is an advanced rape seed mutant having only 26% erucic acid. It is the lowest erucic acid content rapeseed-mustard advance line in Bangladesh than any other rapeseed-mustard cultivated variety. Due to the indeterminate nature of rapeseed still it has some heterogeneity regarding plant height at maturity period. It was done successfully and last January 2023 released a new variety named as BINA Sarisha12.

Evaluation the yield performance of promising rapeseed mutant (M_6)

Six rapeseed mutants (RMT-13, RMT-14, RMT-22, RMT-23, RMT-24 and RMT-25) along with the two check varieties Tori-7 and Binasharisha-11 were taken in the present investigation. This trial was conducted at BINA HQS farm, Mymensingh. The experiment was laid out in a non-replicated design. Seeds were sown on 4 November 2022 at BINA HQS farm, Mymensingh. Plot size was 150m^2 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 (cm), no. of branch plant^{-1}, siliqua length (cm), no. of silique plant^{-1}, no. of seed silique^{-1}, seed yield (kg ha^{-1}), 1000 seed weight (gm), days to flowering and days to maturity were taken from 5 randomly selected plants from each plot. Maturity period was counted when 90% siliqua was matured in a plot. Seed yield of each plot was recorded after harvest and proper drying and then converted into kgha^{-1}. Appropriate statistical analyses were performed for comparison of the mean of each character.

Results obtained from BINA HQS farm, Mymensingh for all the characters are presented in Table 78. Significant variation was observed among the lines and check variety for most of the characters at BINA HQS farm, Mymensingh. On average, the maturity period ranged from 81 to 92 days. RMT-14 required the longest maturity period of 92 days and RMT-26 required the shortest maturity period of 81 days. RMT-24(117cm) and RMT-23 (113cm) produced the tallest plant followed by RMT-22 (112cm). RMT-14 (87cm) was a comparatively dwarfed plant. The mutants RMT-22, RMT-23 and RMT-26 produced a similar number of branches (6) which was higher than all other genotypes and check varieties. RMT-22 and Tori-7 produced the highest number of siliqua plant^{-1} (135) followed by RMT-23 which produced 126 siliqua plant^{-1}, respectively. Number of seeds siliqua^{-1} and siliqua length is a good indicator contributing to seed yields**.**

Maximum seeds siliquae^{-1} and siliquae length was obtained from RMT-13, RMT-22 and RMT-25 that was significantly differ from other mutants and check. Among the genotypes, line RMT-22 produced higher seed yield of 1348 kg ha^{-1} which was statistically similar to seed yield of RMT-25 and RMT-23 (1122 kg ha^{-1}& 1095 kg ha-^{1}). Better yield performance at southern area of RMT-13, RMT-22 and RMT-25 has been selected for future trial.

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 during 4-6 November 2022. 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 forty nine (49) segregating population was evaluated for yield and yield contributing characters (Table 79). Among them twelve (12) was segregating families and other twenty five (25) was single plant. All of the segregating populations were obtained from earlier generation that had been selected from previous trials, whereas single plant population was from earlier generation of F_4 to F_2. Five (5) populations from F_5 and twelve (12) from F_4 were selected for future generation advancement. The selection was facilitated considered the early maturity period (79-82 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 (34) single plants have been selected and harvested separately for future utilization of varietal improvement program. A total of twenty five (25) true breeding lines were selected primarily for further selection that will be grown respective advance generation on the basis of their agronomic performances.

Growing of M_5 to M_2 generation of rapeseed mutants

A large number of 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's farm, Mymensingh. The seeds were sown during 4-6 November 2022. 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 124 segregating population (Table 80) was evaluated for yield and yield contributing characters. Among these, 44 segregating families (M_5 and M_4) and others were (68) 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_5 and ten from M_4 were 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 68 true breeding mutants have been selected primarily. For further selection the selected mutants will be grown for respective advance generation based on their agronomic performances.

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.

Hybridization of Binasarisha-9 and BARI Sarisha-14, BARI Sarisha-17 and BARI Sarisha-18

The aim of this study is to create genetic variability for varietal development process of rapeseeds. Binasarisha-9 was crossed with BARI Sarisha-14, BARI Sarisha-17 and BARI Sarisha-18. The seeds were sown on 10 days interval from 4-13 November 2022. 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 considered 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, 50%. F_1 seeds were harvested separately for growing F_2 population.

Project-2: Varietal improvement of groundnut through induced mutation and other advanced breeding techniques

Groundnut
On- station and on-farm yield trial with bold seeded groundnut mutants

On-farm and on-station trials were carried out with four lines along with one check (Binachinabadam-4) at BINA HQS farm Mymensingh and BINA sub-station farm at, Rangpur, Khagrachari & Ishwardi, and farmer's field at Lalmonirhat, Panchagar, Ishwardi and Mymensingh during Kharif-II season of 2022. The experiment was conducted with RCB design with three replications. Unit plot size was 5.0 m × 4.0 m. Seeds were sown at 15cm distances within rows of 30 cm apart. Recommended fertilizer dose, 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 2.0 m^2 which later converted to t/ha. Shelling percentage was calculated using the following formula-

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

Finally,the data were analyzed following proper statistical design using Statistix 10 version 1.0 Copyright © 1985-2013 and are presented in the Table 81.

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

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 78. Significant differences were observed among the lines and the check variety for yield and yield attributing character. B6/282/80 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 except Khagrachari (Table 78). On an average, the check variety Binachinabadam-4 gave lowest plant height 57.99 (cm) than all the four mutants and the mutant RG-KHA-19-1 gave the highest plant height 75.36 (cm). For pod plant^{-1}, mutant B6/282/80 gave the highest number of pod plant^{-1} (11.46) and mutant RG-KHA-19-1 gave the lowest number pod (9.05). Pod & kernel weight of the mutant B6/282/80 was 70.08 (g.) & 52.36 (g.) which showed higher than the check variety Binachinabadam-4. Mutant RG-KHA-19-1 was recorded highest 100 pod-wt. and 100 kernel wt. (100.70 g and 45.37g, respectively) than the check variety Binachinabadam-4 (81.66g and 40.67g, respectively). From table 1 the shelling percentage of the mutant B6/282/80 was 73.26 significantly higher than the check variety Binachinabadam-4. Yield of the mutants of B6/282/80 was (2.04tha^{-1}) which was higher than the check variety Binachinabadam-4 (1.96tha^{-1}). Considering the yield performance of the mutant line B6/282/80 which has higher pod yield tha^{-1}

along with higher shelling percentage and bigger kernel sizes NSB released a new groundnut variety as BINA Chinabadam11 for Rabi and Kharif season all the groundnut growing areas of Bangladesh. This research was supported by the project 'Development of climate resilient crop varieties and profitable crop management technology through nuclear techniques and enhance crop production through increasing cropping intensity and their adaptation in Haor, Charland, Saline and Hilly areas project' under the ministry of Agriculture.

Regional yield trial with bold seeded mutants of groundnut

With a view to identify high yielding mutant(s) over Binachinabadam-4 andBARI Chinabadam-8, the experiment was conducted at five locations viz. BINA Headquarters', Mymensingh, BINA Sub-station, Rangpur and farmers' field, BINA Sub-station, Ishwardi and farmers' field (Table 79) with 5 mutant lines of groundnut were evaluated and selected for high yielding mutants with bold pods and kernels, and higher shelling percentage. Binachinabadam-4 was included in this experiment as a check variety. The experiment was followed by RCBD with 3 replications. A unit plot size was 4.0 m × 3.0 m. Seeds were sown at 15 cm distances within rows of 30 cm apart. Recommended fertilizer dose, Intercultural operations were also followed. Data were recorded on plant height, pod number, pod yield plant^{-1}, 100-pod and kernel weight from randomly selected 10 competitive plants at maturity. Pod yield was also recorded from an area of 2.0 m^2 which later converted to tha^{-1}. Shelling percentage was calculated using the following formula-

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

Finally, the data were analyzed following proper statistical design using Statistix 10 version 1.0 Copyright © 1985-2013 and are presented in the Table 82.

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

Results showed significant variations among the mutants and check for most of the characters in individual locations and over locations in combined analysis (Table 82). On an average, it was observed that plant heights of BCB-3-1-2, BCB-3-4-1, BCB-4-2-2, BCB-3-4-5 and BCB-3-1-3 were recorded which ranged from 58.11 (cm) to 69.28 (cm). Except BCB-3-1-3 almost all the mutants gave lowest plant height followed by the check variety Binachinabadam-4 66.94 (cm) and BCB-3 62.80 (cm). Highest no. of pod/plant observed in BCB-4-2-2 (17.18) comparing to the check variety Binachinabadam-4 (13.89), BARI Chinabadam-8 (13.53) and BCB-3 (12.88). Pod & kernel weight of the mutant BCB-3-4-1 were 19.90 (g) and 12.58 (g) which showed higher weight than all the check variety. The check variety Binachinabadam-4 was recorded highest 100 pod-weights and 100 kernel weights (149.72g and 50.94g respectively) than all the mutants and other two check variety. From table 1 the shelling percentage of the mutant BCB-4-2-2 (68.77) was significantly higher than the check variety Binachinabadam-4 (61.61), BARI Chinabadam-8 (63.27) and BCB-3 (62.79). Yield of the mutants of BCB-4-2-2 was (2.67tha^{-1}) which was higher than the check variety Binachinabadam-4 (2.51tha^{-1}), BARI Chinabadam-8

(2.50 tha^{-1}) and BCB-3 (2.48tha^{-1}).

Oil content and fatty acid analysis of bold seeded groundnut mutants

All fatty acid contents in F6 generation (Lauric, Myristic, Palmitic, erucic, Stearic, Oleic, Linoleic, and Arachidic acid) SFA/UFA ratio, MUFA/PUFA ratio also showed highly significant differences but oil content showed significant difference ($P \leq 0.05$). Highly significant variations found among the genotypes.In this study, Oleic acid is one of the major unsaturated fatty acids (MUFA) which is found usually in maximum amount among all other fatty acids in groundnut oil. Analysis of variance showed highly significant variations among genotypes of Oleic acid (Table 3). BCB-3 had the highest oleic acid content (17.00%) among parents. Among genotypes BCB 3-1-3 had the highest oleic acid content (31.56%) and BCB 4-2-2 had the lowest oleic acid content (22.06%) (Table 83). Similar to our results significant variation in oleic acid in groundnut was also reported by others (Gulluoglu *et al.*, 2016; Amoha et al., 2020). Additionally, high oleic acid groundnut has longer shelf-life than low oleic groundnut.

Linoleic acid is an important unsaturated fatty acid (PUFA). Analysis of variance showed highly significant variations among genotypes of linoleic acid (**Table 83**). Among parents BCB-4 had the highest linoleic acid content (11.49%) and BCB-3 had the lowest linoleic acid content (13.90%). Among genotypes GC BCB 3-4-1 had the highest linoleic acid content (17.54%) and BCB 3-4-5 had the lowest linoleic acid content (9.40%) (Table3). Similar to our results significant variation in linoleic acid content in groundnut was also reported by others (Gulluoglu *et al.,* 2016; Amoha *et al.*, 2020).The percentage of saturated and unsaturated fatty acids in groundnut oil determines its nutritional and storage characteristics (Dwivedi *et al.*, 2017). The more the unsaturated fatty acids, the healthier the oil will be, though saturated fatty acid content increase storage life. The highest MUFA/PUFA ratio found in BCB 3-1-3 (2.21) and the lowest MUFA/PUFA ratio found in BCB-3-1-2 (1.35). Between parents BCB-4 has the lowest ratio (1.27). The highest percentage of oil found in parent BCB-3 (52.10%) and the lowest percentage found in parent BCB-4 (45.56%) among parents. When it comes to crosses and reciprocal crosses, the highest percentage of oil content showed by BCB 3-1-3 (54.63%) and the lowest percentage of oil content showed by BCB 4-2-2 (39.11%) (Table3). These results of oil content ranged 39.11 - 54.63% which is similar to Shasidhar *et al.* (2017). Chen et al. (2010) who reported the oil percentage of groundnut seed is 44-56%. Considering the yield and quality performance of the mutant further zonal trial will be needed at Kharif-II season.

Advanced yield trial with bold seeded mutants of groundnut

Groundnut (*Arachis hypogaea* L.) is mainly cultivated in more than 100 countries (Pasupuleti e*t al.*, 2013) in the semi-arid and subtropic regions (Oteng-Frimpong et al., 2021) covering an area of 29.59 million hactare with 48.75 million tons production (FAOSTAT, 2019). The seeds and haulms are good sources of income as both cash and fodder crops (Ajeigbe et al., 2015; Oteng-Frimpong et al., 2021). 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 (Ojomo, Omueti, Raji, & Omueti, 1979). Through mutation breeding, several high-yielding environmentally stable varieties of groundnut have already been developed in Argentina, India, Myanmar, and China (Micke & soil, 1984). 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 04 varying environments were also investigated using stability parameters. The experiment was conducted at four locations viz. field at BINA Headquarter, Mymensingh, BINA substation Rangpur, BINA substation Khagrachari, BINA substation Ishwardi by maintaining15cm distances within rows of 30cm apart respectively. The experiment was followed by RCBD with 3 replications. The size of the unit plots were 3.0 m × 3.0 m. Recommended fertilizer dose, 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 2.0 m^2 which later converted to tha^{-1}.Shelling percentage was calculated using the following formula-

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

Finally, the data were analyzed following proper statistical design using Statistix 10 version 1.0 Copyright © 1985-2013 and are presented in the Table 84.

Results showed significant variations among the mutants and check for most of the characters in individual locations and over locations in combined analysis (Table 81). On an average, it was observed that plant heights of BCB-3-1-2, BCB-3-4-1, BCB-4-2-2, BCB-3-4-5 and BCB-3-1-3 were recorded which ranged from 39.32(cm) to 43.31 (cm) and almost all the mutants gave lowest plant height followed by the check variety Binachinabadam-4 45.48(cm) and BCB-3 43.17(cm). Highest no. of pod/plant observed in BCB-4-2-2 (26.01) comparing to the check variety Bina china badam-4 (22.97) and BCB-3 (23.97). Pod & kernel weight of the mutant BCB-4-2-2 were 28.04 g & 20.27 g which showed higher weight than the check variety Binachinabadam-4. The mutant BCB-4-2-2 was recorded highest 100 Pod-weights 125.75 g than the check variety Binachinabadam-4 119.92 g. 100 kernel wt. also recorded higher in the check variety Binachinabadam-4 57.22 g than the other mutants. From **table 85** the shelling percentage of the mutant BCB-4-2-2 72.40% was significantly higher than the check variety Binachinabadam-4 64.98% and BCB-3 66.6%. Yield of the mutants of BCB-4-2-2 was 2.11 tha^{-1} which was higher than the check variety Binachinabadam-4 1.91 tha^{-1} and BCB-3 1.91 tha^{-1}. The results supported from the table 81 showed that different environment the shelling percentage of the mutant BCB-4-2-2 was 72.40% significantly higher than the check variety Binachinabadam-4 and BCB-3. BCB-4-2-2 showed highest yield (2.11 tha^{-1}) from the check variety Binachinabadam-4 (1.91 tha$^{-1)}$. Our study delineated that is a suitable genotype BCB-4-2-2 that can be grown across the environment in Bangladesh while the other genotypes are environment-specific.

Screening of F_5 populations for long and bigger pods with 3-4 kernels

Using a 4 × 4 intra-specific diallel cross of groundnut, breeding material comprised of four groundnut parent genotypes viz., GC-1, Binachinabadam-4, Morocco and Myanmar Badam, having diverse origin. The experiment was conducted at the field experimental plot of Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, Bangladesh during the period of January 2023 to June 2023.

The experiment was conducted with RCB design with three replicates. A unit plot size was 1.0 m × 2.0 m. Seeds were sown at 15cm distances within rows of 30 cm apart. Recommended fertilizer dose, 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 1.0 m^2 which later converted to tha^{-1}. Analysis was carried out using R software.

Significant variation was showed among the cross combinations and the parents for most of the characters (Table 83). Highest plant height was observed from the cross BCB-BB-GC-1-19 (74.93cm).For pods plants^{-1} higher pods per plants observed in BCB-GC-MY-9 and BCB-BB-B4-7 (14.2).Highest pod and kernel weight of the partial mutant BCB-M-MY-5 was 79.07 g. and 56.67 g. which showed higher than the check than the four parents. Highest 100 pod weight was recorded in BCB-BB-GC-1-4 189.00g. and 100 kernel weight was 69.63g in Morocco. From Table 83 the shelling percentage of the 79.20% BCB-M-MY-10 was higher than the other cross combination. Highest yield was recorded in the cross combination BCB-M-MY-5 (3.48 tha^{-1}) which was significantly higher than all parents studied in the experiment.

Screening of F_4 populations for long and bigger pods with 3-4 kernels

Using a 4 × 4 intra-specific diallel cross of groundnut. Breeding material comprised of four groundnut parent genotypes viz., GC-1, Binachinabadam-4, Morocco and Myanmar Badam, having diverse origin. The experiment was conducted at the field experimental plot of Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, Bangladesh during the period of August 2022 to December 2022. From 21 lines a total of 13 lines have been selected primarily for future selection in F_5 generation.

Induced mutation of groundnut through Gamma irradiation

To create genetic variability, seeds of five groundnut variety Lory, Binachinabadam-9, BARI Chinabadam-11 and GC-1were irradiated with physical (150, 180, 200 and 250 Gy) mutagen. Seed were sown on 22 November 2022 at BINA HQSs farm, Mymensingh. The experiment was followed by non- replicated design and sown separately (variety and dose wise). Survived plants produced seeds were harvested separately for growing M_2 generation

Maintenance of groundnut mutant germplasm

Fifty five germplasm were grown at BINA Headquaters, Mymensingh. After harvest, seeds of all germplasm were collected and preserved as breeding materials.

Sesame

Project-3: Varietal improvement of sesame through induced mutation and other advanced breeding techniques

On-station and on-farm yield trial with sesame mutants

Two promising mutants (SM-25 & SM-26) along with two check varieties Binatil-1 and BARI til-5 were evaluated through this trial. This experiment was conducted at BINA HQS, Mymensingh, BINA sub-station farms at Ishwardi, Magura & farmer's field at Ishwardi, Cumilla & Magura during March to June 2023.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 2023. 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 87. 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 84 to 88 days. The mutant SM-25 & SM-26 matured earlier (84 days) than the check varieties Binatil-1 (87 days) &BARI Til-4 (88 days). Binatil-1 produced the tallest (102cm) plant and mutant SM-26 produced the shortest plant height of 93cm followed by BARI Til-4 (94) and the mutant SM-25 (95cm). BARI Til-4 produced 3 branches where the mutant SM-26 bear 2 branches but the mutant SM-25 and the check variety Binatil-1 were uniculm type. BARI Til-4 produced significantly higher number of capsules plant^{-1} (56) followed by the mutant SM-26 (47) and SM-25 (46cm). BARI Til- 4 produced only 38 number of capsules plant^{-1}. The mutant SM-26 had the highest number of seeds capsaules^{-1} (71) with long capsule (3.41cm) size followed by BARI Til-4 (70). The mutant SM-25 had 67 number of seeds capsaules^{-1} with 3.02cm long where as Binalit-1 had 66 numbers of seeds capsaules^{-1} with 3.49cm capsule length. On an average, SM-26 produced the highest seed yield of 1357 kg ha^{-1} followed by the check variety BARI Til-4 (1279 kg ha^{-1}) and the mutant SM-25 produced lowest seed yield of 1153 kg ha^{-1}. Location-wise performance showed that the highest seed yield was produced at BINA sub-station field, Ishwardi (1378kg ha^{-1}) followed by farmer's Field Ishwardi (1301kg ha^{-1}).

From this trial it was observed that, SM-26 was the best mutant among the mutants and check. This mutant will be applied to the NSB for releasing as a new variety.

Regional yield trial with sesame mutants

Four promising mutants along with two check varieties Binatil-4 and BARI til-4 were evaluated through this trial. This experiment was conducted at BINA HQS farm Mymensingh and BINA Sub-station's farm at Ishwardi, Magura and Jamalpur during March to June 2023. 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 2023. 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 88. Significant variations were observed among the mutants and two checks for most of the characters in both of individual locations and combined over locations. Days to maturity ranged from 83 to 96 days in different locations. Mutant ESE-03 (111cm) and check varieties Binatil-4 (111cm) and BARI til-04 (116cm) produced comparatively the tallest plant whereas mutant's ESE-01 (106cm), ESE-04 (107cm) and ESE-06 (106cm) produced the shortest plant height. Both the mutants and checks were profusely branched and ESE-03 produced maximum (3.03) branches $plant^{-1}$ followed by the other mutants and check varieties (2.92) whereas the lowest from ESE-01 (2.38). Binatil-4 produced significantly higher number of capsules $plant^{-1}$ (61) which is statistically different from ESE-01 (46). All other mutants and check BARI til-4 produced almost similar number of capsules plant-^{1} (53-56). Check variety BARI til-4 produced highest number of seeds $capsaule^{-1}$ (99) followed by the mutant ESE-03 (89). Binatil-4 had long capsule length (2.69cm) and ESE-01 also comparatively long capsule length (2.55cm) than others. Highest thousand seed weight (3.03g) in ESE-01, which is statistically identical from others. On an average, Mutants ESE-04 and ESE-06 produced the highest seed yield of (1295 kg ha^{-1}) and (1314 kg ha^{-1}), respectively followed by check varieties Binatil-4 (1270 kg ha^{-1}) and BARI til-4 (1276 kg ha^{-1}). Location-wise performance showed that the highest seed yield was produced at BINA sub-station Jamalpur (1260 kg ha^{-1}) followed by BINA HQS farm, Mymensingh (1231 kg ha^{-1}) and BINA sub-station Magura (1229 kg ha^{-1}).

From this result, it was concluded that mutant's ESE-03, ESE-04 and ESE-06 performed better in yield and other yield contributing characters. Further trials will be needed to confirm this result.

Preliminary yield trial with promising M_6 sesame mutants

Five promising mutants (SES-01, SES-05, SES-06, SES-09 & SES-11) along with two check varieties Binatil-4 &BARI til-4 were evaluated through this trial. This experiment was conducted at BINA Sub-station's farm at Ishwardi and Magura during March to June 2023.

The mutants and the check variety were laid out in a randomized complete block design with three replications. Unit plot size was 12m^2 (4m × 3m) and line to line spacing was maintained 25cm. Seeds were sown on 06 March 2023. 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 89. Significant variations were observed among the mutants and check for most of the characters in both of individual locations and combined over locations. Days to maturity ranged from 86 days (SES-08) to 91 days (SES-11). Mutants SES-09 produced the tallest plant (122cm) whereas mutant SES-09 produced the shortest plant height (105cm). The mutant SES-08 is unicalm but the other mutants and check were profusely branched and SES-11 provided maximum (3.3) branches plant^{-1} followed by the mutant SES-07 (3.1). Mutant SES-11 produced significantly higher number of capsules plant^{-1} (58) which is statistically different from others. The lowest number of capsules plant^{-1} (38) was obtained from SES-08. Mutant SES-08 produced the highest number of seeds capsaule^{-1} (95) followed by the mutant SES-05 (91) and SES-11 (90). Mutant SES-08 had long capsule length (2.44cm) and highest thousand seed weight (3.29g) in SES-11, which is statistically identical from others. On an average, Mutants SES-11 produced the highest seed yield of (1403 kg ha^{-1}) followed by mutants SES-10 (1352kg ha^{-1}) and SES-05 (1337kg ha^{-1}). Location-wise performance showed that the highest seed yield was produced at BINA HQS farm, Mymensingh (1312kg ha^{-1}) followed by BINA sub-station Ishwardi (1302kg ha^{-1}).

Growing of M_6 to M_2 generation of sesame 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 during March 2023. All the seeds were space planted in 3m long five rows with 25cm row spacing. Recommended fertilizer was applied and necessary steps were taken to grow the crop uniformly.

Total 106 segregating population (Table 90) was evaluated for yield and yield contributing characters. Among these, 28 segregating families (M_6 & M_5) and others were (78) 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 six populations from M_6 and 10 from M_5 were selected for future advancement of generation. The basis of the selection was considering the maturity period (84-95 days) with other yield contributing characters. From various early generation single plant also selected considering maturity period, seed color, no. of capsule and other agronomic traits. Forty-four single plants was also selected and harvested separately for future utilization of varietal improvement program. From all of these variants a total of sixty (60) were selected primarily for further selection that will be grown for respective advance generation on the basis of their agronomic performances.

Growing of M_1 population

To create genetic variability, seeds of popular sesame varieties Binatil-1, Binatil-2, Binatil-4 and BARI til-5 were irradiated earlier with 600, 700 and 800Gy of gamma rays. Seeds were sown on 04 April 2023 at BINA HQS 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_2 population.

Hybridization of sesame

Some F_1 seeds were harvested to grow F_2 generation of sesame.

Soybean

Project-4: Varietal improvement of soybean through induced mutation

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

Three promising mutants (SBM-22, SBM-23 and SBM-26) along with two checks Binasoybean-5 and BARI Soybean-6 were evaluated through this trial. The experiment was conducted at BINA HQS farm Mymensingh, BINA sub-station farms at Barishal and farmers' field at Subornochor, Kamalnagar, Haimchar and Barishal during January to April 2023. 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 $20m^2$ ($5m \times 4m$). 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 91.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 106 to 129 days and there were no statistical differences among the mutants and check varieties. The mutant SBM-23 was earlier than others and it required 106 days to mature where the mutants SBM-26& SBM-22 required highest 129 & 128 days to mature, respectively. BARI soybean-6 & Binasoybean-5 required 111 & 110 days to matured. Plant height ranged from 46cm in SBM-23 to 99cm in SBM-22. There were no significant differences for Branches plant^{-1} among the mutants and check varieties. The mutant SBM-22 produced the highest number of branches plant^{-1} (5) and highest number of pods plant^{-1} (84) seeds pod^{-1} (3). The mutant SBM-26 produced 73 numbers of pods plant^{-1} and two check varieties BARI Soybean-6 and Binasoybean-5 produced 74 & 70 pods plant^{-1}, respectively. Pod length ranged from 3.32cm (BARI Soybean-6) to 2.58cm (SBM-23). The highest hundred seed weight was found from the mutants SBM-23 (14.00g) followed by SBM-22 (13.24g). Mutant SBM-22 produced the highest seed yield of 3094 kg ha^{-1} followed by two check varieties Binasoybean-5 (2874 kg ha^{-1}) and BARI Soybean-6 (2891 kg ha^{-1}). Among the locations the highest seed yield of 2878 kg ha^{-1} was obtained from farmer's field Kamalnagar followed by BINA sub-station farm Barishal (2830 kg ha^{-1}) & BINA H.Q. farm Mymensingh (2804 kg ha^{-1}).

From this trial, it was observed that SBM-22 and SBM-26 showed better yield performance than other mutant and check varieties.

Preliminary yield trial with selected soybean mutants

Five promising mutants (SCM-5, SCM-8, SCM-11, SCM-15 and SCM-17) along with check variety Lokon were evaluated through this trial. This experiment was conducted at BINA HQS farm Mymensingh and BINA Sub-station farms at Satkhira during January to April 2023. This experiment was laid out in randomized complete block design with three replications. Sowing was done on 14 January 2023. 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 116 days (SCM-5) to 136 days (SCM-08 & Lokon). Plant height ranged from 32cm (SCM-11) to 105cm (Lokon) and branches plant^{-1} ranged from 1 (SCM-15 & SCM-17) to 4 (SCM-8 & Lokon). The check variety Lokon produced highest number of pods plant^{-1} (64); whereas, the mutant SCM-8 produced 43 pods plant^{-1} and the mutants SCM-5 & SCM-11 produced 26 pods plant^{-1}. The lowest number of pods plant^{-1} was produced by the mutants SCM-15 (17) and SCM-17 (16). Lokon produced the highest number of seeds pod^{-1} (3.90) followed by SCM-17 (3.82). Lokon had the highest pod length (2.67) followed by SCM-5 (2.33) and the rest four mutants have the similar pod length (2.17). Hundred seed weight was higher in SCM-11 (15.96g) and lower hundred seed weight was obtained from Lokon (10.96g). Seed yield obtained from the mutants and checks significantly differd from each other. Mutant SCM-5 produced the highest seed yield of 2517 kg ha^{-1} followed by SCM-11 (2353 kg ha^{-1}) and the check variety Lokon produced 2169 kg ha^{-1}. Among the locations the highest seed yield was obtained from BINA HQS farm Mymensingh (2093 kg ha^{-1}) followed by the BINA sub-station farm at Satkhira (1968 kg ha^{-1}).

From this experiment, it was concluded that SCM-5 and SCM-11 was performed better among the mutants and the check (Table 92). Further trials will be needed to confirm the result.

Screening soybean mutants for salinity tolerance at reproductive stage in hydroponic culture

nThree 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 under saline conditionat reproductive stage in hydroponic culture. The experiment was conducted at BINA HQS, Mymensingh during July to October 2022, and laid out in a completely randomized design (CRD) with three replications. After completion of seedling and vegetative stages in normal condition, artificial salinity was created with NaCl and maintained 8dS m^{-1}, 10 dSm^{-1}and 12 dSm^{-1} in each tray in hydroponic culture solution. Data on visual injury and pod setting rate was recorded from five randomly selected plants of each dose.

Comparing with imposed salinity level and time, pods plant^{-1} and seeds pod^{-1} was decreased day by day. All the genotypes were completed the flowering stage at 8 dSm^{-1}up to 45-55 days (Table 93) and also show moderately tolerant. After 55 days the mutants showed moderately tolerant at 8 dSm^{-1}but after65 days' mutants were unable to set pod formation. Furthermore, Binasoybean-2 and Binasoybean-6 showed moderately tolerant and Lokon performed highly tolerant up to maturity stage.

From the visual salt injury score it was concluded that the mutants SBM-22, SBM-25 and SBM-26 was susceptible for salinity at reproductive stage. Whereas, Binasoybean-2 and Binasoybean-6 showed moderately tolerant and Lokon performed highly tolerant for all stages. Moderately tolerant and tolerant varieties could be used as parent material of salinity stress breeding program.

Screening of salt tolerant soybean genotypes in pot culture

Ten genotypes (nine promising soybean mutants SBM-22, SBM-23, SBM-25, SBM-26, SCM-5, SCM-8, SCM-11, SCM-15 and SCM-17 along with one soybean variety Lokon) were evaluated to investigate the performance in saline condition at reproductive stage.The experiment was conducted at BINA HQS, Mymensingh during Jan to April 2023, and laid out in a completely randomized design (CRD) with three replications. Before seed sowing, artificial salinity was created with NaCl and maintained 4 dSm^{-1}, 6 dS m^{-1} and 8 dS m^{-1} 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 dose.

Comparing with imposed salinity level and time, plant height as well as leaf was decreased. All the germinated genotypes survived at 4 dSm^{-1} up to 21 days (Table 94). All the mutants showed moderately tolerant at 6 dSm^{-1} up to 7 days after sowing. Check variety Lokon performed well with the advancement of time.

Total chlorophyll content was sharply decreased at saline condition. 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 all the mutants were susceptible for salinity except SCM-8, SCM-17 and Lokon performed well and could be selected for further evaluation.

Screening of drought tolerant soybean genotypes under hydroponic culture

Nine promising soybean mutants SBM-22, SBM-23, SBM-25, SBM-26, SCM-5, SCM-8, SCM-11, SCM-15 and SCM-17 along with one soybean variety Binasoybean-2 were evaluated to investigate the performance in drought condition. The experiment was conducted at BINA HQS, Mymensingh during July to October 2022, and laid out in a completely randomized design (CRD) with three replications. Seeds are sowing in normal condition; artificial drought stress was created with 10%, 15% and 20% of PEG in each tray in hydroponic culture solution. Data on visual injury and pod setting rate was recorded from five randomly selected plants of each dose.

Comparing with imposed drought level and time, pods $plant^{-1}$ and seeds pod^{-1} was decreased day by day. All the genotypes were not completing the flowering stage and some showed moderately tolerant. After completion of all treated drought imposed stages five mutants were unable to set pod formation. Furthermore, SBM-23, SBM-26, SCM-11, SCM-17 and Binasoybean-2 showed moderately tolerant up to maturity stage.

From the visual drought injury score it was concluded that five mutants viz., SBM-22, SBM-25, SCM-5, SCM-8 and SCM-15 were susceptible; whereas, SBM-23, SBM-26, SCM-11, SCM-17 and Binasoybean-2 showed moderately tolerant against drought. Moderately tolerant mutants could be used for further evaluation.

Screening of M_4 and M_5 population

A large number of M_5 populations from BU-2, AVRDC-250, AVRDC-266 and AVRDC-262 were grown in plant progeny-rows for selecting desirable mutants at BINA HQS farm, Mymensingh. Sowing was done on 11 December 2022. 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_3 population of soybean

A large number of M_4 populations from AVRDC-366, CMLL-0.3, AVRDC-366, BU soybean-2, YESOY-4, PK-416, LG-92p-1139 and PM-78 were grown in plant progeny-rows for selecting desirable mutants at BINA HQS farm, Mymensingh. Sowing was done on 12 December 2022. 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 twenty five mutants were selected based on their agronomic performances for subsequent generations.

Growing of M_2 population of soybean

Nine bulk population (150, 250 and 300Gy of gamma rays using) of Lokon, YESOY-4 and HIS-WIHS were grown in plant progeny-rows for selecting desirable mutants at BINA HQS farm, Mymensingh. Sowing was done on 12 December 2022. 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 20 mutant variants were selected based on their agronomic performances for subsequent generations.

Growing of M_1 population of soybean

To create genetic variability, seeds of soybean variety AVRDC-262 and BU-2 was irradiated with 150, 200, 250, 300 and 350Gy of gamma rays with 19% moisture content in seeds. Seeds were sown on 12 December 2022 at BINA HQS 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)

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

Sunflower

Project-5: Varietal improvement of sunflower through induced mutations

Evaluation of sunflower line for synthetic and composite variety development

Ten sunflower genotypes were grown in plant progeny-rows at BINA HQS farm, Mymensingh on 12 December 2022. 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 95. On an average, maturity period ranged from 98-125 days. BD9328 and BD9358 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). BD9359 were comparatively dwarf having 122cm plant height. Head Diameter (cm) is one of the major yield contributing characters of sunflower, it was ranged from 11.5-18.0cm. Among the genotypes, BD9382 produced the highest number of seeds $head^{-1}$ (441) followed by BD9349 and BD9401 (408). Considering yield contributing traits further trials will be needed to confirm the results of selected promising lines.

Preliminary yield trial with promising sunflower mutants

Seven sunflower mutants (SFM-01, SFM -02, SFM -03, SFM -04, SFM -05, SFM -06 & SFM -07) and one check (BARI Surjomukhi-2) were grown in plant progeny-rows at BINA HQS farm, Mymensingh and BINA sub-station farm at Jamalpur & Nalitabari on 13 December 2022. 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 96. On an average, maturity period ranged from 100-112 days. SFM-02 and SFM-07 required the shortest maturity period of 100-104 days and SFM-03 required the longest maturity period of 112 days. Plant height ranged from 143.9-184.6cm. BARI Surjomukhi-2 produced the tallest plant (184.6cm) followed by SFM-06 (184.3cm). SFM-02 was comparatively dwarf having 143.9cm plant height. Head Diameter (cm) is one of the major yield contributing characters of sunflower, it ranged from 17.3-21.1cm. Among the genotypes, SFM-02 produced the highest number of seeds $head^{-1}$ (380) followed by SFM-04 and SFM-07 (360). Promising mutants along with check variety BARI surjomukhi-2 had been evaluated for last five years through this trial. Further trials will be needed to confirm the results of selected promising mutants.

Development of dwarf inbred line of sunflower having *GA2oX1* gene

Five mutants (SDM-01, SDM-02, SDM-03, SDM-04 and SDM-05) and a check (BARI Surjomukhi-3) were used in this experiment for earliness and dwarf with higher seed yield. Seeds were grown in plant progeny-rows at BINA HQS farm, Mymensingh and BINA sub-station farm at Ishwardi & Khagrasori on 12 December 2022. 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 97. On an average, maturity period ranged from 106-111 days. SDM-03 required the shortest maturity period of 106 days and SDM-05 required the longest maturity period of 111 days. Plant height ranged from 75.14-85.87cm. BARI Surjomukhi-3 produced the tallest plant (85.87cm) followed by SDM-01 (85.60cm). Head Diameter (cm) ranged from 18.03-22.66cm. Among the genotypes, SDM-02 produced the highest number of seeds head^{-1} (580) followed by SDM-03 and SFM-07 (550). Further trials will be needed to confirm the results of selected promising mutants.

Growing of M_4 to M_2 generation of sunflower mutants

A large number of M_4, M_3 and M_2 variants developed from different irradiated materials with three checks BARI Surjomukhi-2, BARI Surjomukhi-3 and BD9850 were grown for selecting desirable mutant at BINA Head quarter's farm, Mymensingh following augmented block design. The seeds were sown on 12-14 December 2022. All the mutants were grown 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 fertilizer was applied and necessary steps were taken to grow the crop uniformly.

Total 82 segregating population was evaluated for yield and yield contributing characters. Among them 62 was segregating families and other 20 was single plant. All of the segregating populations were obtained from different mutant population that had been selected from previous trials. A total of two families from M_4, three families from M_3 and five families from M_2 were selected and mass for future generation advancement. The selection was facilitated considered the maturity period (90-115 days) with other yield contributing characters. From various early generation single plant also selected considering maturity period, seed color, no. of seeds head^{-1}, head diameter and other agronomic traits. Forty single plants were selected and harvested separately for future utilization of varietal improvement program. A total of 30 true breeding mutants were selected primarily for evaluation in respective advance generation based on their agronomic performances.

Growing of M_1 population of sunflower

To create genetic variability, seeds of BARI Surjomukhi-3 were treated with 0.5, 1.0, 1.5 & 2.0% EMS in seeds. Seeds were sown on 12 December 2022 at BINA HQS farm, Mymensingh. This experiment was followed non-replicated design and sown separately (dose wise). At maturity stage the survived plants produced seeds were harvested separately for growing M_2 population.

Jute

Regional yield trail with two M_8 mutants derived from JRO-524

The yield trail experiment was conducted at seven locations viz. field at BINA farm, Mymensingh, Magura substation & farmers' field, Rangpur substation & farmers' field, farmer's field, Faridpur and Jamalpur (Table 95) with four genotypes i.e. two mutants irradiated from JRO-524, parent (JRO-524) and a check variety, BJRI Tosa Pat-8. Sowing date of different experiments is in Table 98. The experiments were set/ at 5 to 7 cm distances within rows and 30 cm between plants to plant. A unit plot size was 4.0 m × 3.0 m. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc wereapplied in the form of Urea, TSP, MoP, Gypsum and Zinc Sulphate. Intercultural practiceswere followed as and when required. At harvest, data on plant height and base diameter were recordedfrom 5 randomly selected plants and, fiber weight, stick weight were recorded also from selected 5plantsafterpropersundrying which was converted into kg plant^{-1} (Table 96).

Results showed significant variation between the mutants and check for most of the characters in individual locations and over locations in combined analysis. Although no difference was found in combine analysis for plant height but some locations (Magura and Rangpur) significant differences were observed over check and mother variety. Green weight with leaves did not showed statistical significant difference among the mutants and check variety. Broader base diameter (1.55 cm and 1.56cm) were observed in both JRO-1000-9 and JRO-1000-10 mutants respectively over parent (1.48 cm) and check variety(1.47cm)by examining the combine analysis of over five locations. BJM-10-1-3 and BJM-10-1-5 had significantly higher fiber weight (0.34 kg and 0.34 kg respectively) than the parent JRO-524 (0.33 kg) and BJRI Tosa Pat-8 (0.32 kg). Stick yield of BJM-10-1-3 (0.66 kg) andBJM-10-1-5 (0.68 kg) were significantly higher than the parent JRO-524 (0.64 kg). Finally, the mutants BJM-10-1-3 and BJM-10-1-5 which were produced higher base diameter, with leaves, fiber weight, and stick weight comparing to parent JRO-524 and next trial will be conducted in the upcoming growing season (Table 100).

Induced mutation of jute through chemical mutagen

Healthy seeds of jute (var. O- 9897, O-795, O-72,), kenaf (var. HC-95), Mestapat-1 and BJRI deshi patshak-1 were separated from the collected seeds. Two hundred seeds for each treatment were washed with 0.1% (v/v) Tween-20 in distilled water for three times. Then, the seeds were incubated and treated with 0.5, 0.75, 1.0 and 1.5 % of EMS for 2, 3, 4 and 6 hour in an electric shaker at 80 rpm with continuous agitation. Control seeds were incubated in distilled water maintaining the same incubation condition. Treated seeds were washed 8 times with distilled water and dried at room temperature. Finally, the treated seeds were grown in both Petri dish and field conditions atBINA HQS farm, Mymensingh.

The highest germination (100%) of seeds was found in kenaf (HC-95) and jute (O- 9897) at control. The lowest germination (30%) of seeds was found in Mestapat-1 at 1.5% EMS. Germination percentages decreased gradually with the increase of EMS doses (Table 100). It is very common in mutation breeding that with increased doses of radiation, gradual decrease in germination occurs in rice and other crops (Ashraf et al., 2003; Mohamad et al., 2006; Manneh et al., 2007)

Results computed in the Table 101 indicated decreasing trends of root growth of the seedlings. Maximum root length (14 cm) of seedlings in 36 DAS was measured in Mestapat-1 followed by kenaf (HC-95) (10.75cm) at control and the lowest (6.2 cm) was measured in Jute (O-9897) of 36 DAS at 0.75% EMS. In case of kenaf (HC-95) the highest root length was 11.6 cm at 0.5% EMS and the lowest were 10.2 cm at 1% EMS and 36 DAS. Among the three jute varieties the highest root length was found in O-9897 (8.5 cm) at 0.5% and 0.75% EMS in 36 DAS. In case of BJRI deshi patshak the highest and lowest root length (9.75 and 6.6 respectively) was found in 36 DAS at **0.**5% EMS**.**

Results computed in the Table 102 indicated decreasing trends of shoot growth of the seedlings. Maximum shoot length (44.3 cm) of seedlings in 36 DAS was measured in kenaf (HC-95) followed by BJRI deshi patshak (34.3cm) at control and the lowest (24.5 cm) was measured in Jute(O-72) of 36 DAS at 0.75% EMS. In case of kenaf (HC-95) highest shoot length was 45.4 cm at 0.5% EMS and the lowest was 11.5 cm at 1% EMS and 36 DAS. Among the three jute variety the highest shoot length found in (O-9897) which was 26.5 cm at 0.5% EMS in 36 DAS. In case of BJRI deshi patshak the highest and lowest shoot length (34.3and 24.6 respectively) was found in 36 DAS at 0% EMS and 1.5% EMS.

Programme Area-III: Varietal Improvement of Pulse Crops

Project: Varietal improvement of Mungbean using mutation breeding techniques

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

The mungbean (*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. Mungbean 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 fit well in cropping pattern. The objectives of this research were 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 variety BARI Mung-6 were used during Kharif-1 season of 2022 at different locations (BINA sub-stations Ishwardi, Magura & farmer's field Natore and Magura). 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 (t/ha) 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 variety at different locations. It was observed from the Table 103 that, MBM-656-51-2 had shorter plant height than the check varieties at all the locations. From mean over locations, the tested mutant MBM-656-51-2 took only 63 days for maturity while the check variety (BARIMung-6) took 66 days for maturity. The highest number of pods plant^{-1} (17.19) was found in MBM-656-51-2. In respect of seed yield, this mutant produced the highest seed yield of 1.75 t/ha followed by BARI Mung-6 (1.48 t/ha). It will be applied to NSB 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 will be helpful to be applied to NSB as a short duration mungbean variety.

Zonal yield trial of summer mungbean mutants

Despite the importance of synchronous maturity, mungbean pod ripening is not synchronous (Yeates et al, 2000). Uneven pod maturity leads to low yield and low harvesting index (HI) inmungbean (Bushby & Lawn, 1992; Egli & Bruening, 2006). 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 (Bisht et al, 1998 & 2005). 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 and one check variety (Binamoog-8) were sown at BINA sub-station, Barishal; BINA sub-station farm, Magura; BINA sub-station, Ishwardi and BINA sub-station farm, Chapainawabganj. The experiment was conducted in RCBD design with three replications. The size of the unit plots were 4.0 m × 5.0 m. Recommended doses of nitrogen, phosphorus, potassium, sulphur and zinc were applied form Urea, TSP, MoP, Gypsum and Zinc Sulphate. 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., 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 104.

From the Table 104, the mutant MB-03 and MB-07 had shorter duration (63 days and 67 days respectively) than the variety Binamoog-8 (70 days). The mutant MB-03 showed the lowest plant height (44.88 cm) than the variety Binamoog-8 (45.99 cm) and the mutant MB-07 (48.95 cm). Highest pod plant^{-1} was observed in the check variety Binamoog-8 (17.76) compared to the mutants MB-03 (15.34) and MB-07 (17.75). Pod length was higher in the variety Binamoog-8 (7.83 cm) contrasting to the mutants MB-07 (7.81 cm) and MB-03 (7.75 cm). Maximum Seeds pod^{-1} was found in the mutant MB-07 (11.85) comparing to the check variety Binamoog-8 and mutant MB-03 (11.70, and 11.15 respectively). Higher 100 seed weight (5.20 g) was found in the mutant MB-07 comparing to the Binamoog-8 and MB-03 (3.80 and 4.54 respectively). Higher yield was obtained from the mutant MB-07 (1.56 t/ha) comparing to the check variety Binamoog-8 (1.51 t/ha).

Considering the earliness, synchronous pod maturity and yield performance of the mutant MB-07 and MB-03 will be evaluated in the next PVT trial at the Kharif-I season in mungbean growing region. This research was supported by the project ‘Development of climate resilient crop varieties and profitable crop management technology through nuclear techniques and enhance crop production through increasing cropping intensity and their adaptation in Haor, Charland, Saline and Hilly areas project under the Ministry of Agriculture. The authors are grateful to the Bangladesh Climate Change Trust (BCCT) under the Ministry of Environment, Forest and Climate Change and Bangladesh Institute of Nuclear agriculture (BINA), Bangladesh for providing laboratory and field facility throughout the experimental period.

Growing of 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. Fifteen M_4 populations were grown in plant progeny rows for selecting desirable mutant at BINA sub-station Ishwardi during Kharif-I season 2022. A total of 10 mutant lines have been selected primarily for next generation.

Growing of M_1 generation of mungbean for synchronous pod maturity

To create genetic variability, seeds of four popular mungbean varieties (Binamoog-5, Binamoog-8, and Binamoog-9 & Binamoog-10) were irradiated with with $Cobalt_{60}$ gamma rays at 300, 350, 400 & 450Gy doses. Seeds were sown at BINA HQS farm, Mymensingh during Kharif-I season 2022. The experiment was followed by non-replicated design and sown separately (variety and dose wise). Dose wise seeds were collected as bulk. Further experiment will be conducted in next season.

On-station yield trial with four promising lentil mutants along with a check variety BARI Mashur-8

On-stations yield trials were conducted with four mutant lines (LM-99-8, LM-118-9, LM-206-5 and LM-20-4) along with a check variety BARI Mashur-8 at BINA sub-stations Magura, Ishwardi and BINA HQS farm, Mymensingh during 2022-23. The experiment was laid out in a randomized complete block design with three replications. Unit plot size was 12 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. Data are presented in the Table 105.

Results revealed that significant variations were observed among the mutants and the check variety for days to maturity, pods per plant, 100-seed weight and seed yield at the three locations. On an average, maturity period varied from 105 to 110 days. LM-99-8 produced the highest number of pods $plant^{-1}$ and LM-20-4 produced the highest seed yield 1715kg ha^{-1} followed by LM-99-8 with 1618 kg ha^{-1} at Ishwardi. In case of 100-seed weight, higher weight was found in LM-20-4 followed by LM-88-9 at Ishwardi. Mutant LM-20-4 and LM-99-8 had the highest 100-seed weight and produced the highest seed yield at Ishwardi and Mymensingh. When combined over the three locations, the mutant LM-20-4 produced the highest seed yield followed by the mutant LM-99-8. Further trials will be conducted in the next season.

On-farm yield trial with some selected lentil mutants

On-farm yield trials of lentil were conducted with four mutant lines (LM-99-8, LM-118-9, LM-206-5 and LM-20-4) along with a check variety BARI Mashur-8in the farmers’ field at Magura, Ishwardi and Chapainawabganj during 2022-23. 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 106.

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 104 to 110 days. LM-20-4 produced the highest seed yied of 1732 kg ha^{-1} followed by the mutant LM-99-8 with 1675 kg ha^{-1} at Magura.The mutant LM-20-4 produced the highest seed yield 1731 kg ha^{-1} followed by the mutant LM-99-8 andLM-206-5 1627 kg ha^{-1} at Ishwardi. The similar pattern was found at Chapainawabganj. 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.

Advanced yield trial with some selected mutants of lentil

The advanced yield trials of lentil were conducted with four mutants (LM-250, LM-137, LM-150 and LM-300) along with a check variety, BARI Mashur-8 at Mymensingh during 2022-23. 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 107.

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 92 to 96 days where the mutant LM-250 was the earliest (92 days) 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 1678 kgha^{-1} followed by LM-150 1634 kgha^{-1}. Further trial will be conducted in the next season at different lentil growing areas.

Handling of Segregating Materials

Growing of M_6 and M_5 generation of lentil

A total of eight M_5plants were harvested from four doses, 150 Gy, 200 Gy and 250 Gy. Seeds of these M_5plants were grown in plant-progeny-rows at BINA Headquarters farm Mymensingh along with the mother variety. Another set of nine M_6 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 eight M_5 and nine 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

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 Sub-station Magura during Rabi 2022-2023. Forty-one lentil lines were used in this experiment based on their yield and yield contributing character**.** Among exotic lentil lines maximum and minimum yield have been observed in check variety Binamashur-8 (832.5 kg ha^{-1}) &LIEN-SA-31 (133.2kg ha^{-1}), respectively. Average yield of the lines is 484.75 kg ha^{-1}. Days to maturity ranged from 107-122 days. Eighteen (18) lines performed better in term of yield that can be selected for further breeding program. Better performed exotic lines with yield and days to maturity presented in the

Project: Varietal improvement of grasspea through induced mutation

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

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

Theon-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 Magura and Barishal during 2022-2023. 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 109.

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-108 was the earliest for maturity and it is the tallest plant among the mutants and checks. The mutant GM-102 and GM-102 produced the highest number of pods and highest seed yield at Magura. 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.

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

Theon-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, Magura and Barishal during 2022-2023. 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 110.

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 but the mutant GM-108 produced the highest number of pods and highest seed yield followed by the mutant GM-105 all over the locations. The better performed mutant, GM-108 has been registered as a modern high yielding variety, Binakhesari2 in 2023.

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

Theon-farm yield trials were carried out with six selected mutants along with a check variety BARI khasari-2 at BINA Headquarters farm, Mymensingh during 2022-2023. 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 111.

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-309 and GM-326. The three mutants, GM-304, GM-309and GM-326 will be evaluated in the next growing season.

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 52 M_5plants 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 6 M_6 mutants were selected on the basis of earliness, more number of pods and disease reactions. Further selection will be done in the next generation.

Materials Development:

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

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 Sub-station Magura during Rabi 2022-2023. 27 lines were used in this experiment based on their yield and yield contributing character**.** Among exotic grasspea lines and 1 check Binakheshare-1, maximum and minimum yield have been observed in Binakheshare-1 865.8kg ha^{-1} and exotic line IGYT-E-21-216004 (49.95 kg ha^{-1}), respectively. Average yield was 331.56 kg ha^{-1}. Days to maturity ranged from 124-126 days.Five lines (IGYT-LO-19-218004, IGYT-E-13-216012,IGYT-E-3-216042,IGYT-HB-12-217034&IGYT-HB-7-217003)failed to germinate. Eight (8) lines performed better in term of yield andrest of the exotic lines have yield below average. The eight exotic lines presented in the Table 112 can be used for further varietal improvement programs.

Yield and Adaptive trials

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

The trials were conducted withtwo promising blackgram mutants along with a check variety. BARI Mash-3 at BINA substations Magura, Chapainawbabganj, Gopalganj and BINA Headquarters farm Mymensingh during 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). 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 $plot^{-1}$ was recorded and converted into kg ha^{-1}.Appropriate statistical analyses were performed by statiatics-10 software.

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. Combined seed yield was the highest for BM-105 (1763 kg/ha**)**bec*Aus*e of its bigger seed size and higher number of pods $plant^{-1}$. Application will be made to register this mutant line as a variety soon.

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

The trial was conducted withtwo promising blackgram mutants along with a check variety. BARI Mash-3 at three locations, Mymensingh, Magura and Faridpur during 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). 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.

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 115). 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 bec*Aus*e of its bigger seed size and higher number of pods plant-^{1}. This mutant will be registered as a variety this year.

Advanced yield trial with five promising blackgram mutants

The trials were conducted withfivepromising 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.

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.

Project: Varietal improvement of chickpea for problem areas through induced mutation.

Preliminary yield trial of some selected mutants of Chickpea

BINA Regional Station, Gazipur:

The preliminary yield trial was conducted with six mutants with two check varieties Binasola-6 and BARI Sola-7, at Regional station, Gazipur during 2022-23. Seeds were sown in randomized complete block design with three replications. Unit plot size was 3m x 2m and rows were 30 cm apart. Due to unavailable irrigation facilities and unfavorable soil conditions the experiment was not successful. Further trial will be conducted in the next season at different chickpea growing areas.

BINA sub-station Magura:

The preliminary yield trials were conducted with seven mutants with one check variety Binasola-8 BINA at sub-station, Magura during 2022-23. Seeds were sown in randomized complete block design with three replications. Unit plot size was 3m x 2m and rows were 30 cm apart. Intercultural 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 tha^{-1}. Statistical analysis of different characters of the accessions and the check are presented in the Table 117. In the location of BINA sub-station, Magura CIEN-SSA-(32-26) mutant showed the highest seed yield (2.15 t/ha) and Pods plant^{-1} (97.67) than the check variety (Binasola-8) as well as other mutants. Besides this CIEN-SA-15 mutant showed earliest in maturity than the check variety (Binasola-8) as well as other mutants which takes only 127.33 days. Further trial will be conducted in the next season at different chickpea growing areas.

Growing of M_1 generation of Chickpea

To create genetic variability for earliness, higher seed yield and disease tolerance an experiment was set up at BINA sub-station, Ishwardi during Rabi 2022-23. Seeds of Binasola-6& BARI Sola-11 were irradiated with Co_{60} gamma rays at 200, 250, 300 & 350 Gy the non-irradiated seeds were kept as control of parents. Dose wise seeds were collected as bulk. M_2 population will be grown in next season.

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

To select desirable lines with early maturity, high seed yield and tolerance to diseases, an experiment was set up at BINA sub-station, Magura during Rabi 2022-2023. Twenty nine lines were used in this experiment based on their yield and yield contributing character. Among 29 exotic chickpea lines and 1 check variety Binasola-8, maximum and minimum yield was observed in exotic line CAT-9-30 (30.2gm/plant)&CAT-7-51(3 gm/plant) respectively. Days to maturity ranged from 119-128 days. Three lines (CIEN-SA-32, CIEN MED-32&CAT-9-30) performed better yield than the check Binasola-8. Rest of the exotic lines had yield below average. Better performed exotic lines with yield and days to maturity presented in Table 118 can be used for further varietal improvement programs.

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

Growing of M_4 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 seventeen mutant varieties were grown at BINA Headquarter farm during July 2022. Ten mutant variants were selected based on shorter plant height, higher seed yield and disease tolerance for further evaluation. M_3-P-33(1) showed early maturity (161 days) than other mutants and M_3-P-15(1) showed the highest number of pods (1703) per plant. Further experiment will be conducted in the next season.

Project: Varietal improvement of garden pea using mutation breeding techniques

Growing of M_3 generation of garden pea

Seeds of BARI Motor-3 were irradiated with Co_{60} gamma rays. Irradiation doses were 20, 40, 60 and 80Gy. Dose wise seventeen mutant lines were grown at BINA Headquarters' farm during Rabi season 2022-23. Ten mutant lines were selected based on days to maturity and higher seed yield and disease tolerance for further evaluation. Among all mutants, Motorshuti (40 Gy)-1(1)/P-1showed the highest number of pods (9) per plant and N. Motorshuti (60 Gy)-4/P-1was the earliest (51 days) than others. Further evaluation will be conducted in the next season.

Biotechnology Division

PROGRAM AREAI: GENETIC ENGINEERING AND TISSUE CULTURE

Expression and detection of salinity and drought induced genes through Real Time qPCR

One rice cultivar FR13Awas used in this study. The seedling was sowed in two sets one for salinity and another for submergence stress. Afterwards, for salinity stress the plants were stressed by adding NaCl at a final concentration of 150mM and for submergence stress sample were kept under 20cm below standing water in a plastic container. The sample was collected at different time points. In case of salinity stress, e.g. control (0)h, (1)h, (6)h, (12)h, (18)h, (24)h and (72)h and for submergence stress control (0)d, (1)d, (3)d, (5)d, (6)d and (7) days samples were collected. All samples were stored in -80^0C freezer until RNA isolation.Total RNA was extract from shoots and leaves of rice cultivar FR13A using RNAiso Plus total RNA extraction reagent (TAKARA, Japan) for both sets of stress treatments according to the manufacturer's protocol. Total RNA extracted from treated and non-treated leaves and shoot tissues was converted to complementary DNA (cDNA). A Reverse Transcription System was employed for carrying out first-strand cDNA synthesis using Superscript III 1^{st} strand cDNA synthesis kit (Invitrogen, USA) according to manufacturer's protocol (Model: 7500 Fast, Applied Biosystems, Thermo Fisher Scientific, USA). PCR of *OsMGD, g*ene was carried out using specific primers for amplification of PCR products around 180–300 bp length. Actin gene was used as an internal reference in PCR reactions. The PCR products (10µl) were analysed through 1.5 % agarose gel electrophoresis with the use of ethidium bromide. To assess the effect of salt and submergence on the expression of *OsMGD, g*ene, total RNA was isolated from tissues of stressed FR13A. The expression levels of the gene in tissues were evaluated RT-qPCR. The results indicated that expressions of *OsMGD g*ene was up and down regulated until 72h at salinity stress and 7d at submergence stress in cultivar FR13A (Fig: 1a and 2a) . In salinity stress higher expression were found 36h followed by 18h and 72h. On the other hand, in submergence stress higher expression was found in 5d flowed by 7d and 2d. The *OsMGD* gene-maintained chloroplast integrity in high salt and drought stresses. The results of *OsMGD* gene expression under stress detected RT-qPCR will be help in future the gene amplification, cloning and genetic transformation.

Cloning of one salinity and drought tolerant genes *OsMGD* from FR13A through Gateway technology

Three-week-old FR13A rice seedlings were submerged completely at 50 cm under the water surface (at 25–30˚C) for 1–7 days in a tank, in a glass house. Seedlings of the same age were either irrigated with high salt (irrigated with 250mM NaCl), drought (Drou, not irrigated) for 7 days or exposed to cold (4˚C) for 1 day. The healthy rice leaves grown under different conditions were harvested, frozen in liquid nitrogen and stored at –80˚C. Total RNA extracted from treated and non-treated leaves and shoot tissues was converted to complementary DNA (cDNA). A Reverse Transcription System was employed for carrying out first-strand cDNA synthesis by using Superscript III 1st strand cDNA synthesis kit (Invitrogen, USA) according to manufacturer's protocol. The cDNA containing the *OsMGD*gene was amplified by PCR using Q5 High Fidelity DNA polymerase (NEB, USA) with gene-specific primers (PCR1) and subsequently with Gateway adapter primres (PCR2). The *OsMGD* gene actual size is 1076bp. During the research period relatively small size (~ 600bp) amplification was found. In order to get the actual size of the gene, optimization of PCR protocol and conditions are needed.

Silicon-Mediated modulation of defense signaling pathways in *Arabidopsis thaliana* in response to *Myzus persicae* infestation by qRT-PCT

The peach-potato aphid (*Myzus persicae*) poses a significant threat to global agriculture by transmitting over 100 viruses to more than 30 plant families and displaying resistance to conventional insecticides. This study aimed to investigate the potential of silicon (Si) in enhancing plant defenses against aphids and understand its impact on the salicylic acid (SA), jasmonic acid (JA), and ethylene (ET) signaling pathways in *Arabidopsis thaliana*. *Arabidopsis thaliana*, a model plant, and *Myzus persicae*, a generalist aphid pest, were utilized. Silicon treatment involved applying a 2mM concentration of potassium silicate. Transcript levels of three key genes, *PR1* (Salicylic acid pathway), *BGL1* (Jasmonic acid), and *EIN2* (Ethylene pathway), were quantified using RT-qPCR. The study unveiled distinct changes in gene expression following *Myzus persicae* infestation and silicon treatment. Aphid infestation activated the SA pathway, as evidenced by increased *PR1* expression. Surprisingly, silicon treatment led to lower *PR1* induction due to the overexpression of *BGL1*, indicating silicon's potential to modulate the SA pathway and possibly weaken the plant's response to aphids. Aphid feeding suppressed the JA pathway, as shown by reduced *BGL1* expression. In contrast, silicon treatment in infested plants increased *BGL1* expression, suggesting silicon's capacity to enhance the JA pathway and improve defense against aphids. Aphid infestation had minimal impact on the ET pathway, with unchanged *EIN2* expression. Unexpectedly, silicon treatment in aphid-infested plants reduced *EIN2* expression, indicating a potential dampening effect of silicon on the ET pathway. The relationship between silicon treatment, aphid infestation, and plant defense signaling pathways is explained by this study. Application of silicon seems to alter the SA and JA pathways, possibly enhancing plant defenses against *Myzus persicae*. Further research is warranted to unravel the precise mechanisms behind silicon-mediated defense responses and assess their practicality in crop protection strategies against aphid pests, contributing to sustainable and ecologically sound pest management in agriculture.

Expression and cloning of *CaChiVI$_2$* gene in *Capsicum annuum L.* for resistance against heat stress

The genus *Capsicum* is recalcitrant regarding its *in vitro* regeneration potential, which makes it difficult or efficient to apply recombinant DNA technologies via genetic transformation aimed at genetic improvement. So, before initiating the cloning program, optimization of regeneration protocol is pivotal. A number of studies have been carried out on the regeneration of sweet pepper globally and in Bangladesh. But the effectiveness of plant regeneration in different species of pepper (*Capsicum* spp.) varies depending on the plant genotype, the type of initial explants, and the factors and conditions of *in vitro* cultures. To overcome the major constraints of recalcitrant response of sweet pepper (*C. annuum*), the present investigation was started to carry out. This work intended to present an efficient and reproducible *in vitro* regeneration protocol for two selected lines (CKN-1 and CKN-8) of sweet pepper which could be followed for the main project of cloning and genetic transformation with useful candidate genes. The two lines CKN-1 and CKN-8 were selected from 11 extotic sweet pepper lines through a phenotypic study of Biotechnology Division, BINA. Then the seeds of CKN-1 and CKN-8 were used for germinating plantlets which were further used as explants. The cotyledonary leaves were used as explants. The seeds were primarily washed with distilled water and then sterilization was carried out with 70% (v/v) ethanol for 1 min, followed by mild detergent (Tween-20), 0.1% $HgCl_2$ through gentle shaking for 5 min and rinsed three times with autoclaved distilled water. Then the seeds were cultured on full strength MS media containing plant growth regulators (PGRs) such as BAP, NAA and IAA in combinations for callus formation. For induction and development of root, about 3 - 4 cm long shoots were separated and cultured on freshly prepared full and half strength of MS with different concentrations (0.25 - 1.0 mg/l) of IBA. Both media contained 3% sucrose and 0.8% agar with 5.8pH adjusted before autoclaving. All cultures were maintained in 16 hrs photoperiod at 25 ± 2ºC. As the expected response towards shoot initiation from the explants was not found, the experiment will continue to next year.

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. 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. In the present study, we have followed a highly efficient and reproducible *A. tumefaciens* mediated transformation protocol using mature seeds as explants. Mature, healthy and disease free dehusked rice seeds were used as a explant of this study. *Agrobacterium tumefaciens* strain GV3101 harboring *OsCAL* gene which was used for rice transformation. The expression of the gene of interest was under the control of the double constitutive CaMV35S 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^{0}C 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. The 4 days sub cultured 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, 150μM 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, driedonsterile Whatman No. 3 filter paper and transferred onto first selection medium-MSM (MCI containing 250 mg/lcefotaxime) 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 were observed which were finally transferred to fresh MSM media for third selection and allowed to proliferate for 5days at 27 ± 1°C in dark. After third selection, black or brown microcalli were discarded and only granular 'macro calli' were transferred into 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, 30gl^{-1}sucrose, 3.0 gl^{-1}phytagel, pH 5.8 and cefotaxime 250 mgl^{-1}. During the research period a number of embryogenic calli were infected by *OsCAL* gene through A*grobacterium* mediated gene transformation. The research work has been done several times. The transformed calli were shown bacterial over growth in selection and also in regenerated stage. This work is continuing on and optimization will be needed for control the bacterial over growth for infected transformed calli.

Development of high amylose containing rice line through mutagenesis of *Wx* gene using CRISPR/Cas9

The rice *Waxy* (*Wx*) gene plays a major role in seed amylose synthesis and consequently controls grain amylose content. The *Wx* gene expression is highly regulated at the post-transcriptional level. In particular, the GT/TT polymorphism at the 5′splicing site of its 1st intron greatly affects this intron's splicing efficiency. The *Wx* gene is a major gene controlling amylose content in rice endosperm and plays a decisive role in rice cooking and eating quality (ECQ). During the research periods for this program, three advanced rice lines were selected namely, Bina (bio)-BC2-5-2-3-14, Bina (bio)-BC2-5-2-3-42 and Bina (bio)-BC2-5-2-11-27. The selected lines are high yield potentials (>8.0 t/ha), short duration and semi dwarf type but amylose content is low

(<22.0%). Before starting the genome editing research program to find out the callus induction and regeneration ability of the three indica advance rice lines materials is needed. The highest callus induction was observed in Bina (bio)-BC2-5-2-11-27 (90%) followed by Bina (bio)-BC2-5-2-3-14 (82%) and Bina (bio)-BC2-5-2-3-42 (70%). Finally, the embryogenic calli were transferred to sub-culture media for shooting and survived calli were transferred to rooting media. According to callus production ability three advanced lines is better. So preliminarily all three lines will be used in the genome editing program. Before constructing an editing vector, we employed the online software CHOPCHOP (http://chopchop.cbu.uib.no) to identify proper editing target sites using the Nipponbare *Wx* gene (LOC_Os06g04200) as a reference. Two target sites located within the 1st intron but close to the 5′ or 3′ splicing site were selected. To confirm whether these two targeted sequences were suitable for editing the *Wx* gene of all 3 inbred advance lines, we amplified and sequenced fragments, including the targeted sequences and their flanking sequences from genomic DNA of all three advance inbred lines, using primer sets WxP1_F/WxP1_R (for Target1) and WxP2_F/WxP2_F-R (for Target2). The CRISPR*/Cas9* vector pRGEB31 targeting the first intron of the *Wx* was selected for construction. The vector used in this study was based on the vector pCambia1300 backbone. The editing vector pRGEB31 contained a Cas9 expression cassette driven by the Rice snRNA U3 and dual 35S promoter and two sgRNA expression cassettes driven by the rice U3 or U6 snRNA promoters. The editing vector pRGEB31will be transferred into *Agrobacterium tumefaciens* strain GV3101 by heat-shock and consequently delivered into three selected materials cells via *Agrobacterium* mediated transformation.

Callus induction and regeneration efficiency in BRRI dhan29 and determination of lethal dose of EMS

Rice is the primary agricultural product in Bangladesh. The BRRI dhan29, an important rice variety susceptible to disease and pests, challenges rice production. This study aimed to develop a comprehensive protocol for enhancing yield, disease resistance, and genetic variability in BRRI dhan29 by optimizing callus induction and regeneration, as well as determining the LD50% of EMS (ethyl methanesulfonate) for mutagenesis. Mature embryos of BRRI dhan29 were used for callus induction, employing varying concentrations of 2,4-D. Optimal concentrations of 2.0 mg/L 2,4-D and a combination of 10 µg/L NAA and 2.0 mg/L kinetin were identified for efficient callus induction and subsequent plant regeneration, respectively. The acclimatization of in vitro-grown shoots was also conducted. The LD50% of EMS on BRRI dhan29 calli was determined. High concentrations of 2,4-D inhibited callus induction, with the best efficiency (87%) achieved at 2.0 mg/L 2,4-D. NAA and kinetin were crucial for cell division, callus formation, and shoot induction. The combination of 10 µg/L NAA and 2.0 mg/L kinetin led to the highest regeneration rate (74%).In vitro-grown shoots exhibited robust growth during acclimatization, with a high survival rate of approximately 75%. They successfully developed roots and adapted to their new environment. The LD50% of EMS on BRRI dhan29 calli was 0.31%, indicating its potential as a mutagen for creating genetic variations. This study established a successful protocol for callus induction and regeneration in BRRI dhan29 rice, with in vitro-grown shoots adapting well during acclimatization. The LD50 of EMS on BRRI dhan29 calli (0.31%) suggests its suitability for mutagenesis to induce genetic variations. These findings contribute valuable insights to tissue culture-based studies and genetic improvement programs for BRRIDhan-29, offering the potential to enhance rice crops and bolster resistance against diseases.

Growing of T_2 –T_4 generation of rice lines developed through tissue culture and chemical mutagenesis

To create the genetic variability in the rice varieties/land races the callus of BRRIdhan-89, BRRI dhan29, and Fatema were treated with 0.2% EMS (Ethyl Methanesulfonate) for two hours. The treated calli of these rice varieties were subsequently grown in pot and field conditions. After appropriate growth and development, eight plants from T_3 generation were harvested from BRRI dhan89, 17 plants from T_2 generation were selected and harvested from BRRI dhan29 and 25 plants from T_4 generation were harvested from Fatema land races. Selection criteria were duration, height and yield. High-yielding plants with robust productivity were selected for further evaluation. The most promising individuals showing desirable traits will be selected after further evaluation and multiplication in the next generation.

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. 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.In previous tissue culture program 19 irradiated plants were selected out of these 7 was somaclonal, 5 was 12Gy, and 7 was 6Gy irradiated T_2 plant. The selected somaclonal and irradiated plants seeds and leaf sample were collected and preserved. DNA was isolation from the collected leaves sample and PCR was also done. The PCR amplified band sowing some difference with the parent (control). The harvested sample will be sowing in T aman, 2023 for further evaluation.

Effect of gamma radiations on *in vitro* regeneration in *Brassica Napus*

Brassica napus L. belongs to family Brassicaceae (Cruciferae) commonly known as rapeseed. The objective of the study is to initiate *in vitro* culture of *Brassica napus* variety using seeds with and without gamma-radiations and optimize conditions for efficient callus induction and plant regeneration. For radiobiological studies, the dry and uniform sized seeds of variety Binasarisha-4, Binashaisha-9 and BARI sasrisha-14 are exposed to 500, 600, 700, 800, 900, 1000 and 1100Gy of gamma irradiations. The callus and shoot potential are increased with increase in radiation dose up to 800 Gy and afterwards are started decreasing with increase in dose. The percentage of shoot formation are decreased gradually with the increase in radiation dose up to 1000 GY and the shoots are developed small, less vigorous with retarded growth and yellowish in color. Total suppression of shoot formation was observed in cultures derived from seeds treated with 11000 Gy dose.

Transfer of *$OsNHX_2$/ Os HKT_8* genes into rapeseed cultivar through agrobacterium mediated gene transformation

Brassica napus is an important oilseed crop, ranking as the second most important crop for oilseed production worldwide. Two rapeseed varieties were used i.e BARI Sharisha 14 and Binasharisha-9. *Agrobacterium tumefaciens* strain GV3101 harboring *$OsNHX_2$* gene for transformation. The plant expression vector pB2WG7 incorporated the genes of interest *$OsNHX_2$* for selection. The 6 days sub-cultured hypocotyls are collected and *Agrobacterium* infected by immersing them in the *Agrobacterium* culture (GV3101). Hypocotyls are then transferred to the co-cultivation medium. After third selection, hypocotyls are transferred onto regeneration medium. For development of shoots, the regenerated shoots are shifted to 500 ml jar containing shooting medium. The callus and shoot initiation are found higher BARI sarisha 14 (57.99% and 52.46%) followed by Binasarisha-9 (66.78 %and 63.84%). These callus and shoot initiation are gently separated from the mother callus and shoot initiation transferred to fresh MS selection medium for the third selection. During the research period a number of hypocotyls are infected by *OsNH*$_2$ gene through *agrobacterium* mediated gene transformation. The research work has been done several of time. Unfortunately the transformed callus and shoot initiation 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 callus and shoot initiation. This speedy, yet less labor-intensive, protocol overcomes major limitations associated with genetic manipulation in rapeseed. Moreover, this protocol uses hypocotyl 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 plant Arabidopsis like to rapeseed.

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

Regional yield trial with high yielding and short duration rice lines

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. Therefore, the proposed study is set to increase yield or break down the yield ceiling of Binadhan16 (a short duration and medium high yielding rice mutant variety) to introgressing useful genes from accessions of *O. rufipogon*. In Boro, 2022-23 a total eighteen advance rice lines were grown with three standard checks viz Binadhan-16, BRRI dhan96 and Binadhan-17. The design of the experiment was RCBD with three replication sat BINA head quarter, Mymensingh. During the Boro, 2022-23 at

BINA HQs, Mymensingh 11 advance rice lines were selected depending on the duration, plant height and comparable yield with the checks for further evaluation. The tested lines and the check differed significantly for grain yield, plant height and also maturity. The line Bina(bio)-BC2-5-2-3-42 produced the higher yield (9.21 t/ha) followed by line Bina(bio)-BC2-5-2-3-28 (9.05 t/ha) and line Bina(bio)-BC2-5-2-3-14 (8.74 t/ha). Highest plant height was found line Bina(bio)-BC2-5-2-3-6-39 (138cm) followed by line Bina(bio)-BC2-5-2-3-20 (137cm) and the lowest was BRRI dhan96 (98cm) followed by Bina(bio)-BC2-5-2-3-14 (109cm). The yield of the selected lines other agronomic characters need further evaluation. So, selected lines will be transplanted in the next season.

Development of lodging resistance and high yield premium quality rice variety through marker assisted selection

The aromatic rice variety Kataribhog is medium long type, fine grained and highly scented and high priced. But the cultivar is weak stem, highly lodging susceptible, very long growth duration, low grain weight and poor yield. Binadhan-13 is another aromatic rice variety, but this variety has same problem. Farmers mainly grow these varieties for their own consumption and ceremonial purposes. Under these circumstances a program was taken to improve these varieties for yield potential and lodging resistance through hybridization with *Oryza rufipogon* and BR5. In T. aman 2022 about 35 F_4 plants were selected from 68 segregating F_3 populations (Kataribhog x *Oryza rufipogon*)) best on better plant types compare to the parents. The molecular work was done for testing the presence of fragrance gene (*BADH2*) in the selected lines. On the other hand only 19 F_4 plants/lines were selected in T. aman 2022 from the 119 (Binadhan-13x BR5) F_3 populations. The seeds of selected plants were harvested and store for in the next season.

ROGRAMME AREA III: MICROBIAL BIOTECHNOLOGY

Evaluation of PGPR bacterial strains for enhancing growth and yield of rice

This study aimed to assess the impact of various Plant Growth-Promoting Rhizobacteria (PGPR) strains on the growth and yield of BINAdhan-22 rice during the 2022-2023 T. aman season. The objective was to identify potential candidates for sustainable agricultural practices to enhance rice production. The experiment involved seven treatments, including different PGPR bacterial strains, their combinations with 70% of the recommended fertilizer dose, fertilizer alone, and zero-fertilizer. Various parameters, such as plant height, effective tillers per plant, panicle length, filled and unfilled grains per panicle, and crop yield, were measured. The experiment was conducted with seven treatments and three replications. Treatment T_5 (100% recommended fertilizer dose) exhibited the tallest plants, averaging 98 cm, while the shortest plants were observed in T_7 (no fertilizer) at an average of 92.3 cm. T_5 had the highest number of effective tillers per plant, averaging 11.7, whereas T_7 had the lowest, with an average of 7. No significant variations were observed in panicle length across treatments, with consistent results. T_1 (PGPR strain CD1A + 70% of recommended fertilizer dose) showed the highest number of filled grains per panicle, averaging 133.7. T_4 (70% fertilizer) and T_6 (Mix of PGPR and 70% RFD) also had high filled grain counts, averaging 121 per panicle. T_7 (no fertilizer) had the most unfilled grains per panicle, averaging 39, indicating poor grain filling. Conversely, T_6 showed the fewest unfilled grains, averaging 29 per panicle. T_1 produced the highest yield at 5.2 tons/ha, followed closely by T_5 with an average of 5 tons/ha. T_6 also yielded well, averaging 4.8 tons/ha. The lowest yield was recorded in T_7 at an average of 3.5 tons/ha. The results of this study showed the considerable influence of PGPR bacterial strains on the yield and growth of BINAdhan-22 rice. Treatments combining specific bacterial strains, like CD1A, with 70% of the recommended fertilizer dose (T_1) resulted in the highest yields, while treatments without fertilizer (T_7) yielded the least. These findings emphasize the potential of PGPR bacterial strains to enhance rice productivity and underscore the importance of proper fertilizer management for optimal rice growth, contributing to sustainable and improved rice production methods.

Genetic diversity analysis of *Rhizobium* bacteria from faba bean (*Vicia faba*) nodules

The genetic diversity of *Rhizobium* bacteria in faba bean nodules is crucial for optimizing the efficiency of nitrogen fixation, ensuring adaptability to diverse environmental conditions, and maintaining the specificity of symbiotic relationships with faba bean plants. Previous morphological characterization had been conducted, and this reporting year focused on genetic diversity assessment using sequencing of two housekeeping genes (*recA* and *atpD*) and one nodulation gene (*nodC*). The research involved the isolation of rhizobial strains from faba bean nodules and subsequent morphological characterization. In this reporting year, genetic diversity was further explored by sequencing three specific genes: *recA*, *atpD*, and *nodC*. Phylogenetic analyses were performed to identify the strains at the species level. Phylogenetic analysis of the *recA* and *atpD* genes revealed that most of the isolated strains belonged to the species *Rhizobium binae*. This marked the first report of *Rhizobium binae* being associated with faba bean nodules. Analysis of the *nodC* gene indicated that the nodules were similar to those formed by the symbiovar viciae. The study underscores the presence of diverse rhizobial strains associated with faba bean nodules. It highlights the limitations of using the *16S* rRNA gene for species-level identification, as partial sequencing of this gene cannot reliably differentiate between different species. However, it remains valuable for identifying and classifying organisms at the genus level. Notably, the research identified *Rhizobium binae* (R) as the primary symbiont of faba beans in Bangladesh. To achieve more precise species identification, future studies should consider sequencing additional housekeeping genes. This study provides essential insights into the genetic diversity of faba bean rhizobia, laying the foundation for further research on optimizing faba bean symbiosis and agricultural practice.

Soil Science Division

Project-1: Integrated Plant Nutrition System (IPNS) for soil fertility management and increased crop production

Experiment-1: Integrated nutrient management for increased crop production and fertilizer use efficiency (FUE) in Mustard-Boro-T.Aman rice cropping pattern

An experiment was conducted at the farmer's field, Char Nilokkhia, Sadar, Mymensingh using the cropping pattern Mustard- Boro- T. Aman rice during November 2021 to October 2022 to identify the suitable combination of IPNS using organic amendments & inorganic fertilizer for maximizing crop yield and to investigate the effects of organic amendments with chemical fertilizers on N nutrient uptake, FUE (%) and soil fertility. The soil type was non-calcareous dark grey floodplain soils. The experiment was carried out with five treatments for all the three crops. The experiment was laid out in a randomized complete block design with three replications. The treatment combinations were T_1: Control (without N) (basal $P_{30}K_{75}S_{25}Zn_2B_1$), T_2: N @120 kg ha^{-1} on STB, T_3: N @110 kg ha^{-1}+ Rice Straw @5 t ha^{-1} with IPNS, T_4: N @105 kg ha^{-1} + Cow dung @3 t ha^{-1} with IPNS and T_5: N @100 kg ha^{-1} + Vermicompost (2 t ha^{-1}) with IPNS for mustard, $T_{1:}$ Control (without N), T_2: RFD based on STB, T_3: RFD based on STB +Residual Rice Straw, T_4: RFD based on STB +Residual Cow dung and T_5: RFD based on STB +Residual vermicompost for boro rice and $T_{1:}$ Control (without N), T_2: RFD based on STB, T_3: 85% RFD based on STB + residual RS, T_4: 85% RFD based on STB + residual CD and T_5: 85% RFD based on STB + residual VC for T. Aman rice. In first crop (mustard), the yield attributes and the grain and straw yields responded significantly due to the application of inorganic fertilizers with organic amendments. The highest grain yield, straw yield, N uptake by grain and straw and nitrogen use efficiency were obtained in treatment T_5: N @100 kg N ha^{-1} + vermicompost (2 t ha^{-1}) with IPNS. In second crop (boro rice) the grain yield, straw yield and N uptake also responded significantly due to the application of STB based fertilizer and the residual effects of organic amendments applied in previous crop. The highest grain yield, straw yield, N uptake & use efficiency by grain and straw were observed in treatment T_5: RFD based on STB +Residual Vermicompost. In third crop (T. Aman rice) the highest grain yield, straw yield, N uptake & use efficiency by grain and straw were observed in combined T_2: RFD based on STBand T_5: 85% RFD based on STB + residual VC. The results indicated that the use of N @100 kg N ha^{-1} + vermicompost (2 t ha^{-1}) with IPNS for mustard and T_5: RFD on STB + residual vermicompost for Boro rice and T_2: RFD based on STB and/or T_5: 85% RFD based on STB + residual VC for T. Aman rice were found to be more effective and beneficial for the enhancement of crop production, N nutrient uptake and FUE (%) by the crop.

Experiment-2: Effect of organic and inorganic fertilizers on carbon content in soil and increase of yield under rice–rice cropping pattern

The experiment was conducted for increase fertility with carbon stock pool in soil and sustainable crop production in rice- rice cropping system at BINA HQs farm ,Mymensingh during 2022-23. There were five treatments (Viz. T_1 = Control, T_2 = Chemical fertilizer (T. aman: $N_{90}P_{25}K_{50}S_{16}$ and Boro $N_{120}P_{35}K_{80}S_{20}$), T_3 = Chemical fertilizer + cowdung @ 3 t ha^{-1}, T_4 = Chemical fertilizer + vermi-compost @ 2 t ha^{-1} and T_5 = Chemical fertilizer + Eco-compost @ 3 t ha^{-1} with RCBD design and three replications. In this trials Binadhan-24 were used as rice variety for Boro season and Binadhan-17 were used in T.aman season. Yields and yield contributing characters of T. aman rice were significantly influenced with the different fertilizer combination. The highest yield was produced from the treatment T_5 (4.95 t ha^{-1}) although the treatments T_4 and T_3 produced statistically similar yield. The highest straw yield (6.57 t ha^{-1}) was produced from the treatment T_4 and the treatments T_5 and T_3 produced which were statistically similar. The application of organic and inorganic fertilizer influenced significantly the yield and yield contributing characters of Boro rice (Binadhan-24). The highest yield was produced from the treatment T_5 (6.85 t ha^{-1}) along with similar yield statistically from the treatments T_3 and T_4 respectively. The treatment T_2 (7.03 t ha^{-1}) gave the highest straw yield followed by treatments T_3, T_4 and T_5. The results revealed that substantial amount of N, P, K and S fertilizers could be saved with the integrated use of organic manure in rice-rice cropping system. The application of organic carbon through cowdung (CD), vermi-compost (VC) and eco-compost (EC) influences in increasing carbon content in the soil. From the results it may be concluded that recommended dose of nutrients combination along with the organic manure performed better and found suitable for higher crop production.

Experiment-3: Potential effect of different sources of soil amendments for increased soil pH and crop production

The soil reaction of the northern areas of Bangladesh is going down to 4.5 which is alarming for the agricultural crop production. To increase the soil pH, an experiment was conducted in the low pH soil at BINA substation, Rangpur. There were seven treatments for the study (T_1: Control Recommended chemical fertilizer (RCF), T_2: RCF + lime @ 2 t ha^{-1}, T_3: RCF + poultry manure @ 3 t ha^{-1}, T_4: RCF + biochar @ 2 t ha^{-1}, T_5: RCF + lime @ 1 t ha^{-1} + poultry manure @ 1.5 t ha^{-1}, T_6: RCF + lime @ 1 t ha^{-1} + biochar @ 1 t ha^{-1} and T_7: RCF + biochar @ 1 t ha^{-1} + poultry manure @ 1.5 t ha^{-1}) and was randomize complete block design with three replication. The sesame variety BINA Til 2 was used as a test crop in this study. It is observed that due to the treatments there are some positives changes that effects on the yield and yield contributing characters positively. The results of the of the sesame crop var. BINA til 2 due to different treatment significantly variations in all the yield contributing characters like plant height, branches, seed per plant, 1000 seed weight and seed yield. Observing with the treatments effect, considering the seed yield the highest yield was produced from treatment T_6 (RCF + lime @ 1 t ha^{-1} + biochar @ 1 t ha^{-1}) which is combination with the lime and biochar application never-the-less all the treatments combination has significant different from treatment T_1 which received only chemical fertilizers. It is important to indicate that soil is what gives plants their vital support. It is thus recommended to extract samples when the soil has not been disturbed with work such as tilling. Samples can also be taken from the leaves of harvested plants. The favorable soil pH range for plant is 5-8 of which around seven is very suitable for major plant in agriculture but the initial pH value was 4.8 in the experiment site and has increased due to the different treatments to 5.8 which are very noticeable. The mean organic matter ranged from 1.04-1.21 and there are decrease trend in organic matter after the crop cultivation. The nitrogen percentage of experimental site was low to very low and became lower after one year cropping. The phosphorus content at initial and post-harvest soil is almost similar at the experiment site. The potassium content reduced at the experiment site with a very similar amount after one year of crop cultivation. The result showed that potassium depletion take place in the cropping and the recommendation for potassium need to re-adjust again in that soil. The amount of sulphur in post-harvest soil is similar compared to the initial soil. The increased of S is almost double which is very noticeable.

Experiment-4: Determination of optimum and economic doses of nutrients for advance lentil mutant line at BINA substation Ishwardi

Soil fertility is a dynamic property which varies with crops, cropping intensity and input uses. Therefore, to develop an optimum and economically suitable combination of fertilizers for sustaining soil fertility with higher crop productivity field trial of advanced mutant line of lentil was conducted at BINA substation Ishurdi 2022-23 to determine the amount of fertilizer require for higher crop production. There were four levels of N, P, K and S nutrients used. The yield of lentil mutant line affects significantly due to treatment combinations of different nutrients. Considering the nitrogen nutrients, the highest yield (1.485 t ha^{-1}) was produced from treatment T_3 (N - 20) as well as the response curve indicated the same requirement of nitrogen fertilizer. And the highest straw (2.668 t ha^{-1}) yield was obtained from treatment T_4. The lowest grain and straw yield was obtained from T_1 (control) treatment. Considering the phosphorus nutrients, the highest yield (1.471 t ha^{-1}) was produced from treatment T_8 (P - 35) but the response curve indicated that the phosphorus requirement is 32 kg ha^{-1} which produced highest yield. The highest straw (2.954 t ha^{-1}) yield was obtained from treatment T_8 as well. The lowest grain and straw yield was obtained from T_5 (control) treatment.Considering the potassium nutrients, the highest yield (1.675 t ha^{-1}) was produced from treatment T_{10} (K - 15) and the response curve indicated that the potassium requirement is 17 kg ha^{-1} which produced highest yield. The highest straw (3.261 t ha^{-1}) yield was obtained from treatment T_{10} as well. The lowest grain and straw yield was obtained from T_1 (control) treatment. Considering the sulphur nutrients, the highest yield (1.468 t ha^{-1}) was produced from treatment T_{14} (S - 14) as well as the response curve indicated the same requirement of sulphur fertilizer. The highest straw (3.522 t ha^{-1}) yield was obtained from treatment T_{14}. The lowest grain and straw yield was obtained from T_1 (control) treatment. Results demonstrated that the economic doses for optimum crop production for lentil at Ishwardi area showed remarkable yield variation due to lower doses ($N_{100}P_{18}K_{50}S_{12}Zn_2B_1$) of fertilizer applied compared to higher doses ($N_{25}P_{35}K_{25}S_{16}Zn_2B_1$) of fertilizer application. The optimum and economic doses of nutrients may be recommended as $N_{20}P_{32}K_{17}S_{14}Zn_2B_1$ kg ha^{-1} respectively.

Project 2: Development of Upazila Land Suitability Assessment and Crop Zoning System of Bangladesh (Phase-II- KGF Project)

Experiment 5: Validation of Khamari apps fertilizer recommendation at different locations of Bangladesh (Phase-II- KGF Project)

Three experiments were conducted at Mymensingh, Magura and Chapainawabgonj districts of farmer’s field to validate fertilizer recommendation at farm level with the help of NARS Institute and DAE. The experiment was conducted at Mymensingh to evaluate the Khamari apps fertilizer recommendation compared to the farmer’s practices. There were two treatments as T_1: Khamari apps and T_2: Farmers practices with an area of 20 decimal of which 10 decimal for Khamari apps fertilizer recommendation doses and other 10 decimal for farmer’s practices doses of fertilizer. The tested variety was Binasharisha-9 and was sown in 23-11-2022 and harvested at full maturity on 18/02/2023. The yield of mustard at Mymensingh has been influenced by the fertilizer doses of Khamari apps. All the yield contributing characters and yield were found higher in treatment T_1 than T_2. The application of the Khamari apps fertilizer doses produced higher seed yield (1.86 t ha^{-1}) over the fertilizer used by the farmer’s practices (1.51 t ha^{-1}). The highest gross margin for mustard was Tk. 125940/-, which was obtained from the treatment T_1 (Khamari apps) and the percent yield increase over farmer’s practices fertilizer dose was 23.2%. Result indicated that the Khamari apps based fertilizer dose produced higher yield compared to the fertilizer dose of farmer’s practices.The experiment was conducted at Magura to evaluate the Khamari apps fertilizer recommendation compared to the farmer’s practices. There were two treatments as T_1: Khamari apps and T_2: Farmers practices with an area of 20 decimal of which 10 decimal for Khamari apps fertilizer recommendation doses and other 10 decimal for farmer’s practices doses of fertilizer. The tested variety was Binamasur-9 and was sown on 11-11-2022 and harvested at full maturity on 06/03/2023. The yield of lentil at Magura has been influenced by the fertilizer dose of Khamari apps. All the yield contributing characters and yield were found higher in treatment T_1 than T_2. The application of the Khamari apps fertilizer doses produced higher seed yield (2.10 t ha^{-1}) over the fertilizer used by the farmer's practices (1.87 t ha^{-1}). The straw is also produce higher in Khamari apps than farmer's practices.The highest gross margin for mustard was Tk. 207658/-, which is obtained from treatment T_1 (Khamari Apps) and the percent yield increase from farmer's practices fertilizer dose was 12.2%. The total fertilizer cost is higher in Khamari apps fertilizer dose than farmer's practices but the yield is higher in T_1 treatment. Result indicated that the Khamari apps based fertilizer dose produced higher yield compared to the fertilizer dose of farmer's practices. The experiment was conducted at Chapainawabganjto evaluate the Khamari apps fertilizer recommendation compared to the farmer's practices. There were two treatments as T_1: Khamari apps and T_2: Farmers practices with an area of 20 decimal of which 10 decimal for Khamari apps fertilizer recommendation doses and other 10 decimal for farmer's practices doses of fertilizer. The tested variety was Binamasur-8 and was sown on 13-11-2022 and harvested at full maturity on 09/03/2023.The yield of lentil atChapainawabganjhas been influenced by the fertilizer dose of Khamari apps. All the yield contributing characters and yield were found higher in treatment T_1 than T_2. The application of the Khamari apps fertilizer doses produced higher seed yield (2.10 t ha^{-1}) over the fertilizer used by the farmer's practices (2.00 t ha^{-1}). The highest gross margin for lentil was Tk. 207502/-, which was obtained from treatment T_1 (Khamari Apps) and the percent yield increase from farmer's practices fertilizer dose was 5.0%. The total fertilizer cost is lower in Khamari apps fertilizer dose than farmer's practices but the yield is higher in T_1 treatment. Result indicated that the Khamari apps based fertilizer dose produced higher yield compared to the fertilizer dose of farmer's practices.

Experiment-6: Effect of organic amendments for rice production in saline soil

Most distressing ecological stress is salinity that reduced agrarian production. One of the main adaptation processes for plants to tolerate salinity is the accumulation of organic compounds. The main objective of the present study was to mitigate the adverse effects of soil salinity through organic amendments (wooden ash, rice straw, rice husk ash) during the Boro rice cultivation for increase yield of the farmer' of the coastal saline areas of Bangladesh. The field experiment was conducted at the farmer's fields of Tala upazilla under Satkhira district with BINA dhan10, a saline tolerant rice variety in dry season. There were five treatment combinations viz. T_1= Recommended Chemical fertilizer (RCF), T_2= RCF + wooden ash 2.0 t ha^{-1} + rice straw 2.5 t ha^{-1}, T_3= RCF + rice husk ash 2.0 t ha^{-1} + rice straw 2.5 t ha^{-1}, T_4= RCF + wooden ash 2.0 t ha^{-1} + rice husk ash 2.0 t ha^{-1}, T_5= RCF + wooden ash 1.5 t ha^{-1} + rice husk ash 1.5 t ha^{-1} + rice straw 2.0 t ha^{-1}). Application of organic substances reduced the salinity which thus helps for physiological growth of rice. The organic amendment affect positively in reducing salinity of the experiment site. In different treatments, application reduced the salinity which favors the growth and development of rice plant. The initial soil salinity was 6.75 dS/m in the main plot in which the rice seedlings were transplanted. The cumulative effect of different organic amendments reflected in the yield contributing feathers and grain yield of rice. The highest yield was produced (5.81 t ha^{-1}) from T_2 (ash + rice straw) treatment although other treatments produced similar grain yield except T_3 and T_1. Apart from the study, the soil analysis express a little positive change in soil carbon content but other elements (N, P, K and S) are found almost similar due to one season crop cultivation. The combined effect of organic amendment reduced the stress caused by salinity on rice production in saline prone regions, which is advantageous for Bangladeshi farmers. Soil reaction values (pH) range from 7.1-7.5. The top soil organic matter ranged from 1.58 to 1.71%. The total N content of the soils are generally low and mostly around 0.10-0.13%. The available P and S status of the soils ranged from 12.11-13.5 ppm and 12.96-14.23 ppm respectively. The potassium content ranged from 0.17-0.20 meq%. The changes in soil pH, organic matter, total N, available P and S and exchangeable K content was very low due to the treatments and one season cultivation. Salt stress caused a significant decrease in growth and yield of rice and organic matters of ash, rice husk and rice straw improve salinity condition that reflect the growth and yield of rice by minimizing the inhibitory effects of salinity stress. Application of different sources of ash and rice straw produced higher yield of rice in saline area.

Project-3: Impact of Brick Kilns emission on soil quality of agricultural field

Experiment-7: Effect on soil quality due to brick kilns emission around the agricultural land

The study was conducted at Mymensingh Sadar and Fulbariaupzilla of Mymensingh district, during the period from January to April 2023 in dry season. The study was carried out to estimate the soil degradation at 16 different brick kiln. The climate is typically tropical; mild winter (October to March); hot, humid summer (March to June); humid, warm rainy monsoon (June to October). There are sixteen soil samples were collected from different sixteen brick kilns from 50-100 meter distances. The samples were collected from the depth of 0-15 cm by auger from each point and mixed thoroughly to make composite sample. The pH values of the samples of surface soil (0-15 cm) ranged from 5.02 to 7.07 in the burnt soils and from 5.02 to 7.07 with a mean value is 6.42. The organic carbon (OC), it ranged from 0.56 to 3.02 with an average value is 1.55 which expressed indiscriminate OC value in different sample. The nitrogen is low to very low in status among the brick kiln study areas and the average nitrogen value is 0.17. The phosphorus status is wide range with 4.21 to 16.40. The potassium content is ranged from 0.12 to 0.78 which is very wide range and the mean value is 0.25. The sulphur content is seems to be medium to higher with a range from 11.28 to 110.76.This study reported that heavy metals in excessive amounts in soil, water, and air. The Ni content ranged from 0.306 to 2.423 among the tested brick kiln areas. The Mn content ranged from 5.64 to 189.91 among the tested brick kiln areas. Cadmium and cadmium compounds are known human carcinogens. The study results showed that the Cd concentration in farm soil ranged from 0.015 to 0.111 ppm. The results of this study indicated that all of the farm soil samples contained Cd concentration within the range (3.00 ppm) for the uncontaminated soil range.The results showed that the Pb concentration in farm soil ranged from 1.77 to 7.28 ppm in the study areas. A report showed that the Pb status of the soils was maximum acceptable limit of 100 ppm for crop production. The results showed that the iron (Fe) concentration in farm soil ranged from 12.03 to 55.24 ppm in study areas. The extrem heat produced during brick-making operations may cause soil burning and textural disruption in the surrounding areas.

Project-4: Assessing and Mitigating Agro-Contaminants to Improve Water Quality using Integrated Isotopic Approaches (IAEA/RCA RAS5091)

Experiment-8: Assessment and monitoring for the water quality of Turag, Buriganga and Sitalakhyaa River

Rivers located besides the most important industrial areas and capital city of Bangladesh have become highly polluted due to massive industrialization, urbanization and domestic sewage. Therefore, the current study has been undertaken to assess & monitor the water quality of the sites to find out the possible sources of contamination and also hazardous metals, compounds in the water and sediment. Water samples have been collected from eleven different points of Turag, Buriganga and Sitalakhya River adjacent to Dhaka and Narayanganj's urban & industrial area and analyzed for various water quality parameters e.g. pH, EC, heavy metals, NH_4^+ (ppm), NO_3^- (ppm), OC, %N etc. during pre-monsoon, monsoon and post-monsoon seasons. In the collected samples from different point of Turag, Buriganga and Sitalakhya rivers Zn levels in water samples ranged from 0.87 to 3.45 ppm, the lead (Pb) in the water ranged from 0.0052 to 0.0139 ppm. The highest and lowest values were reported at site S_1 and S_5 during the pre-monsoon and monsoon seasons, respectively. Cd levels in the collected water samples from different sites ranged from 0.0007 to 0.0040 ppm. The lowest and highest concentrations were measured at sites S_6 and S_2. High levels of Cd mainly fall into river from the industrial waste disposal. The Cd concentration found in this study is lower than the Bangladesh EQS value. The higher heavy metals in surface water caused by the combined effect of greater vaporizations and lower rainfall during the pre monsoon season. Again, the opposite result was recorded during the rainy season, which could be related to the rainfall effect, which increased the lixiviation process and continued the dilution of heavy metals throughout the rainy season. The dry season (pre-monsoon and post-monsoon) had significantly higher contamination loads and dissolved metals in the water samples, which were decreased during the wet season (monsoon), as the river was found to be highly turbid in wet season. To conclude, the variation in river water flow during different seasons and the anthropogenic activities were the main reasons for this water pollution of Turag River. This could happen due to the discharge of untreated industrial wastes, oils, and municipal wastes, among other things.Therefore, it is high time to take initiatives to save the river from further pollution.

Project-5: Evaluation of different organic wastes for the production of vermicompost and its effect on crop yields and soil fertility using nuclear techniques

Experiment-9: Integrated effects of potassium rich vermicompost with chemical fertilizer on T. aman rice

Field experiment was conducted to reduce the chemical fertilizers with the integrated use of potassium rich -vermicompost (K-rich VC) with chemical fertilizers (CF) in T. aman rice (BINA dhan-17) at the BINA farm, Mymensingh during 2022-23. Six treatments were used in the experiment which were as follows: T_1: Native soil fertility, T_2: 100% NPKS chemical fertilizer, T_3: 50% K from VC+ 50% K from CF+ 100%NPS (IPNS), T_4: 100% K from VC + 100%NPS from CF (IPNS), T_5: 100% K from VC+100%NPS (non-IPNS) and T_6: 100%NPS.The experiment was conducted in a Randomized Complete Block Design with three replications. T. Aman rice (var. Binadhan-17) was transplanted on 4th August 2022 and harvested on the 8th November, 2022. Fertilizer rates were applied on the basis of soil test. In case of manure treatments, IPNS was followed i.e. chemical fertilizer N, P, K and S were balanced according to nutrients supply from organic manures in respective cases. Therefore, N, P, K and S were also reduced from CF treatments in T. aman rice. Nutrient contents of K-rich vermicompost were analysed. K-rich vermicompost and all chemical fertilizers (TSP, MOP and gypsum) were applied during final land preparation except urea. Urea was applied in three equal splits. Yields and yield contributing characters of T. aman rice were significantly influenced with the application of K-rich vermicompost and chemical fertilizers except panicle length. The treatment T_3 (5.5 t ha^{-1}) gave maximum grain yield of T. aman rice followed by the treatment T_2 and T_5 (5.1 t ha^{-1}). The result indicated that reduced rate of chemical fertilizer with incorporation of K rich vermicompost gave statistically similar yields to the sole application of 100% CF. The treatment T_1 (Native soil fertility) gave significantly minimum grain yield (3 t ha^{-1}) of T. aman rice. The results also revealed that 50% reduced rate of K fertilizer and IPNS from K-rich vermicompost or chemical fertilizer might be good option (i.e.50% K from VC+ 50% K from CF+ 100%NPS with IPNS) for the cultivation of T. aman rice. Recorded all the yield contributing characters were maximum in the treatment T_3 except straw yield and unfilled grain panicle^{-1}. Hence, 50% K could be met up with the application of K-rich vermicompost @ 1 t ha^{-1} with IPNS chemical fertilizers (NPS) which was sufficient for attaining the comparable grain yield of T. aman rice to the 100%NPKS.

Therefore 50% K fertilizer could be saved with the application of K-rich vermicompost for the cultivation of T. aman rice.

Experiment-10: Integrated effects of phosphorus and potassium rich vermicompost (PK rich VC) with inorganic fertilizer on Boro rice

Field experiment was conducted to reduce the chemical fertilizers with the integrated use of phosphorus and potassium rich -vermicompost (PK-rich VC) with the chemical fertilizers (CF) in Boro rice (BINA dhan-25) at the BINA farm, Mymensingh during 2022-23. Six treatments were used in the experiment which were as follows: T_1: 100% NS, T_2: 100% NPKS from chemical fertilizer (CF), T_3: 100% P from PK-VC+ 100% NKS from CF (IPNS), T_4: 100% P from PK-VC +100% NKS from CF (non-IPNS), T_5: 50% K from PK-VC +50% K from CF+ 100% NPS from CF (IPNS), T_6: 50%K from PK-VC +50% K from CF+ 100% NPS from CF (Non-IPNS). The experiment was conducted in a Randomized Complete Block Design with three replications. Boro rice (var. Binadhan-25) was transplanted on 12th January 2023 and harvested on the 30th April, 2023. Fertilizer rates were applied on the basis of soil test. In case of manure treatments, IPNS was followed i.e. chemical fertilizer N, P, K and S were balanced according to nutrients supply from organic manures in respective cases. Therefore, N, P, K and S were also reduced from CF treatments in boro rice. Nutrient contents of PK-rich vermicompost were analysed. PK-rich vermicompost and all chemical fertilizers (TSP, MOP and gypsum) were applied during final land preparation except urea. Urea was applied in three equal splits. Yield and yield contributing characters such as grain yield, effective tiller/hill and unfilled grain of boro rice were significantly influenced with the application of PK-rich vermicompost and inorganic fertilizers. The treatment T_3 (6.3 t ha^{-1}) gave maximum grain yield of Boro rice followed by the treatment T_5 (6.2 t ha^{-1}). The result indicated that reduced rate of chemical fertilizers with incorporation of PK rich vermicompost gave higher yields than the sole application of 100% CF. The treatment T_1 gave significantly minimum grain yield (4.3 t ha^{-1}) of Boro rice. The results revealed that 100% reduced rate of P from CF and 33% reduced rate of K (calculated) from CF through IPNS from PK-rich vermicompost (Table 42) or chemical fertilizer might be good option (i.e.100% P from PK-VC+ 100% NKS from CF (IPNS)) for the cultivation of Boro rice. Recorded all the yield contributing characters were maximum in the treatment T_3 with except plant height and unfilled grain. Hence, 100% P and 33% K could be met up with the application of PK-rich vermicompost @ 0.88 tha^{-1} with IPNS chemical fertilizers (NPS) which was sufficient for attaining the comparable grain yield of Boro rice to the 100% NPKS chemical fertilizers. Therefore 100% P and 33% K fertilizer could be saved with the application of PK-rich vermicompost for the cultivation of Boro rice.

Experiment-11: Integrated effect of prepared K rich vermicompost with inorganic fertilizer on cabbage

Field experiments were conducted in two agroecological zones (AEZ) at the BINA sub-station, Rangpur (AEZ-3) and BINA sub-station, Ishurdi (AEZ-11) to investigate the integrated effect of prepared K rich vermicompost with inorganic fertilizer on cabbage yield during 2022-23. The experiments were carried out with seven treatments and three replications in Randomized Complete Block Design (RCBD). The treatments were T_1: Native soil fertility, T_2: 100% NPKS from chemical fertilizer (CF), $T_{3:}$ 40% K from Vermicompost (VC) + 60%K from CF+100%NPS (IPNS), $T_{4:}$ 40% K from VC + 60%K from CF+100% NPS (Non IPNS), T_5: 20% K from VC+80% K from CF +100% NPS (IPNS), T_6: 20% K from VC+80% K from CF+100% NPS (Non IPNS) and T_7: 100% NPS from CF. Local variety of cabbage was used in the experiment at Ishwardi where three weeks old seedlings was transplanted on 18 November 2022. At Rangpur, cabbage (cv: Green-60) was transplanted at 13 November 2022. The distance between plant to plant was 40 cm. The unit plot size was 4 m × 3 m. The whole amount of vermicompost, TSP, MoP, Gypsum, Zinc sulphate and Solubor boron were broadcast at the time of final land preparation and urea was top dressed in three equal splits at 10, 25 and 45 days after transplanting. Fertilizers were applied on the basis of soil test. Nutrient contents in K rich vermicompost were analyzed. Weeding, irrigation and other intercultural operations were done as and when necessary. The cabbage was harvested on 24 February 2023 at Ishwardi and 27 February, 2023 at Rangpur. Yield and yield contributing characteristics of cabbage were significantly influenced with the different treatments at Rangpur and Ishwardi during 2022-23. Maximum edible yield of cabbage (78 t ha^{-1}) was obtained in the treatment T_4 (40% K from VC + 60% K from CF+ 100% NPS (Non IPNS) followed by the treatment T_2 (76 t ha^{-1}) at BINA Sub-Station Rangpur. In case of BINA Sub-Station Ishwardi, the treatment T_4 (40% K from VC + 60% K from CF+ 100% NPS (Non IPNS) produced the highest edible yield (68.7 t ha^{-1}). In both locations the lowest edible yield of cabbage was recorded in the control treatment T_1 where no fertilizer was applied. Yield contributing characters of cabbage were also significantly influenced with the combined use of chemical fertilizer and K- rich vermicompost. The treatments T_4 gave the highest results regarding yield contributing characters of cabbage such as plant height, fresh weight and edible weight in both the locations. The results revealed that 40% K from VC + 60% K from CF+ 100% NPS with Non IPNS system enhanced more crop growth which influenced the fresh as well as edible yield of cabbage in field condition. However, considering of maximum yield, the treatments T_4 (40% K from VC + 60% K from CF+ 100% NPS (Non IPNS) could be recommended for maximum yield for the cultivation of cabbage.

Project-6: Fertilizer management for relay cropping system

Experiment-12:Comparative study on the effects of zero tillage and conventional tillage systems with different doses of fertilizer on yield of mustard

Field experiments were conducted at BINA Sub-Station Ishwardi and BINA Sub-Station Barishal to investigate the effect of zero tillage and conventional tillage systems with different doses of fertilizer on Mustard. The experiments were set side by side with zero tillage and conventional tillage systems with five fertilizer treatments for each system. The fertilizer treatments for both the systems were T_1: Native soil fertility only, T_2 : 100% NPKS, T_3 : 75% NPKS , T_4 : 125% NPKS and T_5 : 150% N + 100% PKS. The experiments were carried out in a RCB design with three replications. Fertilizers applied on the basis of soil test (STB) and requirement of the crop. At sowing time, soil moisture in the zero-tillage system was around 40 -45% at those locations where in the conventional tillage system seeds were sown in the field capacity after preparation of land with power tiller. Seeds of mustard (Binashrisha-9) were sown on 11th November 2022 in the zero-tillage system where in the conventional tillage system seeds were sown on the 26th November 2022 at BINA substation, Ishwardi and Barishal. The unit plot size was 4 m × 3 m at the locations. Fertilizers were applied on the basis of soil test and the rates of fertilizer have been given in the Table 51. The whole amount of TSP, MoP, Gypsum, Boric acid and Zinc sulphate (Mono hydrate) were applied before sowing in the zero-tillage system where those fertilizers were applied at the time of final land preparation in the conventional tillage system. Urea was applied in three splits. First split was applied at 12 days after sowing (DAS) and 2nd and 3rd splits were applied at 25 DAS and 40 DAS. Weeding, irrigation and other intercultural operation were done as and when necessary. The mustard was harvested on 19th February 2023 in case of Zero tillage condition and 28th February, 2023 in case of conventional tillage condition. Yield and yield contributing characters were recorded during harvest. Yield contributing characters of mustard were significantly influenced with the use of chemical fertilizer in two tillage systems at BINA substation, Ishwardi and Barishal. The treatment T_4 (125% NPKS) gave the highest results on yield contributing characters of mustard at zero and conventional tillage system. Maximum grain yield (1.66 t ha^{-1} and 1.47 t ha^{-1} respectively) was recorded in the treatment T_4 in zero tillage system at both locations where the treatment T_4 gave maximum grain yield (1.53tha^{-1} and 1.14 tha^{-1} respectively) in the conventional tillage system at Ishwardi Sub-station and Barishal Sub-station. The treatment T_1 gave the lowest grain yield of mustard where no fertilizer was applied. 125% NPKS gave maximum grain yield of mustard at zero tillage system. Zero tillage system produced higher grain yield than the conventional tillage system because it offers earlier sowing than conventional tillage system. Sowing times were delay due to land preparation in the conventional tillage system which affected the growth of mustard and ultimately lower yield was obtained in the conventional tillage than the zero tillage system. The results indicated that earlier sowing of mustard in zero tillage system is good option for minimizing the sowing time of mustard than conventional tillage system and 125%NPKS fertilizer doses could be used for the zero tillage system in the cultivation of mustard. Therefore, fertilizer doses of $N_{139}P_{26}K_{79}S_{24}$ kg ha^{-1} for Ishurdi and Barishal could be used in the cultivation of mustard under zero tillage system.

Experiment-13: Effects of selected doses of fertilizers on mustard under zero tillage at farmer's field

Field experiments were conducted at the farmer's field of Mojlishpur, Narsingdi during 2022-23 to see the effects of various fertilizer doses on mustard under zero tillage system. Four treatments combination were used in the experiment which were T_1: 100%NPKS, T_2: 75%NPKS, T_3: 125% NPKS and T_4: 150%N +100%PKS. The experiments were conducted in RCBD with three replications. At sowing time soil moisture was around 45 -50%. So, the condition of germination for seed of mustard was well in zero tillage system. Seeds of mustard (Binashrisha-9) were sown in zero tillage system on 23th Nov. 2022. Fertilizers were applied on the basis of soil test. TSP, MoP, gypsum, zinc (2.0 kg^{-1}) and boron (2.0 kg ha^{-1}) were applied before the sowing of mustard seeds. Urea was top dressed in two equal splits. First split was applied 12 days after sowing (DAS) and second split was applied 30 DAS. Weeding, irrigation and other intercultural operation were done as and when necessary. The mustard crop was harvested on the 28th February 2023. Yield and yield contributing characters were recorded after harvesting. Maximum seed yield (1.72 t ha^{-1}) was recorded with the treatment T_4 (150%N +100%PKS) which was significantly differed from other treatments. The result indicated that application of all kinds of fertilizers with increasing rates have tremendous influence on seed yield of mustard in zero tillage system. The lowest seed yield (1.28 t ha^{-1}) was recorded in the treatment T_2 where 75% NPKS fertilizer was applied. Straw yield of mustard was not significantly affected with the different treatments. Yield contributing characters like plant height, no. of pods $plant^{-1}$ and seeds pod^{-1} were not significantly influenced with the different treatments. The results revealed that 150% N+100%PKS fertilizer doses enhanced more crop growth which influenced to obtain maximum seed yield of mustard under zero tillage systems. Therefore, fertilizer doses of N_{167} $P_{21}K_{63}$ S_{19} Zn_2B_2 for Narsingdi area could be adopted in the cultivation of mustard for getting maximum seed yields under zero tillage system.

Experiment-14: Comparative study on the effects of zero tillage and conventional tillage systems with different doses of fertilizer on the growth and yield of wheat

Field experiments were conducted at BINA Sub-Station, Ishwardi, Gopalgonj and Shatkhira to investigate the effect of zero tillage and conventional tillage systems with different doses of fertilizer on wheat. The experiments were set side by side with zero tillage and conventional tillage systems with six fertilizer treatments for each system. The fertilizer treatments for both the systems were T_1: Native soil fertility only, T_2: 100% NPKS, $T_{3:}$ 75% NPKS, $T_{4:}$ 50% NPKS, T_5: 125% NPKS and T_6: 150% NPKS +75%PKS. The experiments were carried out in a RCB design with three replications. Fertilizers applied on the basis of soil test (STB) and requirement of the crop. At sowing time, soil moisture in the zero tillage system was around 40 -45% at three locations where in the conventional tillage system seeds were sown in the field capacity after preparation of land with power tiller. Seeds of wheat (Binagom-1) were sown on 15th Nov. 2022 in the zero tillage system where in the conventional tillage system seeds were sown on the 29th November 2022 at BINA substation, Gopalgonj and Shatkhira. At BINA substation, Ishwardi seeds of wheat (Binagom-1) were sown on 13th November 2022 in the zero-tillage system where in the conventional system seeds were sown on the 1st December 2022.The unit plot size was 4 m × 3 m at three locations. The whole amount of TSP, MoP, Gypsum, Boric acid and Zinc sulphate (Mono hydrate) were applied before sowing in the zero-tillage system where those fertilizers were applied at the time of final land preparation in the conventional tillage system. Urea was applied in three splits. First split was applied at 12 days after sowing (DAS) and 2nd and 3rd splits were applied at 25 DAS and 40 DAS. Weeding, irrigation and other intercultural operations were done as and when necessary. In case of zero tillage, wheat was harvested on 10th March 2023 at Ishwardi and 13th March 2023 at Gopalgonj and Shatkhira. But the date of harvesting was 10 days later in case of conventional tillage in all the three locations. Yield and yield contributing characters were recorded during harvest.

Yields of wheat were significantly influenced with the different treatments at three locations. Yields of wheat were significantly influenced with the use of chemical fertilizer in two tillage systems in every location. The treatment T_5 (125% NPKS) gave the highest results on grain yields of wheat at zero and conventional tillage system in three locations except Shatkhira. At three locations grain yields and straw yields of wheat in conventional tillage were higher than zero tillage. Maximum grain yield (3.7 t ha^{-1}) was recorded in the treatment T_5 in conventional tillage system in Gopalganj Sub-Station. The treatment T_1 gave the lowest grain yield of wheat in three locations where no fertilizer was applied. 125% NPKS gave maximum grain and straw yield of wheat in three locations at conventional tillage system. Zero tillage system produced slightly lower grain yield than the conventional tillage system but it offers earlier sowing than conventional tillage system. Sowing times were delay due to land preparation in the conventional tillage system which delay the harvesting time of wheat and ultimately affect next crops. The results indicated that earlier sowing of wheat in zero tillage system is good option for minimizing the sowing time of wheat than conventional tillage system and 125%NPKS fertilizer doses could be used for the system in the cultivation of wheat. Therefore, fertilizer doses of $N_{139.4}P_{17.5}K_{73.3}S_{12.3}$ kg ha^{-1} for Ishurdi and $N_{145}P_{24.1}K_{74.6}S_{10.1}$ kg ha^{-1}for Gopalgonj and Shatkhira could be used in the cultivation of wheat under zero tillage system.

Project-7: Fertilizer recommendation for elite mutants/variety developed at BINA

Experiment-15: Evalution of different Boro and T. aman rice mutants against different doses of fertilizers

Five mutants for each Boro and T. aman were assessed for the optimum fertilizer dose at BINA headquarters in Mymensingh during 2022–2023. Treatment combinations were T_1 = 80% of recommended chemical fertilizers (RCF), T_2 = 100% RCF, and T_3 = 120% of RCF in a RCBD with three replications. Mutants of Bora and T. aman rice (M1, M2, M3, M4, and M5) produced 5.76, 6.80, 5.25, 6.51, and 5.38 t ha-1, as well as 3.79, 4.00, 5.05, 4.59, and 5.77 t ha^{-1} in T_3 treatment, respectively. It may be concluded that urea-TSP-MoP-gypsum-zinc fertilizers such as 470-144-182-80-7.7 kg ha^{-1} for Boro and 234-60-120-27-5.4 kg ha^{-1} for T. aman are suitable for all the mutants to increase rice production.

Project-8: Carbon sequestration in soils of Bangladesh using stable tracer techniques

Experiment-16: Effect of organic and inorganic fertilizers on yield and yield contributing characters of rice under rice-rice cropping system

A field experiment was conducted to evaluate the performance organic and inorganic fertilizer on yield and yield attributing characters of rice. Two crop residue levels viz., crop residue (6-7 cm height), and no crop residue were verified with different organic and inorganic combinations such as 100% recommended dose of chemical fertilizers (RDF), 75% RDF +3.0 t ha^{-1}poultry manure (PM), 75% RDF +2.0 t ha^{-1} PM + 1.0 t ha^{-1}biochar (BC) and 100% RDF + 2.0 t ha^{-1} BC including control. Factorial experiment was laid out in a randomized complete block design, with five treatments with three replications. The plot size was 3.0m × 4.0m = 12 m^2. Rice (BINAdhan-24) was the test crop. Available N, P, and K nutrient contents were analyzed following standard methods. After harvesting the crop, data on plant height, panicle length, effective tiller, grain yield, straw yield and nitrogen content were collected.The yield of Boro rice was significantly influenced by the different treatment combinations. The grain yield ranged from 3.76 to 5.76 t ha^{-1}. The highest yield (5.76 t ha^{-1}) wasfound in the treatment combination of 75% RDF +2.0 t ha^{-1} PM +

1.0 t ha^{-1}biochar and the lowest yield (3.02 t ha^{-1}) was observed in the control treatment. The straw yield ranged from 4.70 to 6.82 t ha^{-1}. The highest straw yield (6.82 t ha^{-1}) was recorded in the treatment combination of 75% RDF +2.0 t ha^{-1} PM + 1.0 t ha^{-1} biochar and the lowest was obtained from the control treatment. For the grain and straw yield, all the treatments were identical exceptcontrol. The treatment, 100% RDF shows similar result. Crop residue significantly increased grain and straw yield of rice.

Experiment-17: Soil characterization of BINA HQs farm, Mymensingh 2023

Different soil and crop management practices play an important role in distribution of organic matter throughout the soil profile, soil biological properties and soil carbon and nitrogen dynamics. Soil characterization of BINA headquarters farm, Mymensingh was done to evaluate the physico-chemical characteristics of the soil from different blocks of the farm area. Composite soils from different blocks of the farm area were collected after harvesting the T-Aman in 2022.The pH of the farm area is slightly acidic to neutral, The OC% of the soils are low to medium. Total nitrogen contents are low in soil. Available phosphorus content is medium in range. Exchangeable K (meq%) contents are very low to low in range. Available sulphur (ppm) content is low to medium in range.

Soil Micronutrients and Heavy Metals:

Project-9: Soil fertility status of some ntensive crop growing areas under major AEZs and balanced fertilization

Experiment-18: Requirement of Zinc and Boron application for Rice-Rice Cropping Pattern

Intensification of agricultural land use coupled with cultivation of modern varieties has remarkably increased in Bangladesh. This in turn has resulted in deterioration of soil fertility, with emergence of macro- and micro-nutrient deficiency of crops. With this point in view, a study was undertaken to evaluate the effect of Zn and B application on the yield of T. *Aman* and Boro rice and to find out the optimum rates of Zn and B for the T. *Aman* **-** Boro rice cropping pattern in AEZ 9. The experimental soil samples were collected and analysed for some basic properties of soils included pH and organic matter contents, macronutrients included N, P, K, S contents and micronutrients included Zn and B contents. All analysis was done following standard methods. There were four treatments for the T. *Aman* (T_1: Zn_0B_0, T_2: $Zn_2B_{1.5}$, T_3: Zn_4B_2, T_4: Zn_6B_3, and six treatments for Boro rice as $T_{1.1}$ (Zn_0B_0), $T_{2.1}$ (Zn_2B_2), $T_{2.2}$ (Zn_0B_0), $_{3.1}$ (Zn_4B_2), $T_{3.2}$ (Zn_0B_0), $T_{4.1}$ (Zn_0B_0). Subscripts of Zn and B represent kg ha^{-1}. Each treatment replicated three times. Nitrogen, P, K, S were recommended and equal rates for all plots. The Zn-B treatments were imposed on the first and second crop, as shown above. The Zn was added as $ZnSO_4$ and B was as H_3BO_3. The results show that Zn @4 kg $ha^{-1}$and B application @ 2 kg $ha^{-1}$to the first crop or, Zn @ 2 kg ha^{-1} and B application @ 2 kg ha^{-1} to the first and again in the second rice crop can give maximum grain yield in rice - rice cropping pattern.

Soil Microbiology:

Project-10: Development of PGPR biofertlizer and its effects on crop production

Experiment-19: Effect of plant growth promoting Rhizobacteria (PGPR) as biofertilizer for Mustard in pot condition

Global concern over the use of chemicals in agriculture has diverted the attention of researcher towards sustainable agriculture by utilizing the multiple potentials of plant growth promoting rhizobacteria (PGPR) such as *Azospirillum, Azotobacter, Bacillus, Pseudomonas* etc. as biofertilizer. Biofertilizers not only provides nitrogen but also provides plant growth promoting substances such as indole acetic acid, gibberellins, vitamin B etc. Biofertilizers can enhanced the yield by 20 –30% and activate the soil biologically. A pot experiment on mustard (Binasarisha-9) was conducted at the Soil Science Division of BINA, Mymensingh for screening plant growth promoting rhizobacterial (PGPR) strains for efficient biofertilizer production during 11th December, 2022. The experiment was laid out in CRD with three replications. There were eight treatments viz. T_0: control (no fertilizer, no inoculants), T_1: 100% N (RDF), T_2: PGPR (strain1), T_3: PGPR (strain 2), T_4: PGPR (strain1) + 85% N, T_5: PGPR (strain2) + 85% N, T_6: PGPR (strain1+ strain2) + 75% N and T_7: PGPR (strain1+ strain2) + 100% N. 10 liter plastic pots were filled with 11kg soil and fertilizer dose calculated according to soil weight. Phosphorus, potassium, sulphur, zinc and boron were applied as basal application $P_{30}K_{75}S_{25}Zn_2B_1$ $kgha^{-1}$. Full amount of P, K, Zn, B and S was applied prior to sowing. N (N_{120}) as urea was applied in 2 splits at 7and 30 days after germination. The seeds were inoculated with the culture of PGPR strains 30 minutes before sowing in each pot except control pots. The crop was harvested at maturity on 3rd March, 2023. Data on yield and yield components like plant height, root length, siliqua length, branch $plant^{-1}$, siliqua $plant^{-1}$, $seedspod^{-1}$, seed yield and stover yield were recorded from 5 randomly selected plants as per treatments and replication. After collection, the data were analyzed statistically following statistic-10 software. Biofertilizer application increased plant height and root length significantly over uninoculated control. The highest plant height was observed when plants were inoculated with biofertilizer. Data on plant height and root length recorded higher in T_7 followed by T_4 and T_5 treatments. Siliqua length was found higher in the treatments T_7 and followed by T_4 T_5 and T_6 treatments. Branches plant^{-1}, siliqua plant^{-1} and seed siliqua^{-1} were found higher in the treatments T_7 and followed by T_4 and T_2 treatments. The highest seed weight per plant (4.8 gm) and stover yield (6.98 gm) were recorded in the treatment T_7 followed by T_4 (4.2 gm and 5.6 gm) and T_5 (3.38 gm and 5.31gm). However, absolute use of biofertilizer may not enhance the productivity of the food grain. They cannot replace the chemical fertilizers for getting maximum crop yields. The improved level of productivity was achieved by combined application of biofertilizer and chemical fertilizer. The present investigation revealed that, based on the attributes of growth and in terms of yield, the best treatment was mix PGPR strain with fertilizer dose of 100% N (treatment T_7) performed better in mustard (Binasarisha-9) at pot condition along with single PGPR strain with 85% N (treatment T_4). Thus fertilizer dose with 85% N with single PGPR strain could be used as treatment for further experiment.

Experiment-20: Effect of plant growth promoting rhizobacteria (PGPR) as biofertilizer on rice

A field experiment on rice ((Binadhan-16) was conducted at farmer's field, Char Nilakhkhia, sadar, Mymensingh for evaluating the effect of plant growth promoting rhizobacteria (PGPR) as biofertilizer during 3rd August, 2022 under Mustard-Boro rice -T aman rice cropping pattern. The experiment was laid out in Randomized complete block design (RCBD) with three replications. There were seven treatments viz. T_1: control (100% N, RDF), T_2: PGPR (single strain) + 90%N, T_3: PGPR (mix strain) + 90% N, T_4: PGPR (single strain) + 75% N, T_5: PGPR (mix strain) + 75% N, T_6: PGPR (single strain) + 60% N and T_7: PGPR (mix strain) + 60% N. Phosphorus, Potassium, Sulphur, Zinc and Boron were applied as basal application @ $P_{25}K_{80}S_{14}Zn_2B_1$ kgha^{-1}. Entire amount of P, K, Zn, B and S was applied prior to transplanting. N as urea was applied in equal 3 splits at 7, 30 and 55 days after transplantation. Rice seedlings were inoculated with liquid PGPR inoculants before transplanting. The crop was harvested in its maturity on 24 October, 2022. Data on yield components like plant height, root length, effective tiller hill^{-1}, panicle length, grain per panicle, grain yield and straw yield were recorded from 5 randomly selected plants as per treatments and replication before harvest. After collection, the data were analyzed statistically following statistic-10 software. Data on root length was recorded higher in T_4 followed by T_1, T_2 and T_3 treatments. Considering the yield attributes i.e. effective tiller number per hill, panicle length and grain number per panicle the application of recommended inorganic fertilizer was found to perform the best. Plant/hill was recorded in the treatments T_4 followed by T_1 and T_2. Grain/panicle was found higher in the treatments T_2 followed by T_1, T_4 and T_3. Highest grain yield were recorded in the treatment T_1 (5.30 t/ha) followed by T_2 (5.07 t/ha) and T_4 (4.92 t/ha). The highest straw yield were recorded in the treatment T_1 (8.40 t/ha) followed by T_2 (7.97 t/ha) and T_4 (7.77 t/ha). However, absolute use of biofertilizer may not enhance the productivity of the food grain. They cannot replace the chemical fertilizers for getting maximum crop yields. The improved level of productivity was achieved by combined application of biofertilizer and chemical fertilizer. Single PGPR strain with fertilizer dose of 90% N performed better in rice (Binadhan-16) at field condition For better conclusion further study should be conducted.

Experiment-21: Effects of Rhizobial strain on growth, nodulation and Yield of French bean

A field experiment was conducted to select the rhizobial inoculants/strains to produce efficient biofertilizer for the cultivation of french bean at Sutiakhali, Mymensingh during 2022-23. There were seven treatments viz. Inoculants FBR-1, FBR-2, FBR-3, FBR-4 along with two nitrogen dose viz N_{15} kg ha^{-1} and N_{30} kg ha^{-1} and one uninoculated control. The experiment was conducted in a Randomized Complete Block Design with three replications. Plot size was $4m^2$ (2m×2m). Phosphorus, Potassium and Sulphur were applied as basal application @ 20 kg ha^{-1}, 40 kg ha^{-1}, 10 kg ha^{-1}. Irrigation and weeding were done as and when necessary. Nodulation data were recorded at vegetative stage. Data on grain yield was recorded at ripening time. Yield attributing parameters were recorded after harvest of crop. Results showed significant increase in nodulation, plant height and yield with inoculated treatments over uninoculated control treatment. At 40 DAS, different growth parameters of french bean were collected. The highest shoot length (cm) and nodule fresh wt. $plant^{-1}$ were recorded in the treatment T_2 whereas effective nodule $plant^{-1}$ was highest in the treatment T_4. Total pod $plant^{-1}$, total green pod yield (t ha^{-1}) were highest in the treatment $T_{2.}$ Yield was greater over control and the fertilizer treatments N_{30} kg ha^{-1} and N_{15} kg ha^{-1}. Among four *Rhizobium* inoculants/strains (FBR-1, FBR-2, FBR-3, FBR-4), the FBR-1 strain showed over all good performance but among the inocluants FBR-1 gave the maximum green pod yield as vegetables of french bean. There is no nodulation in the control uninoculated treatments which means that there was lack of indigenous french bean *Rhizobium* in soil at Sutiakhali, Mymensingh. The result indicated that the *rhizobium* inoculants FBR-1 could be used for the production of biofertilizer for the cultivation of french bean.

Agricultural Engineering Division

Highlight of the Research Results

- Under field condition, rice line BSB-26 is capable to produce yield 5.89 t ha^{-1} and 4.55 t ha^{-1} under supplemental irrigation and rainfed condition, respectively.
- Seed yield and straw yield of mustard decreased with the increase of sowing-time soil moisture.
- Long-term water-table dynamics showed that the patterns of monthly water-table at Mymensingh were decreased over time, which meant that the withdrawal rate was higher than the recharge.
- Maximum yield (2.68 t ha^{-1}) of sunflower mutant was obtained in irrigating at vegetative, pre-flowering, and heading stages.
- Soil moisture stress during the growing period of lentil significantly affected the seed yield. The cultivar LM-1 was affected minimum due to moisture stress among the mutants.

- Foliar spray and replacement of fertilizer that contain chloride (KCl) had a positive effect on grain yield of Boro rice (Binadhan-10) under saline condition and able to produce 6.4 t ha^{-1} yield.
- For watermelon, in farmer's practice 10 nos. of irrigations was required (27 cm) whereas improved management like providing 'T. Aman rice residue layer below 20 cm root zone area' required less irrigations (8 nos, 18 cm) at Batiaghata, Khulna.
- Under field condition, sacrificing 10% yield, MEF-27 is capable to save about 34% irrigation water under irrigation at 7 days AWD (throughout the growing season).

- Application of 3 irrigations at 30, 75, and 110 days after sowing along with twin-line and 30% excess of recommended fertilizer application produced the maximum grain yield of hybrid maize cultivars.

- The highest production (12.5 t/ha) and BCR (3.5) of garlic were found with three irrigations along with organic matter @ 2 kg/m^2 in zero tillage practice.

- Under sandy loam soil, stage-wise every-furrow irrigation having twin-row line of plants produced the highest yield of potato compared to other management practices.

- The seed yields of mustard cultivars decreased with the increasing duration of water-logging.

- The accuracy of the irrigation sensor was found good (94 – 99% accuracy) under field condition.
- A smart insect controller has been developed. Further study is needed to evaluate the performance of the device.

- A biochar machine has been developed. Further study is needed to evaluate its performance, energy efficiency and economics.

- There was distinct increasing trend of monthly temperature at different decadal time scales (average of the decade) compared to that of base-year. For the monthly rainfall, there is evidence of distinct variation/fluctuating pattern over the months under both SSP4.5 and SSP8.5 emission scenarios.

Drought screening and irrigation management for field crops

Evaluation of some Aman rice lines under different soil moisture stress (Field)

The field experiment was conducted at BINA HQs, Mymensingh to study the response of the cultivars to different levels of soil moisture stress. The scheduled treatments were: T_1 = Control (Farmer's practice,i.e. rain-fed and irrigation), T_2= Supplemental irrigation at 15 days after disappearance of ponded water, T_3= Supplemental irrigation at 25 days after disappearance of ponded water, and T_4 = Only rain-fed after establishment. Treatments were imposed after establishment (3 weeks from transplanting).The cultivars were: V_1 =BSB-24, V_2 = MPQR-62, V_3=MPQR-12, V_4 = BRRI dhan75 (check-1), V_5 = Binadhan-17 (check-2) and V_6 =BRRI dhan49 (check-3). The design was RCBD with split-plot technique. The seedling was 26 days old and transplanted on 27 July 2022. During the cropping period, 792 mm rainfall occurred. The statistical analysis was performed using statistical software of IRRI, "STAR". The irrigation treatments showed significant difference in grain yield, 1000 grain weight and seed panicle^{-1}. With the increase of water deficit (T_1 to T_5), the yield decreased. The cultivars showed significant differences in all parameters. The highest yield (5.21 t ha^{-1}) was obtained from cultivar V_5 (BSB-24). The cultivarsBSB-24, MPQR-62, and MPQR-12 were able to produce 3.92 t ha^{-1} under rain-fed condition at Mymensingh, but supplemental irrigation (3-4 Nos.) increased yield up to 5.19 t ha^{-1}. Among the cultivars, the line BSB-26 was the best as it was able to produce yield (4.55 t ha^{-1}) under rain-fed condition and with supplemental irrigation (5.89 t ha^{-1}).

Optimization of soil moisture for direct seeded mustard under zero tillage

The field study was conducted at BINA HQ, Mymensingh to determine optimum soil moisture condition under zero tillage condition for higher yield of mustard (Binasarisha-9). The imposed treatments were: T_1 = Control (Farmer's practice, full tillage at farmer's moisture level), T_2 = Sowing at full saturation and 10-20% visible water stagnation/ponding, T_3 =Sowing at 80% saturation, T_4 =Sowing at full saturation and T_5 = Sowing at optimum moisture condition (37% VMC). Recommended fertilizer was applied before sowing except urea. First 50% urea was applied at 12 DAS and the rest was applied before flowering stage. Irrigation was applied when PASM (Plant Available Soil Moisture) goes below 50% of field capacity. Soil moisture was monitored by using TDR-300 (digital moisture meter). The soil was silty-loam and field capacity was about 36-38%. In full saturation condition, soil moisture was observed as 50-54%. During sowing of mustard seeds, existing moisture of soil were 36-38%. The germination rate was about 86-89% in all the treatments but final yieldable plants were reduced to about 53% in treatment (T_2) compare to treatment (T_1). In treatment T_2, the early vegetative growth was comparatively low. The maximum seed and straw yield, (1.89 t ha^{-1}) was obtained in the treatment (T_1) and minimum seed yield (1.25 t ha^{-1}) was obtained in the treatment (T_2). From overall observation it was noticed that seed yield and straw yield showed decreasing trend due to increase of sowing time soil moisture. To confirm the result, the experiment will be repeated in the next year.

Studies on groundwater dynamics for sustainable water management

Monitoring groundwater table fluctuation at BINA H_{Qs}

The experiment was conducted to know the temporal and spatial pattern and trend of water-table. The water-table (WT) data were collected with the help of BINA developed water-table indicator at respected BINA sub-stations and BINA H_{Qs}. Water table data recording protocol were: (i) weekly for dry period (March- April) and (ii) 15 days interval for the rest of the year. The patterns and trends of water-table data were examined by graphical method. Monthly water-table (WT) fluctuation pattern at BINA Head-quarters at Mymensingh in the yearly cycle (July-June) of 2011-12, 2012-13, 2016-17, 2010-21 and 2021-22. Normally, the suction limit is considered at 8 m from ground surface. It showed that the maximum depth to WT tend to below the suction limit of Shallow Tube Well (STW) started from month of December-January at Mymensingh (BINA, H_{Qs}) for cycle year 2016-17, 2020-21 and 2021-22. On the other hand, the maximum depth to WT tend to below the suction limit of STW started from month of February to March for cycle year 2011-12 and 2012-13. The patterns of monthly water-table yearly cycle (July – June) at Mymensingh indicated that, the depth of water-table was decreased over time, meaning that the withdrawal rate was higher than recharge.

Drought screening and irrigation management for field crops

Irrigation management for sunflower mutants

The field experiment was conducted at BINA H_{Qs}, Mymensingh to find out the optimum irrigation requirement for sunflower mutants. The imposed treatments were: T_1 = Irrigation at vegetative, pre-flowering, heading, & seed filling stages (4 irrigations); T_2 = Irrigation at vegetative, pre-flowering, and heading stages (3 irri.); T_3 = Irrigation at 50% depletion of available soil moisture (ASM); and T_4 = Pre- or post sowing irrigation, and then irrigation at 70% depletion of available soil moisture (ASM). The design was RCBD (Split-plot) with three replications and sunflower mutant lines were: L_1 = LP 300 and L_2 = DP 250. Soil moisture was monitored by using TDR-300 (digital moisture meter). The irrigation treatments showed significant difference. Maximum yield (2.68 t h^{-1}) was obtained in the treatment T_2 followed by the treatment T_1 (2.57 t h^{-1}) and minimum yield was obtained in the treatment T_4 (2.18 t h^{-1}). The mutants showed insignificant differences except flower diameter. The maximum seed yield (2.44 t h^{-1}) was found in mutant L_1 (LP-300). The maximum yield (2.70 t h^{-1}) was found in combination treatment T_2L_2 and the lowest yield (2.16 t h^{-1}) was obtained in treatment combination T_4L_2. To produce 1 kg of sunflower seeds, 347 litters, 326 litter and 214 litter water is required under the treatments T_2, T_3 and T_4, respectively, while normal irrigation (T_1) required 478 litters. Stage-wise irrigation of sunflower cultivation is important and maximum yield obtained irrigation at vegetative, pre-flowering, and heading stages for mutant line LP 300 (L_1) and DP 250 (L_2).

Evaluation of some Lentil lines under different soil moisture stress in pot condition

The experiment was carried out at BINA H_{Qs}, Mymensingh to find out the effect of different soil moisture stress on lentil. The imposed drainage treatments were: T_1 = Sowing at field capacity and irrigation will be applied when root zone moisture will drop at 50% of PASM; T_2= Sowing at 80% FC and no irrigation over the growing season; T_3=Sowing at 60% FC and no irrigation over the growing season; T_4 =Sowing at field capacity and no irrigation over the growing season. When volumetric moisture content reached at 16%, irrigation was applied so that plant available moisture reached at 80%, 60% and 40% of field capacity for treatment T_2, T_3 and T_4, respectively. Time to time treatment wise soil moisture was monitored by using TDR-300 (Digital Moisture Meter). The test cultivars were:V_1 = LM-1, V_2 = LM-2, V_3 = LM-3, V_4= LM-4 and V_5 =Binamasur-8 (Check) and V_6 =Binamasur-10 (Check).The experimental design was RCBD (split-plot), with 3 replications. 38 cm diameter bucket (38 cm diameter at top) was used as pot with 45 cm effective depth of soil. The statistical analysis was performed using statistical software of IRRI, "STAR". The treatments demonstrated significant effect in all treatments except root length and 1000 grain weight. In control treatment T_1, per plant yield was maximum (0.799 g) and per plant yield was decreased due to increase stress. Same pattern was observed of parameters per plant straw yield, plant height, pod per plant and seed per plant. There was no effect due to moisture stress on branch per plant and root length. The cultivars showed significant difference in per plant seed yield, straw yield, root length and seed per plant and plant height. Maximum yield per plant (0.615 g) was obtained in the cultivar, V_1 (LM-1). The interaction between treatment and variety showed insignificant effect except per plant seed and straw yield. From interaction effects, cultivar V_1 (LM-1)was obtained maximum seed yield per plant under normal and stress condition than that of others cultivars as well as check varieties (Binamasur-8 and Binamasur-10). Soil moisture stress during the growing period of lentil showed a significant effect and cultivar, LM-1 demonstrated minimum effect due to increasing moisture stress on seed yield than others cultivars along with two checks (Binamasur-8 and Binamasur-10).

Solute transport study in Boro rice cultivation and simulation modeling using one-dimensional model HYDRUS-1D in lysimeter condition

The experiment was conducted at raised-bed Lysimeter, BINA H_{Qs}, Mymensingh. to study the movement of solutes under different irrigation practices and suggest optimum fertilizer application under different irrigation practices. Simulation model HYDRUS-1D was used to generate scenario under different situations. The test crop was Boro Rice, Binadhan-24. Initial and harvest-time soil solutes, input amounts and solutes from drainage were used for model inputs. The scheduled irrigation treatments were: Normal irrigation (Continuous ponding) (T_1), Irrigation at 3 days AWD (throughout the growing season) (T_2), and Irrigation at 5 days AWD (throughout the growing season) (T_3). The design was RCBD, with three replications. Initial soil samples were collected from each boxes of lysimeter (45 cm interval) for knowing initial nutrients status of soil. Fertilizer was applied with recommended dose (Urea-240 kg/ha, TSP-115 kg ha^{-1}, MoP-70 kg ha^{-1}, Zymsum-47.5 kg ha^{-1} and ZnSO4– 3.5 kg ha^{-1}). Drainage collection during crop period and during the monsoon was done for measuring solutes (NO^+_3, NH^+_4, PO^-_4, Cl^-, S, Ca^{++}, etc.) of collected drainage water. Last year we installed the software, ran it with arbitrary data, and field experimentation has been completed. All related data were taken. The irrigation treatments showed significant difference except pant height and tiller per plant. All yield attributing characters of Binadhan-24 showed decreasing pattern with the increase of water stress except tiller per plant. Maximum yield (6.94 t ha^{-1}) was obtained in the treatment T_1 [Normal irrigation (Continuous ponding)] followed by T_2 (6.01 t ha^{-1}) and minimum yield was obtained in T_3 (5.11 t ha^{-1}). To produce 1 kg of rice, 910 litters and 841 litters water was required under the treatments T_2 and T_3, respectively, while normal irrigation (T_1) required 1021 litters. Field experimentation has been completed and model calibration along with execution is going on.

Development of appropriate irrigation management strategy for increasing yield in saline area

Effects of irrigation management and amendments in Boro rice in saline area

From the findings of last two year's experiments, the best one among six treatments was intended to simplify, and the treatment was spitted down. The experiment was carried out at farmer's field Batiaghata, Khulna. The 35 days seedlings were transplanted on 14 January 2023 at Batiaghata, Khulna. The test variety was Binadhan-10. Recommended dose of fertilizers for Binadhan-10 was Urea, TSP, MoP, Gypsum, and Zinc @217, 110, 70, 45, and 4.5 kg ha^{-1}. The experimental design was RCBD, with 3 replications. The imposed treatments were (splitted of earlier best treatment):T_1 = Continuous saturation + high density (15 cm × 15 cm) + 50% recommended fertilizer except MoP + K_2SO_4 equivalent to 50% K+ OM (Tricompost @100 kg $acre^{-1}$) + Foliar application of N-P-K-S-Zn (4 times: 25, 35, 45, 60 DAT) [Control], T_2= Continuous saturation + high density (15 cm × 15 cm) + 100% recommended fertilizer + OM (Tricompost @100 kg $acre^{-1}$), T_3 = Continuous saturation + high density (15 cm × 15 cm) + 75% recommended fertilizer + OM (Tricompost @100 kg $acre^{-1}$) + Foliar application of N-P-K-S-Zn (4 times: 25, 35, 45, 60 DAT) and T_4 = Continuous saturation + high density (15 cm × 15 cm) + 50% recommended fertilizer + OM (Tricompost @100 kg $acre^{-1}$) + Foliar application of N-P-K-S-Zn (4 times: 25, 35, 45, 60 DAT). The statistical analysis was performed using statistical software of IRRI, "STAR". BCR analysis was performed considering full production cost. From previous two years (2020-21 and 2021-22) findings, best treatment was T_5 [Continuous ponding (3-5 cm) + 50% recommended fertilizer except MoP + K_2SO_4 equivalent to 50% K+ OM + no ridge, high density (15 cm x 10 cm) + Change of standing water 20 days interval + Foliar application of N-P-K-S-Zn (4 times : 25, 35, 45, 60 DAT)]. The treatments showed significant difference in all the parameter except tiller per plant and grain yield. The highest yield (6.40 t ha^{-1}) was obtained in treatment T_1 followed by T_3. Minimum yield (5.80 t ha^{-1}) was obtained in T_2 where no foliar spray was applied. Effect of foliar spray and omission of fertilizer that contains chlorine had positive effect in case of Boro rice (Binadhan-10) cultivation under saline condition.

Effect of irrigation regimes and other management practices on water-melon

Watermelon is one of the important profitable and short duration crops in saline area of Bangladesh. After harvesting T. Aman rice (Nov-Dec), farmers of that area (Batiaghata, Khulna) are not so interested to cultivate Boro rice due to water scarcity at flowering to booting stage. Besides, salinity problem is another cause not to cultivate Boro rice. So they are motivated to cultivate watermelon during January to May. During mid March to mid April, they faced salinity problem due to shortage of fresh irrigation water with arid condition. To overcome this problem, following experiment was taken. The experiment was conducted to determine optimum irrigation management strategy for higher yield and water productivity of water-melon at Batiaghata, Khulna. The imposed treatments were: T_1 = Existing farmer's practice (Irrigation: Initially 3-4 days interval and after establishment 7-8 days interval); T_2 = Existing with improved arrangement (providing a parabolic 1-2″ clay layer below 20 cm root zone area) with residue covering of previous crop (T. Aman); T_3 = Existing with improved arrangement (providing Aman crop residue layer below 20 cm root zone area) with residue covering of previous crop (T. Aman).The design was RCBD with three replications and used watermelon cultivar was Sweet Dragon (Hybride). Two to three fruits per plant were observed with average weight (3 to 4 kg). In farmer's practice (T_1), it was required 10 nos. of irrigations (27 cm) whereas treatment (T_3) required 9 nos. of irrigations (18 cm).

During sowing time, soil EC was around 2 dS/m and gradually increased but not more than 4 dS/m. There was no significant difference of soil EC for different treatments. In farmer's practice (T_1), it was required 10 nos. of irrigations (27 cm) whereas treatment (T_3) required 9 nos. of irrigations (18 cm). There was no significant difference of soil EC for different treatments and net treatments unable show good result against conventional practice.

Drought screening and irrigation management for field crops

Evaluation of Boro rice lines under different soil moisture stress (in Lysimeter condition)

The experiment was conducted in Lysimeter at BINA, H_{Qs}, Mymensingh to investigate the response of the Boro line to different level of soil moisture stress. The scheduled treatments were: T_1 = Normal irrigation [3 days AWD (Alternate Wetting Drying) means, water was applied after 3 days of disappearance of standing water]; T_2= Irrigation at 7 days AWD (throughout the growing season) and T_3= Irrigation at 85% depletion of available soil moisture (throughout the growing season). Treatments were imposed after establishment of crop (3 weeks from transplanting). Tested line was MEF-27 and check variety was BRRI dhan28. Three series of containers (3 replicates) were used. The experimental design was split plot in RCB. Thirty four days old seedlings were transplanted on 09 January 2023 and harvested on 27 April 2023. The statistical analysis was performed using statistical software of IRRI, "STAR". The cultivar showed significant difference, except grain yield, tiller plant^{-1} and seed panicle^{-1}. The maximum grain yield (5.89 t ha^{-1}) was found with MEF-27 (V_1). Maximum plant height (90 cm) and panicle length (24.44 cm) were observed with BRRI dhan28 (V_2). The irrigation treatments showed significant difference except tiller plant^{-1} and filled grain panicle^{-1}. The maximum yield (6.35 t ha^{-1}) was found in the treatment T_1 (3 Days AWD) and under stress conditions, T_2 and T_3 obtained 5.55 t ha^{-1} and 5.01 t ha^{-1}, respectively. Maximum 1000 grain weight (22.74), panicle length (23.12 cm) and filled grain panicle^{-1} (121 nos.) were observed in the treatment T_1 (3 Days AWD).In case of interaction effects, the maximum yield (6.41 t ha^{-1}) was found in the treatment combination T_1V_1 and the lowest yield (4.87 t ha^{-1}) was obtained in treatment combination T_3V_2 (Table not shown). Under stress condition [Irrigation at 85% depletion of available soil moisture (throughout the growing season)], MEF-27 and BRRI Dhan28 obtained 5.21 t ha^{-1} (maximum) and 4.87 t ha^{-1} (minimum), respectively. 780 litters and 825 litters water are required to produce 1 kg rice under the treatments T_2 and T_3, respectively, while normal irrigation (T_1) required 971 litters. Sacrificing 13% and 21% yield, MEF-27 is capable to save about 30% and 33% irrigation water (under T_2 and T_3, respectively). Sacrificing 13% yield, MEF-27 is capable to save about 30% irrigation water under irrigation at 7 days AWD (throughout the growing season) if treatment is applied after 3 weeks of transplanting.

Evaluation of Boro rice lines under different soil moisture stress in Field condition

The field experiment was conducted at BINA, $H_{Qs,}$ Mymensingh to investigate the response of the Boro line to different level of soil moisture stress. The scheduled treatments were: T_1 = Normal irrigation [3 days AWD (Alternate Wetting Drying) means, water applied in Lysimeter after 3 days of disappearance (standing water of field)]; T_2= Irrigation at 7 days AWD (throughout the growing season) and T_3= Irrigation at 85% depletion of available soil moisture (throughout the growing season). Treatments were imposed after establishment of crop (3 weeks from transplanting). Tested line was MEF-27 and check variety was BRRI dhan28. Three series of containers (3 replicates) were used. The experimental design was split plot in RCB. Thirty three days old seedlings were transplanted on 08 January 2023 and harvested on 26 April 2023. The statistical analysis was performed using statistical software of IRRI, "STAR". The cultivar showed significant difference, except grain yield, tiller plant^{-1} and seed panicle^{-1}. The maximum grain yield (5.78 t ha^{-1}) was found with MEF-27 (V_1). Maximum plant height (92 cm) and panicle length (24.61 cm) were observed with BRRI dhan28 (V_2). The irrigation treatments showed significant difference except tiller plant^{-1} and filled grain panicle^{-1}. The maximum yield (6.19 t ha^{-1}) was found in the treatment T_1 (3 Days AWD) and under stress conditions, T_2 and T_3 obtained 5.57 t ha^{-1} and 5.21 t ha^{-1}, respectively. Maximum 1000 grain weight (22.57), panicle length (23.33 cm) and filled grain panicle^{-1} (118 nos.) were observed in treatment T_1 (3 Days AWD). In case of interaction effects, the maximum yield (6.22 t ha^{-1}) was found in the treatment combination T_1V_1 and the lowest yield (5.12 t ha^{-1}) was obtained in the treatment combination T_3V_3 (Table was not shown). Under stress condition [Irrigation at 85% depletion of available soil moisture (throughout the growing season)], MEF-27 and BRRI Dhan28 obtained 5.28 t ha^{-1} (maximum) and 5.15 t ha^{-1} (minimum), respectively. The cultivars V_1 andV_2 produced reasonable yield under stress condition (T_3) compared to normal irrigation condition. 777 litters and 793 litter water were required to produce 1 kg rice under T_2 and T_3, respectively, while normal irrigation (T_1) required 1056 litters. Sacrificing 10% and 16% yield, MEF-27 is capable to save about 34% and 37% irrigation water (under T_2 and T_3, respectively). Sacrificing 10% yield, MEF-27 is capable to save about 34% irrigation water under irrigation at 7 days AWD (throughout the growing season) if treatment is applied after 3 weeks of transplanting.

Development of appropriate irrigation management strategy for increasing crop yield in char land

Irrigation management for hybrid maize for higher yield and water productivity

The experiment was conducted in three locations, namely Ishwardi, Jamalpur, and Nalitabari, during Rabi season to find out the best irrigation management practice for higher yield and profitability of hybrid maize. The irrigation treatments were: Farmer's irrigation practice (T_1);Irrigation at 30-55-80-120 days after sowing (4 irrigations) (T_2); Irrigation at 30- 75 -110 days after sowing (3 irrigations) plus additional management (with twin-line, N-S orientation, 30% excess fertilizer of recommended dose) (T_3); Irrigation at 70% depletion of available soil moisture (ASM) (T_4); Irrigation at 30- 75 -110 days after sowing (3 irrigations) plus additional management (with twin-line, N-S orientation)(T_5). The Cultivars were BARI hybrid maize17 (V_1), and locally cultivated hybrid maize DURJOY5577 (V_2) and Five Star 8855 (V_3). Randomized complete block design (RCBD) with split-plot was used for the experiment by assigning the irrigation in the main plots and cultivars in the sub-plots. The treatments were replicated three times. ***At Sherpur,*** the highest yield (13.13 t ha^{-1}) was obtained with the application of 3 irrigations (Irrigation at 30- 75 -110 days after sowing plus additional management with twin-line, N-S orientation) and 30% excess fertilizer of recommended dose. The cultivars 'DURJOY 5577'and Five Star 8855(V_2) showed statistically similar result. From interaction effects, the cultivar V_3 under treatment T_3 produced the highest yield. ***At Ishwardi,*** the highest yield (12.73 t ha^{-1}) was obtained in the treatment T_3. Among the varieties, the highest yield was obtained in Five Star 8855(V_2).From interaction effects; the cultivar V_3 under treatment T_3 produced the highest yield. ***At Jamalpur,*** the treatments demonstrated significant effect on grain yield. The highest yield (13.09t ha^{-1}) was obtained in the treatment T_3, irrigation was applied at 30, 75, and 110 days after sowing plus additional management (with twin-line, N-S orientation, 30% excess fertilizer of recommended dose). The cultivars showed significant effect on cob length and yield. The highest grain yield was obtained in Five Star 8855(V_3). Interaction effects of treatments and cultivars on grain yield demonstrated that cultivar V_3 under treatment T_3 produced the highest yield. The BCR of crop yield is presented on the basis of treatments applied in the experiment. From the last two years study, it was found that application of three irrigations at 30, 75, and 110 days after sowing along with twin-line, N-S plant orientation and 30% excess fertilizer produced the maximum grain yield of maize.

Irrigation management for garlic cultivars for higher yield and water productivity under zero tillage condition

The experiment was conducted at the farmer's field of Haybatpur and Chalan Bill (Gurudaspur) of Natore to develop appropriate irrigation management practice for higher yield of garlic. The experiment consisted of four treatments: farmer's irrigation practice (T_1); Four irrigation frequency (1^{st}:Irrigation @ 20-25 days after sowing + 2^{nd} to 4^{th} Irrigation @23-26 days interval) (T_2); Three irrigation frequency (1^{st}: at 20-25 days after sowing + 2^{nd}: at 45-46 DAS + 3^{rd}: at 60 DAS) + Organic matter at basal dose @ 2kg decimal^{-1} (T_3); Three irrigation frequency (1^{st}: at 20-25 days after sowing + 2^{nd}: at 45-46 DAS + 3^{rd}: at 60 DAS) (T_4). The cultivars used were Binarosun-1 (V_1) and Italy hybrid (V_2). Randomized complete block design (RCBD) with split plot arrangement was used for the experiment by assigning the irrigation in the main plots and cultivars in the sub-plots. The statistical analysis was performed using statistical software "Statistix10" (version 10.0). The highest yield (12.54 t ha^{-1}) was obtained with the application of three times irrigation (1^{st}: at 20-25 days after sowing + 2^{nd}: at 45-46 DAS + 3^{rd}: at 60 DAS) + Organic matter at basal dose @ 2kg decimal^{-1} (T_3). Local cultivar namely 'Italy hybrid' showed the highest yield. In case of interaction effects, treatment $T_3$and variety V_2 produced the highest yield. The cultivars V_2 produced higher yield compared to V_1 under all treatments. BCR of garlic production found positive for all cases. The highest BCR was found in treatment T_3 in both the locations. Garlic production was found profitable in the Natore area and the highest yield and BCR was found with the application of three times irrigation and organic matter at basal dose with zero tillage practice.

Effectiveness of irrigation regimes on the yield and water productivity of potato in cropping pattern in the char-land of Rangpur region

The experiment was conducted at the farmer's field of Tista, Lalmonirhat during rabi season of 2021-2022 to identify the water saving irrigation schedule for potato and following the cropping pattern 'Potato-Groundnut-T. Aman' at the Charland of Rangpur region. There were five different irrigation treatments as: Farmers' irrigation practice including farmer's line spacing (T_1); Alternate furrow irrigation at different stages (e.g. 1+1+1+1) with Farmer's line spacing (T_2); Every furrow irrigation but deficit mode (1+1+1+0), with Farmer's line spacing (T_3); Stage-wise (1+1+1+1) every-furrow irrigation with twin-row [e.g. First line 22.5 cm from border, then line spacing 20cm - 45cm- 20cm -20 cm – 45 cm -20cm-20cm-45 cm, and so on) plus 30% excess of recommended fertilizer (T_4); Every furrow irrigation but deficit mode (1+1+1+0) with Twin-row plus 30% excess fertilizer (T_5). BARI Alu 25 was used as test crop. Randomized complete block design (RCBD) with split plot arrangement was used for the experiment. The size of each plot was 4 m ×3m. The experimental land was fertilized with BARI recommended dose (Urea@1.42t/ha, TSP@0.89t/ha, MoP@1.21 t/ha, Gypsum@0.49t/ha, Zinc Sulphate @0.040t/ha, Magnesium Sulphate@0.65t/ha, Compost@ 41t/ha). The tubers were planted on 1st November 2022. Irrigation was given through poly pipe. Irrigation was given through poly-pipe. The pump discharge rate was determined and time of irrigation application was recorded with 'stop watch'.

The crop was harvested on 27 December 2022. The highest average yield was obtained with the application of Stage-wise (1+1+1+1) every-furrow irrigation with twin-row (treatmentT_4). This may be due to higher plant density and optimum irrigation. The Treatment T_4 showed the highest yield with water productivity of 3000.9 kg $ha^{-1}cm^{-1}$ and saved 13.01 % irrigation. Under sandy loam soil, stage-wise every-furrow irrigation having twin-row line of plants produced the highest yield of potato compared to others management practices tested.

Drought screening and irrigation management for field crops

Response of Binasharisha-9 to water-logging at different growth stages

The experiment was conducted at BINA HQ, BINA substation Barishal and farmer's field at Satkhira in Rabi season of 2022-2023to identify the effect of water-logging at different growth stages of Binasharisha-9. There were five different irrigation treatments as: Farmers' irrigation practice with no water-logging) (T_1); Water-logging at seed sowing stage (2 days after sowing) for 2 days (T_2); Water-logging at early growth stage (15 DAS) for 2 days (T_3); Water-logging at early growth stage (15 DAS) for 4 days (T_4); Water-logging at early growth stage (15 DAS) for 6 days (T_5); Water-logging at early growth stage (15 DAS) for 2 days and vegetative growth stage (30 DAS) for 2 days (T_6). Binasarisha-9 (V_1) and BARI Sarisha-13 (V_2) were used as test crop. Randomized complete block design (RCBD)was used for the experiment. The treatments were replicated three times. The size of each sub-plot was 3m ×3m. The experimental plots were fertilized with BARI recommended dose (Urea @300kg/ha, TSPP @180kg/ha, MoP@100 kg/ha, Gypsum @180 kg/ha, Boric Acid @0.10kg/ha, Zinc Oxide @0.5 kg/ha, Compost@8 t/ha). The experiment was conducted between November-February 2022-23. Water-logging was created as per treatments applying water through poly pipe. The statistical analysis was performed using statistical software "Statistix10" (version 10.0). The treatments showed significant effect on yield at Barishal and Satkhira, but not at BINA HQs. The cultivar Binasarisha-9 (V_1) performs better Barishal and shows similar result in BINA HQ and Satkhira with cultivar BARI Sarisha-13 (V_2)The yield of the cultivars was very low with higher duration of water logging condition. Although the Binasarisha-9 sustained in the 4 days and 6 days water logging condition.

Development of Irrigation System for BINA-developed Varieties for Hill areas of Bangladesh.

Development of efficient irrigation practice for citrus crops for hilly area of Bangladesh

The experiment was carried out at farmer's field in hill track of Jadurampara, Khagrachari to ensure efficient use of Jhiri-water and maximize water productivity for citrus crops and develop efficient irrigation practice for lemon production in hill slopes. The imposed treatments were:T_1= Control/ Farmers practice (water carrying by labor) /no irrigation; T_2 = Drip Irrigation using power sprayer. The tested cultivar was local cultivar Kagji. Drip irrigation system was settled in the slope of hill for applying irrigation on 30 lemon trees whereas no irrigation was applied in another 10 tree (as control). Irrigation was applied for 5 times in the dry months (December-March). Single dripper was used for each tree. Water source for irrigation was Jhiri of hill which is located on the underneath of the hill. A water pump including 6 Hp engine (which is locally used for spraying chemicals at orchards) was used for uplifting the waters from the jhiri to the tank (1000ltr) which is placed on the top of the hill (around 120-150 ft). Dripper were placed on the base of each tree and connected with the water tank using water conveying pipes. The highest average yield was obtained in the treatment T_2 . The treatment T_1 produced the lowest yield of lemon. On average, 300 lemons was harvested in each tree where drip irrigation was applied and around 180-200 lemon was produced in non-irrigated lemon trees (sold @ 5-7 tk/piece).

Automatic irrigation management system for field crops

Design and Development of an Automated Irrigation System for Rice

The study was carried out to measure the accuracy of the sensor to develop an automated irrigation system for rice. The system prototypes consists of an ESP32 microcontroller, four ultrasonic sensors, a 12V pump with a 5V relay module, Blynk cloud, and an IFTTT webhook that connects to Google Sheets. The ESP32 receives data from the ultrasonic sensors and controls the pump through the relay module based on the water height. The data is sent to the Blynk cloud for monitoring and control through a smartphone or PC. The IFTTT webhook connects the system to Google Sheets, allowing users to monitor the water level and track changes over time. The system was implemented by placing four ultrasonic sensors, a breadboard, a DC pump, a relay, and an ESP32 microcontroller in a lysimeter field at BINA, Mymensingh. The sensors were positioned to face downwards toward the bottom of the lysimeter field and were connected to the ESP32 microcontroller via the breadboard. The DC pump was used to circulate water within the lysimeter field, while the relay was used to turn the pump on and off based on the water level in the field. The ESP32 microcontroller was programmed to read data from the sensors and control the pump and relay. The system was tested by monitoring the water level in the lysimeter field over a period of time. The data collected from the sensors were analyzed to determine the performance of the system in maintaining a desired water level. The results of the accuracy calculation showed that the ultrasonic sensors had an average accuracy of 96.4%. The system displays each sensor value on the OLED display, along with the average water height display and the pump on/off operation. This helps to monitor the water level and pump status in real time. Each sensor value is displayed separately, allowing to monitor the water level at each point in the field. The average water height display shows the overall water level in the field, which is calculated based on the readings from all the sensors. The pump on/off operation is also displayed, indicating whether the pump is currently running or not. The prototype module utilizes ultrasonic sensors to determine the water level in the rice field and a relay module with a water pump to automate the irrigation process. The Blynk app and IFTTT webhook provide remote monitoring and data logging capabilities, allowing users to track and analyze the system's performance over time. The accuracy of the sensor found good under field condition. Further study will be carried out in the upcoming year with testing the prototype device in the field.

Development of low-cost small scale farm machinery suitable for farmers

Development of Smart Insect Controller

Pest infestation causes damage to sown seeds, seedlings, fruits, seeds, flowers, buds, leaves, roots, and tubers of crops in the field. Ultrasonic devices emit sound of predetermined frequency, when targeted at pests; they make them uncomfortable within the area of coverage thereby repelling them away from the area without affecting the environment and non-target organisms. Application of lights can trap pests with effective wave lengths and can prevent pests from entering a cultivation area by presenting light at various wavelengths and intensities. The study was carried out with a view to control the various pests a smart repellant is developed. Arduino Nano, Node MCU, Solar Panel, Solar Charge Controller, Battery, Buck Converter, Relay, Boost Circuit, GSM,GPS, Speaker, Capacitor, Resistor. This Solar Power Generation system works on the principle of auto power generating from different sources. A solar panel is used for power generating elements and restores it in a battery. Solar takes sunlight and produces some energy and stores it battery. This solar cell is controlled by the Arduino Nano Micro-controller. The voltage trap net consists of a mesh or grid that is electrified with a low-voltage electrical charge. When an insect comes into contact with the net, the electrical charge immobilizes or eliminates the insect. The device emits ultrasonic sound waves at specific frequencies that are uncomfortable or irritating to insects. The ultrasonic sound waves act as a repellent, discouraging insects from approaching the device. RGB Lights are incorporated into the device, attracting insects that are attracted to light sources. The lights can be used to lure insects towards the device, where voltage traps net will electrified the pests. The device is equipped with sensors to detect movement or unauthorized access. Further study will be continued to evaluate the performance of the device.

Development of Bio-char Production Machine.

Biochar is a type of charcoal produced from organic materials such as agricultural waste, wood chips, and crop residues through a process called pyrolysis. Traditionally, biochar production has relied on fossil fuel-based heat sources, such as wood or gas-fired kilns, which can contribute to greenhouse gas emissions and environmental pollution. Biochar production machines with electricity as a heat source is an innovative device designed to efficiently convert biomass into biochar using electrical energy as a heat source. The study was conducted to design and develop a Bio-char production machine. Crop residues, straw, husks, stalks, or any other biomass materials can be used for biochar production. The biochar machine will contain approximately 250 kg of hard wood or 160 kg soft wood at a time. Biomass needed to be chipped and dried properly before loading to the reactor for the pyrolysis .Heater Board (1000W),Glass wool, Temperature Controller were used to complete the reactor. Crop residues, straw, husks, stalks, or any other biomass materials can be used for producing biochar in the developed machine. The biochar machine will contain approximately 250 kg of hard wood or 160 kg soft wood at a time. Further research will be carried to explore the performance, energy efficiency and economic feasibility of the machine.

Climate changes and its impact on hydrological aspects and crop production at different Aez / hydrological regions of Bangladesh

Future climate scenario and its impact on hydrologic components

The experiment objectives were: (1) To predict climate change using Global Climate Model, and (2) to estimate change in hydrologic components due to climate change. At first global climate models were calibrated with the existing data of Bangladesh Meteorological Department (1985-2014). Based on the performance of 35 models, the top 3 models were selected and used for predicting the future scenario of rainfall and mean temperature (monthly data). The hydrological parameters such as ET_0, PET, runoff, recharge, and drought indices (e.g. Aridity index, PI, SPI) were calculated using predicted climatic data. There is distinct increasing trend of monthly temperature at different decadal time scales (average of the decade) compare to that of base-year. In almost all cases (except 2040-50 decade, during June-August), the predicted temperatures are higher than the base-temperature. Under SSP4.5 emission scenario, in contrast to base year, there is two distinct peak of the temperature - one at about March-April and another at September (except 2090-2100 decade). On the contrary, under SSP8.5 emission scenario, the first peak appears during April-May and the second peak at Sept.- Oct. For the monthly rainfall, there is evidence of distinct variation/fluctuating pattern over the months under both the emission scenarios.

Plant Pathology Division

Evaluation of mutants/advanced lines of rice for sheath blight and bacterial blight during aman season

An experiment was conducted to evaluate the level of field resistance/tolerance of advanced mutants/lines of rice against sheath blight and bacterial leaf blight in aman season of 2022 under inoculated field condition. Five mutants and 11 advanced lines of rice along with 4 varieties were used. The experiment was conducted in a randomized block design with three replications at BINA farm, Mymensingh. Twenty-five days old seedlings were transplanted in the field on 29 July 2022. Ten hills in each plot were inoculated at the booting stage with *X. oryae* pv. *oryzae* by clipping method. Similarly, ten hills in each plot were inoculated at the booting stage with seven days old culture of *R. solani*. Plants were assessed for bacterial leaf blight and sheath blight severity after two and three weeks of inoculation, respectively following the scale (0-9) developed at IRRI (2013). Eight advanced lines and mutants of rice showed moderately resistant reaction to bacterial leaf and fourteen mutant/lines showed moderately susceptible reaction to sheath blight under inoculated field condition in Aman season.

Evaluation of some promising mutants and advanced lines of rice for bacterial blight and sheath blight during boro season

Sixteen advanced lines along with four varieties were screened for resistance/tolerance to sheath blight and bacterial leaf blight during boro season of 2022-23 under inoculated field condition. The experiment was conducted in a randomized complete block design with three replications at BINA farm, Mymensingh. Thirty five days old seedlings were transplanted on 28 January 2023. The fertilizers were applied as per recommended doses. Ten hills in each plot were inoculated at the booting stage with *X. oryae* pv. *oryzae* by clipping method. Similarly, ten hills in each plot were inoculated at the booting stage with seven days old culture of *R. solani*. Plants were assessed for bacterial leaf blight and sheath blight severity after two and three weeks of inoculation, respectively following the scale (0-9) developed at IRRI (2013). Twelve advanced lines of rice were found to be moderately resistant to bacterial leaf blight and sixteen lines showed moderately susceptible reaction to sheath blight under inoculated field condition in boro season.

Evaluation of mustard-rapeseed lines against alternaria blight disease

A field evaluation of three mustard lines (RT-35, RT-38 and RT-39) and a check variety (Tori-7) against alternaria blight disease was conducted during November 2022 to February 2023 under natural field condition at BINA farm, Mymensingh. Experiment was laid out in a randomized complete block design with individual plot size of 6.0 m^2 with three replications. Seeds were sown on 13 November 2022. The severity scale 0-5 was followed for assessing the disease reaction at early pod maturity stage. The lowest disease incidence was recorded in the line RT-39 (25.7%) and the check variety Tori-7 had the highest one (51.9%). All four lines of mustard showed moderately susceptible reaction and the check variety was susceptible to alternaria blight.

Field evaluation of advanced lines of groundnut against foot and root rot and cercospora leaf spot

Seven advanced lines of groundnut along with one variety were evaluated for their resistance to foot and root rot and cercospora leaf spot diseases under field conditions at Mymensingh in 2023. The experiment was conducted in a randomized complete block design with three replications. The unit plot size was 2 m x 2 m. Spacing between rows and plants were 40 cm and 15 cm, respectively. Seeds were sown on 23 January 2023. The disease severity was assessed following the scale 0-4 and 0-5 for foot and root rot and cercospora leaf spot, respectively. Three lines (BCB-3, BCB-4 and BCB-4-2-2) showed moderately resistant reaction and rest 4 lines (BCB-3-4-1, BCB-3-4-3, BCB-3-4-5 and BCB-3-1-2) showed moderately susceptible reaction to cercospora leaf spot.

Evaluation of soybean mutants against collar rot and yellow mosaic disease

An experiment was conducted at BINA farm, Mymensingh to screen the mutants of soybean against collar rot and Soybean Mosaic Virus (SMV) during during rabi season of 2022-23 under inoculated condition. Three mutants (SBM-02, SBM-05 and SBM-07) and two check varieties (Binasoybeean-5 and Binasoybeean-6) were used in this experiment by following RCBD design with three replications. The unit plot size was 2.0 m × 1.50 m. Seeds were sown on 15 December maintaining row to row distance 75 cm and line to line distance 30 cm. The fertilizer was applied at recommended doses. Twenty seedlings of thirty days old were inoculated with 10 days old culture of *Sclerotium rolfsii* in each plot. With appearance of visible symptoms, observation on disease severity of collar rot was made at pod ripening stage following (0-9) scale and the severity of yellow mosaic was recorded on a 0-8 scale. Two mutants of soybean (SBM-02 and SBM-07) showed tolerant reaction to collar rot disease and three mutants (SBM-02, SBM-05 and SBM-07) showed resistant reaction to yellow mosaic disease.

Evaluation of lentil mutants against root rot and stemphylium blight disease

Three trials using three advanced mutants and two check varieties of lentil were conducted to screen lentil mutants against root rot and stemphylium blight at Ishwardi, Magura and Chapainowabganj during the winter season of 2022-23 under inoculated condition. The experiment was conducted in randomized complete block design with three replications. The seeds were sown in rows on last week of November 2022 in three locations. Distance between rows and seeds were 30 cm and 5 cm, respectively. The root rot and stemphylium blight disease incidence and severity was recorded using standard disease rating scale 0-9. Two mutants (LM-20-4 and LM-118-9) were found tolerant in Ishwardi, but LM- 20-4 showed moderately susceptible reaction and LM-118-) showed susceptible reaction in rest two locations. In case of stemphylium blight three advanced mutants showed moderately resistant reaction in Ishwardi and Chapainawabganj.

Evaluation of black gram mutants against cercospora leaf spot, powdery mildew and yellow mosaic

An experiment was conducted to evaluate black gram mutants against cercospora leaf spot, powdery mildew and yellow mosaic virus diseases. Screening was done under natural field conditions at BINA farm, Mymensingh in kharif-2 season of 2022. The experimental material included three advanced mutants (BM-4, BM-42 and BM-63) and two check varieties (Binamash-2 and BARI Mash-3) of black gram which were screened in a randomized complete block design with three replications. The seeds were sown on 11 October 2022 and the unit plot size was 2.0 m x 1.2 m. The recommended doses of fertilizer were applied and normal cultural practices were followed. The incidence and severities of CLS, powdery mildew and YMV were recorded from flowering to maturity. Three advanced mutants (BM-63, BM-105 and BM-108) of blackgram showed moderately resistant reaction against cercospora leaf spot, powdery mildew and yellow mosaic.

Management of storage disease of onion bulb with gamma radiation

An experiment was carried out in the laboratory of Plant Pathology Division, BINA to control the black mold disease of onion with radiation. Onion bulbs (variety Taherpuri) were irradiated at BINA using ^{60}Co gamma source with four different doses: 800Gy, 900Gy, 1000Gy and 1100Gy. The non-irradiated onion bulbs were kept as control (0Gy). The experiment was conducted with CRD having four replications. The irradiated and non-irradiated bulbs were kept at ambient conditions for four months. Data on disease incidence of black mold (%) was recorded for four times at one month interval during the whole storage period. After 4 months of storage, the disease incidence increased upto 56.5% in the control, in 800Gy it was 15.2%, in 900Gy it was 14.1%, in 1000Gy it was 12.6% and in 1100Gy it was 8.4%. At the end of the storage the disease incidence increased upto 56.5% from 16.2% in the control, in 800Gy it was upto 15.2% from 4.8%, in 900Gy it was upto 14.1% from 4.4%, in 1000Gy it was upto 12.6% from 3.9% and in 1100Gy it was upto 8.4% from 3.5%. Therefore, disease incidence decreased with increased dose of radiation and increased with the passage of time in all treatments as well as the control.

Evaluation of different waste products for mass production of *Trichoderma*

Present study was undertaken to select effective substrate (s) for mass multiplication of *Trichoderma*. Twelve different waste products (rice straw, rice bran, chickpea bran, lentil straw, lentil bran, blackgram straw, peanut shell, saw dust, wheat bran, wheat straw, mungbean straw, cow dung) were evaluated in the laboratory of Plant Pathology Division, BINA following completely randomized design with four replications. The substrates were filled in the conical flasks (250ml) and sterile water was added in order to keep 60% moisture approximately and sterilized in an autoclave at 121.6°C (15 psi). Discs (5mm) of *Trichoderma* from 7 days old culture were inoculated in aseptic condition @ 5-6 discs/flask. The inoculated flasks were incubated for at 26^0C. After a month of inoculation, the entire content of the flasks was mixed thoroughly using a sterile glass rod. Then 1g substrate was taken and was serially diluted to get the final dilution of 10^7. One ml from this solution was spread over a petridish containing PDA medium. The inoculated petriplates were incubated at 26±1ºC for 7 days. The number of colony of *Trichoderma* spp. was expressed as cfu/g substrate. The highest number of colony was found in the chickpea bran (398 cfu $\times 10^7$/g) followed by wheat straw (280 cfu $\times 10^7$/g), rice bran (270 cfu $\times 10^7$/g) and peanut shell (255 cfu $\times 10^7$/g). The least number colony (68 cfu $\times 10^7$/g) was formed in saw dust followed by rice straw (109 cfu $\times 10^7$/g).

Characterization of *Trichoderma* isolates and their evaluation against major soil borne pathogens

This research aimed to isolate and identify native strains of *Trichoderma* spp. with potential activity against major soil borne pathogens. Twenty isolates of *Trichoderma* spp. were collected from rhizosphere soil of crop fields by soil dilution techniques. The isolates of *Trichoderma* spp. were characterized morphologically. The antagonistic activity of the isolates against the pathogen, *Sclerotium rolfsii* was evaluated through dual culture assay. Seven biochemical tests like hydrolysis of aesculin, starch, casein, tween 80, polypectate, gelatin test and reduction of tetrazolium test were conducted on PDA. The growth inhibition of *S. rolfsii* (%) ranged from 47.6-73.8%. The maximum inhibition against *S. rolfsii* was recorded by the isolate TR2 (73.8%), followed by TR8 (73.7%) and TR18 (73.5%). The minimum inhibition was recorded by the isolate TR7 (47.6%) followed by TR10 (63.2%), TR16 (63.6%) and TR12 (63.7%). Among 20 isolates, 15 isolates confirmed positive result and the rest 8 isolates had negative result in Hydrolysis of Starch. In hydrolysis of Casein, **a**ll 20 isolates confirmed positive result. In hydrolysis of Tween 80, all 20 isolates showed negative result. In hydrolysis of Gelatin, 16 isolates confirmed positive result and the rest 7 isolates had negative result. In reduction of Tetrazolium, all 20 isolates had negative result. In hydrolysis of Polypectate, 20 isolates confirmed positive result.

Evaluation of new fungicides against sheath blight of rice

The present study was undertaken to evaluate the new molecule of fungicides against *R. solani*. This experiment was conducted in Aman season of 2022 at BINA HQ, Mymensingh and Nalitabari under inoculated field condition. The disease susceptible Aman rice variety BR11 was used as the test material. Each plot was inoculated at the booting stage with seven days old culture of *Rhizoctonia solani*. The fungicides like Iglare 24 SC, Amister top 325SC, Seltima Nativo 75 WG and Contaf 5 EC were applied two times at 15 days interval after the first appearance of the disease with the doses of 1.5 ml/L, 1ml/L, 2g/L, 0.4g/L and 1ml/L of H_2O, respectively. In Mymensingh Iglare 24 SC was found to be superior in three different stage of plant growth in terms of low disease incidence (65.27b%, 77.95%, 81.83%), and low disease severity (4.86, 7.00 and 8.93). At Nalitabari, Nativo 75 WG performed the best in reducing disease incidence (70.94%, 84.85%, 85.97%) as compared to the control.

Evaluation of new fungicides for the control of bakanae of rice

To control bakanae disease five fungicides from different fungicidal groups were evaluated for their efficacy against seed-borne *Fusarium* spp. as seed treatment at BINA farm, Mymensingh and Nalitabari during Aman season of 2022. A rice variety BRRI dhan 32 which is susceptible to bakanae disease was used for the study. Fungicides were evaluated at the recommended dose. Twenty two days old seedlings of each plot were inoculated by dipping their roots in freshly prepared inoculum suspension of *Fusarium sp.* (10^5 spores mL^{-1}) for overnight. Overall performance of the fungicides was found to be better in suppressing the seed-borne *Fusarium sp.* and increasing seed germination. Among the fungicides, no disease was found in Safezim and Tufan treated plot in Mymensingh and Naliatbari.

Management of Stemphylium blight disease of lentil

An experiment was carried out by using four chemical fungicides along with one bio-agent at BINA sub-station Ishwardi, Magura and Chapainawabganj following RCBD with three replications during Rabi 2022-23 to manage stemphylium blight. Four chemical treatment and one bio-agent viz. Amister top, Seltima, Nativo 75 WG, Filia 525 SE and *Trichoderma asperellum* (Suspension 2×10^6/ml) along with control plot were tested in the field. In Ishwardi, the mean incidence of stemphylium blight in treated plot ranged from 21.66-63.33% where Filia 525 SE performed the best for lower percent of disease incidence (21.66%), minimum leaf infection/plant (10.33%) and the highest yield (1.706 t/ha). The highest disease incidence was found in control (76.67%). In Magura, the mean incidence of stemphylium blight in treated plot ranged from 20-35%, and Filia 525 SE performed the best for lower percent of disease incidence (20%), minimum leaf infection/plant (12.37%) and the highest yield (1.758 t/ha). In Chapainawabganj, the mean incidence of stemphylium blight in treated plot ranged from 16.56-31.86% and Amister top 325SC performed the best for lower percent of disease incidence (16.56%) and minimum leaf infection/plant (9.3%).

Isolation and molecular characterization of *Ustilaginoidea virens* causing false smut of rice

An experiment was conducted to isolate and characterize *Ustilaginoidea virens* causing false smut of rice in the laboratory of Plant Pathology Division, BINA. Rice grain samples showing typical false smut symptoms were collected from different location of Kurigram, Rangpur and

Mymensingh during Aman 2022. The pathogen was isolated from the infected ball and tranferred on PSA medium. The PSA plates were incubated at 28 ± 2 °C for 15 days. After 15 days of incubation, as the colonies grew, they were periodically transferred to fresh PSA media and kept for full plate growth. After one month very poor growth was found. A standard protocol for isolating *U. virens* will be established in the next year and then subsequent characterization will be done.

Molecular identification of *Fusarium* spp. associated with bakanae disease of rice in Bangladesh and assessment of their pathogenicity

An experiment was carried out in the laboratory of Plant Pathology Division, BINA to assess the variability of *Fusarium* from bakanae disease infected rice in Bangladesh and evaluating their pathogenicity on susceptible rice cultivar. Infected rice plants having typical symptom of bakanae disease were collected from BINA sub-station, Chapainawabgonj, Cumilla, Barishal, BINA regional station Gazipur and BINA HQ, Mymensingh. Fifteen isolates of *Fusarium* spp. isolated from symptomatic diseased plants and these will be characterized for their morphology, pathogenicity and molecular variability using universal rice primers (URP) in next year.

Screening for alternaria blight disease of mustard-rape seed through conventional and gene based molecular marker

A study was conducted to identify the source of resistance gene against alternaria leaf spot disease in mustard plants. Thirteen different varieties/advanced lines were evaluated in 2022-23 at the experimental field of BINA HQ in Mymensingh. A specific fragment of ~600bp was amplified by PCR using primers *Acola-sens*: 5′-GCAGCA TCTGCTGTTGGG G-3′ and *Acola-reverse*: 5′-CAAGGTCAGCATCCATAAAGCC-3′ for *A. brassicicola* isolates. At 60 days after sowing (DAS), two varieties (Binasarisha-4 and Binasarisha-8) showed a moderately susceptible response with a Disease Incidence (DI) rating of 3, while seven varieties exhibited a susceptible response with a DI rating of 4. Four varieties exhibited a highly susceptible reaction with a DI rating of 5. At 70 DAS, eight genotypes showed a susceptible response with a DI rating of 4, while five lines were exhibited a 0highly susceptible reaction with a DI rating of 5. At the final assessment (80 DAS), all 13 genotypes showed a highly susceptible response with a DI rating of 5. Three varieties, namely Binasarisha-7, Binasarisha-8, and BARI Sarisha-18, exhibited high yields despite their susceptibility to alternaria leaf spot disease.

Detection of blast resistant gene(s) in BINA germplasm and advance lines of rice by usings gene based molecular markers

Experiments were conducted to identify blast-resistant fragrant genes in some indigenous, advanced lines and cultivated rice varieties for the development of a durable blast-resistant rice varieties based on phenotypic screening and molecular analysis. A total of seventy genotypes which included thirty indigenous varieties, forty advanced lines were selected to detect the presence of major blast resistance genes, i.e *Pish* and *Pi9* which are the effective blast-resistant genes against blast isolates in Bangladesh. Advanced rice lines showed better performance as compared to cultivated lines. Two primers (*pish*, *pi 9*) were tested and found that eleven genotypes carried *pish* gene, twenty genotypes carried the *pi9* genes and other genotypes carried no blast-resistant genes.

Detection of bacterial blight resistant gene(s) in BINA germplasm and advanced rice lines by using gene based molecular markers

The present study was undertaken to identify bacterial blight resistant genes in some indigenous, advanced lines and cultivated rice varieties based on pathogenicity tests and molecular screening. A total of seventy genotypes which included thirty indigenous varieties and forty advanced lines were selected to detect the presence of major bacterial blight resistant genes, i.e., *Xa4, xa5, xa13, Xa21* and *Xa23*, using molecular markers. Among them, forty-seven genotypes carried the *Xa4* gene, forty genotypes carried the *xa5* gene and one genotype carried the *xa13* gene, eighteen genotypes had two *(Xa4 + xa5)* and 1 genotype had three (*Xa4* + *xa5* + *xa13*) BB resistant genes.

Morpho-molecular screening of gamma irradiated wheat mutants for blast resistance

Seeds of two varieties (BARI Gom-26, BARI Gom-33) and one CIMMYT line (CIMMYT Line-2) were irradiated with four different doses of gamma rays (150, 200, 250 and 300Gy). The irradiated seeds were sown at BINA HQ Research Farm, Mymensingh. Among the treatments, 150 Gy and 300 Gy reduced the disease significantly. Molecular detection of 2NS/2AS translocation in mutant lines were also done using specific primers. The size of the band (259 bp) confirmed the 2NS/2AS translocation in mutant lines. From this morpho-molecular study, CIMMYT Line-2 (150Gy), BARI Gom-26 (150 Gy), BARI Gom-33 (300 Gy), BARI Gom-26 (300Gy) having 2NS/2AS translocation were observed as high yielding lines suppressing wheat blast significantly.