Bangladesh J. Nuclear Agric, 35: 63-70, 2021 *ISSN 0258-7130*

BINAMASH-2, A GAMMA RAY INDUCED HIGH YIELDING BLACKGRAM MUTANT VARIETY

S. Roy[1]*, S.M.A. Alim[1], S.R. Ghosh[2], M.R.I. Akondo[1], S. Chowhan[3] and M.K.J. Ali[4]

Abstract

Blackgram is one of the most important pulse crops extensively grown in Bangladesh with multiple uses. Genetic improvement of blackgram is highly impeded due to narrow genetic base whilst hybridization and recombination is rather difficult because of its auto-gamous nature. Viewing these constraints, an induced mutation, using gamma irradiation, creating genetic variation, resulting in the creation of new varieties with better characteristic was undertaken. The mutants were derived from three popular varieties, BARI Mash-1, BARI Mash-2 and BARI Mash-3 which were treated with gamma irradiation (400, 500 and 600 Gy doses) subsequent selection and field trials were conducted with a view to select mutant with desired traits during 2011 to 2020. The mutant BM-404 out yielded the checks and other mutants with other desired characters like earliness, bolder seed and erect plant type. This mutant also showed moderately resistant to Yellow Mosaic Virus, cercospora leaf spot and Hairy caterpillar. Therefore, we applied to the National Seed Board (NSB) of Bangladesh for registration and the mutant line BM-404 was registered namely Binamash-2 as a national modern variety in 2021.

Key words: Black gram, high yielding, mutant, variety

Introduction

Blackgram or urdbean (*Vigna mungo*) is widely cultivated in the Indian subcontinent including Bangladesh and to a lesser extent in Thailand, Australia, and other Asian and South Pacific countries. It is a nutritious and most commonly tailored stress-tolerant legume with a cheap source of vegetable protein, amino acids and so for poor people. The crop plays a major role in improving soil fertility owing to their ability to fix atmospheric nitrogen and it is also well suited for various cropping systems like dry farming and intercropping. In Bangladesh during 2018-2019, urdbean was grown over an area of 0.618 lakh hectares with the production of 0.690 lakh metric tonnes whilst the average yield of 1100 kg ha^{-1} was low as compared to the cereal crops. In order to break the yield bottleneck in black gram, efforts are needed to develop high yielding varieties with better growth habit.

[1]Plant Breeding Division, Bangladesh Institute of Nuclear Agriculture, BAU Campus, Mymensingh
[2]Entomology Division, Bangladesh Institute of Nuclear Agriculture, BAU Campus, Mymensingh
[3]BINA sub-station, Ishurdi, Bangladesh Institute of Nuclear Agriculture, BAU Campus, Mymensingh
[4]BINA sub-station, Jamalpur, Bangladesh Institute of Nuclear Agriculture, BAU Campus, Mymensingh
*****Corresponding authors' email: agsnigdharoy@gmail.com

Genetic improvement is highly impeded due to narrow genetic base of the crop as a result research on this species has lagged behind that of cereals and other legumes. Therefore, improvement of this crop is needed through utilization of available genetic diversity. Expanding genetic variation may offer better traits for the genetic improvement of the crop for sustainable food production and other qualities. Induced mutagenesis creates a new variation in the traits of interest for genetic enhancement like improved yield and other polygenic characters with no disruption in the plant's basic chromosome structure. Mutation induction has become an established tool in plant breeding to supplement existing germplasm and improve cultivars in certain specific traits (Kurobane *et al.,* 1979). Mutagenesis has been widely used as a potent method of enhancing variability for crop improvement (Singh and Singh, 2001). Induced mutation, using physical and chemical mutagen, is a way to generate genetic variation, resulting in the creation of new varieties with better characteristic (Wongpiyasatid, 2000). Gamma rays are the most energetic form of electromagnetic radiation; their energy level is from ten to several hundred kilo electron volts and they are considered as the most penetrating compared to other radiations (Kovacs *et al.,* 2002). Mutation breeding is suitable choice of creating variability in self-pollinated crops such as blackgram. Therefore, the present mutation breeding programme was initiated to identify mutants with high yield potential, earliness, erect, and determinate type plant growth habit of blackgram.

Materials and Methods

Dry, healthy and uniform sized seeds of black gram variety, BARI Mash-1, BARI Mash-2 and BARI Mash-3 were treated with gamma rays at 350, 400, 450 and 500Gy doses from BINA radiation source, [Cobalt sixty (Co^{60})]. The irradiated seeds were immediately sown at BINA headquarters farm, Mymensingh in 2011 and the M_1 population was grown at close spacing where the first two pods formed on each M_1 plants were harvested considering mutation experiments as and kept separately dose and variety wise to grow M_2 generation in the next season. A total of 192 plant-progeny-rows were grown from four doses in M_2 generation and 28 M_2 plants were selected to grow M_3 generation and subsequent M_4 generation was grown and selection were made with desirable mutants. Through preliminary yield trial seven mutants of good performed lines were selected considering their field performance as compared to the checks (Binamash-1, BARI Mash-2 and BARI Mash-3) during 2016 and they were put into Advanced Yield Trial (AYT) along with a popular check variety, BARI Mash-3 during Kharif 2017. Considering the superior performance of the selected mutant line BM-404 of BARI Mash-3 derived from 400Gy, multi-location yield trials were conducted with this line in various agro-ecological zones of the country during 2018 and 2019. Unit plot size was 4m x 3m. Row to row and plant to plant distances were 40 cm and 8-10 cm, respectively. Data on days to maturity, plant height (cm), primary branches plant^{-1}, pods plant^{-1}, seeds pod^{-1}, 100-seed weight and yield plot^{-1} were recorded. Plot yield was converted to kg ha^{-1}. The trials were conducted simultaneously both in the experimental farms and in the farmers' field following two management practices (research management and farmers' management). The most popular variety and mother BARI Mash-3 was used in all the multilocation trials as check. In the research management practice trials

were replicated and farmers' practices were non-replicated. Intercultural practices like weeding and thinning were done for its maximum growth and pesticide was applied to control diseases as and when necessary. Reaction to major diseases like Cercospora leaf spot, Powdery mildew and Yellow Mosaic Virus and insect-pests infestation under field condition were recorded during 2020.

Results and discussion

The mutants BM-211, BM-401, BM-102, BM-404, BM-108, BM-401 and BM-409 were put under preliminary yield trials with three checks at two locations, Magura and Chapainwabganj during 2016. From the Table 1, it was observed that significant differences were found for all the characters among the mutants grown except number of seeds pod^{-1} at both the locations. The mutant BM-409 was the tallest whilst BM-211, BM-102 and BM-404 were the shortest among the mutants and checks in combined mean of two locations. In case of primary branches plant^{-1} BM-401 and BM-404 had the highest number of branches per plant. The mutants BM-201 and BM-404 produced the highest number of pods plant$^{-1.}$ The higher 100-seed weight were found in the mutants BM-404 and BM-409 as well as higher seed yield at both the locations. Singh (1996) characterized mutations obtained in *Vigna mungo* as gene mutations and found long pod and bold seeded mutants with better yield which is in support of the bold seeded mutants BM-409, BM-404 and BM-211. Combining mean of two locations showed that mutant BM-409 produced the highest seed yield followed by the mutants BM-108 and BM-404.

The advanced yield trials were conducted with three promising blackgram mutants along with a check varietiy BARI Mash-3 at Magura and Chapainawabganj during 2017. Results revealed that there was significant difference for most of the characters except seeds pod^{-1} (Table 2). BM-404 was the shortest among the mutants and checks at Magura and Chapainawabganj. In case of primary branches and pods plant^{-1}, BM-404 had the highest number of branches and pods plant^{-1}. Higher 100-seed weight (g) was found in the BM-409 and BM-404. Seed yield was the highest for BM-404 because of its higher 100-seed weight and higher number of pods plant^{-1}. Jain (1975) suggested that improvement in grain yield in legume crops could be achieved through restructuring of plant types to determinate, erect and compact growth habits which totally in support of the mutant BM-404 with erect, short, determinate type plant growth habit and higher yield.

The zonal yield trials were conducted with two promising blackgram mutants along with a check varietiy BARI Mash-3 at Magura and Chapainawabganj during 2018. Results revealed that there was significant difference for most of the characters except seeds per pod (Table 3). The mutant line BM-404 matured earlier than the other mutant and the check variety, BARI Mash-3 in both locations Magura and Chapainawabganj. Sonu *et al.* (2019) found mutants with different gamma rays produced early mutants which was similar to this result. The check variety, BARI Mash-3 was the tallest among the mutant and check. In case of number of pods per plant, BM-404 had the higher number of pods than the other mutant and the check variety, BARI Mash-3. Seed yield was the highest for the BM-404 because of its higher number of pods per plant and also higher 100-seed weight (g). Combining mean

of two locations, it was observed that BM-404 produced the highest seed yield (1.45 t ha^{-1}). This result was the similar with the findings that the early mutants with altered agronomic characteristics like yield and growth habit were isolated in *Vigna mungo* (Kumar *et al.* 2009).

Table 1. Performance of seven promising mutants along with three check varieties, BARI Mash-1, BARI Mash-2 and BARI Mash-3 grown at Magura and Chapainawabganj during 2016

Mutants/Variety	Plant height (cm)	Primary branches $plant^{-1}$ (no.)	Pods $plant^{-1}$	Seeds pod^{-1} (no.)	100 seeds weight (g)	Yield (kg ha^{-1})
Magura						
BM-211	40.8 abc	1.4 b	35.6 cdc	5.8	4.1 bc	1235ab
BM-401	41.5ab	1.7 b	39.6 abc	5.5	3.6 bc	1196ab
BM-102	40.2 bc	1.7 b	37.5 bcd	5.8	3.5 bc	1166ab
BM-404	37.8 c	3.8 a	42.2 ab	5.9	5.2a	1350a
BM-108	38.2 c	1.7 b	32.0 de	5.8	3.4c	1186ab
BM-409	43.7 a	1.6b	40.0 abc	6.0	5.5a	1283a
BM-201	39.5 bc	1.8 b	44.5 a	5.9	3.8bc	1183ab
BARI Mash-2	41.6 ab	1.4 b	31.3 e	5.9	4.2 b	1243ab
BARI Mash-3	38.9bc	1.9 b	31.7 de	5.7	3.9 bc	1166ab
BARI Mash-1	40.4 bc	1.8 b	40.7 abc	5.4	3.8 bc	1231a
CV(%)	4.36	30	12.5	3.2	17	4.7
Chapainawabganj						
BM-211	40.4 c	1.3 bc	26.2 ab	6.2	6.6a	1266bc
BM-401	43.2 abc	1.2 bc	24.8 abc	6.1	5.3ab	1300ab
BM-102	41.2 bc	1.0 c	23.5 bc	6.1	4.0c	1266bc
BM-404	44.4 a	1.9 a	27.0 ab	6.1	7.0a	1200c
BM-108	46.4 a	1.2 a	28.2 a	6.3	4.1c	1350a
BM-409	45.5 ab	1.5 ab	21.2 c	6.2	6.3a	1293abc
BM-201	43.2 abc	1.1bc	27.5 ab	5.5	6.3a	1283abc
BARI Mash-2	43.9 abc	1.2bc	25.7 ab	6.0	7.0a	1266bc
BARI Mash-3	45.6 ab6	1.2 bc	26.5 ab	6.3	6.6a	1233bc
BARI Mash-1	45.8ab	1.2 bc	26.9 ab	5.9	7.0	1187bc
CV(%)	4.55	19.68	8.12	3.87	19.16	3.81
Combined over locations						
BM-211	40.6	1.3 b	30.9	6.0	5.3a	1250ab
BM-401	42.3	2.9 a	32.0	5.8	4.4b	1248ab
BM-102	40.7	1.3 b	30.5	5.9	3.7c	1216bc
BM-404	41.1	2.8 a	34.6	6.0	6.1a	1275a
BM-108	42.3	1.4 b	30.1	6.0	3.7c	1268a
BM-409	44.6	1.5 b	30.6	6.1	5.9a	1288a
BM-201	41.3	1.5 b	36.0	5.7	4.5b	1233bc
BARI Mash-2	42.7	1.3 b	28.5	5.9	5.6a	1254d
BARI Mash-3	42.2	1.5 b	29.1	6.1	5.2a	1199c
BARI Mash-1	43.1	1.5 b	33.8	5.6	4.9b	1209bc
CV(%)	4.425	27.84	10.31	3.535	18.08	4.255

*Figures followed by same letter in a column did not differ significantly at 5% level.

Table 2. Mean of yield and yield contributing characters of three selected mutants of blackgram grown at two locations, Magura and Chapainawabganj during 2017

Mutants/Variety	Plant height (cm)	Primary branches plant^{-1} (no.)	Pods plant^{-1}	Seeds pod^{-1} (no.)	100-seeds weight (g)	Yield (kg ha^{-1})
Magura						
BM-404	38.2 bc	3.8 a	42.2 ab	5.9	3.7 bc	1538a
BM-108	38.6 bc	1.7 b	32.0 de	5.8	3.1 c	1514a
BM-409	43.7 a	1.6 b	40.0 abc	6.0	5.5 a	1352b
BARI Mash-3	40.9ab	1.9 b	31.7 de	5.7	3.9 bc	1508a
CV%	6.27	26.25	14.85	2.20	25.30	5.75
Chapainawabganj						
BM-404	42.1b	2.9 a	37.0 a	6.1	6.3a	1838a
BM-108	46.4 a	1.2 bc	28.2 ab	6.3	4.6b	1722ab
BM-409	45.5 ab	1.5 ab	21.2 c	6.2	6.3a	1714ab
BARI Mash-3	46.6 a	1.2 bc	26.5 ab	6.3	6.0a	1590b
CV%	4.84	27.78	23.26	1.53	14.00	5.90
Combined						
BM-404	44.1a	3.3a	39.6a	6.0	5.0a	1688a
BM-108	40.5b	1.4b	30.1	6.0	3.85c	1618a
BM-409	44.6a	1.5b	30.6	6.1	5.90a	1533ab
BARI Mash-3	42.2ab	1.5b	29.1	6.1	4.95b	1549ab
CV%	4.38	27.68	15.06	0.95	17.55	4.44

*Figures followed by same letter in a column did not differ significantly at 5% level

Table 3. Mean of yield and yield contributing characters of two promising mutants of blackgram grown at two locations, Magura and Chapainawabganj during 2018

Variety/mutants	Days to maturity	Plant height (cm)	Primary branches plant^{-1} (no.)	Pods plant^{-1}	Seeds pod^{-1} (no.)	100-seeds weight (g)	Yield (kg ha^{-1})
Magura							
BM-404	74b	51.9 ab	3.8	42.2 a	6.6	4.37 a	1502a
BM-108	75b	48.2 c	2.7	35.0 a	6.7	3.80b	1341b
BARI Mash-3	79a	56.0 ab	2.2	27.1b	6.6	4.52a	1400b
CV%	3.48	7.49		21.72	0.87	8.875	5.75
Chapainwabganj							
BM-404	74c	32.10	1.8	40.0 a	6.1	4.49a	1412 a
BM-108	76ab	32.7	1.2	31.5 a	6.3	3.60b	1320 b
BARI Mash-3	78a	35.0	2.2	29.2 b	6.3	4.56a	1300 b
CV(%)	2.63	4.60	24.74	16.95	1.85	12.69	4.44
Combined							
BM-404	74c	42.5	2.8	41.1a	6.35	4.43a	1456a
BM-108	76b	40.4	1.9	33.2b	6.50	3.70b	1330b
BARI Mash-3	79a	45.0	2.2	28.1b	6.45	4.54a	1350b
CV(%)	3.297	5.40	40.78	19.18	1.187	10.81	4.91

On-station and farmers' field trials were carried out with two promising lines and a most popular check variety with BARI Mash-3 at Mymensingh, Magura, Chapainawabganj and Gopalgonaj during 2019 and 2020. The mutant line BM-404 produced the highest seed yield followed by BM-108 and check variety, BARI Mash-3 in the research management practice at all the locations (Table 4). Similar trend of seed yield was found by the line in farmers' management practices (Table 5). Average seed yield of BM-404, BM-108 and BARI Mash-3 were 1644, 1485, and 1452 kg per hectare, respectively, (Table 6).

It was observed from five years average mean yield (Table 7) that the mutant BM-404 produced the highest yield (1480 Kg/ha) followed by the mutant BM-108 and the check BARI Mash-3 (1394 and 1359 Kg/ha) respectively. Mutagens have been successfully utilized to generate promising traits particularly for isolating mutants with desirable characters of economic importance (Shah *et al*. 2008; Usharani and Kumar 2015) which is in support of the high yielding mutant BM-404 of blackgram with determinate plant type and higher number of pods with bolder seeds.

Table 4. Seed yield of mutant lines along with the check variety BARI Mash-3 grown at four research stations during 2019 and 2020

Mutants/ Variety	Seed yield (kg ha^{-1})							
	2019			2020				
	Mymensingh	Magura	Average	Mymen.	Magura	Chapai	Gopalganj	Average
BM-404	1421a	1408a	1415a	1732a	1531a	2074a	1721a	1719a
BM-108	1331ab	1325ab	1328ab	1503b	1389b	1895b	1473b	1595b
BARI Mash-3	1208b	1315ab	1261b	1479c	1412b	1836b	1461b	1547b
CV (%)	8.1	3.78	5.78	8.89	5.27	6.41	9.46	5.47

Table 5. Seed yield of selected mutant lines grown at farmer's field at Mymensingh, Magura, Faridpur and Gopalganj during 2019 and 2020

Mutants/ Variety	Seed yield (kg ha^{-1})						
	2019			2020			
	Mymensingh	Magura	Average	Mymensingh	Faridpur	Gopalganj	Average
BM-404	1311a	1304a	1307a	1623a	1669a	1416a	1569a
BM-108	1205b	1225b	1215b	1560b	1338b	1223b	1374b
BARI Mash-3	1246b	1216b	1231b	1550b	1318b	1201b	1356b
CV (%)	4.26	3.88	3.93	2.51	13.67	9.24	8.24

Table 6. Comparative seed yield (kg/ha) of the selected mutants/variety grown at research station and farmer's field during 2019 and 2020

Mutants/Variety	Seed yield (kg ha^{-1})					
	Research management (kg ha^{-1})		Farmer's management (kg ha^{-1})		Average	
	2019	2020	2019	2020	2019	2020
BM-404	1415a	1719a	1307a	1569a	1362a	1644a
BM-108	1328b	1595b	1215b	1374b	1272b	1485b
BARI Mash-3	1261bc	1547b	1231b	1356b	1246b	1452b
CV (%)	5.78	5.47	3.92	8.24	4.71	6.72

Table 7. Combined means over five years for seed yield (kg ha^{-1}) of the two mutants along withe the check variety, BARI Mash-3

Mutants/Variety	2016	2017	2018	2019	2020	Mean over five year
BM-404	1251a	1688a	1456a	1361a	1644a	1480a
BM-108	1268a	1618a	1330b	1272b	1485b	1394b
BARI Mash-3	1199b	1549b	1350b	1246b	1452b	1359b
CV (%)	2.9	4.29	1.0	4.66	6.72	4.41

Remarks about the susceptibility to diseases and insect-pests

A. Disease reaction

Disease reaction against Cercospora leaf spot and Powdery mildew and Yellow Mosaic were examined under field condition during 2020 at Mymensingh. Results were presented in table 8, 9 and 10. There was not much disease incidence in test mutants and check variety for Cercospora leaf spot and Powdery mildew in field. All the tested mutants along with a check variety, BARI Mash-3 showed moderately susceptible to the diseases.

Table 8. Incidence of Cercospora leaf spot disease in some selected mutants/variety of blackgram at Mymensingh during 2020

Genotypes/Variety	Cercospora leaf spot		
	PDI	DS	Reaction
BM-404	55.00	23.28	MS
BM-108	58.33	20.72	MS
BARI Mash-3	66.67	25.04	MS

Table 9. Incidence of Powdery mildew disease in mutants/variety of blackgram at Mymensingh during 2020

Genotypes/Variety	Powdery mildew		
	PDI	DS	Reaction
BM-404	60.00	44.67	MS
BM-108	63.33	32.09	MS
BARI Mash-3	60.00	39.33	MS

All the tested entries along with a check variety, BARI Mash-3 showed moderately susceptible to susceptible to the Yellow Mosaic Virus disease.

Table 10. Incidence of Yellow Mosaic in selected mutants/variety of Blackgram at Mymensingh during 2020

Genotypes/ Variety	Yellow Mosaic		
	PDI	DS	Reaction
BM-404	4.76	14.07	MS
BM-108	6.14	18.09	MS
BARI Mash-3	20.68	36.42	S

MS = Moderately Susceptible, S = Susceptible; DS = Diseases severity; PDI = Percent Disease Index

B. Insect-pests infestation

Naturally low insect pest infestation is occurred in black gram and there was no pod borer infestation in blackgram. The caterpillar infestation was occurred in black gram during experimentation (Table 11). Tested mutants and check were moderately tolerant and moderately susceptible to this insect pest.

Table 11. Infestation of Hairy caterpillar in selected mutants/variety of blackgram at Mymensingh during 2020

Genotypes/Variety	Hairy caterpillar	
	(0-9 scale)	Reaction
BM-404	3	MR
BM-108	5	MS
BARI Mash-3	7	MS

In respect of yield potential, earliness, erectness with determinate type plant habit and diseases reaction, BM-404 performed the best over year and location. Therefore, the mutant has been registered as a variety, Binamash-2 for cultivation all over the country.

References

Jain, H.K. 1975. Breeding for yield and other attributes in grain legumes. Indian J Genet 35: 169–187.

Kovacs, E. and Keresztes, A, 2002. Effect of gamma and UV-B/C radiation on plant cell. Micron. 33: 199-210. Kurobane I, Yamaguchi H, Sander C, Nilan.

Kumar, V., Sharma, A.K., Singh, V.P., and Kumar, M. 2009. Characterization of pre-breeding genetic stocks of urdbean (*Vignamungo* (L.) epper) induced through mutagenesis. In: ShuQY (ed) Induced plant mutations in the genomics era. Food and Agriculture Organization of the United Nation, Rome, pp 391–394

Kurobane, I., Yamaguchi, H., Sander, C. and Nilan, R. 1979. The effects of gamma irradiation on the production and secretion of enzymes and enzymatic activities in barley. Env. Exp. Botany. 19: 75-84. lgnacimuthu S, Babu CR (1989).

Shaha, T.M., Mirza, J.I., Haq, M.A. and Atta, B.M. *Pak. J. Bot*. 2008, 40(2): 605-613.

Singh, R.K. 1996. Gamma ray induced bold seeded mutant in *Vignamungo* (L.) Hepper. Indian J Genet 56(1): 104–108.

Singh, M. and Singh, V.P. 2001. Genetic analysis of certain mutant lines of urdbean for yield and quality traits in M_4 generation. Ind. J. Pulses Res. 14(1): 60-62.

Sonu, G., Rafiq, M.W., Amin, R.L., Raina, A., Amin, R. and Samiullah, K. 2019. Induction of morphological mutations and mutant phenotyping in black gram [*Vigna mungo* (L.) Hepper] using gamma rays and EMS. International Journal of Plant Research. 32: 464–472.

Wongpiyasatid, A., Chotechuen, S. and Hormchan, P. 2000. Induced mutations in mungbean breeding Regional yield trail of mungbean mutant lines. Kasetsart J. (Nat. Sci.). 34: 443-449.