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DOI: https://doi.org/10.3329/bjnag.v37i1.69932 ***Short communication***

SELECTION OF SESAME MUTANTS FOR HIGHER YIELD AND YIELD CONTRIBUTING TRAITS THROUGH GAMMA RAY IRRADIATION

M.K. Khatun*, R.M. Emon, M.S.H. Bhuiyan, M.A. Malek and S.A. Mahmud

Abstract

The experiment was conducted to observe their performance regarding seed yield and yield attributes, and to select promising mutant(s) having higher seed yield with shorter maturity periods. Five mutants along with the mother variety and one check variety were evaluated following a randomized complete block design with three replications at three sesame growing areas of Bangladesh during Kharif-I, 2017. Analysis of variance showed highly significant variations among the mutants and checks for most of the characters in individual locations and combined over locations. The mutant SM-07 produced the highest seed yield (1522 kg ha^{-1}) at each location with taller plants and the shortest maturity period. The heatmap and correlation matrix showed a significant positive correlation among the no. of branch plant^{-1}, no. of pod plant^{-1}, and the seed yield. Considering mean seed yield over locations, three mutants viz., SM-07, SM-06 and SM-04 produced higher seed yield (1522, 1483 ,and 1461 kg ha^{-1}, respectively) with took short days (83-85 days) to maturity. These three mutants need to be further zonal evaluation for conformity of their performance.

Keywords: Sesame, Oilseed, Mutants and Yield

Sesame (*Sesamum indicum* L.) is an important oilseed crop in the world. It is referred to as the 'queen of oilseeds' due to its regard by the users and owing to its oil quality (Bedigian and Harlan, 1986). Sesame is mainly a crop of warmer areas including Asia and Africa (Ashri, 1988). In Bangladesh, the total production of sesame (both winter & summer) is 31,060 metric tons (BBS, 2021-22). The average productivity of sesame has lowered ranging from 1440 to 2340 kg ha^{-1} compared to the past 20 years (Raikwar and Srivastava, 2013) which has led to a gap in the demand and the supply. The reduction in seed yield was attributed mostly to a reduction in number of seeds per plant and seeds per capsule rather than seeds size (Malek *et al.*, 2012). It is an excellent rotation crop of cotton, maize, groundnut, wheat, and sorghum. It reduces nematode populations that attack cotton and groundnut (Elbadri and Yassin, 2010). Its deep and extensive root system makes it an excellent soil builder. It also improves soil texture, retains moisture and reduces soil erosion. Considering the importance of sesame, the development of higher yielding sesame variety is persistent demand.

For any plant breeding program, the creation of genetic variation followed by selection plays an important role in developing improved crop varieties. Therefore, genetic variations in useful traits are prerequisites for any crop improvement program. Like another breeding program the action of variability transpires to be the primary step to get desirable

Plant Breeding division, Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh-2202
Corresponding author's e-mail: khadija_bina@yahoo.com

types. Mutation breeding has long been known as a potential technique to unlock additional genetic variability for supplementing conventional crop breeding methodology. Mutation breeding is a widely used technique for creating genetic variation for numerous crops in Bangladesh and around the world (Acquaah, 2012; Malek et al., 2014; 2016, 2020; 2022). Mutagenesis offers a unique scope for creating variation, as it may alter even those genes that are common to all the varieties of a species. Induced mutation has been extensively and successfully used for the improvement of many crops including oilseed crops like sesame. Sesame oil quality was improved by mutation breeding, which also produced variations in seed production and other yield components (Kang et al., 1998; Chowdhury et al., 2009; Ong'injo and Ayiecho, 2009; Savant and Kothekar, 2011, Malek M.A. 2021). Henceforth an attempt was made to assess the information on various quantitative characters that help to identify high yielding sesame mutants.

Seeds of sesame variety Binatil-1 were irradiated with 500, 600, 700 and 800 Gy doses of gamma rays using Co^{60} gamma cells to create genetic variations. Irradiated seeds were then sown to grow the M_1 generation at BINA, Mymensingh in 2011 for selecting desirable mutants in subsequent generation selection was made in each of the M_2, M_3 and M_4 generations based on desired agronomic traits. From M_5 populations, five M_6 homozygous and true breed mutants namely SM-01, SM-04, SM-05, SM-06 and SM-07 were selected based on desired agronomic traits for further evaluation. These five true breeding mutants along with the mother variety Binatil-1 and check variety Binatil-2 were evaluated at three sesame growing areas of Bangladesh in 2017 following a randomized complete block design with three replications. Seeds were sown within the first week of March 2017 maintaining unit plot size of $20m^2$ (5.0m × 4.0m) with a line spacing of 25cm and 6-8cm for the plant to plant within rows. Recommended production packages like weeding, thinning and application of fertilizers, irrigation, pesticides, etc. were done uniformly to ensure normal growth and development of the plants in each plot as and when necessitated.

Data were taken on different morphological traits and yield attributes like plant height, number of branches plant^{-1}, number of siliquae plant$^{-1,}$ and number of seeds siliquae $^{-1}$ from 10 randomly selected representative plants from each plot at the maturity stage. The collected data were analyzed statistically according to the design followed using the analysis of variance (ANOVA) technique following Gomez & Gomez (1984). The mean values were compared by DMRT at a 5% level of significance.

In the M_5 generation, the analysis of variance for different quantitative characters revealed that mean values were highly significant for all the traits indicating the existence of high genetic variability among the mutants for yield and yield components. In other words, mutation induced substantial genetic variability among the lines. Significant variations for different quantitative characters have also been reported in sesame earlier by Begum and Dasgupta (2015) and in other oilseed crops (Ali *et al*., 2002; Hasan *et al*., 2006; Mahmud *et al*., 2008) that's findings confirmed the present observation.

Table 1. Analysis of variance (ANOVA) of seven traits with significance levels in sesame mutants

Sources of variation	df	Days to maturity	Plant height (cm)	No. of branch plant^{-1}	No. of capsules plant^{-1}	No. of seeds capsules $^{-1}$	Capsules length (cm)	Seed yield (kg ha^{-1})
Replication	2	0.190	0.19	0.016	2.33	0.05	0.000	4
Mutant	6	50.571***	238.48***	13.683***	791.00***	709.90***	3.435***	125173***
Location	2	1.714	481.00***	0.111**	574.43***	663.86***	0.129***	665
Genotype × Location	12	13.714***	57.83***	0.111***	41.93***	65.19***	0.169***	2551***
Error	40	1.290	3.69	0.016	2.83	3.25	0.001	213

P Value ≤ 0.05 (*) P Value ≤0.01 (**) P Value ≤ 0.001 (***)

The results of the analysis of variance (ANOVA) of the quantitative traits of the tested genotypes are presented in (Table 1). Statistical analyses performed on various agro-morphological traits revealed the presence of significant variation for all the traits of sesame mutants. The differences among mutants for all the traits under study viz., plant height (cm), no. of branch plant^{-1}, no. of capsules plant^{-1}, no. of seeds capsules^{-1}, capsules length (cm), seed yield (kg ha^{-1}), days to maturity were highly significant (***P<0.001). The analysis of variance results showed that there was a considerable amount of variation among the tested mutants.

Results of mean values of three individual locations and combined over three locations for all the characters have been presented in Table 2. The genotypic variation in days to maturity, morphological parameters (plant height & no. of branch plant^{-1}), yield attributes (no. of capsules plant^{-1} & no. of seeds capsules^{-1}) and seed yield in sesame was significant (Table 2). The maturity period is the most important and frequently observed character which can be modified in oilseed using induced mutation. Significant differences were observed for days to maturity in different locations. In combined over locations, days to maturity varied from 83 days in SM-07 to 90 days in Binatil-2 having a non-significant difference with SM-01 & Binatil-2 which required 88 days to mature. It is observed that, most of the mutants matured earlier than the mother variety. This result revealed that through induced mutation maturity period can be shortened. Induction of early maturity in the mutants of oilseed has been reported by Shah & Rahman (2009) in mustard and Begum and Dasgupta (2014) in sesame which confirms the present result.

The tallest plant was recorded in SM-07 (131cm) followed by SM-04 & SM-06 (128 cm) with same statistical rank. The shortest plant was recorded in SM-05 (117cm). Genetic variation in plant height and no. of branch plant^{-1} was also observed by many workers. The development of shorter mutants in oilseed *Brassica* has been reported by Shah *et al*. (1990) and Malek *et al*. (2012a). These results also confirm that induced mutation can be altered the plant stature in oilseed crops. The highest seed yield was recorded in SM-07 (1522 kg ha^{-1}) followed by SM-06 (1483 kg ha^{-1}) & SM-04 (1461 kg ha^{-1}). The mutant SM-07 and

SM-06 produced higher seed yield due to the production of higher no. of capsules plant^{-1} and higher no. of seeds capsules $^{-1}$. The result also indicated that those genotypes having greater no. of branches also showed higher no. of capsules plant^{-1}.

Table 2. Mean performance of sesame mutants along with mother & check varieties for different quantitative characters

Locations	Mutants/ Check	Days to maturity	Plant height (cm)	Branches plant^{-1} (no.)	Capsules plant^{-1} (no.)	Seeds capsule^{-1} (no.)	Capsule length	Seed yield (kg ha^{-1})
BINA sub-station Magura	SM-01	88a	122b	1.0d	71c	75d	2.57e	1386d
	SM-06	86b	134a	2.0c	78b	87b	2.81c	1481b
	SM-07	84c	135a	3.2a	86a	85b	2.90b	1520a
	SM-04	85bc	133a	2.0c	78b	88b	2.90b	1433c
	Binatil-1	88a	124b	0.0e	60d	97a	4.55a	1255f
	SM-05	86b	118c	1.0d	61d	73d	2.67d	1265f
	Binatil-2	88a	122b	2.7b	70c	79c	2.52f	1300e
BINA sub-station Ishurdi	SM-01	89b	126a	1.0d	53c	54d	2.53d	1317b
	SM-06	84d	115d	2.0c	75a	83a	2.79cd	1483a
	SM-07	82e	122b	2.72b	75a	84a	3.45b	1500a
	SM-04	86c	119c	2.0c	65b	76b	2.50d	1492a
	Binatil-1	92a	119c	0.0e	52c	85a	4.53a	1235c
	SM-05	85cd	113e	1.0d	51c	58d	2.45d	1217c
	Binatil-2	89b	115d	3.7a	62b	71c	3.04c	1340b
BINA sub-station Chapainawabganj	SM-01	87b	125c	1.0c	57f	72f	2.55e	1347c
	SM-06	85c	134ab	2.0b	73c	85c	2.87c	1485b
	SM-07	83d	136a	3.2a	85a	92a	3.07b	1546a
	SM-04	84cd	131b	2.0b	77b	82b	2.67d	1458b
	Binatil-1	84cd	120d	0.0d	62e	88b	3.82a	1260d
	SM-05	87b	120d	1.0c	64de	78e	2.59de	1208e
	Binatil-2	93a	120d	3.5a	66d	76e	2.64de	1260d
Combined means over locations	SM-01	88b	124c	1.0d	60.33e	67g	2.55f	1350d
	SM-06	85c	128b	2.0c	75.33b	85c	2.82c	1483b
	SM-07	83d	131a	3.0b	82a	87b	3.14b	1522a
	SM-04	85c	128b	2.0c	73.33c	82d	2.69e	1461c
	Binatil-1	88b	121d	0.0e	58f	90a	4.30a	1250f
	SM-05	86c	117f	1.0d	58.67f	69.69f	2.57f	1230g
	Binatil-2	90a	119e	3.0a	66d	75.33e	2.73d	1300e
Location means								
BINA sub-station, Magura		86^{NS}	126.86a	1.71b	72a	83.43a	2.99b	1377a
BINA sub-station, Ishurdi		87	118.43b	1.86a	61.86c	73c	3.04a	1369b
BINA sub-station, Chapainawabganj		86	126.57a	1.81a	69.14b	81.86b	2.89c	1366c

Location means showed that BINA sub-station Magura produced highest seed yield (1377.14 kg ha^{-1}) & the lowest seed yield observed in BINA sub-station Chapainawabganj (1366.29 kg ha^{-1}). The maturity period of three locations was non-significant.

In the environment, at Magura seed yield ranged from 1230 to 1525 kg ha^{-1} with 1377 kg ha^{-1} as the median (Fig. 1) among seven genotypes the mutant SM-07 produce highest average seed yield 1520 kg ha^{-1}. Seed yield ranged from 1200 to 1525 kg ha^{-1} with the median 1340 kg ha^{-1} in Ishurdi (Fig. 2), whereas the mutant SM-07 produce highest average seed yield 1500 kg ha^{-1}. At Chapainawabganj seed yield ranged from 1201 to 1550 kg ha^{-1} and the median 1347 kg ha^{-1}, in this location highest average seed yield 1500 kg ha^{-1} was produced by the mutant SM-07 (Fig. 3).

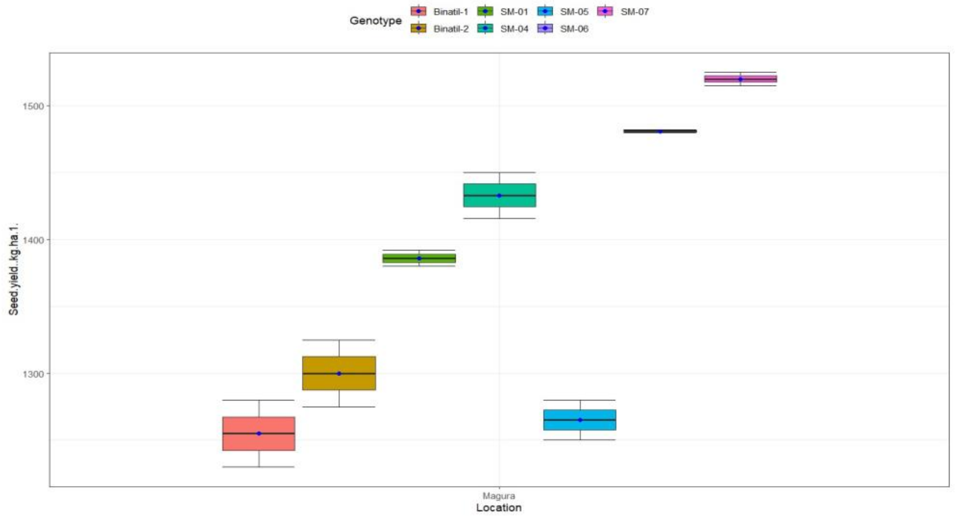

Fig. 1. Boxplot of genotype performance for seed yield (kg ha^{-1}) of seven genotypes for Magura

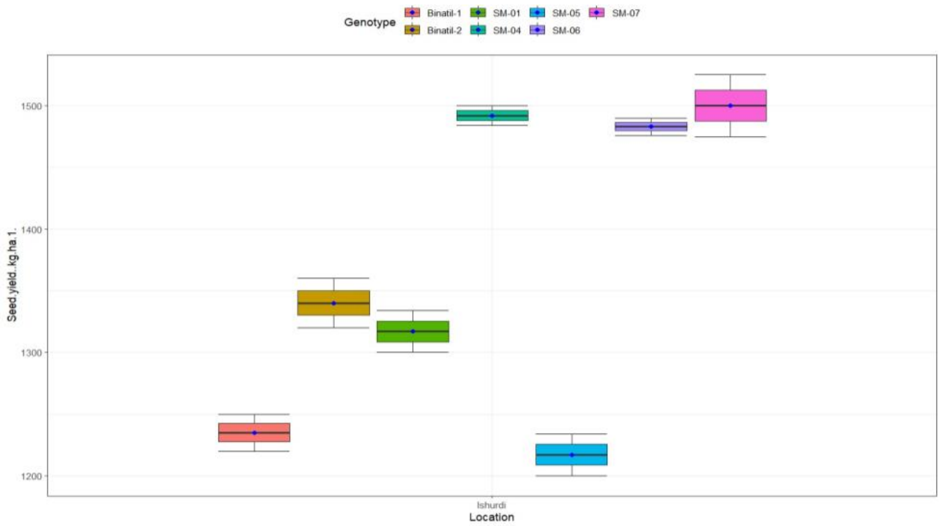

Fig. 2. Boxplot of genotype performance for seed yield (kg ha^{-1}) of seven genotypes for Ishurdi

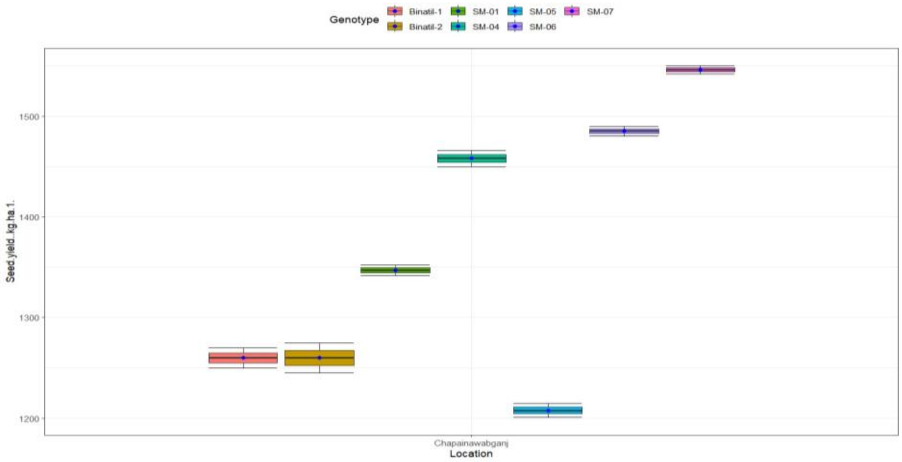

Fig. 3. Boxplot of genotype performance for seed yield (kg ha^{-1}) of seven genotypes for Chapainawabganj

Table 3. Estimation of the correlation coefficient of seven traits with significance levels in sesame mutants

Variable	PH	NBP^{-1}	NPP^{-1}	NSP^{-1}	PL	SY	DM
PH	1	0.43ns	0.85*	0.51ns	-0.03ns	0.97***	-0.74ns
NBP^{-1}		1	0.77*	0.30ns	-0.17ns	0.57ns	-0.20ns
NPP^{-1}			1	0.50ns	-0.17ns	0.93**	-0.73ns
NSP^{-1}				1	0.73ns	0.42ns	-0.42ns
PL					1	-0.22ns	0.09ns
SY						1	-0.73ns
DM							1

Legend: PH = Plant height (cm), NBP-1 = No. of branch plant^{-1}, NCP-1 = No. of capsule plant^{-1}, NSC-1 = No. of seeds capsule^{-1}, CL = Capsule length (cm), SY = Seed yield (kg ha^{-1}), DM = Days to maturity

From the correlation coefficient of seven traits with significance levels in sesame mutants (Table 3), it was observed that plant height showed a significant positive correlation with no. of capsule plant^{-1} and seed yield (kg ha^{-1}) and a negative non-significant association with pod length (cm) and days to maturity. No. of the branch, plant^{-1} showed a positive significant association with no. of capsule plant^{-1} and a negative non-significant association with capsule length (cm) and days to maturity. No. capsule plant^{-1} also showed a positive significant correlation with seed yield (kg ha^{-1}) and a negative non-significant association with capsule length (cm) and days to maturity. No. of seeds, capsule^{-1} showed a positive non-significant correlation with capsule length (cm) and seed yield (kg ha^{-1}) and a negative non-significant association with days to maturity. Capsule length (cm) showed a positive non-significant correlation with days to maturity and a negative non-significant correlation with seed yield (kg ha^{-1}). Seed yield (kg ha^{-1}) showed a negative non-significant correlation with days to maturity.

The results of the present study suggested that plant height (cm), no. of branch plant^{-1} and no. of capsule plant^{-1} were the most important characteristics for achieving/ getting higher seed yield. Therefore, selection based on these characteristics may bring out the desired improvement towards enhancing the seed yield in sesame.

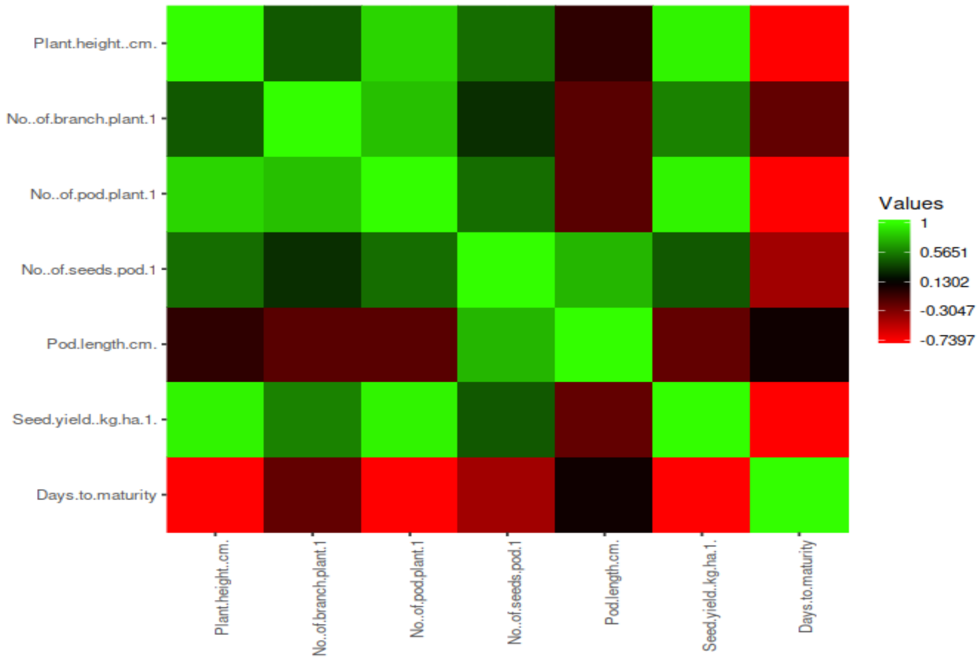

Fig. 2. Heatmap generated exploiting the correlation matrix revealing the relevance among the traits

The relative correlation among the seed yield-related traits is indicated by the gradient of color; the lemon color denotes the highest correlation, and the red color means the lowest correlation (Fig. 2). No. of capsule plant^{-1} and seed yield (kg ha^{-1}) were significantly positively correlated with plant height this result is similar to the findings of Emon *et al.*, 2023. The capsule length (cm) and days to maturity were negatively correlated. There was a positive significant correlation between no. of branch plant^{-1} and no. of capsule plant^{-1} but a negative non-significant correlation between capsule length (cm) and days to maturity. No. capsule plant^{-1} also showed a positive significant correlation with seed yield (kg ha^{-1}) and a negative non-significant association with capsule length (cm) and days to maturity. No. of seeds, capsule^{-1} showed a positive non-significant correlation with capsule length (cm) and seed yield (kg ha^{-1}) and a negative non-significant association with days to maturity. Capsule length (cm) showed a positive non-significant correlation with days to maturity and a negative non-significant correlation with seed yield (kg ha^{-1}). Days to maturity indicated a weakly negative, non-significant relationship to seed yield (kg ha^{-1}).

The present study revealed that among the mutants and mother variety, three mutant's SM-04, SM-06 and SM-07 performed better for seed yield and other yield contributing characters which can be selected for further trials to develop new mutant varieties. Heatmap and correlation matrix indicated a positive significant correlation among no. of branch plant^{-1}, no. of capsule plant$^{-1,}$ and seed yield. Moreover, this suggests that gamma ray irradiation with 600 to 700 Gy can be fruitfully applied to induce mutants in sesame with higher seed yield and other improved agronomic traits.

Reference

Acquaah, G. 2012. Principles of plant genetics and breeding, 2nd edn| Wiley.

Ahmad, M., Khan, M.A., Zafar, M., and Sultana, S. 2009. Environment-friendly renewable energy from sesame biodiesel. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, *32*(2), 189-196.

Ali, N.A.A.Z.A.R., Javidfar, F., and Attary, A.A. 2002. Genetic variability, correlation and path analysis of yield and its components in winter rapeseed (*Brassica napus* L.). *Pakistan Journal of Botany (Pakistan)*.

Ashri, A. 1988. Sesame breeding-objectives and approaches. *Oil Crops: Sunflower, Linseed and Sesame. International Development Research Center (IDRC), Ottawa, Canada*, 157-164.

BBS, 2021. Summary Crop Statistics Area, Yield Rates and Productions of Minor Crops 2020-21. Bangladesh Bureau of Statistics, Ministry of Planning, Government of the People's Republic of Bangladesh. pp:1.

Bedigian, D., and Harlan, J.R. 1986. Evidence for cultivation of sesame in the ancient world. *Economic botany*, *40*, 137-154.

Begum, T., and Dasgupta, T. 2014. NDUCED GENETIC VARIABILITY, HERITABILITY AND GENETIC ADVANCE IN SESAME (*Sesamum indicum* L.). *SABRAO Journal of Breeding & Genetics*, *46*(1).

Begum, T., and Dasgupta, T. 2015. Amelioration of seed yield, oil content and oil quality through induced mutagenesis in sesame (*Sesamum indicum* L.). *Bangladesh Journal of Botany*, *44*(1), 15-22.

Chowdhury, S., Datta, A.K., Saha, A., and Maity, S. 2009. Radiation-induced two oil rich mutants in sesame (*Sesamum indicum* L.). *Indian Journal of Science and Technology*, *2*(7), 51-59.

Elbadri, G.A., and Yassin, A.M. 2010. 12 Sesame's Protective Role in Crop Nematode Control. *Sesame: The genus Sesamum*, 211.

Emon, R.M., Sakib, M.N., Khatun, M.K., Malek, M.A., Haque, M.S., and Alam, M.A. 2023. Microsatellite marker assisted molecular and morpho-physiological genetic diversity assessment in 38 genotypes of sesame (*Sesamum indicum* L.). *Journal of Phytology*, *15*, 43-51.

Ghulam, S., Haq, M.A., Chaudhry, M.B., and Rabbani, I. 2008. Evaluation of early and high yielding mutants of sesame (*Sesamum indicum* L.) for different genetic parameters. *JOURNAL OF AGRICULTURAL RESEARCH (Pakistan)*.

Gomez, K.A., and Gomez, A.A. 1984. *Statistical procedures for agricultural research*. John wiley & sons.

Hasan, M., Seyis, F.A.T.İ.H., Badani, A.G., Pons-Kühnemann, J., Friedt, W., Lühs, W., and Snowdon, R. J. 2006. Analysis of genetic diversity in the Brassica napus L. gene pool using SSR markers. *Genetic Resources and Crop Evolution*, *53*, 793-802.

Javed, M.A., Siddiqui, M.A., Khan, M.K.R., Khatri, A., Khan, I.A., Dahar, N.A., and Khan, R. 2003. Development of high yielding mutants of Brassica campestris L. cv. Toria selection through gamma rays irradiation. *Asian Journal of Plant Sciences*, *2*.

Kang, C.W., Roh, J.H., Lee, S.W., Park, C.B., Lee, J.I., Lee, S.T. and Kim, W.S. 1998. A high oil, linoleic fatty acid content and yielding new sesame mutant variety" Yangbaeckkae". *RDA Journal of Industrial Crop Science*.

Khatri, A.B.D.U.L.L.A.H., Khan, I.A., Siddiqui, M.A., Raza, S.A.B.O.O.H.I., and Nizamani, G.S. 2005. Evaluation of high yielding mutants of Brassica juncea cv. S-9 developed through gamma rays and EMS. *Pakistan journal of botany*, *37*(2), 279.

Mahmud, F., Rasul, M.G., and Rahim, M.A. 2008. Genetic diversity analysis in some advanced lines of Brassica napus. *Sci. Asia*, *34*, 432-434.

Malek, M.A. 2020. Binatil-2: a gamma rays induced mutant variety of sesame. Bangladesh Journal of Nuclear Agriculture 33 & 34: 151-158.

Malek, M.A., Begum, H.A., Begum, M., Sattar, M.A., Ismail, M.R., and Rafii, M.Y. 2012. Development of two high yielding mutant varieties of mustard ['*Brassica juncea*'(L.) Czern.] through gamma rays irradiation. *Australian Journal of crop science*, *6*(5), 922-927.

Malek, M.A., Emon, R.M., Khatun, M.K., Bhuiyan, M.S.H., Nevame, A.Y.M. and Alam, M.A. 2022. Binasoybean-6: a high yielding mutant soybean variety developed through sustainable mutation breeding. *Legume Research-An International Journal*, *45*(2), 143-148.

Malek, M.A., Ismail, M.R., Monshi, F.I., Mondal, M.M.A. and Alam, M.N. 2012. Selection of promising rapeseed mutants through multi-location trials. *Bangladesh Journal of Botany*, *41*(1), 111-114.

Malek, M.A., Rafii, M.Y., and Khatun, M.K. 2016. Selection of rapeseed mutants for higher yield and yield contributing traits. *Journal of the Bangladesh agricultural university*, *14*(2), 141-146.

Malek, M.A., Rafii, M.Y., Afroz, S.S., Nath, U.K., and Mondal, M. 2014. Morphological characterization and assessment of genetic variability, character association, and divergence in soybean mutants. *The Scientific World Journal*, *2014*.

Morris, J.B. 2002. Food, industrial, nutraceutical, and pharmaceutical uses of sesame genetic resources. In *Trends in new crops and new uses. Proceedings of the Fifth National Symposium, Atlanta, Georgia, USA, 10-13 November, 2001* (pp. 153-156). ASHS Press.

Najeeb, U., Mirza, M.Y., Jilani, G., Mubashir, A.K. and Zhou, W.J. 2012. Sesame. *Technological Innovations in Major World Oil Crops, Volume 1: Breeding*, 131-145.

Ong'Injo, E. O. and Ayiecho, P. O. 2009. Genotypic variability in sesame mutant lines in Kenya. *African crop science journal*, *17*(2).

Raikwar, R.S. and Srivastva, P. 2013. Productivity enhancement of sesame (*Sesamum indicum* L.) through improved production technologies. *African Journal of Agricultural Research*, *8*(47), 6073-6078.

Savant, K.D. and Kothekar, V.S. 2011. Induction of variability in fatty acid profile in sesame (*Sesamum indicum* L.). *Journal of Phytology*, *3*(12), 01-03.

Shah, S.A. and Rahman, K. 2009. Yield and growth response of rapeseed (*Brassica napus* L.) mutants to different seeding rates and sowing dates. Pak. J. Bot., 41(6): 2711–2716.

Shah, S.S., Ali, I. and Rehman, K. 1990. Induction and selection of superior genetic variables of oil seed rape (*Brassica napus* L.). *Nucleus*, *27*.

Venkataramana Bhat, K., Babrekar, P.P. and Lakhanpaul, S. 1999. Study of genetic diversity in Indian and exotic sesame (*Sesamum indicum* L.) germplasm using random amplified polymorphic DNA (RAPD) markers. *Euphytica*, *110*, 21-34.