Journal of Advances in Biology & Biotechnology

Volume 27, Issue 12, Page 752-761, 2024; Article no.JABB.127896
ISSN: 2394-1081

Mutation Breeding for Genetic Improvement and the Development of High Yielding Mutant Variety of Sesame (Binatil-3)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/jabb/2024/v27i121823

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/127896

Original Research Article

Received: 10/10/2024
Accepted: 12/12/2024
Published: 29/12/2024

ABSTRACT

Sesame plays an important role in human nutrition. Sesame seed contain fat, protein, carbohydrates, fiber and some minerals. The seeds of creamy seed-coat color of popular sesame variety Binatil-1 were irradiated with gamma rays to create genetic variability for earliness, higher seed yield and other desirable agronomic traits. The experiment was conducted at BINA

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Cite as: *Khatun, Mst. Khadija, Md. Abdul Malek, Reza Mohammad Emon, Md. Saikat Hossain Bhuiyan, and Shahinur Islam. 2024. "Mutation Breeding for Genetic Improvement and the Development of High Yielding Mutant Variety of Sesame (Binatil-3)". Journal of Advances in Biology & Biotechnology 27 (12):752-61. https://doi.org/10.9734/jabb/2024/v27i121823.*

headquarters farm, Mymensingh during March-May (Kharif-I) 2002 to 2007 and 47 mutants were primarily selected based on their better field performance including seed yield plant^{-1} and other important agronomic traits. The mutant SM-10-04 (mutant of Binatil-1 with 500Gy of gamma rays) was found to be superior compared to other mutants and the mother variety. The evaluation trials were conducted during March-May (Kharif-I) season at different sesame growing areas of Bangladesh. Significant variations were observed both in individual location and combined over locations for most of the traits. Reactions to major disease (stem rot) and insect-pests (hairy caterpillar, hawk moth and pod borer) infestations were also studied. BINA applied to the National Seed Board (NSB) of Bangladesh for registration of the superior mutant SM-10-04 as an important sesame variety. The NSB of Bangladesh registered the mutant SM-10-04 as an improved sesame variety naming Binatil-3 in 2013 for commercial cultivation in Bangladesh. Induced mutations can be extensively and successfully used for the improvement of sesame in respect of changing branching habit and different in seed coat colour along with higher seed yield. This can be considered as a milestone achievement in mutation breeding. This variety may partially fulfill the challenges of increasing demand of edible oils and also has an opportunity for increase cultivable land under sesame in Bangladesh.

Keywords: Binatil-3; gamma irradiation; high yielding; mutant; sesame.

1. INTRODUCTION

A cultivated sesame (*Sesamum indicum*L.) is belong to the family Pedaliaceae, has x=13, and 2n=26 chromosomes (Wang et al., 2023) and (Miao et al., 2024) demonstrated that sesamea species can be classified into three cytogenetic groups based on chromosome number. It is called the “Queen of oil seeds” because of its high oil content, delicious nutty aroma, and flavors (Johnson et al., 1979) and is traditionally categorized as a healthy food in Asian countries (Miyake et al., 2005). “Sesame seeds contain high levels of fatty acids (45%–55%), proteins (19%–25%) and rich in essential minerals, including magnesium, phosphorus, calcium, iron, and zinc. Sesame seeds also contain vitamins B and E and have some antioxidant properties” (Langyan et al., 2022; Mostashari & Mousavi Khaneghah, 2024). “Sesame is unique because it contains two antioxidants, sesamin, and sesamolin, and a third antioxidant, sesamole which make its more stable than other oils” (Dossou et al., 2023; Wan et al., 2023). Brown or black seeded are valued more for oil whereas, white seeded are rich in iron. According to ElKhier et al. (2008), the majority of sesame seeds are utilized to extract oil, with the remaining seeds being consumed for food. The oil of sesame seed is renowned for its stability because it strongly resists oxidative rancidity even after long exposure to air (Global Agri Systems, 2010).

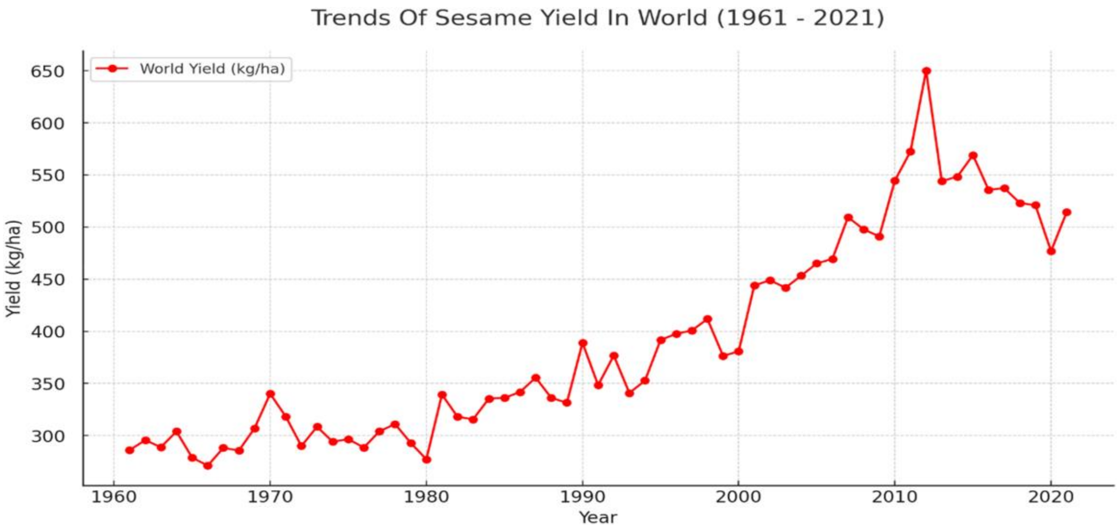

Fig. 1. Evolution of sesame yield in the world from 1961 to 2021 by region (Source: FAOSTAT (2024) and the authors' visualization)

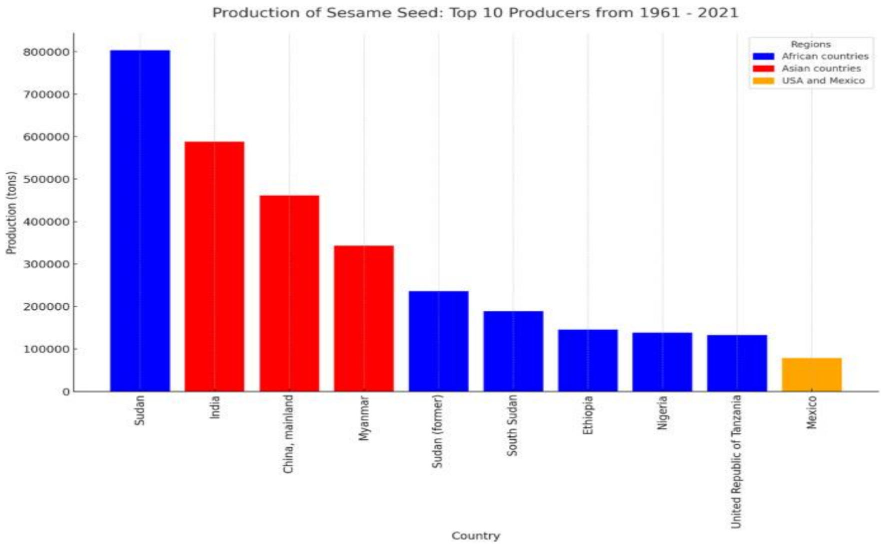

Fig. 2. Production of sesame seed: Top 10 producers per region from 1961 to 2021 region (Source: FAOSTAT (2024) and the authors' visualization)

Sesame is a self pollinated crop and often has lower genetic variability than out crossing crops (Charlesworth, 2003). Mutation is one of the popular methods to generate genetic variation (Acquaah, 2012; Malek et al., 2014; 2016; 2020; 2022). Mutations occur randomly throughout the genome and within the locus or genes; thereby not only producing desired mutation but allowing the emergence of other mutations that can increase the diversity of a germplasm (De Vicente et al., 2004). Induced mutations with gamma ray irradiation are often performed due to their wide availability and flexibility of use (Forster & Shu, 2012). According to Gaafar et al. (2016), gamma rays are a type of ionizing radiation that cause cells to produce free radicals, which can alter the components of the cell and affect various aspects of a plant's morphology, anatomy, biochemistry, and physiology depending on the dosage of gamma irradiation.Effect of gamma irradiation in diversification of genetic variation was recorded by Indriatama et al. (2016) in wheat, Laskar & Khan (2017) in lentil and Malek et al. (2014) in soybean.

"The production of sesame is greatly depending on the cultivars, cultural techniques, and growing conditions. Sesame is a low yielder and worldwide average yield is only 535kg ha^{-1}" (Brigham, 1987). "Mutation breeding helps in creating variability not only in agro-morphological traits like yield and yield components, but also a better oil quality profile can be achieved in sesame" (Kang et al., 1998; Chowdhury et al., 2009; Ong'injo and Ayiecho, 2009; Savant and Kothekar, 2011). "The major constraints in sesame production worldwide are lack of wider adapting cultivars, shattering of capsules at maturity, non-synchronous maturity, poor stand establishment, lack of fertilizer responses, profuse branching, and low harvest index" (Ashri, 1994). "Besides these, improvement of sesame has been slow mainly due to lake of adequate research and efficient breeding programs" (Ashri, 1998). Therefore, the present investigation was undertaken with the objectives to determine the effects of gamma irradiation in sesame, the mutant-environment interaction on sesame yield and finally to develop a high yielding mutant variety of sesame.

2. MATERIALS AND METHODS

Binatil-3 (*Sesamum indicum* L.) has been developed from the sesame variety, Binatil-1. The seeds of Binatil-1 were exposed to different doses of gamma rays (500, 600, 700 and 800Gy) using Co^{60} gamma source in mutation breeding laboratory at BINA, Mymensingh and grown as M_1 generation during March-May, 2002. During evaluation (March-May, 2003) of the irradiated population in M_2 generation, a large number of variants for different traits including seed yield were observed. Forty seven mutants were primarily selected in M_3 generation considering their better field performance including seed yield plant^{-1} and other important agronomic traits as compared to the mother variety in March-May, 2004. These experimental materials were grown in M_4 and M_5 generations to study their breeding behavior in respect of seed yield and yield contributing traits to select elite mutants during 2005, 2006 and 2007.

Observation trial was conducted with a large number of M_5 mutant variants at BINA hqs. farm, Mymensingh and BINA sub-station farm at Ishurdi in 2008. After that, advanced yield trial was conducted in the BINA sub-station farms at Magura and Ishurdi during March-May, 2009 with five M_6 mutants (SM-03-04, SM-05-04, SM-08-04, SM-10-04 and SM-11-04) and two check varieties (Binatil-1 and BARI Til-2). Multi-location trials (on-station and on-farm) were conducted in various agro-ecological zones of the country in 2010, 2011 and 2012 in the experimental farms and also in the farmers' field following research management as well as farmers' management. On-station yield trial with advanced sesame mutants was conducted in the BINA sub-station farms at Magura and Ishurdi in 2010 with three M_7 mutants (SM-03-04, SM-10-04 and SM-11-04) and two checks (Binatil-1 and BARI Til-2).

On-station and on-farm yield trial with advanced sesame mutants was conducted in the farms of BINA sub-station at Ishurdi, Magura and Rangpur; and farmers' field at Jashore, Pabna and Rajshahi in 2011. Another on-station yield trial with advanced sesame mutants was conducted in the farms of BINA sub-station at Ishurdi and Magura in 2012. There were three advanced mutants (SM-10-04, SM-054 and SM-067) and two checks (Binatil-1 and BARI Til-2) were evaluated in 2011 and 2012. All these experiments were laid out in randomized complete block (RCB) design with three replications. Unit plot size was $20m^2$ (4m × 5m) keeping 25cm spacing between rows and 6-8cm among the plants in a row. Seeds were sown in 1st week of March in 2011 and 2012. Recommended production packages like application of recommended doses of fertilizers, weeding, thinning, irrigation, application of pesticide etc. were properly followed to ensure normal growth and development of the plants. Data were taken for plant height, branches plant^{-1}, capsules plant^{-1} and seeds capsule^{-1} from 10 randomly selected plants from each plot. Maturity period was counted when 80% capsules were matured and most of the plants turned into straw or yellowish color in each plot. Seed yield of each plot was recorded after proper drying and then converted into kgha^{-1}. Reactions to major disease (stem rot) and insect-pests (hairy caterpillar, hawk moth and pod borer) infestations were also studied. Appropriate statistical analyses were performed for comparison of means of each character. Using the computer program Statistix 10, an analysis of variance was performed in accordance with the experimental design. 5% level of significance was used to compare mean differences among the treatments (Gomez & Gomez, 1984).

3. RESULTS

Environmental effects on plant growth, development and yield is an important factor for crop improvement as well as developmentof new variety. Selection of desirable mutants was made from M_2 during 2003 and homogeneity was confirmed in M_5 generation during 2007. A large number of M_5 mutant variants were put into observation trial (non-replicated) at BINA headquarters farm, Mymensingh and BINA sub-station farm at Ishurdi in 2008. Five mutants, SM-03-04, SM-05-04, SM-08-04, SM-10-04 and SM-11-04 were primarily selected to put them into advanced yield trial on the basis of their desirable morphological characters and yield contributing traits compared to the mother variety.

The mean values for different characters of the mutants and checks for advanced yield trials with M_6 mutants during 2009 are presented in Table 1. The results showed significant variation among the mutants and checks for most of the characters. Among the mutants and checks, mutant SM-10-04 took the shortest maturity period of 85 days and check BARI Til-2 took the highest maturity period of 95 days. Plant height ranged from 115cm (SM-10-04) to 133cm (BARI Til-2). The number of branches is one of the most important yield contributing traits in sesame. Number of branches plant^{-1} was highest in BARI Til-2 (2.6 per plant) followed by SM-10-04 (2.5), where Binatil-1 is unicum, i.e. non-branched. It is observed that, most of the mutants are branched but the mother variety Binatil-1 is unicum, i.e. non-branched. This result revealed that induced mutation can be changed the branching habit of sesame. The mutant SM-10-04 produced the highest seed yield (1671 kgha^{-1}) followed by SM-11-04 (1584 kgha^{-1}). These two mutants had also significantly higher number of capsules plant^{-1}. Number of seeds capsules^{-1} ranged from 67 in BARI Til-2 to 93 in SM-03-04.

Table 1. Mean performance of M_6 sesame mutants and two checks for different quantitative characters at Magura in 2009

Mutants/ Varieties	Days to maturity	Plant height (cm)	No. of branches plant^{-1}	No. of capsules plant $^{-1}$	No. of seeds capsule^{-1}	Seed yield (kgha^{-1})
SM-03-04	88d	128b	0.7d	41c	93a	1411c
SM-05-04	90c	127b	1.0c	41c	83c	1062d
SM-08-04	92b	117c	1.3b	43bc	76d	1095d
SM-10-04	85e	115c	2.5a	53a	70e	1671a
SM-11-04	93b	129b	0.7d	48ab	89b	1548b
Binatil-1	88d	125b	0.0e	41c	90ab	1443c
BARI Til-2	95a	133a	2.6a	42bc	67f	1378c

Same letter (s) in a column didn't differ significantly at 5% level of probability

Table 2. Mean performance of sesame mutants and two checks for different quantitative traits in 2010

Locations	Mutants/ Varieties	Days to maturity	Plant height (cm)	No. of branches plant^{-1}	No. of capsules plant $^{-1}$	No. of seeds capsule^{-1}	Seed yield (kgha^{-1})
Magura	SM-03-04	91bc	92b	1.9c	63a	74b	1185b
	SM-10-04	89cd	109a	2.8b	58ab	73b	1328a
	SM-11-04	91b	104a	2.2c	57b	73b	1240b
	Binatil-1	88d	101ab	0.0d	49c	82a	1243b
	BARI Til-2	93a	101ab	3.2a	59ab	67c	1178b
Ishurdi	SM-03-04	84b	110a	0.0b	33c	69ab	1250c
	SM-10-04	88a	124a	2.2a	48b	64bc	1517a
	SM-11-04	85b	124a	0.0b	34c	74a	1150c
	Binatil-1	74c	116a	0.0b	58a	60c	1400ab
	BARI Til-2	89a	113a	2.4a	47b	59c	1293bc
Combined (means overtwo locations)	SM-03-04	87b	101c	1.0c	48ab	71ab	1218c
	SM-10-04	88b	117a	2.5b	53a	73a	1423a
	SM-11-04	88b	114ab	1.1c	45b	69b	1195c
	Binatil-1	81c	108bc	0.0d	53a	71ab	1322b
	BARI Til-2	91a	107bc	2.8a	53a	63c	1236c

Same letter (s) in a column didn't differ significantly at 5% level of probability

The results of on-station yield trial during 2010 for each location and combined over locations are presented in Table 2. The results showed significant variation among the mutants and two checks for all the characters at both the locations and combined over locations except plant height at Ishurdi. On an average, BARI Til-2 took the longest maturity period of 91 days and Binatil-1 took the shortest maturity period of 81 days. The mutants, SM-03-04, SM-10-04 and SM-11-04 took the maturity period of 87 days, 88 days and 88 days, respectively. The mutant SM-10-04 had the tallest plant (117cm) having non-significant difference with SM-11-04 (114cm) and SM-03-04 had the shortest plant (101cm). BARI Til-2 produced the highest number of branches (2.8) followed by SM-10-04 (2.5) while Binatil-1 was unicum. The mutant SM-10-04, Binatil-1 and BARI Til-2 produced the highest number of capsules plant^{-1} (53) having non-significant difference with SM-03-04 (48). The mutant SM-10-04 produced the highest number of seeds capsule^{-1} (73) which showed non-significant difference with Binatil-1 and SM-03-04. The lowest number of capsules plant^{-1} was observed in BARI Til-2. Finally, the mutant SM-10-04 produced the highest seed yield of 1423 kgha^{-1} followed by the check Binatil-1 (1322 kgha^{-1}) and another check BARI Til-2 produced the seed yield of 1236 kgha^{-1}.

On-station and on-farm yield trial conducted during 2011 showed significant variations for all the traits among the mutant and checks in each location and combined over locations except days to maturity. The average plant height in all locations revealed that the mutants SM-10-04, SM-058 and SM-067 were taller in height than

Binatil-1 and only SM-067 was taller than BARI Til-2. The mutant SM-10-04 had higher number of branches plant^{-1} as compared with variety Binatil-1 (unicum) and BARI Til-2. The higher number of capsules as well as higher number of seeds capsules^{-1} in SM-10-04 resulted in significantly higher seed yield in all the locations. The mutant SM-10-04 produced the highest seed yield of 1825 kgha^{-1} at Jashore and 1763 kgha^{-1} at Magura (Fig. 3).

The results of on-station yield trial during 2012 showed the significant variations for all the traits among the mutants and two checks in both locations except for days to maturity (Table 3). The tallest plant height was found in the mutants SM-058 and SM-067 at Ishurdi and Magura, respectively. The average number of branches ranged from 2.1-3.5, where the mutant SM-10-04 produced the highest number of branch. The number of capsules plant^{-1} was significantly higher 78 in the mutant SM-10-04 followed by 66 in SM-058 and SM-067 in combined means over two locations. Bearing of three capsules axils^{-1} is one of the important features of the mutant SM-10-04. The mutant SM-10-04 produced significantly higher number of capsules as well as higher number of seeds capsules^{-1} which resulted in significantly higher seed yield in both locations (average yield 1505 kgha^{-1}). The mutant SM-10-04 beard hairy stems which protect them from aphid infestation naturally.

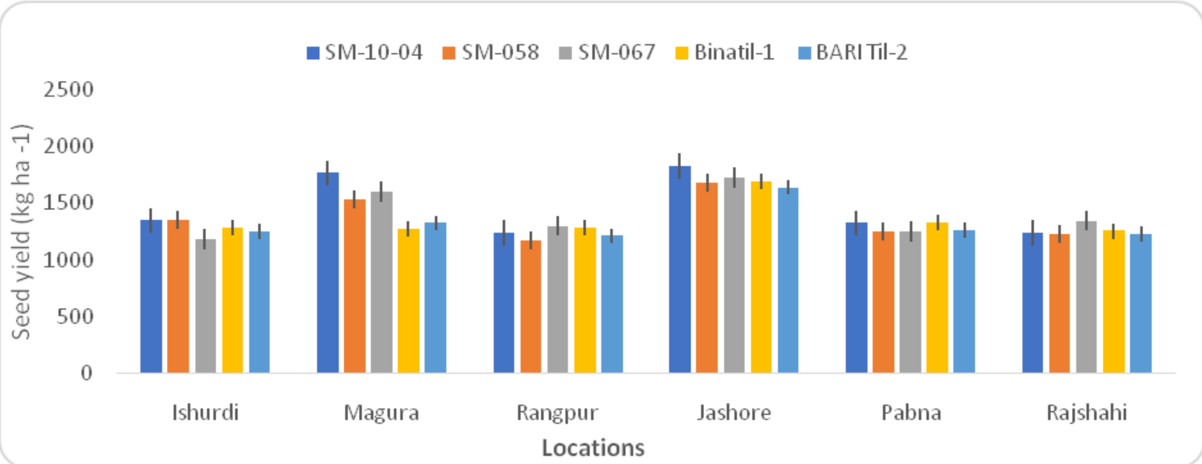

Fig. 3. Mean seed yield performance of sesame mutants at different locations during 2011

Table 3. Mean performance of sesame mutants along with two checks for different quantitative traits during 2012

Locations	Mutant/ Varieties	Days to maturity	Plant height (cm)	No. of branches plant^{-1}	No. of capsules plant^{-1}	No. of seeds capsule^{-1}	Seed yield (kgha^{-1})
Ishurdi	SM-10-04	90c	93b	3.5a	88a	67a	1450a
	SM-058	95a	95a	3.3ab	73b	63c	1360b
	SM-067	92bc	90c	2.9b	70b	65b	1260c
	Binatil-2	91bc	87d	3.4a	61c	62c	1270c
	BARI Til-2	93b	90c	3.5a	72b	58d	1280c
Magura	SM-10-04	86c	107c	2.3b	69a	76a	1560a
	SM-058	92a	108c	2.5b	64b	69b	1460b
	SM-067	91ab	113a	2.1b	61b	66c	1420b
	Binatil-2	90b	104d	3.0a	56bc	69b	1275c
	BARI Til-2	89b	111b	3.1a	54c	63d	1325c
Combined means over two locations	SM-10-04	88c	101a	2.9b	78a	72a	1505a
	SM-058	93a	102a	2.9b	66b	66b	1410b
	SM-067	91b	102a	2.5c	66b	66b	1340bc
	Binatil-2	90b	96b	3.2a	58d	65b	1273c
	BARI Til-2	91b	101a	3.3a	63c	61c	1302c

**Same letter (s) in a column didn't differ significantly at 5% level of probability*

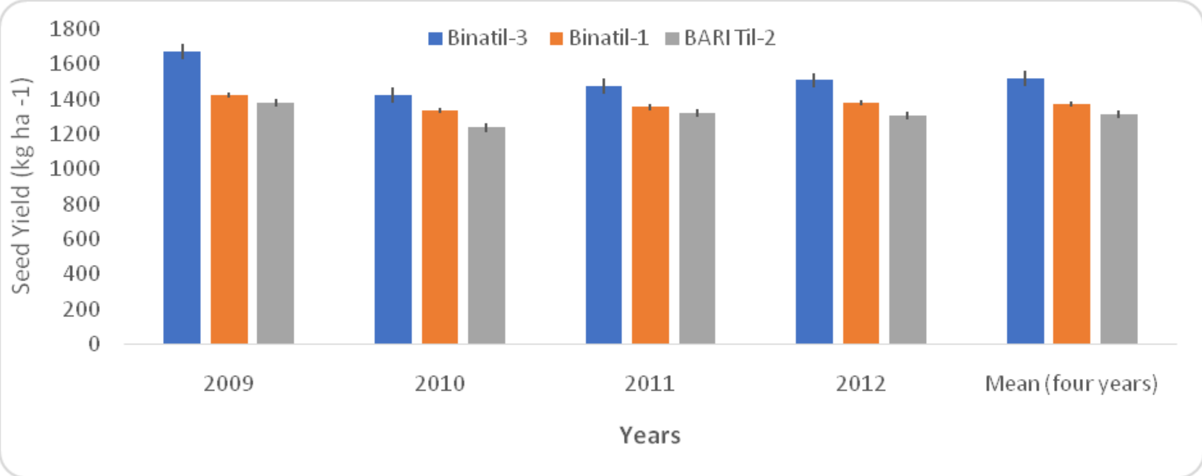

Fig. 4. Year-wise mean seed yield (kgha^{-1}) of the new variety Binatil-3 as compared to checks

Overall performance for yield and yield related attributes of the new variety, Binatil-3 has been analyzed considering the mean seed yield of all trials conducting during 2009-2012. Four years seed yield results show that the new variety Binatil-3 produced the higher mean seed yield (1518 kgha^{-1}) as well as year-wise seed yield as compared with two check varieties. Two checks, Binatil-1 and BARI Til-2 produced the seed yield (average of four years) of 1372 kgha^{-1} and 1310 kgha^{-1}, respectively (Fig. 4).

4. DISCUSSION

Many crops have benefited greatly from induced mutation, including oilseed crops like sesame (Das & Haque, 1997; Li & Chen, 1998; Mehta & Singh, 1998; Sorour et al., 1999; Govindarasu & Ramamoorthi, 2000; Sheeba et al., 2003, 2005; Chowdhury et al., 2009; Diouf et al., 2010; Begum & Dasgupta, 2010, 2011, 2014). The increases in the number of capsule was due to an increase of flowers number and yield characters in some other variety developed using gamma rays were reportedin mungbean (Tickoo & Chandra, 1999) soybean (Mehetre et al., 1999; Malek et al., 2014, 2022) and grass pea (Waghmare & Mehra, 2000). The increase in the number of capsule plant^{-1} among sesame mutants was reported by Hoballah (1999). Arslan et al. (2007) reported that the gamma-ray-induced mutants having improved plant architecture in sesame, including uniform growth habits, closed capsules, and resistance to Fusarium blight. The higher number of capsules as well as higher number of seeds capsules^{-1} in SM-10-04 resulted in significantly higher seed yield in all the locations. These results were in agreement with previous observations of Pathak and Dixit (1992) that reported a positive relationship between plant height, capsules plant^{-1} and seed yield. Positively increase in seed yield due to the effect of gamma-rays induction was also reported earlier by many researchers likes in sesame and rapeseed-mustard (Malek et al., 2012; Begum & Dasgupta, 2015; Malek,2020). Sureja and Sharma (2000), Reddy and Haripriya (1992) also reported a positive and highly significant relationship between number of seed capsule^{-1}, number of capsule plant^{-1} and seed yield plant^{-1}. Seed yield is the most important trait for development of a promising crop variety. Mutants of oilseed crops having higher seed yield over mother variety also reported in sesame (Malek, 2020). Throughout the world including Bangladesh, the utilization of gamma ray induced mutation techniques for varietal improvement of sesame (Bhuiyan et al., 2019; Malek, 2020) and other oilseed crops; particularly in soybean (Malek et al., 2022), rapeseed-mustard (Malek et al., 2016; Malek et al., 2020, Bhuiyan et al., 2021) is still underutilized. Moreover, the development of mutant variety Binatil-3 indicated the potentiality of evolving higher seed yielding variant through induce mutation.

5. CONCLUSION

The newly release mutant variety “Binatil-3” has been developed from Binatil-1. The seed coat colour of Binatil-3 is brownish but the seed coat colour of Binatil-1 is creamy and Binatil-1 is uniculm but Binatil-3 is branched. This result revealed that induced mutations can be extensively and successfully used for the improvement of sesame in respect of changing branching habit and different in seed coat colour along with higher seed yield. The mutant also showed lower incidence of insect-pests infestation. This can be considered as a milestone achievement in mutation breeding.There is an opportunity to increase cultivable land under sesame cultivation which can mitigate the challenges of increasing demand of edible oil in Bangladesh. This can be considered as a milestone achievement in mutation breeding.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

ACKNOWLEDGEMENT

The authors are sincerely acknowledged Bangladesh Institute of Nuclear Agriculture (BINA) for all the research support and facilities to conduct this experiment.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

Acquaah, G. (2012). *Principles of plant genetics and breeding* (2nd ed.). Wiley-Blackwell Publishing. 740 p.

Arslan, Ç., Uzun, B., Ülger, S., & Çağırgan, M. İ. (2007). Determination of oil content and fatty acid composition of sesame mutants suited for intensive management conditions. *Journal of the American Oil Chemists' Society*, 84, 917–920.

Ashri, A. (1994). Genetic resources of sesame: Present and future perspectives. In R. K. Arora & K. W. Riley (Eds.), *Sesame biodiversity in Asia: Conservation, evaluation and improvement* (pp. 25–39). IPGRI Office for South Asia, New Delhi, India.

Ashri, A. (1998). Sesame breeding. *Plant Breeding Review*, 16, 179–228.

Begum, T., & Dasgupta, T. (2010). A comparison on the effect of physical and chemical mutagenic treatments in sesame (*Sesamum indicum* L.). *Genetics and Molecular Biology*, 33, 761-766.

Begum, T., & Dasgupta, T. (2011). Effect of mutagens on character association in sesame (*Sesamum indicum* L.). *Pakistan Journal of Botany*, 43, 243-251.

Begum, T., & Dasgupta, T. (2014). Induced genetic variability, heritability and genetic advance in sesame (*Sesamum indicum* L.). *SABRAO Journal of Breeding and Genetics*, 46, 21–33.

Begum, T., & 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.

Bhuiyan, M. S. H., Malek, M. M., Sarkar, M. M. A., Islam, M., & Akram, M. W. (2019). Genetic variance and performance of sesame mutants for yield contributing characters. *Malaysian Journal of Sustainable Agriculture*, 3(2), 27-30.

Bhuiyan, Saikat & Malek, Md & Emon, R.M. & Khatun, Mst. (2021). Yield performance of radiation induced rapeseed mutants at M8 generation. World Journal of Biology and Biotechnology. 6. 31. 10.33865/wjb.006.03.0448.

Brigham, R. D. (1987). Status of sesame (*Sesamum indicum* L.) breeding in the USA. *Agronomy Abstracts*, Annual Meetings, 57. American Society of Agronomy, Madison, Wisconsin, (abstract).

Charlesworth, D. (2003). Effects of inbreeding on the genetic diversity of populations. *Philosophical Transactions of the Royal Society of London*, 358, 1051–1070.

Chowdhury, S., Datta, A. K., Saha, A., & Maity, S. (2009). Radiation-induced two oil rich mutants in sesame (*Sesamum indicum* L.). *Indian Journal of Science and Technology*, 2, 51-52.

Das, M. L., & Haque, M. M. (1997). Response of sesame seeds to gamma ray and EMS in M1 generation. *Bangladesh Journal of Botany*, 26, 75-78.

De Vicente, M. C., Lopez, C., & Fulton, T. (2004). *Genetic diversity analysis with molecular marker data: Learning module*. International Plant Genetic Resources Institute (IPGRI), Rome, Italy.

Diouf, M., Boureima, S., Diop, T., &Çağırgan, M. (2010). Gamma rays-induced mutant spectrum and frequency in sesame. *Turkish Journal of Field Crops*, 15, 99-105.

El Khier, M. K. S., Ishag, K. E. A., & Yagoub, A. E. A. (2008). Chemical composition and oil characteristics of sesame seed cultivars grown in Sudan. *Research Journal of Agriculture and Biological Sciences*, 4(6), 761-766.

FAOSTAT. (2024). *Statistical database*. Food and Agricultural Organization of the United Nations. http://faostat.fao.org

Forster, B. P., & Shu, Q. Y. (2012). Plant mutagenesis in crop improvement: Basic terms and applications. In Q. Y. Shu, B. P. Forster, & H. Nakagawa (Eds.), *Plant mutation breeding and biotechnology* (pp. 9-20). CAB International & FAO.

Gaafar, R. M., Hamouda, M., & Badr, A. (2016). Seed coat color, weight and eye pattern inheritance in gamma-rays induced cowpea M2-mutant line. *Journal of Genetic Engineering and Biotechnology*, 14(1), 61–68.

Global Agri Systems. (2010). *Dehulled and roasted sesame seed oil processing unit*. 18/08/11.

Gomez, K. A., & Gomez, A. A. (1984). *Statistical procedures for agricultural research*. John Wiley & Sons, USA.

Govindarasu, R., & Ramamoorthi, N. (2000). Increased genetic variability following hybridization and mutagenesis in sesame. *Indian Journal of Genetics*, 60, 251-253.

Hoballah, A. A. (1999). Selection and agronomic evaluation of induced mutant lines of sesame. In *Induced mutations for sesame improvement* (IAEA-TECDOC, pp. 71-84). International Atomic Energy Agency (IAEA), Vienna.

Indriatama, W. M., Trikoesoemaningtyas, S. I., Aisyah, H., & Human, S. (2016). Pendugaan ragam genetik dan heritabilitaskarakteragronomigandum (*Triticum aestivum* L.) hasilberbagaiperlakuanteknikiradiasisinar gamma. *JurnalIlmiahAplikasiIsotop dan Radiasi*, 12(2), 79–88.

Johnson, L. A., Suleiman, T. M., & Lusas, E. W. (1979). Sesame protein: A review and prospectus. *Journal of the American Oil Chemists' Society*, 56, 463–468.

Kang, C. W., Rho, J. H., Lee, S. W., Park, C. B., Lee, J., et al. (1998). A high oil, linoleic fatty acid content and yielding new sesame mutant variety "Jangbaeckkae". *RDA Journal of Industrial Crop Science*, 40, 83–88.

Koffi Dossou, S. S., Xu, F. T., Dossa, K., Rong, Z., Zhao, Y. Z., & Wang, L. H. (2023). Antioxidant lignans sesamin and sesamolin in sesame (*Sesamum indicum* L.): A comprehensive review and future prospects. *Journal of Integrative Agriculture*, 22(1), 14–30. https://doi.org/10.1016/j.jia.2022.08.097

Langyan, S., Yadava, P., Sharma, S., Gupta, N. C., Bansal, R., Yadav, R., Kalia, S., & Kumar, A. (2022). Food and nutraceutical functions of sesame oil: An underutilized crop for nutritional and health benefits. *Food Chemistry*, 389, Article 132990. https://doi.org/10.1016/j.foodchem.2022.132990

Laskar, R. A., & Khan, S. (2017). Assessment on induced genetic variability and divergence in the mutagenized lentil populations of micro sperma and macrosperma cultivars developed using physical and chemical mutagenesis. *PLoS ONE, 12*(9), 1–18.

Li, Y., & Chen, Q. M. (1998). Induction of male sterility mutation in sesame (*Sesamum indicum* L.) and a preliminary study of the genetics of the mutation. *Chinese Journal of Oil Crop Science, 20*, 24–27.

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., et al. (2012a). 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. (2020). Yield performance of rapeseed mutant at M8 generation. *Bangladesh Journal of Nuclear Agriculture, 33 & 34*, 73–82.

Malek, M. A., Emon, R. M., Khatun, M. K., Bhuiyan, M. S. H., Nevame, A. Y. M., et al. (2022). Binasoybean-6: A high yielding mutant soybean variety developed through sustainable mutation breeding. *Legume Research*. https://doi.org/10.18805/LRF-651

Malek, M. A., Rafii, M. Y., Afroz, M. S. S., Nath, U. K., & Mondal, M. M. A. (2014). Morphological characterization and assessment of genetic variability, character association and divergence in soybean mutants. *The Scientific World Journal, 2014*, 1–12.

Malek, M., Rafii, M., & Khatun, M. (2016). Selection of rapeseed mutants for higher yield and yield contributing traits. *Journal* *of the Bangladesh Agricultural University, 14*(2), 141–146.

Mehetre, S. S., Mahajan, C. R., Shinde, R. B., & Ghatge, R. D. (1999). Assessment of gamma induced genetic divergence in M2 generation of soybean. *Indian Journal of Genetics, 56*, 186–190.

Mehta, A. K., & Singh, C. B. (1998). A gamma irradiated dichotomously branched plant type in *Sesamum*. *Plant Science, 11*, 233–235.

Miao, H., Wang, L., Qu, L., Liu, H., Sun, Y., Le, M., Wang, Q., Wei, S., Zheng, Y., Lin, W., Duan, Y., Cao, H., Xiong, S., Wang, X., Wei, L., Li, C., Ma, Q., Ju, M., Zhao, R., Li, G., Mu, C., Tian, Q., Mei, H., Zhang, T., Gao, T., Zhang, H. (2024). Genomic evolution and insights into agronomic trait innovations of *Sesamum* species. *Plant Communications, 5*(1), Article 100729. https://doi.org/10.1016/j.xplc.2023.100729

Miyake, Y., Fukumoto, S., Okada, M., Sakaida, K., Nakamura, Y., et al. (2005). Antioxidative catechol lignans converted from sesamin and sesaminoltriglucoside by culturing with *Aspergillus*. *Journal of Agriculture and Food Chemistry, 53*, 22–27.

Mostashari, P., & Mousavi Khaneghah, A. (2024). Sesame seeds: A nutrient-rich superfood. *Foods, 13*(8), 1153.

Ong'injo, E. O., &Ayiecho, P. O. (2009). Genotypic variability in sesame mutant lines in Kenya. *African Crop Science Journal, 17*, 101–107.

Pathak, H. C., & Dixit, S. K. (1992). Genetic variability and interrelationship studies in black seeded sesame (*Sesamum indicum* L.).*MadrasAgriculturalJournal,79*,94–100.

Reddy, C. D. R., & Haripriya, S. (1992). Genetic character association and path coefficient analysis in parents and their F1 sesame. *Journal of Maharashtra Agricultural University, 17*, 55–57.

Savant, K. D., &Kothekar, V. S. (2011). Induction of variability in fatty acid profile in sesame (*Sesamum indicum* L.). *Journal of Phytology, 3*, 1–3.

Sheeba, A., Anbumalarmathi, J., Babu, S., & Ibrahim, S. M. (2005). Mutagenic effect of gamma rays and EMS in M1 generation in sesame (*Sesamum indicum* L.). *Research on Crops, 6*, 303–306.

Sheeba, A., Ibrahim, S. M., &Yogameenakshi, P. (2003). Induced chlorophyll mutation studies in sesame (*Sesamum indicum* L.). *Sesame and Safflower Newsletter, 18*, 33–38.

Sorour, W. A. I., Hussein, M. H., & El-imam, M. A. (1999). Gamma-ray induced mutations in sesame (*Sesamum indicum* L.) I. Selection of useful mutants. *Bulletin Faculty Agriculture University of Cairo, 50*, 516–531.

Sureja, A. K., & Sharma, R. R. (2000). Genetic variability and heritability studies in garden pea (*Pisum sativum* L.). *Indian Journal of Horticulture, 57*, 243–247.

Tickoo, J. L., & Chandra, N. (1999). Mutagen induced polygenic variability in Mungbean (*Vigna radiata* (L.) Wilczek). *The Indian Journal of Genetics and Plant Breeding, 59*(2), 193–201.

Waghmare, V. N., & Mehra, R. B. (2000). Induced genetic variability for quantitative characters in grass pea (*Lathyrus sativus* L.). *Indian Journal of Genetics, 60*(1), 81–87.

Wan, Y., Zhou, Q., Zhao, M., & Hou, T. (2023). Byproducts of sesame oil extraction: Composition, function, and comprehensive utilization. *Foods, 12*(12), 2383. https://doi.org/10.3390/foods12122383

Wang, X., Wang, S., Lin, Q., Lu, J., Lv, S., Zhang, Y., Wang, X., Fan, W., Liu, W., Zhang, L., Zhang, X., You, J., Cui, P., & Li, P. (2023). The wild allotetraploid sesame genome provides novel insights into evolution and lignan biosynthesis. *Journal of Advanced Research, 50*, 13–24. https://doi.org/10.1016/j.jare.2022.10.004

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The peer review history for this paper can be accessed here:
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