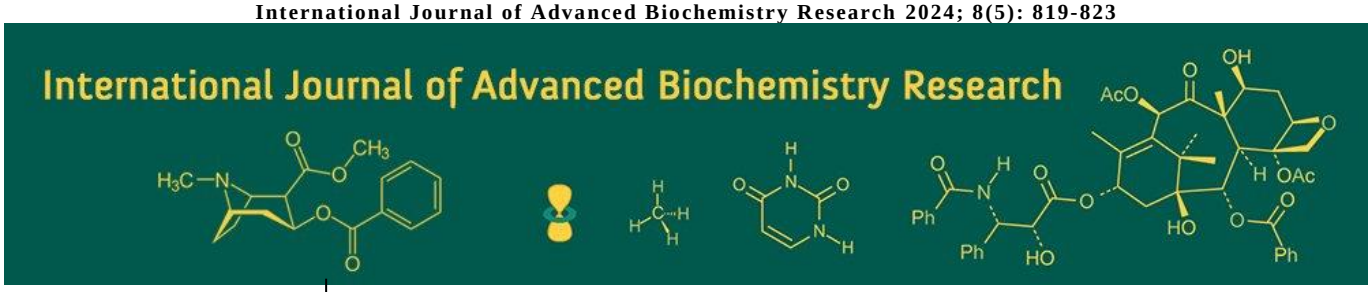

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Estimation of heritability and genetic advance in mutant populations of sesame (*Sesamum indicum* L.)

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Abstract
An experiment was carried out to estimate the heritability and genetic advance in mutant populations of sesame (*Sesamum indicum* L.) with regard to yield and its components. The study involved three sesame cultivars: GT-10, TKG-22, and Gophya Local, which were exposed to various doses of gamma radiation (400Gy, 500Gy, 600Gy, and 700Gy) at the Bhabha Atomic Research Centre (BARC) in Trombay, Mumbai. The M_2 generation was cultivated along with control during the *Kharif* season of 2020. In cultivar GT-10, high GCV was recorded for seed yield per plant, followed by the number of branches per plant. The highest PCV was noted for seed yield per plant, followed by the number of branches per plant, the number of capsules per plant, and the number of seeds per capsule. For cultivar TKG-22, high GCV was observed for seed yield per plant, followed by the number of capsules per plant. The highest PCV was seen for seed yield per plant, followed by the number of capsules per plant, the number of branches per plant, and the number of seeds per capsule. In the Gophya Local cultivar, a moderate GCV was observed for the number of capsules per plant, followed by seed yield per plant and the number of seeds per capsule, while high PCV was recorded for the number of capsules per plant, followed by seed yield per plant. Traits such as seed yield per plant, number of branches per plant, capsule length, and number of seeds per capsule in genotype GT-10 showed high heritability with a significant genetic advance as percentage of the mean. Similarly, in genotype TKG-22, traits like seed yield per plant and the number of capsules per plant exhibited high heritability coupled with a substantial genetic advance as percentage of the mean. This indicates the presence of additive gene action, suggesting that phenotypic selection for these traits would be effective for future breeding programs.

Keywords: Genetic variability, genetic advance, heritability, GCV, PCV, gamma rays

Introduction
Sesame (*Sesamum indicum* L.) is an ancient domesticated oilseed crop known worldwide as the "Queen of oilseeds." Its seeds are a rich source of healthy fats, protein, B vitamins, minerals, fibre, antioxidants, and other beneficial plant compounds (Bedigian and Harlan, 1986) [3]. Sesame consumption is steadily increasing due to its unique nutritional values, including high contents of vitamins A and E, minerals, fibre, desirable fatty acids, carbohydrates (~13.5%), and protein (~24%). Furthermore, population pressure, urbanization, and changing lifestyles have increased the global demand for sesame products. Approximately 70% of the world's sesame seeds are processed to produce food oil, while the seedcake left after oil processing is used to prepare livestock meals. Global annual human consumption of sesame is about 65% in the form of processed food oil and 35% as grain (Teklu *et al*., 2022) [16].

Sesame is cultivated in tropical and subtropical countries, mainly in the hotter and drier parts of Africa, India, and the Mediterranean region. In India, sesame yields are very low, making the evolution of high-yielding, high-oil content, and short-duration cultivars a primary objective. Sesame being a self-pollinated crop species, there is a lack of genetic variability. Attempts have been made to generate variability through crossbreeding, but the desired success has not been achieved yet. Conventional breeding methods rely on natural genetic variability due to spontaneous mutations or hybridization. Moreover, mutagenesis is an effective tool for improving the genetic architecture of plants in a short time (Uzun *et al*., 2003) [17].

The assessment of variability shall be carried out through biometrical techniques, namely the Genotypic Coefficient of Variation (GCV) and the Phenotypic Coefficient of Variation (PCV). Small differences between GCV and PCV indicate minimal environmental influence. Variability in terms of GCV and PCV alone is insufficient to determine the amount of heritable variability, so heritability must be estimated to provide precise information about the extent to which a particular genetic character can be transmitted to successive generations. Heritability estimates may sometimes be misleading; therefore, an estimation of heritability coupled with genetic advance estimates is required to assess the heritable portion of the total variation. The genetic variability offered by mutagenic agents is of extreme importance in plant breeding. Treating biological materials with different mutagenic agents significantly increases the variability in quantitative characters. Estimating the extent of heritability and genetic advance in the mutant population of the M_2 generation will provide valuable information for further selection and breeding for improvement in sesame.

Materials and Methods

The experimental material included in this study comprised three cultivars of sesame: GT-10, TKG-22, and Gophya Local. Dry, uniform seeds of these cultivars were irradiated with 400Gy, 500Gy, 600Gy, and 700Gy gamma rays at BARC (Bhabha Atomic Research Centre), Trombay, Mumbai. Untreated seeds of each variety served as the control. The seeds of each treatment were sown in the field to raise the M_1 generation, following a Randomized Block Design with five replications, along with the control. The M_2 generation was raised during *Kharif*, 2020, from seeds harvested in the M_1 generation. The study aimed to estimate heritability and genetic advance in the M_2 generation of three sesame cultivars. In the M_2 generation, seeds were sown in fifteen rows of 5.0 m length with 30 cm spacing between rows and 10 cm between plants in five replications of randomized block design. Observations were recorded for different characters like days to 50% flowering, days to maturity, plant height, number of branches per plant, number of capsules per plant, length of capsule, number of seeds per capsule, 1000 seed weight (g), and seed yield per plant. The phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were computed using the formulae suggested by Burton (1952) [5]. Heritability in the broad sense was computed for each character using the formula suggested by Lush (1940) [7]. Genetic advance (GA) for a particular trait was estimated by adopting the method suggested by Johnson *et al*. (1955) [6].

Results and Discussion

Among different methods available to detect the induced variability in the mutagenic population, mean and components of variance serve as suitable statistical parameters (Scossiroli, 1977) [13]. The genotypic coefficient of variation provides a means to study the genetic variability generated in quantitative characters (Johnson *et al*., 1955) [6].

The parameters of genetic variability were further elaborated with the help of statistics like range, mean, coefficient of variability, heritability, genetic advance, and genetic advance as percent of mean for all three cultivars, *i.e*., GT-10, TKG-22, and Gophya Local, for all characters as shown in Tables 1, 2, and 3, respectively.

Coefficients of Variation

The genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) revealed that PCV was higher than GCV for all characters in the M_2 generation.

Cultivar GT-10: GCV ranged from 3.56% (days to maturity) to 32.04% (seed yield per plant). High GCV was observed for seed yield per plant (32.04%) followed by the number of branches per plant (24.24%). Moderate GCV was observed for the number of seeds per capsule (18.40%) followed by the number of capsules per plant (17.87%), capsule length (12.28%), and plant height (11.69%). Low GCV was observed for days to maturity (3.56%), oil content (3.73%), 1000 seed weight (6.39%), and days to 50% flowering (7.36%). PCV ranged from 4.06% (oil content) to 37.02% (seed yield per plant). High PCV was observed for seed yield per plant (37.02%) followed by the number of branches per plant (29.45%), number of capsules per plant (25.19%), and number of seeds per capsule (23.50%). Moderate PCV was observed for plant height (17.66%) followed by capsule length (14.42%). Low PCV was observed for oil content (4.06%) followed by days to maturity (5.44%), 1000 seed weight (7.58%), and days to 50% flowering (8.60%) (Table 1).

Cultivar TKG-22: GCV ranged from 1.77% (oil content) to 27.42% (seed yield per plant). High GCV was observed for seed yield per plant (27.42%) followed by the number of capsules per plant (21.03%). Moderate GCV was observed for the number of branches per plant (19.49%) followed by the number of seeds per capsule (11.94%). Low GCV was observed for oil content (1.77%) followed by days to maturity (3.56%), days to 50% flowering (4.76%), 1000 seed weight (6.03%), capsule length (6.90%), and plant height (9.89%). PCV ranged from 2.28% (oil content) to 33.19% (seed yield per plant). High PCV was observed for seed yield per plant (33.19%) followed by the number of capsules per plant (26.34%), number of branches per plant (26.20%), and number of seeds per capsule (20.38%). Moderate PCV was observed for plant height (15.60%). Low PCV was observed for oil content (2.28%) followed by days to maturity (4.67%), days to 50% flowering (6.96%), 1000 seed weight (7.30%), and capsule length (9.76%) (Table 2).

Genotype Gophya Local: GCV ranged from 2.07% (oil content) to 19.18% (number of capsules per plant). Moderate GCV was observed for the number of capsules per plant (19.18%) followed by seed yield per plant (18.56%) and number of seeds per capsule (11.41%). Low GCV was observed for oil content (2.07%), days to maturity (3.39%), 1000 seed weight (4.00%), days to 50% flowering (4.86%), capsule length (7.39%), and plant height (9.91%). PCV ranged from 2.87% (oil content) to 26.81% (number of capsules per plant). High PCV was observed for the number of capsules per plant (26.81%) followed by seed yield per plant (26.05%). Moderate PCV was observed for the number of seeds per capsule (17.53%) followed by plant height (15.85%) and capsule length (11.13%). Low PCV was observed for oil content (2.87%), days to maturity (5.07%), 1000 seed weight (5.22%), and days to 50% flowering (7.06%) (Table 3).

The phenotypic and genotypic coefficient of variation (PCV and GCV) for various traits were analyzed in the M_2 generation. High GCV and PCV were noted for seed yield

per plant and the number of branches per plant in the GT-10 cultivar, as well as for seed yield per plant and the number of capsules per plant in the TKG-22 cultivar. These findings align with previous research by Anitha and Manivannan (2014) [1] and Sanghani *et al*. (2016) [12], who reported high GCV and PCV for the number of branches per plant, seed yield per plant, and the number of capsules per plant. Similar results were found by Maibam *et al.* (2018) [8] for seed yield per plant and the number of capsules per plant, and by Patil and Lokesha (2018) [11] for seed yield per plant and the number of capsules per plant. Additionally, Mohanty *et al*. (2020) [10] reported high GCV and PCV for seed yield per plant, the number of capsules per plant, and the number of branches per plant.

Moderate GCV and PCV were observed for plant height, the number of seeds per capsule, the number of capsules per plant, and capsule length in the GT-10 cultivar. The TKG-22 cultivar showed moderate GCV and PCV for the number of branches per plant and the number of seeds per capsule, while the Gophya Local genotype showed moderate values for seed yield per plant, the number of capsules per plant, and the number of seeds per capsule. These observations are consistent with the findings of Vanishree *et al*. (2013) [18], Patil and Lokesha (2018) [11], and Mohanty *et al*. (2020) [10], who reported moderate GCV and PCV for plant height and the number of seeds per capsule in sesame.

Low GCV and PCV were recorded for days to 50% flowering, days to maturity, 1000-seed weight, and oil content across all three cultivars. These results corroborate the findings of Sheeba *et al*. (2003) [14], Singh *et al*. (2020) [15], and Sanghani *et al*. (2016) [12] in sesame. Mohanty *et al*. (2020) [10] also reported low GCV and PCV for days to 50% flowering and days to maturity in sesame.

Heritability (%)

In the GT-10 cultivar, the heritability of various traits showed significant variation, ranging from 42.71% for days to maturity to 84.45% for oil content. The traits with the highest heritability estimates were oil content (84.45%), seed yield per plant (74.90%), days to 50% flowering (73.32%), capsule length (72.50%), 1000 seed weight (70.99%), number of branches per plant (67.71%), and number of seeds per capsule (61.31%). Traits with moderate heritability included the number of capsules per plant (50.34%), plant height (43.84%), and days to maturity (42.71%).

For the TKG-22 cultivar, heritability ranged from 34.28% for the number of seeds per capsule to 68.26% for seed yield per plant. High heritability estimates were observed for seed yield per plant (68.26%), 1000 seed weight (68.24%), number of capsules per plant (63.73%), and oil content (60.18%). Moderate heritability was recorded for the number of branches per plant (55.32%), capsule length (49.97%), days to 50% flowering (46.81%), days to maturity (40.73%), plant height (40.17%), and the number of seeds per capsule (34.28%).

In the Gophya Local genotype, heritability estimates varied from 39.06% for plant height to 58.66% for 1000 seed weight. None of the traits in this genotype showed high heritability. Moderate heritability estimates were found for 1000 seed weight (58.66%), oil content (51.70%), number of capsules per plant (51.21%), seed yield per plant (50.73%), days to 50% flowering (47.34%), days to maturity (44.73%), and plant height (39.06%).

Genetic Advance

In the GT-10 cultivar, the genetic advance ranged from 0.30% (1000 seed weight) to 18.10% (plant height) for various characters under study. None of the characters in the GT-10 cultivar recorded high genetic advance. Moderate genetic advance was observed for plant height (18.10%), followed by the number of seeds per capsule (17.10%), and the number of capsules per plant (16.20%). Low genetic advance was recorded for 1000 seed weight (0.30%), followed by capsule length (0.50%), number of branches per plant (1.70%), seed yield per plant (2.90%), oil content (3.40%), days to maturity (4.40%), and days to 50% flowering (5.80%).

In the TKG-22 cultivar, genetic advance ranged from 0.30% (1000 seed weight) to 17.60% (number of capsules per plant) for various characters under study. None of the characters in the TKG-22 cultivar recorded high genetic advance. Moderate genetic advance was recorded for the number of capsules per plant (17.60%), followed by plant height (13.40%). Low genetic advance was recorded for 1000 seed weight and capsule length (0.30%), followed by the number of branches per plant and oil content (1.40%), days to 50% flowering (2.90%), seed yield per plant (3.10%), days to maturity (3.30%), and number of seeds per capsule (8.10%).

In the Gophya Local genotype, genetic advance ranged from 0.20% (1000 seed weight and capsule length) to 14.90% (plant height) for various characters under study. None of the characters in the Gophya Local genotype recorded high genetic advance. Moderate genetic advance was recorded for plant height (14.90%), followed by the number of capsules per plant (12.30%). Low genetic advance was recorded for 1000 seed weight and capsule length (0.20%), followed by oil content (1.40%), seed yield per plant (1.50%), days to 50% flowering (3.50%), days to maturity (4.80%), and number of seeds per capsule (7.90%).

Genetic Advance as Percent of Mean

In the GT-10 cultivar, genetic advance as percent of mean ranged from 4.79% (days to maturity) to 57.13% (seed yield per plant) for various characters under study. The high estimates of genetic advance as percent of mean were obtained for seed yield per plant (57.13%), followed by the number of branches per plant (41.09%), number of seeds per capsule (29.68%), number of capsules per plant (26.12%), and capsule length (21.53%). Moderate genetic advance as percent of mean was recorded in plant height (15.95%), followed by days to 50% flowering (12.98%) and 1000 seed weight (11.09%). The character days to maturity (4.79%) and oil content (7.06%) exhibited low genetic advance as percent of mean.

In the TKG-22 cultivar, genetic advance as percent of mean ranged from 2.83% (oil content) to 46.68% (seed yield per plant) for various characters under study. The high estimates of genetic advance as percent of mean were obtained for seed yield per plant (46.68%), followed by the number of capsules per plant (34.59%), and the number of branches per plant (29.86%). Moderate genetic advance as percent of mean was recorded in the character number of seeds per capsule (14.40%), followed by plant height (12.91%), 1000 seed weight (10.26%), and capsule length (10.05%). The character oil content (2.83%), followed by days to maturity (3.92%) and days to 50% flowering (6.71%), exhibited low genetic advance as percent of mean.

In the Gophya Local genotype, genetic advance as percent of mean ranged from 3.06% (oil content) to 28.28% (number of capsules per plant) for various characters under study. The high estimates of genetic advance as percent of mean were obtained for the character number of capsules per plant (28.28%), followed by seed yield per plant (27.23%). Moderate genetic advance as percent of mean was recorded in the character number of seeds per capsule (15.28%), followed by plant height (12.75%), and capsule length (10.10%). The character oil content (3.06%), followed by days to maturity (4.67%), 1000 seed weight (6.31%), and days to 50% flowering (6.88%) exhibited low genetic advance as percent of mean.

In the present investigation, GCV (%), PCV (%), heritability, genetic advance, and genetic advance as percent of mean were estimated in the M_2 generation. The trait seed yield per plant, number of branches per plant, capsule length, and number of seeds per capsule in the GT-10 genotype showed high heritability with high genetic advance as percent of mean. In the TKG-22 genotype, the trait seed yield per plant and the number of capsules per plant showed high heritability with high genetic advance as percent of mean, indicating the presence of additive gene action. In the Gophya Local genotype, none of the traits recorded high heritability with high genetic advance as percent of mean. These results were in accordance with the findings reported by Babu (2005) [2] and Mary and Jayabalan (1995) [9] for the number of branches per plant, Sanghani *et al*. (2016) [12] for the number of capsules per plant and seed yield per plant in the M_2 generation of sesame genotypes GT-2, Param, and Vikrant, and Maibam *et al*. (2018) [8] for the number of capsules per plant. Vasline *et al*. (2000) [19] also reported similar results for the number of branches per plant, number of capsules per plant, and seeds per capsule. Anitha and Manivannan (2014) [1] found high heritability for the number of capsules per plant and seeds per capsule. Sheeba *et al*. (2003) [14] reported high heritability and genetic advance for capsule length in the sesame variety Co-1 in the M_2 generation. Boranayaka *et al*. (2010) [4] reported high heritability and moderate genetic advance for the characters number of capsules per plant and capsule length in the sesame variety SVPR-1 in the M_2 generation. High heritability and genetic advance for a character would indicate the predominance of additive gene action on the trait, making it likely to respond effectively to phenotypic selection (Johnson *et al*., 1955) [6].

Table 1: Estimates of genetic parameters for various yield and its contributing characters in M_2 generation of cv.GT-10

Sr. No.	Characters	Mean	Range		GCV (%)	PCV (%)	Heritability (%)	Genetic advance (%)	GAM (%)
			Min	Max					
1)	Days to 50% flowering	44.84	36.00	52.00	7.36	8.60	73.32	5.80	12.98
2)	Days to maturity	91.88	81.00	102.00	3.56	5.44	42.71	4.40	4.79
3)	Plant height (cm)	113.76	75.00	153.00	11.69	17.66	43.84	18.10	15.95
4)	No. branches/plant	4.09	2.40	6.80	24.24	29.45	67.71	1.70	41.09
5)	No. of capsules/plant	62.20	35.00	98.00	17.87	25.19	50.34	16.2	26.12
6)	Capsule length (cm)	2.28	1.70	2.80	12.28	14.42	72.50	0.50	21.53
7)	No. of seeds/capsule	57.52	34.00	80.00	18.40	23.50	61.31	17.10	29.68
8)	1000 seed weight (g)	2.71	2.20	3.00	6.39	7.58	70.99	0.30	11.09
9)	Oil content (%)	47.47	44.20	50.10	3.73	4.06	84.45	3.40	7.06
10)	Seed yield/plant (g)	5.12	2.36	9.45	32.04	37.02	74.90	2.90	57.13

Table 2: Estimates of genetic parameters for various yield and its contributing characters in M_2 generation of cv.TKG-22

Sr. No.	Characters	Mean	Range		GCV (%)	PCV (%)	Heritability (%)	Genetic advance (%)	GAM (%)
			Min	Max					
1)	Days to 50% flowering	43.36	38.00	51.00	4.76	6.96	46.81	2.90	6.71
2)	Days to maturity	83.96	77.00	94.00	2.98	4.67	40.73	3.30	3.92
3)	Plant height (cm)	104.00	75.00	134.00	9.89	15.60	40.17	13.40	12.91
4)	No. branches/plant	4.64	2.80	7.40	19.49	26.20	55.32	1.40	29.86
5)	No. of capsules/plant	50.97	32.00	75.00	21.03	26.34	63.73	17.60	34.59
6)	Capsule length (cm)	2.52	1.90	2.83	6.90	9.76	49.97	0.30	10.05
7)	No. of seeds/capsule	56.34	37.00	78.00	11.94	20.38	34.28	8.10	14.40
8)	1000 seed weight (g)	2.95	2.45	3.25	6.03	7.30	68.24	0.30	10.26
9)	Oil content (%)	50.48	48.25	52.80	1.77	2.28	60.18	1.40	2.83
10)	Seed yield/plant (g)	6.62	2.64	11.24	27.42	33.19	68.26	3.10	46.68

Table 3: Estimates of genetic parameters for various yield and its contributing characters in M_2 generation of cv. Gophya Local

Sr. No.	Characters	Mean	Range		GCV (%)	PCV (%)	Heritability (%)	Genetic advance (%)	GAM (%)
			Min	Max					
1)	Days to 50% flowering	50.28	44.00	57.00	4.86	7.06	47.34	3.50	6.88
2)	Days to maturity	101.88	91.00	109.00	3.39	5.07	44.73	4.80	4.67
3)	Plant height (cm)	116.48	80.00	154.00	9.91	15.85	39.06	14.90	12.75
4)	No. of capsules/plant	45.35	23.00	65.00	19.18	26.81	51.21	12.30	28.28
5)	Capsule length (cm)	2.38	1.85	2.80	7.39	11.13	44.07	0.20	10.10
6)	No. of seeds/capsule	51.56	40.00	66.00	11.41	17.53	42.31	7.90	15.28
7)	1000 seed weight (g)	2.85	2.55	3.10	4.00	5.22	58.66	0.20	6.31
8)	Oil content (%)	46.50	43.30	49.32	2.07	2.87	51.70	1.40	3.06
9)	Seed yield/plant (g)	5.41	2.80	8.96	18.56	26.05	50.73	1.50	27.23

Conclusion

The investigation into the sesame cultivars GT-10, TKG-22, and Gophya Local in the M_2 generation revealed significant genetic variability, heritability, and genetic advance for various traits. Overall, the study underscores the potential for significant genetic improvement in sesame through targeted selection of key traits. The observed high heritability and genetic advance for important yield-related traits in the GT-10 and TKG-22 cultivars suggest these genotypes can be effectively improved through simple phenotypic selection. The findings align with previous research, reinforcing the reliability of the results and providing a strong foundation for future breeding programs aimed at enhancing sesame productivity and quality.

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