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Exploring Transgressive Segregation for Enhanced Yield in F_2 Segregants of Sesame (*Sesamum indicum* L.)

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Authors' contributions

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

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ABSTRACT

The experiment involved F_2 generation of three superior crosses of sesame: Thilak X Ayali 1, Thilathara X Ayali 2 and Thilak X Ayali 5, grown in a Compact Family Block Design. A total of 200 plants were grown with a spacing of 30 x 25 cm, and observations were recorded on yield related characters. Significant variation was found among most traits, except for capsule length, capsule

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width, number of seeds per capsule and the number of primary branches. The cross Thilathara X Ayali 2 exhibited a high frequency of transgressive segregants for multiple traits, particularly for seed yield per plant, making it highly promising for further breeding efforts. Plant height had the highest mean and range, showing considerable potential for selection. CV analysis revealed high variability for traits like the number of capsules per plant and seed yield per plant. In contrast, low variability and high stability was observed for traits like capsule length, number of seeds per capsule and days to maturity. Higher PCV and GCV were recorded for traits like days to first flowering, number of capsules per plant, and seed yield per plant, showing substantial genetic and environmental influences. Moderate PCV and GCV were found for plant height and days to maturity, while traits like capsule length, number of seeds per capsule, and capsule width had the lowest PCV and GCV, indicating limited genetic variation. Days to first flowering and days to maturity showed high heritability combined with high genetic advance, suggesting the preponderance of additive gene action and are ideal for simple selection. Traits like capsule length, capsule width, and number of seeds per capsule showed low heritability and genetic advance, making them less ideal for selection. The cross, Thilathara X Ayali 2 should be prioritized in future generations to recover desirable segregants, especially for economically important traits like seed yield.

Keywords: Sesame; F2 segregants; GCV; PCV; total transgressive segregants (TTS); significantly transgressive segregants (STS).

1. INTRODUCTION

Sesamum (*Sesamum indicum* L.), one of the most ancient oil crops, has been referred to as the 'queen of oilseeds' by virtue of its high-quality oil. It has been under cultivation in Asia for over 5,000 years [1]. India is very rich in diversity in cultivated sesame. Its domestication started from the wild progenitor *Sesamum malabaricum* in the Indian subcontinent about 5000 years ago.

Sesame is rich in oil (50%) and protein (18-20%). Nearly 78% of the sesame seed produced in India is used for oil extraction, 21.5% for sowing purpose and rest is used in confections and in religious Hindu ceremonies. Nearly 73% of the oil is used for edible purposes, 8.8% for hydrogenation and 4.2% for industrial purpose in the manufacture of paints, pharmaceuticals and insecticides. Seeds are eaten fried and mixed with sugar and in several forms in sweet meats. The oil is an important cooking oil in south India.

The success of any crop improvement program largely hinges on the nature and extent of genetic variability within the crop. In often-cross pollinated crops like sesame, the natural variability for yield and its component traits is quite limited. Therefore, assessing the genetic variation for yield and related traits, along with their heritability and genetic advance, is crucial for breeders. The F_2 generation is ideal for obtaining superior transgressive segregants, as the segregation pattern in a cross reveal the genetic diversity and assists breeders in identifying outstanding individual plants. The evaluation of yield potential of a genotype as early as possible after hybridization is more advantageous since the frequency of a superior genotype is greater in early generations than in later ones. Moreover, the selection for quantitatively inherited characters such as yield is not efficient in early generations, mainly attributed to the masking effect of heterosis, the segregation due to heterozygosity and the large environmental influence. Early generation selection for yield starts in F_2 on a single plant basis and on a family basis as early as F_3. Single plant selection can be attempted because each plants represents a distinct genotype.

2. MATERIALS AND METHODS

The experimental material consists of F_2 segregants of three superior crosses of sesame derived from a LXT analysis including Thilak X Ayali 1, Thilathara X Ayali 2 and Thilak X Ayali 5. The segregating population was laid out in a Compact Family Block Design during February - May 2024 in the experimental plot of Department of Genetics and Plant Breeding, College of Agriculture, Vellayani. Altogether 200 plants were maintained. Seeds were sown in rows at a spacing of 30 X 25 cm. Biometric observations were recorded for nine characters *viz,* days to first flowering, number of primary branches, number of capsules per plant, capsule length (cm), capsule width (cm), number of seeds per capsule, days to maturity, plant height (cm) and seed yield per plant (g). The data were subjected to analysis of variance (ANOVA) and various genetic parameters were worked out using GRAPES software, version 1.1.0 [2].

The data was subjected to Bartlett's test of homogeneity [3], since it revealed significance, pooled RBD Analysis of variance was performed using 3 families Thilak X Ayali 1, Thilathara X Ayali 2 and Thilak X Ayali 5 as treatments with 5 replications and 5 progeny lots as locations. These 3 crosses were used for studying transgressive segregation; 25 plants from each cross for each character were studied. Plants in the F_2 generation that exceeded the average mean values of the two parent plants were identified as total transgressive segregants (TTS). Among these, those with significantly higher values than the better parent was classified as significantly transgressive segregants (STS). The phenotypic and genotypic components of variance were calculated using the formula provided by Lush [4]. Heritability in the broad sense was determined following the formula outlined by Hanson et al. [5], while genetic advance was estimated using the method suggested by Johnson et al. [6].

3. RESULTS AND DISCUSSION

The segregating population exhibited a wide range for all the characters studied (Table 1). Maximum coefficient of variation was recorded for number of capsules per plant (41.091) followed by seed yield per plant (40.163). The least coefficient of variation was recorded for capsule length (6.58) closely followed by number of seeds per capsule (6.774). The character number of capsules per plant exhibited a wide range of 78.96 to 109.94 indicating scope for selection for the character among the segregating generation. The number of primary branches also exhibited a wide range which can also be considered a selection criteria for higher yield since the character has been reported to be having a high positive correlation with seed yield [7]. The characters capsule length and capsule width did not reveal a high variation in the segregating generation.

The PCV and GCV for the characters days to first flowering, number of primary branches and seed yield per plant was comparatively high indicating sufficient scope for selection. The GCV values were relatively low than the respective PCV values for the characters number of primary branches, number of capsules per plant, number of seeds per capsule and seed yield per plant suggesting the influence of environment on these characters. Highest PCV and GCV were recorded for characters seed yield per plant, number of capsules on secondary branches, number of capsules on primary branches and number of capsules per plant. High values of PCV and GCV in segregating populations of sesame were reported for number of branches per plant and seed yield per plant by Siva Prasad et al. [8] and Bharathi and Reddy [9] and Mahdy et al. [10]. The high estimates of PCV and GCV were also reported for number of branches per plant [11,12,13], number of capsules per plant [14,15] and seed yield per plant [16,17] in sesame.

The experiment revealed high heritability and high genetic advance for the characters days to first flowering, days to maturity and plant height suggesting preponderance of additive gene action and the scope of improvement through selection. High estimates of heritability and genetics advance for plant height was reported by Siva Prasad et al. [8] in F_2 and F_3 generations of sesame suggesting the possibilities of achieving high genetic progress through selection. Nazrul (2022), Gedifew et al. [13], Mahla et al. [16], Akkiligunta et al. [15] and Takele and Dhabessa [17] also reported high heritability and high genetic advance for the characters seed yield per plant, number of branches per plant and number of capsules per plant in sesame.

Genetic analysis for transgressive segregation in F_2 is helpful for determining prepotency of various crosses achieving efficiency in early generation selection. This can reduce the population size in later generation which helps in handling of the breeding material. The transgressive segregants are produced by an accumulation of favourable genes affecting yield and yield governing characters. The percentage of total transgressive segregants (TTS) and significantly transgressive segregants (STS) in the F_2 generation across three cross combinations are represented in Table 2.

Table 1. Mean, co-efficient of variation, heritability (broad sense) and genetic advance as percent of mean for yield related characters in F_2 progenies of sesame

Sl.No.	Characters	Mean	Range	CV	PCV	GCV	H^2	GA
1.	Days to first flowering	49.66	45.78-53.55	19.598	55.424	51.843	87.5	99.898
2.	Number of primary branches	5.13	4.78-16.46	17.085	15.955	6.12	14.7	4.82
3.	Number of capsules per plant	94.45	78.96-109.94	41.091	45.701	20.002	19.2	18.034
4.	Capsule length (cm)	2.09	2.09-2.09	6.58	7.24	3.019	17.4	2.594
5.	Capsule width (cm)	0.74	0.73-0.75	10.379	11.369	4.642	16.7	3.903
6.	Number of seeds per capsule	51.41	50.95-51.87	6.774	7.257	2.605	12.9	1.927
7.	Days to maturity	100.56	97.99-103.12	8.647	27.258	25.85	89.9	50.499
8.	Plant height (cm)	100.73	97.47-104.06	20.456	33.222	26.177	62.1	42.49
9.	Seed yield per plant (g)	14.65	13.32-15.97	40.163	43.754	17.359	15.7	14.186

Table 2. Percentage of total transgressive segregants (TTS) significantly transgressive segregants (STS) in the F_2 generation

Characters	Thilak X Ayali 1		Thilathara X Ayali 2		Thilak X Ayali 5	
	TTS	STS	TTS	STS	TTS	STS
Days to first flowering	57.14	57.14	14.81	9.25	29.7	27.72
Number of primary branches	100	78.57	100	100	100	63.36
Number of capsules per plant	35.71	14.28	66.66	40.74	56.43	33.66
Capsule length (cm)	7.14	7.14	29.62	24.07	18.81	31.48
Capsule width (cm)	100	100	100	100	100	100
Number of seeds per capsule	7.14	0	29.62	22.22	14.85	7.92
Days to maturity	92.85	92.85	16.66	16.66	46.53	46.53
Plant height (cm)	64.28	28.57	40.74	1.85	11.88	11.88
Seed yield per plant (g)	35.71	14.28	61.11	31.48	49.5	14.85

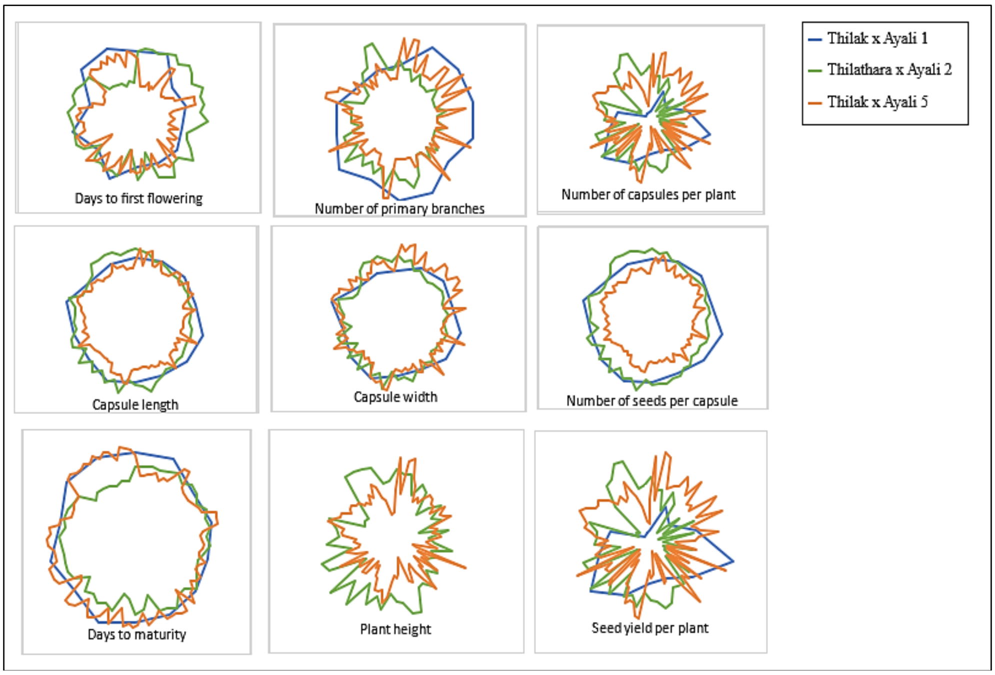

Fig. 1. Variation for the yield related characters in the F_2 segregating populations of three crosses of sesame

The estimation of percentage of total transgressive segregants (TTS) and significantly transgressive segregants (STS) revealed a very high level of segregation with respect to most of the characters. The TTS and STS was very high for the character days to first flowering, days to maturity and plant height among the segregants for the cross Thilak x Ayali 1. The cross Thilathara x Ayali 2 exhibited maximum values of TTS and STS for the characters number of primary branches, number of capsules per plant, number of seeds per capsule and seed yield per plant. Selection from the segregating population of the cross Thilathara x Ayali 2 will be advantageous for the yield related characters. The highest percentage of total transgressive segregants (TTS) and significantly transgressive segregants (STS) for the character days to first flowering and days to maturity was observed in the cross Thilak X Ayali 1 (57.14% and 92.85% respectively). For the character number of primary branches per plant, all the three crosses have the highest percentage of total transgressive segregants (TTS) value (100%), while the cross Thilathara X Ayali 2 has highest significantly transgressive segregants (STS) value (100%). High estimates of transgressive segregation were reported for various characters like plant height [9], days to 50% flowering [18] and seed yield per plant [10,12] in sesame [19,20].

4. CONCLUSION

Significant variation was observed among most traits, except for capsule length, capsule width, number of seeds per capsule, and the number of primary branches. Plant height had the highest mean and range, indicating significant variation and potential for selection. Coefficient of Variation (CV) analysis revealed that capsule length, number of seeds per capsule, and days to maturity had low CV values, implying greater trait stability. In contrast, the number of capsules per plant and seed yield per plant had higher CV, indicating greater environmental or genetic variability. Higher PCV and GCV were recorded for traits like days to first flowering, number of capsules per plant, and seed yield per plant, reflecting greater genetic and environmental influence. Moderate PCV and GCV were observed for plant height and days to maturity, while the lowest values were recorded for capsule length, number of seeds per capsule, and capsule width, indicating limited genetic variation for these traits. High heritability coupled with high genetic advance for days to first flowering and days to maturity suggests these traits are influenced by additive gene action, making them ideal for simple selection. The analysis suggests that while certain traits are more influenced by genetic factors and suitable for selection, others are heavily impacted by environmental variability. The cross Thilathara X Ayali 2, exhibited a high frequency of transgressive segregants for multiple traits, should be advanced for further breeding to recover desirable segregants, especially for economically important traits like seed yield and stands out for its breeding potential and should be prioritized in future generations for improved yield and related traits.

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 the writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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