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Genetic Potential of Sesame: A Study on Variability, Heritability and Genetic Advance

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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

Aims: This study aimed to evaluate 140 genotypes of sesame germplasms along with five check varieties to assess heritability, variability, and genetic advance for yield and yield-related agronomic characters, with the goal of improving yield potential through breeding programs.
Study Design: The evaluation was conducted using an augmented design with four blocks during the kharif season of 2021.
Methodology: The investigation took place at the S.K.N. College of Agriculture's institutional farm during the kharif season of 2021, utilizing 140 sesame germplasm lines and five check varieties from ICAR-National Bureau of Plant Genetic Resources. The germplasm was evaluated in an Augmented Design with each line planted in a 4-meter row, organized across four blocks, and standard agronomic practices were followed to ensure healthy crop development.

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Results: Significant differences among the germplasm lines were observed for days to 50 percent flowering, days to maturity, plant height, capsule-bearing length, capsules per plant, seeds per capsule, branches per plant, capsule length, chlorophyll content, test weight, and seed yield. This indicates substantial variability among the germplasm lines. Traits such as seed yield per plant, capsules per plant, and primary branches per plant exhibited high phenotypic and genotypic coefficients of variation. High heritability coupled with high genetic advance as a percentage of the mean was noted for seed yield per plant, capsules per plant, primary branches per plant, and test weight, suggesting the influence of additive gene action, thereby making simple selection effective for improving these traits.

Conclusion: The evaluation of sesame germplasms revealed significant variability for various yield and agronomic traits, with traits like seed yield per plant, capsules per plant, and primary branches per plant showing potential for improvement through breeding programs. High heritability and genetic advance suggest the influence of additive gene action, facilitating effective selection strategies for enhancing yield potential in sesame.

Keywords: Sesame; variability; heritability; genetic advance; seed yield.

1. INTRODUCTION

"Sesame (*Sesamum indicum* L.) is one of the oldest oilseed crop in world and it is native to tropic and sub-tropic regions. It's known with various names such as sesamum, til, gingelly, simsim, gergelim *etc*. It is an annual, self-pollinated oil seed crop. The genus sesamum belongs to the order *tubiflorea*, family *pedaliaceae* which consists of sixteen genera and sixty species [1], but only *sesamum indicum* (2n = 26) has been recognized as cultivated species. Several historical records indicated that sesame probably originated in Ethiopia (Africa) and from there, it was introduced into India and China and became a popular food in Southern Asia, South Europe and North-East Africa. It spread into West Asia and then to India, China and Japan and became secondary distribution centers" [2].

"The total area in India under sesame during 2022-23 was 15.23 lakh hectares with the production of 8.02 lakh tonnes with productivity of 527 kg/hectare" [3]. "The total area in Rajasthan under sesame during 2022-23 was 2.16 lakh hectares with the production of 0.78 lakh tonnes with productivity of 360 kg/hectare" [2]. Gujarat, Rajasthan, Uttar Pradesh, Madhya Pradesh, Maharashtra, Andhra Pradesh, Orissa, Tamil Nadu, West Bengal and Karnataka are major sesame growing states of the country. In Rajasthan, Pali, Nagaur, Jodhpur, Jalore, Bhilwara, Sirohi, Ajmer and Alwar are major sesame producing districts.

"Inspite of sesame possessing high nutritional value and resistance to abiotic stress like drought it has low yielding capacity compared to other oilseed crops. The major problems in sesame cultivation are non-synchronous maturity, indeterminate growth habit narrow adaptability, yield instability, seed shattering, non-availability of high yielding varieties with resistance to stresses and the presence of fertilization barriers *etc."* [4], and strong competition from other oil crops such as soybean, sunflower and peanut. Further, sesame has been given less attention by the farmers because of poor yield due to non-availability of cultivars to suit the diverse agro climatic conditions. Therefore, development of improved high yielding varieties adapted to local conditions has become top priority.

"The development of improved cultivars is mainly governed by the magnitude of genetic diversity in the base material and the extent of variability for the desired characters. Genetic variability is of great interest to the plant breeder as it plays a vital role in framing a successful breeding programme. Heritability is the transmissibility of a character into future generations. Genetic advance refers to the difference between the mean genotypic values of selected population and the original population from which these were selected. Heritability estimates together with genetic advance is generally more helpful in prognosticating the genetic gain under selection than heritability estimates alone" [4].

2. MATERIALS AND METHODS

The present investigation was conducted at the institutional farm, S.K.N. College of Agriculture, Jobner during *kharif* season, 2021. The experimental material consisted of 140 sesame germplasm lines along with 5 check varieties *viz*., RT 372, TKG 22, TC 25, RT 346 and PARGATI obtained from Germplasm Evaluation Division, ICAR-National Bureau of Plant Genetic Resources, New Delhi. The experimental material was evaluated in Augmented Design during *kharif,* 2021. Each germplasm line was sown in a plot of single 4 meter row length with the whole germplasm lines was distributed in 4 blocks with 5 check varieties. Each check varieties was sown after 7 germplasm lines. Row to row and plant to plant distance was maintained 30 cm and 15 cm, respectively. All the agronomical practices were followed to raise a good and healthy crop. The data of were recorded from five plants were selected randomly and tagged before flowering from each entry. However, data on days to 50 per cent flowering, days to maturity and 1000-seed weight was recorded on whole plot basis. The observations were recorded on following characters: days to 50 per cent flowering, days to maturity, plant height, capsule bearing length, capsules per plant, capsules on main stem, seeds per capsule, branches per plant, capsule length, chlorophyll content, 1000-seed weight and seed yield per plant.

To test the variation among the germplasm lines analysis of variance *via* adopting standard statistical methods [5]. The phenotypic coefficient of variation (PCV) and genotypic coefficient of variance (GCV) were estimated using the formula proposed by Burton [6] and Johnson et al. [7]. Heritability in broad sense was calculated according to the formula suggested by Johnson et al. [7]. From the heritability estimates, the genetic advance and genetic gain was calculated by the formula given by Johnson et al. [7].

3. RESULTS AND DISCUSSION

Analysis of variance (Table1) revealed significant differences among the genotypes for different characters except capsules on main stem indicating presence of sufficient variability in the material. Mean, range, genotypic and phenotypic coefficient of variation, heritability (broad sense) and genetic gain were analyzed are shown in Table 2.

PCV and GCV estimates are closer and parallel for all the characters, indicating that these characters are less influenced by environment and comparatively stable. A wide range of variability was exhibited for characters such as seed yield per plant, capsules per plant, and primary branches per plant indicating that there is scope for selection of suitable initial material in breeding for further improvement.

“Genetic variability is a basic information needed for the breeders to improve the crops by adopting appropriate method of selection based on variability that exist in the material. In this regard, it is necessary to partition the total variability into heritable and non-heritable components viz., genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV) and further to compute heritability and genetic advances for various quantitative traits. Comparison of variability between two traits is possible with coefficient of variation as it is free of units. As expected, the PCV values were greater than the GCV values for all the characters indicating considerable influence of environment on the expression of these characters under field conditions” [4].

The phenotypic and genotypic coefficient of variation of germplasm was high for seed yield per plant, capsules per plant and branches per plant. Similar observations were reported by Sumathi and Muralidharan [8], Gangadhara et al. [9], Narayanan and Murugan [10], Bharathi et al. [11], Ismaila and Usman [12], Teklu et al. [13,14] and Aristya et al. [15] for capsules per plant and seed yield per plant, Chandra [16] and Pavani et al. [17] for branches per plant and Kumar et al. [18] for seed yield per plant. High PCV and GCV estimates for characters indicate existence of the substantial variability in these characters.

The values of phenotypic and genotypic coefficients of variation were moderate for plant height, capsule length and seeds per capsule, test weight, capsule bearing length, capsules on main stem, chlorophyll content and days to 50 per cent flowering. These results were in accordance with the reports of Soundharya [19] and Bharathi et al. [11] for capsule length, Teklu et al. [14] and Ismail and Mohamed [20] for capsule bearing length and Gangadhara et al. [9] for capsule length, test weight and seeds per capsule.

The values of PCV and GCV were low for days to maturity. This result were in accordance with the findings of Gangadhara et al. [9] and Pavani et al. [17].

Genetic coefficient of variation does not provide the clear indication of proportion of heritable component of variation. The heritability estimate of a quantitative character is very important as phenotypic expression of a genotype may be altered by environment at various stages of its development.

Table 1. Mean sum of squares and variance for different quantitative characters in Sesame

Source of variation	d.f	Days to 50 per cent flowering	Days to maturity	Plant height (cm)	Capsule bearing length (cm)	Capsules per plant	Seeds per capsule	Capsules on main stem	Branches per plant	Capsule length (cm)	Chlorophyll content (SPAD)	Test weight (g)	Seed yield per plant (g)
Blocks(b-1)	3	2.27	0.58	0.19	126.85	96.58**	2.93	8.73	0.03	0.02**	5.49	0.01	0.01
Entries (c+g)-1	144	32.05**	11.40**	417.71**	157.69**	200.77**	36.20**	9.54**	2.13**	0.07**	55.60**	0.53**	1.42**
Checks (c-1)	4	6.57**	8.70*	62.06**	133.61**	63.07**	23.20**	17.82**	11.96**	0.01**	20.03**	0.30**	1.80**
Germplasm(g-1)	139	28.18**	10.70**	386.57**	155.95**	190.78**	32.03**	8.71	1.86**	0.06**	48.59**	0.50**	1.40**
Checks Vs Germplasm	1	672.70**	119.60**	6169.23**	495.82**	2139.00**	668.68**	91.89**	0.30**	0.74**	1171.79**	4.88**	2.25**
Error (b-1) (c-1)	12	1.48	2.67	0.25	38.93	18.21	5.10	4.02	0.06	0.00	2.33	0.07	0.28

**, ** Significant at 5 per cent and 1 per cent level of significance, respectively*

Table 2. Variability parameters for different quantitative characters in sesame

Characters	Mean	Range	GCV	PCV	Heritability (per cent)	G.A. as per cent of mean
Days to 50 per cent flowering	41.80	30.00 – 52.00	12.36	12.70	94.76	24.79
Days to maturity	91.24	84.00 – 98.00	3.11	3.59	75.08	5.54
Plant height (cm)	94.87	30.60 - 132.40	20.72	20.72	99.94	42.66
Capsule bearing length (cm)	41.20	10.00 - 70.40	26.26	30.31	75.04	46.86
Capsules per plant	33.71	12.40 - 80.20	38.97	40.98	90.46	76.36
Seeds per capsule	51.22	15.80 - 60.80	10.13	11.05	84.08	19.14
Capsules on main stem	7.81	2.40 - 14.20	27.71	37.79	53.77	41.85
Branches per plant	3.60	1.20 - 8.40	37.26	37.86	96.86	75.53
Capsule length (cm)	2.09	1.40 - 2.90	11.85	12.04	97.23	24.07
Chlorophyll content (SPAD)	39.05	25.07 - 51.07	17.42	17.85	95.20	35.01
Test weight	2.35	1.00 - 4.37	27.87	30.17	85.33	53.03
Seed yield per plant (g)	2.34	1.03 - 5.17	45.37	50.65	80.24	83.73

Heritability (in broad sense) was high (>60 per cent) for plant height, capsule length, primary branches per plant, chlorophyll content, days to 50 per cent flowering, capsules per plant, test weight, seeds per capsule, seed yield per plant, days to maturity and capsule bearing length except capsules on main stem indicating that characters were least influenced by environment and selection of such characters may be useful. Similar results were shown earlier by Ahemd and Ahemd [21] and Teklu et al. [14] for days to 50 per cent flowering; Sumathi and Murlidharan [8] and Hika et al. [22] for days to maturity; Teklu et al. [14] for plant height and capsules per plant; Krishnaiah et al. [23] for seeds per capsule; Ashokavaradhan et al. [24] for test weight; Soundharya et al. [19] and Abhijatha et al. [25] for primary branches per plant and Saxena and Bisen [26] and Ismail and Mohamed [20] for seed yield per plant.

“Heritability estimates alone do not provide reliable information about the gene action governing the expression of a particular character. High heritability coupled with high genetic advance as per cent of mean would be more reliable and useful in formulating selection procedure” [7]. High heritability coupled with high genetic advance as per cent of mean was observed for most of the characters *viz*., seed yield per plant, capsules per plant, branches per plant, test weight, capsule bearing length, plant height, chlorophyll content, days to 50 per cent flowering and capsule length. Similar results have been reported earlier by Teklu et al. [14] for days to 50 per cent flowering; Patil and Lokesha [27] and Teklu et al. [14] for plant height, Ismaila and Usman [12] and Revathy et al. (2012) for primary branches per plant and Revathy et al. (2012), Ismaila and Usman [12] and Hika et al. [22] for seed yield per plant. High heritability combined with high genetic advance indicated that these traits were governed largely through additive effect of genes and improvement in these characters may be achieved through simple phenotypic selection.

“High heritability coupled with moderate genetic advances as per cent mean was recorded for seeds per capsule revealed the predominance of both additive and non-additive gene action. This offers the best opportunity for improvement of this trait through mass selection and progeny selection. And High heritability coupled with low genetic advances as per cent of mean was recorded for days to maturity which indicates dominant and epistatic gene action, it is not effective for selection” [4]. Similar results have been reported earlier by Ahmed and Ahmed [21] and Pavani et al. [17].

4. CONCLUSION

In conclusion, our study highlights significant genetic variability in sesame germplasms, with traits like seed yield per plant, capsules per plant, and primary branches per plant showing promising potential for selection. High heritability coupled with substantial genetic advance suggests the predominance of additive gene action, facilitating straightforward phenotypic selection for improvement. These findings offer valuable guidance for sesame breeders in developing improved varieties with enhanced yield potential and overall agronomic performance.

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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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