PLANT SCIENCE TODAY
ISSN 2348-1900 (online)
Vol x(x): xx–xx
https://doi.org/10.14719/pst.7855

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RESEARCH ARTICLE

Genetic variability and principal component analysis of sesame genotypes using morphological traits

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OPEN ACCESS

ARTICLE HISTORY
Received: 21 February 2025
Accepted: 25 March 2025
Available online
Version 1.0 : 28 April 2025

Check for updates

Additional information
Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

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Indexing: Plant Science Today, published by Horizon e-Publishing Group, is covered by Scopus, Web of Science, BIOSIS Previews, Clarivate Analytics, NAAS, UGC Care, etc See https://horizonepublishing.com/journals/index.php/PST/indexing_abstracting

CITE THIS ARTICLE
Bharathi Kumar K, Mahalingam A, Paramasivan M, Sathish KR, Indira GP. Genetic variability and principal component analysis of sesame genotypes using morphological traits. Plant Science Today (Early Access). https:/doi.org/10.14719/pst.7855

Abstract

Sesame is one major oilseed crop cultivated in India. The demand for the sesame oil is increasing but the productivity of sesame in India is around 537 kg/ha. Selection based on the yield along with the other yield component traits is essential by studying of character association to assess the relationship among yield and its components characters for selection while developing new varieties. The present study was conducted to access the variability and relationship between the yield and its component characters in sesame (*Sesamum indicum* L.). The experiment was laid out with 26 advance lines along with checks in Regional Research Station, Vriddhachalam during the *Kharif* 2023 season and evaluated in two replications in Randomized Complete Block Design. The high Genotypic Co-efficient of Variation (GCV) was noticed for number of branches per plant (19.9 %), number of capsules per plant (11.3) and seed yield (16.4). High heritability along with high genetic advance was recorded for seed yield per plant, number of branches per plant and number of capsules per plant indicating prime role of additive genetic components for the expression and indicating better scope of use of direct selection for those traits. The trait Number of capsules per plant showed positive correlation (0.148) with seed yield. Number of capsules per plant showed positive direct effects on seed yield while days to maturity showed negative direct effects. In the Principal component analysis PC1, PC2 and PC3 explained cumulative variance of 68.44 %.

Keywords

character association; PCA analysis; sesame; variability

Introduction

Sesame (*Sesamum indium* L.) is called as "Queen of oilseeds" as it is traditional, ancient and oilseed crops cultivated in India. Sesame is one of the high nutritious oilseed crops containing protein content of 18-25 %, carbohydrates of 13.5 % and oil content of 44 -58 %). Sesame seed is a better source of minerals calcium, phosphorous, zinc, manganese, copper and iron. It is widely preferred for its quality oil among the consumers for its oleic and linoleic acid content (1). In India, sesame is cultivated in an area of 16 lakh hectares with a production of 124.79 lakh tonnes and productivity of 573 kg/ha (2). The demand of high-quality oilseed like sesame oilseeds is increasing during the last decade by increase of the health awareness among the consumers towards the nutritional value of sesame seed oil. In such situation the demand of sesame seeds increasing globally and so plays a major role by earning Rs. 3159.47 during the year 2020-21 crores of revenue in exports (2). Increase of the productivity is important for the demand. Selection merely

based on yield is not effective as yield is a poly genetically governed trait and highly subjective to the environment conditions. Selection based on its component characters increases yield as they are not only less complex but are also relatively show simple inheritance and less influenced to environmental deviations.

Improvement for the yield is normally realised by using genetically diverse parents in the breeding programmes and profound knowledge of genetic variability in crops is very essential for effective selection in development of varieties. Character association among yield and its component characters plays a major role in selection while developing new varieties. Principal Component Analysis (PCA) explains the relationship pattern among the genotypes under study. It describes traits relative contribution to the observed variability in the genotype's collection. PCA is highly effective and useful for identifying plant features that classify the uniqueness of promising genotypes (3).

Materials and Methods

The experimental trial was conducted during the season *Kharif* in the year 2023 in Regional Research Station, Vriddhachalam, Tamil Nadu, India. Twenty six lines comprising of 17 advanced breeding lines with brown, black and white seeded and 9 released sesame varieties (Table 1.) were evaluated in the statistical design of Randomized Complete Block Design with two replications. Each genotype was raised in 5m length with spacing of 30 x 30 cm. The soil was red sandy loam with P^H -6.5 with medium N and K and low P content. Recommended crop production practices were followed to raise a good crop. The following traits were recorded *viz.,* days to 50 % flowering (days), days to maturity (days), plant height (cm), number of branches per plant, number of capsules per plant, capsule length (cm) and seed yield (g/plot). The biometrical observations for the study were recorded from five randomly selected plants for each genotype from two replications. The mean values were used for statistical analysis. The coefficient of variation, heritability in broad sense and genetic advance were calculated using equations (4, 5). The correlation coefficients and path analysis were carried out (6). The statistical analysis involved aggregating the mean data from each replication for ANOVA (Analysis of Variance) to explore the significant variations and the software used is TNAUSTAT, OPSTAT. The mean phenotypic data were subjected to PCA using GRAPES Version 1.1.0.

Results and Discussion

Analysis of variance revealed that there are significant contribution differences ($P < 0.05$) among the sesame genotypes under study (Table 2). The *per se* performance of the genotypes revealed the genotype VS 20 - 001 was early in flowering (33 days). The genotype Co 1 recorded maximum plant height of 179 cm. Highest seed yield of 971 g/plot was observed in genotype VS 19 - 073 and the results are presented in Table 3.

The range, mean, variability analysis results were calculated for the seven quantitative traits *viz.,* days to 50 % flowering, days to maturity, plant height (cm), number of branches per plant, Capsule length (cm) and seed yield presented in Table 4. Wide variability was observed for seed yield (552 - 971 g/plot) and other characters also.

PCV showed higher values than GCV suggesting less impact of environmental factors on the studied traits. The moderate GCV of 19.9 % was revealed for number of branches per plant followed by number of capsules per plant (11.3 %) and seed yield (16.4 %).

The high magnitude of PCV and GCV for seed yield, number of branches per plant and number of capsules per plant indicating the presence of ample amount of variation for these characters. The high heritability of more than 60 % combined with high genetic advance as percent of mean for seed yield (78.4 %) and moderate heritability for number of branches per plant (57.2 %) capsules per plant (37.2 %) revealed that these characters were controlled by additive gene action (7-9). High heritability values indicate as a measure of genetic advancement through phenotypic selection (4). In the present study higher heritability followed by genetic advance for the seed yield and number of branches per plant were recorded. This suggested that selection for these traits would be effective for crop improvement as suggested by earlier workers.

Table 1. Details of sesame lines under study

S. No.	Name of the culture	S. No.	Name of the culture	S. No.	Name of the culture
1	VS 19-062	11	VS 18 -007	21	VRI 3
2	VS 19-064	12	VS 19 -023	22	VRI 4
3	VS 20-001	13	VS 19 -032	23	TMV 3
4	VS 20-030	14	VS 19 -050	24	TMV 4
5	VS 20-031	15	VS 19 -054	25	TMV 7
6	VS 20-040	16	VS 19 -073	26	CO 1
7	VS 19-018	17	VS 20 -021		
8	VS 19-019	18	GT 10		
9	VS 19-045	19	TKG 22		
10	VS 18 -003	20	VRI (SV) 2		

Table 2. Analysis of variance for seven biometrical traits

Particulars	Mean sum of squares	Error sum of squares	SE	CD	CV (%)
Days to 50 per cent Flowering	5.031	0.52	0.51	1.49	1.97
Days to maturity	20.17	1.60	0.89	2.60	1.46
Plant Height (cm)	260.48	51.86	3.60	14.38	3.21
No. of branches per plant	5.50	1.49	0.86	2.52	17.21
No. of capsules per plant	298.39	68.11	8.25	24.02	14.59
Capsule Length (cm)	0.09	0.02	0.10	0.16	5.75
Seed yield g/plot	31007.61	1879.35	43.53	126.29	8.16

Table 3. Mean performance of the sesame genotypes

S. No.	Name of the genotypes	Days to 50 per cent flowering	Days to maturity	Plant height (cm)	No. of branches per plant	No. of capsules per plant	Capsule length (cm)	Seed yield g/ plot
1	VS 19-062	38	90	166	7.5	62	2.9	552
2	VS 19-064	38	90	168	9.5	72	2.6	556
3	VS 20-001	33	86	148	7.7	99	2.9	555
4	VS 20-030	38	87	158	6.8	75	2.6	651
5	VS 20-031	38	91	159	9.9	75	2.8	637
6	VS 20-040	37	89	166	7.5	60	2.8	896
7	VS 19-018	38	82	149	6.4	75	2.7	914
8	VS 19-019	38	84	153	10.0	90	2.9	924
9	VS 19-045	36	81	147	7.7	81	2.7	949
10	VS 18 -003	38	89	165	5.5	78	3.1	650
11	VS 18 -007	37	87	168	6.3	79	3.2	602
12	VS 19 -023	38	90	160	4.3	71	3.2	657
13	VS 19 -032	36	86	141	6.5	77	2.6	652
14	VS 19 -050	36	85	177	4.9	85	2.6	696
15	VS 19 -054	35	86	147	4.7	81	2.9	716
16	VS 19 -073	35	85	179	6.7	106	2.9	971
17	VS 20 -021	38	88	160	5.7	75	3.1	587
18	GT 10	38	85	150	8.3	76	2.5	724
19	TKG 22	34	80	146	6.4	70	3.0	747
20	VRI (SV) 2	36	87	164	5.4	80	2.5	654
21	VRI 3	38	85	152	6.3	78	2.6	768
22	VRI 4	34	85	164	6.8	75	2.9	765
23	TMV 3	38	94	152	10.4	117	2.5	653
24	TMV 4	38	85	169	9.0	87	2.6	690
25	TMV 7	38	86	137	7.4	78	2.7	722
26	CO 1	38	92	179	7.9	79	3.0	622
	G.Mean	**36.7**	**86.5**	**158.5**	**7.1**	**80.0**	**2.8**	**712**
	S.E.	**0.5**	**0.9**	**5.1**	**0.9**	**8.3**	**0.1**	**43**

Table 4. Estimates of PCV, GCV, heritability and genetic advance for seven traits

Characters	Mean	Range		PCV (%)	GCV (%)	Heritability (%)	Genetic advance	GAM (%)
		Min	Max					
Days to 50 per cent Flowering	36.7	33.0	38.0	4.5	4.1	81.2	2.78	7.6
Days to maturity	86.5	80.0	93.5	3.8	3.5	85.3	5.7	6.7
Plant Height	158.4	136	179	7.88	6.43	66.74	17.87	1.12
No. of branches per plant	7.1	4.3	10.4	26.3	19.9	57.2	2.21	31.0
No. of capsules per plant	80.0	60.2	116.8	18.4	11.3	37.3	11.32	14.2
Capsule length	2.8	2.5	3.2	8.8	6.6	57.0	0.28	10.3
Seed yield kg/plot	711.8	552.0	970.6	18.5	16.4	78.4	212.87	29.9

Table 5. Correlation analysis of seven studied quantitative traits

Characters	Days to 50 per cent flowering	Days to maturity	Plant height	No. of branches per plant	No. of capsules per plant	Capsule length	Seed yield
Days to 50 per cent flowering	**1.000**	0.534**	0.051	0.279*	-0.205	-0.0896	-0.249
Days to maturity		**1.000**	0.338*	0.277*	0.059	0.067	-0.615**
Plant height			**1.000**	-0.107	0.018	0.244	-0.074
No. of branches per plant				**1.000**	0.284*	-0.311*	0.005
No. of capsules per plant					**1.000**	-0.121	0.148
Capsule length						**1.000**	-0.090
Seed yield							**1.000**

The estimates of correlation coefficients between seed yield and other yield contributing traits were given in Table 5. Relative higher magnitude of correlation coefficients indicating a strong heritable association among various yield contributing characters. Therefore, selection based on the phenotype would be effective for yield improvement. The number of capsules per plant had positive significant correlation with number of branches per plant (0.284) (10, 11). Days to maturity exhibited significant positive association with plant height (0.338) and number of branches per plant (0.277). Seed yield was positively correlated with the number of branches per plant and days to maturity was negatively correlated with seed yield as observed earlier (8, 9). This type of character association indicates the improvement in seed yield can be achieved by improving the characters like number of capsules per plant and number of branches per plant. Path coefficient analysis describes the cause and effect of yield contributing traits and quantifies the relative importance of each trait (9, 10). The direct and indirect effects of various characters on seed yield are given in Table 6. Number of capsules per plant had the maximum positive direct effects (0.187) on seed yield while days to maturity (-0.889) showed the maximum negative direct effect i.e. early maturing genotypes were also higher yielders. Similar results

Table 6. Path analysis for and its component traits

Characters	Days to 50 per cent flowering	Days to maturity	Plant Height	No. of branches per plant	No. of capsules per plant	Capsule length	Seed yield per plant
Days to 50 per cent flowering	**0.183**	-0.448	0.011	0.044	-0.038	0.000	-0.249
Days to maturity	0.098	**-0.839**	0.072	0.043	0.011	0.000	-0.615
Plant height	0.009	-0.283	**0.213**	-0.017	0.003	0.000	-0.074
No. of branches per plant	0.051	-0.232	-0.023	**0.156**	0.053	-0.001	0.005
No. of capsules per plant	-0.038	-0.050	0.004	0.044	**0.187**	0.000	0.148
Capsule length	-0.016	-0.056	0.052	-0.049	-0.023	**0.002**	-0.090

were observed in previous results (11) for the number of capsules per plant. The residual effect was 0.517 (11), indicating furthermore characters are contributing to yield (9-14). Seed yield was found to be positively correlated with number of capsules per plant (0.148) while days to maturity were significantly and negatively correlated with the seed yield (-0.615) which was a good sign for escaping drought in high-yielding genotypes of sesame. Similar results were reported by earlier workers (15, 16). The results suggests that traits like number of capsules per plant have a positive and significant impact on seed yield and make them valuable criteria for selection criteria. Hence greater emphasis must be given on these associated traits as criteria for selection to target improvement of seed yield.

Principal Component Analysis (PCA)

PCA with the integration of yield and yield-attributing traits enabled us to estimate the correlations involving components and therefore identified 7 principal components (PC). Out of the seven quantitative variables examined in this study, PCA analysis indicated that the first three PCs (PC1, PC2 and PC3) had cumulative variability of 68.43 % across each attribute and demonstrated an eigenvalue greater than one (>1) (Fig. 1) (Table 7). First two PCs (PC1 and PC2) accounted for 28.72 % and 23.81 % of the variation respectively, meaning that they explained 52.53 % of the variation collectively. According to the PCA variable plot (Fig. 2) and PCA biplot (Fig. 3, Table 8). Similarly recorded number of capsules per plant contribution to seed yield.

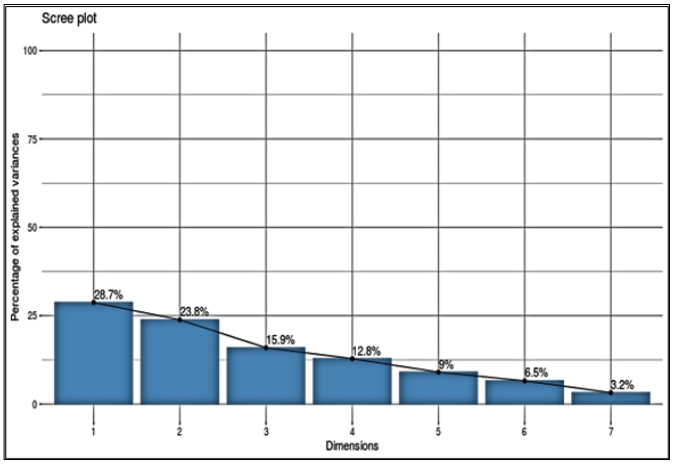

Fig. 1. Scree plot showing the Eigen value of variation for seven traits in sesame.

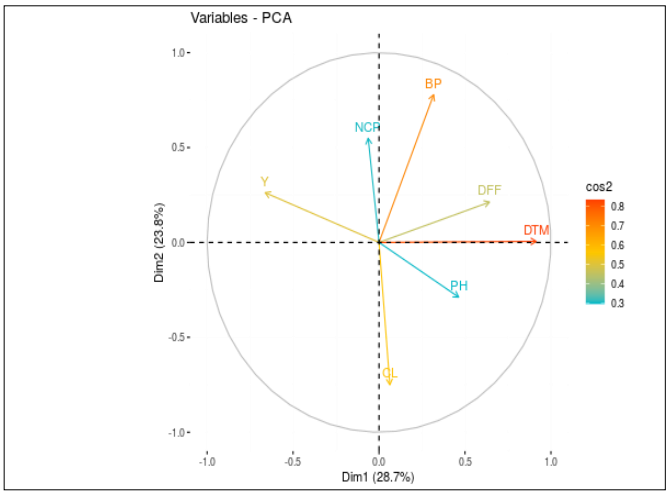

Fig. 2. Variable plot showing the correlation between the traits.

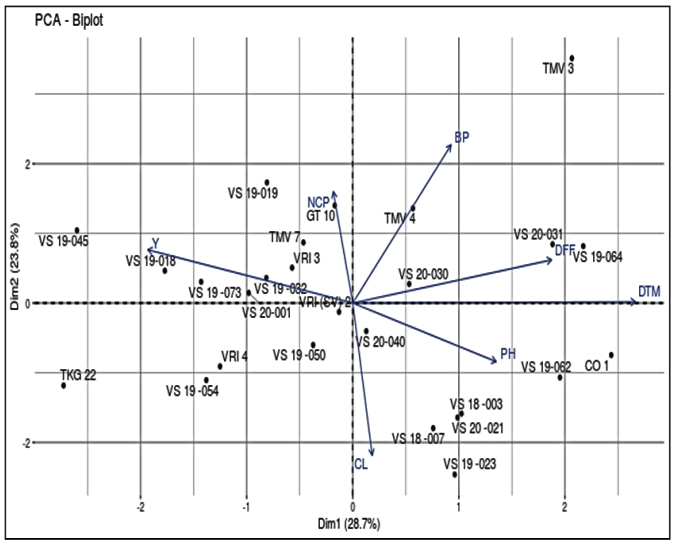

Fig. 3. Biplot of first two principal components showing the association of genotypes and the quantitative traits.

The genetic material positioned within the precise quadrant as the attribute vectors display enhanced performance for those traits, as shown in Fig. 4. For seed yield and number of capsules per plant the genotypes GT 10, TMV 7, VRI 3, VS 19-019, VS 19-018, VS 19-023 VS 20-00, VS 19-032 showed enhanced performance. The genotypes TMV 3, TMV 4, VS 20-030, VS 20-031, VS 19-064 for the traits number of branches per plant and days to 50 % flowering showed enhanced performance. For Plant height and capsule length Co1, VS 19-062, VS 18-003, VS 20-021, VS 19-023, VS 18-007, VS 20-040 showed high enhanced performance for this trait.

Table 7. Eigen value per cent of total variation

Prin comp	Eigen value	Percentage of variance	Cumulative percentage of variance
PC1	2.01	28.72	28.72
PC2	1.667	23.812	52.532
PC3	1.113	15.904	68.436
PC4	0.897	12.819	81.255
PC5	0.631	9.008	90.264
PC6	0.458	6.536	96.8
PC7	0.224	3.2	100

Table 8. Individual PCA Value

Variables	PC1	PC2	PC3	PC4	PC5	PC6	PC7
Days to 50 per cent flowering	-0.453	0.165	-0.496	0.356	-0.159	0.487	0.364
Days to maturity	-0.644	0.004	0.142	-0.115	-0.076	0.144	-0.724
Plant height	-0.327	-0.223	0.44	0.613	0.433	-0.227	0.188
No. of branches per plant	-0.224	0.603	0.015	0.08	-0.375	-0.655	0.102
No. of capsules per plant	0.044	0.425	0.703	-0.123	-0.131	0.488	0.231
Capsule length	-0.044	-0.581	0.215	0.093	-0.765	-0.044	0.134
Seed yield	0.467	0.203	-0.017	0.674	-0.196	0.147	-0.476

Conclusion

The present study revealed the traits such as seed yield, number of branches per plant and number of capsules per plant recorded detectable amounts of GCV, PCV coupled with a high range of broad sense heritability and genetic advance. The number of capsules per plant is positively correlated and showed high direct effects on seed yield indicating selection of number of capsules per plant can be used as selection criteria for evolving new varieties for higher seed yield. In PCA 1 and PCA 2 the number of capsules per plant and number of branches per plant contributed more variations in the study. Therefore, more importance should be given during the selection in the breeding programme for these traits in accordance with the previous studies (17-18).

Acknowledgements

Authors are grateful to ICAR, AICRP Sesame Regional Research Station, Vriddhachalam, Tamil Nadu Agricultural University for providing field study.

Authors' contributions

BKK conducted the whole experiment and collected the data. MA supported in the field trial. PM supported in formulation of manuscript. SR supported in statistical analysis. IGP supported the manuscript preparation.

Compliance with ethical standards

Conflict of interest : Authors do not have any conflict of interests.

Ethical issues: None

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