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Genetic Variability and Selection Indices for Improving Seed Yield in Sesame (*Sesamum indicum* L.)

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Abstract

Variability and selection indices were studied involving 35 genotypes of sesame for yield and its contributing traits. The analysis of variance indicated significant variations among the genotypes for all the studied traits, suggesting abundant variability in the experimental material. Higher magnitude of both PCV and GCV were recorded for biological yield per plant, seed yield per plant, harvest index and number of capsules per plant. High heritability coupled with high genetic advance as percent of mean was observed for biological yield per plant, seed yield per plant, number of capsules per plant, harvest index, number of branches per plant, number of internodes per plant, 1000 seed weight, height to first capsule, length of capsule and plant height which indicated that these traits are governed by additive gene action. Using the discriminant function technique, a total of thirty-one selection indices were developed, considering seed yield per plant and its four constituent components. In general, the more the number of characters included in a selection index, the better was its performance. The index based on five characters viz., seed yield per plant, number of capsules per plant, number of seeds per capsule, biological yield per plant and harvest index had highest genetic advance and relative efficiency of 26.99g and 612.92% respectively followed by an index based on four characters i.e. seed yield per plant, number of capsules per plant, biological yield per plant and harvest index which possessed genetic gain and relative efficiency of 26.28g and 596.95% respectively. The use of both these indices is advocated for selecting high yielding genotypes of sesame.

Key words : *Variability, heritability, GCV, PCV, genetic advance, selection indices, sesame.*

Introduction

Sesame (*Sesamum indicum* L.) holds significant importance as an oilseed crop. It belongs to the order Tubiflorae, family Pedaliaceae. The cultivated species of sesame is *Sesamum indicum* L. is proven to be domesticated in India around 5000 B.C. based on the archaeological evidence of charred sesame found in Harappa civilization (1). Sesame is referred to as the “Queen of oilseeds” for its high quality and stability of oil which is due to the presence of high polyunsaturated fatty acids and antioxidants in the oil (2). It contains 40 to 63 per cent oil, which contains significant amount of oleic and linoleic acids (3, 4). Globally, the sesame is grown in an area of 12 million ha with a production of 6.3 million tonnes and productivity of 508.1 kg/ha (5). In India, area and production under sesame were 1.722 million ha and 0.816 million tonnes, respectively with an average productivity of 474 kg/ha (6). Sesame exhibits a high level of tolerance to drought conditions and possesses the ability to adapt and produce seeds even in environments with relatively high temperatures (2). Low yield level is due to lack of wider adaptability, non-synchronous maturity, nonavailability of superior high yielding varieties with built in resistance to biotic and abiotic stresses and presence of pre and post fertilization barriers (7). Despite the potentiality of this crop, sesame is still a minor crop of developing countries grown in sub-marginal and marginal land under rainfed condition with little research activities. The extensive germplasm collections of sesame showcase a wide range of genetic variability within the crop. The determination of genetic variability and its partitioning into various components is essential for understanding the genetic nature of yield and its components. Furthermore, understanding the heritability of traits is crucial for selection-based improvement as it provides insight into the extent to which a particular characteristic can be inherited and passed on to future generations. Yield being a complex character is influenced by various component characters, which are polygenetically inherited and highly subjected to environmental variation. An application of discriminant function analysis gives information on proportionate weightage that should be given to a particular yield component. In this technique, since desirable genotypes are discriminated against undesirable ones based on character combinations, it is called the discriminate function technique. In order to have a comprehensive knowledge about genetic variability for yield and its contributing traits and to find out suitable selection indices using all possible combinations of contributing traits, the present study in sesame was under taken.

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Materials and Methods

A field experiment was conducted at the Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh during summer season 2022 in randomized block design with three replications by using thirty-five genotypes of sesame (*Sesamum indicum L.*) by involving sixteen quantitative characters. Each entry was accommodated in a single row of 3 m in length with a spacing of 30 x 10 cm. Analysis of variance was carried out as per the procedure given by (8). Genotypic and phenotypic correlation coefficients of variability were estimated according to the (9). Heritability and genetic advance were estimated using the formula suggested by (10). Construction of selection indices was done by using the discriminant function technique developed by (11).

Results and Discussion

Analysis of variance revealed that the mean square for genotypes was highly significant for all the traits. This showed that substantial variability provides a good prospect for improving traits of interest in sesame breeding programmes. While the presence of non-significant variation for replications implicating that the low amount of error due to the environment. A similar result has been reported by (12, 13) indicating the presence of a sufficient amount of genetic variability among the genotypes for all the 16 characters studied. The magnitude of PCV was slightly greater than GCV revealed a very little influence of environmental factors influencing the expression of these characters. This indicated that phenotypic variability may be considered as reliable measure of genotypic variability. Similar results have also been reported (14, 15). High magnitude of genotypic coefficient of variation and phenotypic coefficient of variation was observed for biological yield per plant followed by seed yield per plant,harvest index and number of capsules per plant. Most of the results are in agreement with the earlier reports of (16, 17).

Heritability estimate along with genetic advance are normally more helpful in predicting the gain under selection than heritability estimates alone. High estimates of heritability were observed for all the characters viz., oil content followed by protein content, number of capsules per plant, seed yield per plant, length of capsule, plant height, biological yield per plant, harvest index, days to maturity, 1000 seed weight, number of branches per plant, height to first capsule, days to 50 per cent flowering, number of internodes per plant, width of capsule and number of seeds per capsule. Most of the results are in agreement with the earlier reports of (18, 19, 20). High heritability for the above traits which were controlled by polygenes might be useful to the plant breeders for making effective selection. The estimates of genetic advance expressed as percentage of mean were found high for biological yield per plant followed by seed yield per plant, number of capsules per plant, harvest index, number of branches per plant, number of internodes per plant, 1000 seed weight, height to first capsule, length of capsule, plant height. High heritability accompanied with high genetic advance indicates that the heritability is due to additive genetic effect and selection may be effective, while high heritability coupled with low genetic advance indicates the predominance of non-additive gene action. High estimate of heritability coupled with high genetic advance expressed as percentage of mean for biological yield per plant followed seed yield per plant, number of capsules per plant, harvest index, number of branches per plant, number of internodes per plant, 1000 seed weight, height to first capsule, length of capsule, plant height. These characters exhibit a predominance of additive gene action and have significant selective value, making them suitable for targeted improvement through effective selection pressure.Most of the results are in agreement with the earlier reports of (19, 20).

In addition, the plant breeder has certain desired plant characteristics in his mind while selecting for a particular genotype and for this he applies various weights to different traits for arriving on decisions. This suggests the use of selection index which gives proper weight to each of the characters to be considered. (21) showed that the selection based on such an index is more efficient than selecting individually for various characters. The discriminant function analysis, initially formulated by (11) and first implemented by (22) in the same year, provides valuable insights into determining the appropriate weightage to be assigned to specific yield components.

A total of 63 selection indices (Table-2) based on five characters constructed in all possible combinations revealed that selection efficiency was higher over straight selection when the selection was based on individual components. Number of capsules per plant (Table 2), showed a genetic advance of 18.77% which was higher than those calculated for other characters including seed yield per plant. This suggests that number of capsules per plant proved to be better index selection based on one character.

The highest genetic gain of 24.69% was obtained when selection was made simultaneously based on discriminant function of two characters, e.g. number of seeds per capsule (X3) and biological yield per plant (X4). When three characters, e.g. number of capsules per plant (X2), number of seeds per capsule (X3), harvest index (X5) were taken together, the genetic advance increased

Table-1 : Analysis of variance of randomized block design for 16 characters of sesame genotypes.

Source of variation	DF	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of branches per plant	No. of capsules per plant	Height to first capsule (cm)	No. of internodes per plant	Length of capsule (cm)
Replication	02	1.02	2.12	4.52	0.01	8.19	5.56	0.24	0.06
Treatment	34	24.07**	58.72**	181.81**	0.52**	259.73**	41.22**	9.27**	0.32**
Error	68	4.53	5.55	14.51	0.07	5.37	6.59	0.20	0.02

Table-1 : Contd.....

Source of variation	DF	Width of capsule (cm)	No. of seeds per capsule	1000 seed weight	Seed yield (g/plant)	Oil content (%)	Protein content (%)	Harvest index (%)	Biological yield (g/plant)
Replication	02	0.007	13.85	0.06	1.63	0.67	0.70	1.28	5.73
Treatment	34	0.09**	47.70**	0.72**	14.74**	48.90**	10.18**	214.75**	117.43**
Error	68	0.02	10.44	0.08	0.52	0.63	0.24	18.03	8.53

*,** significant at 5% and 1% level, respectively.

Table-2 : Range, mean, genotypic and phenotypic coefficient variation, heritability and genetic advance in percent over mean for 16 characters of sesame genotypes.

Characters		Range	Variance					
	Mean	Min	Max	GCV (%)	PCV (%)	Heritability (%)	GA	GA% mean
Days to 50 per cent flowering	40.31	35.00	47.33	6.33	7.03	81.20	4.74	11.75
Days to maturity	83.38	76.00	93.67	5.05	5.31	90.50	8.25	9.89
Plant height (cm)	70.35	56.56	84.99	10.61	11.06	92.00	14.75	20.97
No. of branches per plant	2.05	1.37	2.86	18.78	20.27	85.80	0.74	35.85
No. of capsules per plant	42.66	24.73	68.91	21.58	21.81	97.90	18.77	44.00
Height to first capsule (cm)	24.57	17.47	32.93	13.82	15.08	84.00	6.42	26.10
Number of internodes per plant	11.42	7.95	16.97	15.22	15.38	97.80	3.54	31.01
Length of capsule (cm)	2.72	1.97	3.59	11.67	12.08	93.30	0.63	23.22
Width of capsule (cm)	0.84	0.74	0.96	5.83	6.56	78.90	0.09	10.67
No. of seeds per capsule	61.22	54.95	67.83	5.75	6.51	78.10	6.42	10.48
1000 seed weight	3.11	2.27	4.06	14.84	15.78	88.50	0.89	28.76
Seed yield (g/plant)	8.07	4.07	12.79	26.95	27.44	96.50	4.40	54.52
Oil content (%)	47.96	39.53	55.63	8.36	8.42	98.70	8.21	17.11
Protein content (%)	24.14	19.59	26.86	7.54	7.63	97.70	3.71	15.35
Harvest index (%)	38.69	22.08	48.34	20.93	21.86	91.60	15.96	41.26
Biological yield (g/plant)	21.62	12.53	38.06	27.86	28.93	92.70	11.95	55.26

to 24.06%. Combination of four characters, i.e seed yield per plant (X1), number of capsules per plant (X2), biological yield per plant (X4), and harvest index (X5) at a time recorded still high genetic gain (26.28%). The function that includes all the five characters gave the highest genetic advance (26.99%).

Thus, study revealed that the index, which includes more than one character, gave high genetic advance, suggesting the utility of construction of selection indices for effecting simultaneous improvement of several characters. (21) stated that the superiority of selection based on index increases with an increase in the number of characters under selection. (23, 24) in sesame opined that an increase in performance of individual trait results in an increase of genetic gain and relative efficiency.

A perusal of the data presented in Table-4 indicated that selection efficiency improved with an increase in number of characters in combination with yield. For example, average selection efficiency was 261.09% when one character was included in selection function. It was increased to 399.60% with two, 379.27% with three, 496.42% with four and 612.92% with five characters.

Some of the selection indices with high relative efficiency listed in Table 5 indicated that the highest efficiency was observed with five characters combination (612.92%). Selection indices with five characters, i.e. seed yield per plant (X1), number of capsules per plant (X2), number of seeds per capsule (X3), biological yield per plant (X4) and harvest index (X5), therefore, appear to be more useful. Comprehensive examination of this table indicated number of capsules per plant (X2), biological yield per plant (X4), harvest index (X5), seed yield per plant(X1) and number of seeds per capsule(X3) were in order of X2>X4=X5>X1=X3 being involved in more number of character combinations.

In practical terms, plant breeders often prioritize

Table-3 : Selection index, discriminant function, expected genetic advance in seed yield and relative efficiency from the use of different selection indices in sesame.

Sr. No.	Selection index	Discriminant function	Expected genetic advance	Relative efficiency (%)	Relative efficiency per character (%)
1.	X_1 Seed yield per plant	$0.96X_1$	4.40	100.00	100.00
2.	X_2 No. of capsules per plant	$0.97X_2$	18.77	426.20	426.20
3.	X_3 No. of seeds per capsule	$0.78X_3$	6.41	145.54	145.55
4.	X_4 Biological yield per plant	$0.93X_4$	11.95	271.34	271.34
5.	X5 Harvest index	$0.92X_5$	15.96	362.39	362.39
6.	$X_1 + X_2$	$0.97X_1 + 0.97X_2$	19.45	441.74	220.87
7.	$X_1 + X_3$	$0.99X_1 + 0.78X_3$	8.07	183.26	91.63
8.	$X_1 + X_4$	$0.97X_1 + 0.93X_4$	14.11	320.31	160.15
9.	$X_1 + X_5$	$0.97X_1 + 0.92X_5$	16.67	378.63	189.31
10.	$X_2 + X_3$	$0.97X_2 + 0.78X_3$	17.23	391.31	195.65
11.	$X_2 + X_4$	$0.97X_2 + 0.93X_4$	19.87	451.23	225.61
12.	$X_2 + X_5$	$0.97X_2 + 0.92X_5$	22.34	507.36	253.68
13.	$X_3 + X_4$	$0.78X_3 + 0.93X_4$	24.69	560.84	280.42
14.	$X_3 + X_5$	$0.78X_3 + 0.92X_5$	13.68	310.78	155.39
15.	$X_4 + X_5$	$0.93X_4 + 0.92X_5$	19.84	450.55	225.27
16.	$X_1 + X_2 + X_3$	$1.03X_1 + 0.93X_2 + 0.92X_3$	9.07	206.15	68.718
17.	$X_1 + X_2 + X_4$	$1.20X_1 + 1.09X_2 + 0.88X_4$	20.87	474.00	158.00
18.	$X_1 + X_2 + X_5$	$1.38X_1 + 0.58X_2 + 0.74X_5$	16.12	365.96	121.98
19.	$X_1 + X_3 + X_4$	$1.22X_1 + 1.01X_3 + 0.88X_4$	14.83	336.66	112.22
20.	$X_1 + X_3 + X_5$	$1.22X_1 + 0.63X_3 + 0.74X_5$	19.42	441.01	147.00
21.	$X_1 + X_4 + X_5$	$1.56X_1 + 0.83X_4 + 0.76X_5$	9.79	222.34	74.11
22.	$X_2 + X_3 + X_4$	$1.15X_2 + 1.02X_3 + 0.96X_4$	13.44	305.10	101.70
23.	$X_2 + X_3 + X_5$	$1.16X_2 + 0.86X_3 + 0.84X_5$	24.06	546.48	182.16
24.	$X_2 + X_4 + X_5$	$0.79X_2 + 1.07X_4 + 0.89X_5$	18.96	430.46	143.48
25.	$X_3 + X_4 + X_5$	$0.77X_3 + 1.05X_4 + 0.88X_5$	20.46	464.55	154.85
26.	$X_1 + X_2 + X_3 + X_4$	$1.19X_1 + 1.10X_2 + 1.03X_3 + 0.8X_4$	21.75	493.81	123.45
27.	$X_1 + X_2 + X_3 + X_5$	$1.59X_1 + 0.37X_2 + 0.46X_3 + 0.6X_5$	15.33	348.10	87.025
28.	$X_1 + X_2 + X_4 + X_5$	$1.53X_1 + 0.77X_2 + 0.87X_4 + 0.7X_5$	26.28	596.95	149.24
29.	$X_1 + X_3 + X_4 + X_5$	$1.59X_1 + 0.75X_3 + 0.84X_4 + 0.7X_5$	24.78	562.85	140.71
30.	$X_2 + X_3 + X_4 + X_5$	$0.65X_2 + 0.67X_3 + 1.12X_4 + 0.8X_5$	21.15	480.29	120.07
31.	$X_1 + X_2 + X_3 + X_4 + X_5$	$1.58X_1 + 0.62X_2 + 0.64X_3 + 0.9X_4 + 0.74X_5$	26.99	612.92	122.58

Table-4 : Average selection efficiency of different combination of characters in sesame.

No. of characters in the index	Relative Efficiency (%)
One	261.09
Two	399.60
Three	379.27
Four	496.42
Five	612.92

achieving maximum gain while utilizing a minimal number of characters or traits.With this view, relative efficiency per character was also worked out for each selection index. It was observed that maximum relative efficiency per character (280.42%) was observed in selection index comprised of number of seeds per capsule and biological yield per plant (X3+X4) followed by 253.68% value in case of number of capsules per plant and harvest index (X2+X5). The current study also indicated that the discriminant function method for selecting plants seems to be the most effective or promising approach than the straight selection for grain yieldalone and hence, due weightage should be given tothe important selection indices while makingselection for seed yield advancement in sesame.

Conclusions

It can be concluded from variability parameters that, additive gene action was operating for traits viz., biological yield per plant, seed yield per plant, harvest index and number of capsules per plant. Overall, selection index consisting of five traits *viz*., seed yield per plant, number of capsules per plant, number of seeds per capsule, biological yield per plant and harvest index could be

Table-5 : Highest Relative efficiency with character combinations in sesame.

Sr. No.	Character	Relative efficiency (%)
1.	Number of capsules/plant	426.20
2.	Number of capsules/plant + harvest index	507.36
3.	Numberof seeds/capsule + biological yield/plant	560.84
4.	Seed yield/plant + number of capsules/plant + biologicalyield/plant	474.00
5.	Number of capsules/plant + numberof seeds/capsule + harvest index	546.48
6.	Seed yield/plant + numberof seeds/capsule + biologicalyield/plant + harvest index	562.85
7.	Seed yield/plant + number of capsules/plant + biologicalyield/plant + harvest index	596.95
8.	Seed yield/plant + number of capsules/plant + numberof seeds/capsule + biological yield/plant + harvest index	612.92

advantageously exploited in the sesame breeding programmes.

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