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RELATIONSHIP OF F_2 SEGREGATION PATTERN WITH GENETIC DIVERGENCE OF PARENTS IN SESAME

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ABSTRACT

Twenty nine varieties of sesame collected from 11 states of India were evaluated in rabi season. Based on D^2 and canonical analysis, the varieties were grouped into nine clusters. The pattern of clustering did not show any relationship with geographic origin. In a study of pattern of F_2 segregation in 25 crosses involving 10 parents distributed in six clusters, eight crosses showed high breeding potential. The parents involved in these eight potential crosses had moderate genetic divergence.

Key words: Sesame, *Sesamum indicum*, D^2 statistic, genetic diversity.

Sesame (*Sesamum indicum*) is an important oilseed crop of Orissa mainly grown in kharif season. It is also cultivated in rabi season covering a sizeable part (34.5%) of the total acreage put under oilseeds [1]. The rabi sesame, locally called *Maghi Rasi*, is sown during September–October on the residual moisture. The traditional local varieties as well as the improved modern varieties developed in Orissa and other states of the country are not adapted to rabi season which is characterized by short days and low temperature. The varieties for the season should combine high yield potential with thermo– and photoperiod insensitivity. With the above points in view, two field experiments were conducted with the following objectives:

(i) Experiment I was conducted to evaluate the performance of the 29 sesame varieties in respect of yield and other related traits in rabi season and to assess genetic divergence among them.

(ii) Experiment II aimed to study the pattern of F_2 segregation in 25 crosses involving 10 parents and to find out its relationship with genetic diversity of the parents.

MATERIALS AND METHODS

Experiment I had 29 varieties (Table 1) collected from 11 states, including 6 from Orissa (Table 2). In Experiment II, 25 crosses (F_2s) involving 10 varieties were used along with their parents (Table 3). The experiments were conducted in randomized block design with two replications during rabi 1989. Each plot consisted of four 3.5 m long rows with a spacing of 30 x 10 cm in Experiment I and 40 x 10 cm in Experiment II.

Observations in Experiment I were recorded on five randomly chosen plants in the two middle rows for seven quantitative characters (Table 1). The sample means were used for multivariate analysis [2]. Group constellation was made following Tocher's method [3] and canonical analysis following Anderson [4]. In Experiment II, 10 randomly chosen competitive plants from the middle rows of the parents and 20 plants from crosses were sampled for recording observations on five traits (Table 5). The variation of individual F_2s for different characters was analysed in terms of range, variance, and phenotypic and genotypic coefficients of variation. The segregation pattern of the crosses was analysed in terms of frequency of positive transgressive segregant (FPTS) and the magnitude of transgression. Average positive transgression of a cross was measured as the difference of the mean of the PTS and the better parent mean. The relationship of the parameters of variation for yield in F_2 with parental diversity was measured by D^2 statistic was examined by computing correlation coefficients among them. Further, the performance of 10 top yielding F_2s was examined in relation to the parental diversity classified as high, medium and low on the basis of their performance for each of the five traits including yield.

RESULTS AND DISCUSSION

The varieties differed significantly in respect of the seven characters, indicating presence of substantial variation in the material (Table 1). The low level of seed yield/plant ranging from 0.47 g in TMV 5 to 3.09 g in T 173 possibly occurred due to thermo– and photoperiod sensitivity of the genotypes under short day condition of rabi season. Considering seed yield and its components, such as capsule number, seed number and branch number, nine varieties (T 173, T 4, BS 5-18-6(G), Kanak, B 14, SP 1162, Phule Til 1, B 67 and Krishna) were found to be superior as they yielded more than the Kamakshyanagar Local, a variety of Orissa. Among these nine cultivars, Kanak and BS 5-18-6(G) are grown in Orissa, while the remaining seven are cultivated in other states (Table 2).

On the basis of general mean ($\overline{X}$) and standard error (SE) for each of the seven characters, the genotypes were grouped into three categories as high for values more than ($\overline{X}$ + SE), medium for values $\overline{X} \pm$ SE, and low for less than ($\overline{X}$ – SE). This classification also indicated considerable genetic variability in the material in spite of the fact that 27 out of 29 cultivars were bred for kharif season.

In D^2 analysis, the contribution of different characters to genetic divergence revealed major importance of number of capsules/plant (84.1%), followed by 1000-seed weight (7.5%), seeds/capsule (4.8%) and seed yield/plant (3.5%). The canonical analysis indicated that in Vector 1 (Z_1), the important characters responsible for genetic divergence in the major axis of differentiation were capsules/plant (0.959) followed by seeds/capsule (0.229); and

Table 1. Character means of 29 sesame varieties used in Experiment I

Variety	Days to flowering	Plant height (cm)	Branches per plant	Capsules per plant	Seeds per capsule	1000-seed weight (g)	Yield/plant (g)
Gouri	39.5(H)	116.8(H)	3.8(H)	26.3(M)	67.4(M)	2.37(L)	1.60(M)
TC 25	33.5(L)	100.6(M)	2.8(M)	24.9(M)	65.2(L)	2.51(M)	1.44(M)
Madhavi	38.0(H)	109.2(H)	3.4(H)	29.4(M)	66.0(M)	2.37(L)	1.72(M)
B 67	35.5(M)	100.0(M)	1.6(L)	26.8(M)	58.1(L)	2.16(L)	1.98(H)
SP 1162	33.5(L)	88.7(L)	3.0(M)	23.3(L)	76.4(H)	2.91(H)	2.03(H)
Krishna	38.5(H)	92.1(L)	3.0(M)	28.2(M)	61.8(L)	2.45(L)	1.85(H)
RAUSS 1	34.0(L)	*86.9(L)*	*1.3(L)*	24.9(M)	71.6(M)	2.46(M)	1.26(L)
T 4	33.0(L)	88.8(L)	2.5(M)	32.4(H)	70.0(M)	2.63(M)	3.05(H)
T 173	36.0(M)	104.2(M)	2.7(M)	**38.7(H)**	*56.4(L)*	2.34(L)	**3.09(H)**
Kayakulam 1	35.0(L)	107.9(H)	2.6(M)	31.1(H)	63.1(L)	2.40(L)	1.13(L)
Phule Til 1	35.0(L)	103.1(M)	2.6(M)	30.8(H)	63.8(L)	2.86(H)	2.01(H)
Punjab Til 1	*32.0(L)*	102.5(M)	2.4(M)	34.8(H)	77.1(H)	2.40(L)	1.70(M)
CST 785	35.0(L)	102.6(M)	3.6(H)	26.2(M)	72.3(H)	2.78(H)	1.45(M)
Tilottama	36.5(M)	108.7(H)	2.7(M)	26.5(M)	64.3(L)	*2.14(L)*	1.34(L)
BS 5-18-6 (G)	34.0(L)	99.9(M)	3.4(H)	35.3(H)	65.7(M)	2.58(M)	2.35(H)
Kanak	34.0(L)	95.5(L)	3.3(H)	32.0(H)	70.9(M)	2.47(M)	2.08(H)
Vinayak Mutant	40.5(H)	**117.8(H)**	3.4(H)	30.5(H)	**84.5(H)**	2.70(H)	1.26(L)
B 14	35.5(M)	104.6(M)	2.7(M)	24.9(M)	73.4(H)	2.65(M)	2.08(H)
Kalika	37.5(M)	98.3(M)	3.1(M)	28.6(M)	73.4(H)	2.38(L)	1.48(M)
TMV 5	41.0(H)	98.4(M)	2.0(L)	*15.1(L)*	76.0(H)	2.53(M)	*0.47(L)*
E 8	41.5(H)	104.2(M)	**3.9(H)**	25.3(M)	65.6(M)	2.38(L)	1.53(M)
TNAU 10	**42.5(H)**	105.1(H)	2.7(M)	15.4(L)	67.4(M)	2.59(M)	0.95(L)
AT 17	41.0(H)	99.8(M)	2.1(L)	18.1(L)	76.4(H)	2.73(H)	0.55(L)
AT 18	*32.0*(L)	96.9(L)	1.7(L)	18.6(L)	68.4(M)	2.87(H)	0.96(L)

(Contd.)

Table 1. *(contd.)*

Variety	Days to flowering	Plant height (cm)	Branches per plant	Capsules per plant	Seeds per capsule	1000-seed weight (g)	Yield/plant (g)
Pratap	37.5(M)	108.0(H)	1.8(L)	17.7(L)	71.6(M)	2.48(M)	1.39(L)
Penisal	39.0(H)	89.5(L)	3.1(M)	21.0(L)	68.2(M)	2.66(M)	1.52(M)
T 13	35.5(M)	100.8(M)	1.8(L)	28.1(M)	64.4(L)	***3.23(H)***	1.28(L)
Vinayak	36.0(M)	109.2(H)	2.6(M)	26.8(M)	68.3(M)	2.69(H)	1.20(L)
KNL	33.5(L)	102.5(M)	2.8(M)	29.2(M)	65.5(L)	2.67(H)	1.06(L)
Mean	36.4	101.5	2.7	26.6	68.7	2.56	1.58
SE ±	1.1	3.3	0.4	3.1	3.1	0.10	0.15
CD: at 5%	3.2	9.7	1.2	8.9	8.9	0.30	0.40
at 1%	4.4	13.0	1.6	12.1	12.0	0.40	0.60

*H, M and L in parentheses indicate high, medium and low character values, respectively.

Maximum and minimum values are shown in bold and italics, respectively

in Vector 2 (Z_2), 1000-seed weight (0.785) followed by yield/plant (–0.612). These results confirmed the character contribution assessed by D^2 analysis. Contribution of days to flowering, plant height and branch number appeared to be negligible. This may be mainly attributed to the fact that the varieties were early maturing and the expression of plant height and branch number was affected by the short day condition of rabi season.

The D^2 values ranged from 6 (between TC 25 of Punjab and Kamakshyanagar Local of Orissa) to 58038 (between SP 1162 and E 8, both from Andhra Pradesh). Following the Tocher's method, the 29 varieties were grouped into nine clusters, seven of which were multivariety clusters (Table 2). These multivariety clusters included varieties from different states irrespective of geographical distances. On the other hand, the varieties from the same state were included in different clusters. In the present study, the three standard varieties of Orissa, Vinayak (a pure line selection), Kanak (a selection from the cross Vinayak x T_4) and Kalika (a mutant of Vinayak) were included in three different clusters (II, V and VII). Thus, the clustering pattern was not related to the geographical origin corroborating earlier findings [5]. Further, it also suggests that it was not geographic origin but selection pressure which played a greater role in determining the genetic closeness/divergence among the varieties. Similar conclusions were made by Bhatt [6] who suggested that selection could cause greater diversity than the geographical distance.

Based on seven characters, canonical analysis confirmed the clustering pattern obtained by the D^2 statistic. The composition of the clusters and their relative disposition remained almost the same (Fig. 1). The first canonical root accounted for 91.2% of the total variability

Table 2. Clustering pattern of 29 sesame varieties of Experiment I and their geographical source

Cluster	Variety	Origin	Cluster	Variety	Origin
I	Gouri(1)*	A.P.	II	B 67(4)	W.B.
	TC 25(2)	Punjab		T 173(9)	W.B.
	E 8(21)	A.P		TNAU 10(22)	T.N.
	T 13(27)	U.P.		AT 18(18)	Gujarat
	KNL(29)	Orissa		Vinayak (28)	Orissa
III	Madhavi(3)	A.P.	IV	Kayakulam 1(10)	Kerala
	Punjab Til 1(12)	Punjab		Phule Til 1(11)	Maharashtra
	BS 5-13-6G(15)	Orissa		CST 785(13)	U.P.
	Vinayak Mutant(17)	Kerala		Tilottama(14)	Kerala
				B 14(18)	W.B.
V	RAUSS 1(7)	Bihar	VI	SP 1162(5)	A.P.
	Kanak(16)	Orissa		TMV 5(20)	T.N.
				AT 17(23)	Gujarat
				Penisal(26)	Orissa
VII	Krishna(6)	Bihar			
	Kalika(19)	Orissa			
VIII	T 4 (8)	U.P.	IX	Pratap (25)	Rajasthan

*Variety numbers in parentheses correspond to those in Fig. 1.

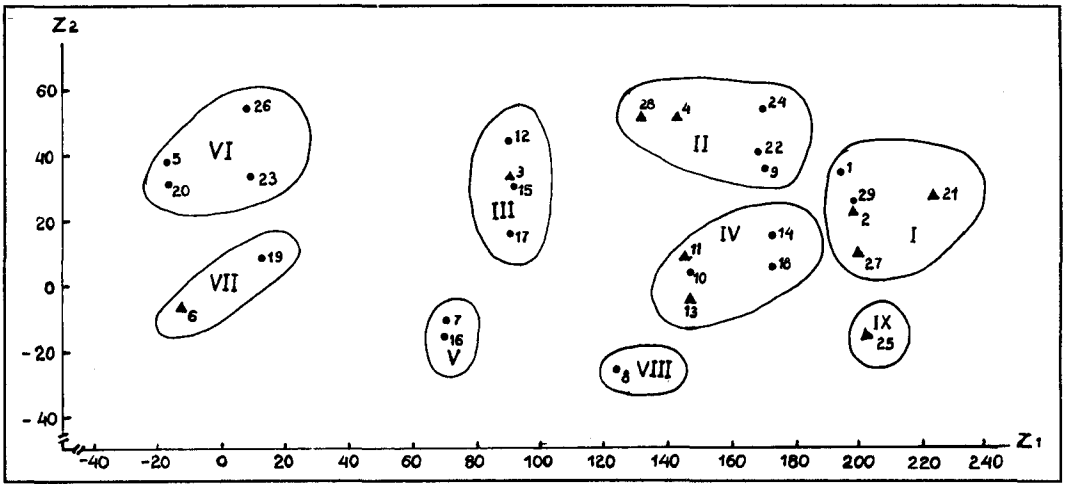

Fig. 1. Two dimensional representation of divergence of 29 sesame varieties using the first two canonical (Z_1 and Z_2) as coordinates, grouping obtained by D^2 analysis superimposed. Solid triangles indicate parents involved in crosses.

Table 3. Frequency of positive transgressive segregates (PTS) and magnitude of transgression for yield (g) in F_2 of 25 crosses and parental divergence in sesame

Cross	F_2 range	Better parent mean	Frequency of PTS (%)	Mean of PTS	Average positive transgression	Mean of top 10% plants	D^2 between parents
B 67 x CST 785	0.20–1.68	1.18	3	1.46	0.27	1.38	3229
B 67 x E 8	0.19–1.89	0.88	12	1.29	0.41	1.67	7173
B 67 x Krishna	0.23–1.69	1.29	4	1.48	0.19	1.48	27985
B 67 x Madhavi	0.09–1.84	1.05	5	1.32	0.27	1.38	3279
B 67 x Phule Til 1	0.13–2.64	1.44	5	1.84	0.40	1.92	1935
B 67 x Pratap	0.05–2.41	1.14	8	1.64	0.50	2.00	7903
CST 785 x Pratap	0.06–3.51	1.18	12	1.90	0.72	2.63	3150
CST 785 x T 13	0.02–2.93	1.18	12	1.89	0.71	2.43	3047
CST 785 x TC 25	0.14–2.55	1.18	9	1.49	0.31	1.89	3507
CST 785 x Vinayak	0.09–3.10	1.39	9	2.27	0.88	2.89	3284
E 8 x Krishna	0.09–2.10	1.29	11	1.65	0.36	1.84	57288
E 8 x Madhavi	0.09–1.87	1.05	9	1.47	0.42	1.74	18086
E 8 x Phule Til 1	0.19–2.40	1.44	5	1.65	0.21	1.70	6395
E 8 x Pratap	0.13–2.54	1.14	13	1.61	0.48	2.17	2199
E 8 x T 13	0.13–3.48	0.88	33	1.34	0.46	3.00	905
E 8 x TC 25	0.06–2.93	0.95	29	1.56	0.61	2.62	659
Krishna x Madhavi	0.08–1.46	1.29	2	1.44	0.15	1.29	12137
Krishna x Phule Til 1	0.08–1.50	1.44	1	1.50	0.06	1.37	25626
Krishna x T 13	0.11–2.61	1.29	3	1.86	0.57	1.70	45658
Krishna x TC 25	0.13–2.35	1.29	6	1.99	0.71	2.12	45935
Madhavi x TC 25	0.18–2.26	1.05	8	1.58	0.53	1.96	12062
Phule Til 1 x TC 25	0.17–2.31	1.44	10	1.81	0.37	2.09	3031
Pratap x T 13	0.21–2.28	1.14	13	1.60	0.46	2.00	653
Pratap x TC 25	0.14–3.96	1.14	7	2.54	1.40	3.02	1503
T 13 x TC 25	0.08–5.87	0.95	16	1.87	0.92	3.57	220

and the first two canonical roots together shared 99.8% of variation. This indicated that a two-dimensional representation could give a good picture of the configuration of the populations in the seven dimensional space.

Significant differences among the means and variances for individual crosses (F_2s) were found in respect of yield and four of its components, thus offering ample scope for selection in yield improvement. On the basis of mean, variance, heritability and genetic advance for yield, 8 crosses (CST 785 x Pratap, CST 785 x T 13, CST 785 x Vinayak, E 8 x Pratap, E 8 x T 13, E 8 x TC 25, Pratap x TC 25 and T 13 x TC 25) showed high breeding potential for advancement through pedigree breeding. Further, analysis of nature and magnitude of transgressive segregation and also mean performance of 10% top yielding plants revealed high breeding potential of the same crosses, suggesting that selection for yield in F_2 and later generations would result in substantial improvement (Table 3). Average positive transgressions in these crosses were high, ranging from 0.46 g in E 8 x T 13 to 1.40 g in Pratap x TC 25.

Significant positive correlations among all the parameters of variability and transgressive segregation were observed except frequency of positive transgressive segregates with mean of positive transgressive segregates and average positive transgression (Table 4). On the other hand, negative correlation of parental diversity with all the parameters were not significant except with the mean of positive transgressive segregates. However, this negative association with F_2 mean, frequency of positive transgressive segregates and mean of top 10% plants was of moderate magnitude. This suggested that crosses among parents with wide diversity may not generate potential hybrids. Further, the D^2 values between the parents of the 8 potential crosses ranged from

Table 4. Correlation coefficients among the parameters of variability and transgressive segregation for yield in F_2 and their parental diversity (D^2) in sesame

Parameter	D^2	F_2 mean	F_2 variance	Positive transgressive segregates		Average positive trans-gression	Mean of top 10% plants
				frequency	mean		
Mean of F_2 cross	-0.34						
Variance of F_2 cross	-0.27	0.65**					
Frequency of positive transgressive segregates	-0.31	0.66**	0.46*				
Mean of positive transgressive segregates	-0.58**	0.42*	0.50**	-0.12			
Average positive transgression	-0.17	0.56**	0.72**	0.27	0.79**		
Mean of top 10% plants	-0.33	0.78**	0.83**	0.61**	0.53**	0.76**	
Genetic advance	-0.30	0.86**	0.94**	0.52**	0.57**	0.77**	0.86**

*,** Significant at 5% and 1% levels, respectively.

220 in the cross T 13 x TC 25 to 3284 in CST 785 x Vinayak and were considered to be moderate. Thus, it can be concluded that a cross would have higher potential when the parents are moderately diverse rather than less or highly diverse [7, 8].

The breeding potential of crosses in relation to parental performance was assessed by classifying the 29 varieties in Experiment I into high, medium and low on the basis of *per se* performance for yield and four of its components. Based on this, the crosses were classified as high x high, high x medium, high x low, medium x medium, medium x low, and low x low combinations. The performance of the 10 top yielding F_2s was examined in relation to combination of parental performance for each of the five characters. It was observed that 9 out of the 10 top yielding crosses (F_2s) were either high x medium or medium x low combinations for yield and the remaining cross was a medium x medium combination (Table 5). But high x low combinations did not give crosses with high yield potential. When the parental combinations of these crosses were considered for all the five traits, it was found that 26 out of 50 crosses were either high x medium or medium x low, 5 high x low, and the remaining 19 were of similar parental performance. The results, thus, indicated that high x

Table 5. Classification of 10 top yielding F_2 populations and ranking of their parents for five economic traits

Cross	Plant yield	Capsule number	Seed number	Seed weight	Branches per plant
E 8 x TC 25	M x M	M x M	M x L	M x M	H x M
T 13 x TC 25	L x M	M x M	L x L	H x M	L x M
CST 785 x Vinayak	M x L	M x M	H x M	H x H	H x M
E 8 x T 13	M x L	M x M	M x L	M x H	H x L
CST 785 x Pratap	M x L	M x L	H x M	H x M	H x L
Phule Til 1 x TC 25	H x M	H x M	L x L	H x M	M x M
Pratap x TC 25	L x M	L x M	M x L	M x M	L x M
CST 785 x T 13	M x L	M x M	H x L	H x H	H x L
E 8 x Pratap	M x L	M x L	M x M	M x M	H x L
Krishan x TC 25	H x M	M x M	L x L	M x M	M x M
Frequency of:					
H x L	0	0	1	0	4
(H x M) + (M x L)	9	4	5	4	4
(H x H) + (M x M) + (L x L)	1	6	4	6	2

Note: H, M and L indicate high, medium and low levels of performance of the parents in respective traits.

medium and medium x low crosses would be better than high x high, medium x medium, low x low, and even high x low crosses for yield improvement. This supports the results obtained with parental divergence as measured by D^2 statistic.

It may be inferred from the results of the present study that the varieties with moderate genetic divergence as measured by D^2 values or by per se performance in respect of yield and its components are likely to produce potential crosses. Thus, while choosing parents in a hybridization programme for yield improvement, assessment of per se yield performance and important yield components of the varieties may be considered a simpler and more convenient criterion than going for complicated statistical analysis to measure genetic divergence among them by D^2 statistic.

REFERENCES

1. Anonymous. 1990. Orissa Agricultural Statistics, 1989–90, Directorate of Agriculture and Food Production, Orissa, Bhubaneswar: 34–35.

2. P. C. Mahalanobis. 1936. On the generalised distance in statistics. Proc. Natl. Inst. Sci. India, **2**: 49–55.

3. C. R. Rao. 1952. Advanced Statistical Methods in Biometrical Research, John Wiley and Sons, New York.

4. T. W. Anderson. 1958. An Introduction to Multivariate Statistical Analysis. John Wiley and Sons, New York.

5. M. S. Thangavelu and S. Rajsekharan. 1983. Genetic divergence in sesamum. Madras Agric. J., **70**(4): 211–214.

6. G. M. Bhatt. 1970. Multivariate analysis approach to selection of parents for hybridization aiming at yield improvement in self- pollinated crops. Aust. J. Agric. Res., **21**: 1–7.

7. V. S. Chauhan and B. B. Singh. 1982. Heterosis and genetic variability in relation to genetic divergence in soybean. Indian J. Genet., **42**: 324–328.

8. V. Arunachalam and A. Bandyopadhyay. 1984. Limits to genetic divergence for occurrence of heterosis — experimental evidence from crop plants. Indian J. Genet., **44**: 548–554.