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Combining ability studies in sesame (*Sesamum indicum* L.)

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SUMMARY

Combining ability analysis in a set of ten parents, 45 F_1's (excluding reciprocal) and their 45 F_2's in a diallel crossing programme for yield and yield contributing traits revealed significant estimates of mean squares due to gca and sca for all the characters in both the generations. The estimates of gca/sca variance ratios suggested that variances due to sca were greater than variances due to gca for most of the traits in F_1 and F_2 except for plant height and days to maturity in F_1 indicating the preponderance of non-additive effects. Equal importance of additive and non-additive gene actions were observed for 1000 seed weight in F_1. A comprehensive examination of results revealed ABT-22, ABT-23 and AT-34 as good general combiners and crosses AT-90 x AT-104, ABT-22 x G.Til-1, ABT-23 x AT-34 and AT-104 x G.Til-2 as good specific combiners for yield and yield contributing characters.

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Key words : Combining ability, gca, sca, Gene action and sesame

Sesame (*Sesamum indicum* L.) is one of the most ancient oilseed crops of India. The crop is cultivated almost throughout India for its high quality oil and it has tremendous potential for export. It ranks third in term of total oilseeds area and fourth in terms of total oilseeds production in the country. The selection of parents on the basis of *per se* performance does not necessarily lead to desirable results. The knowledge of combining ability is prerequisite in any plant breeding programme for varietal improvement and for evolving a hybrid. Hence, attempts have been made to study the general combining ability and specific combining ability effects for yield and its component traits in sesame.

MATERIALS AND METHODS

Ten genetically diverse genotypes *viz*., AT-90, AT-92, AT-104, AT-114, BAVJ-1, ABT-22, ABT-23, AT-34, G.Til-1 and G.Til-2 were crossed during *Kharif* 2002 following 10 x 10 diallel mating design excluding reciprocals. Five seeds were grown during *Kharif* 2003 for advancing the generation and F_2 seeds were collected from the F_1 plants. Thus, the experimental materials comprised of 10 parents, 45 F_1's and 45 F_2's and these were planted at Main Oilseeds Research Station, Junagadh Agricultural University, Junagadh during *Kharif* 2004 in a Randomized Block Design with three replications at a spacing of 45 x 15 cm. Each entry consisted of a single row of 4 meter length for each of parents and F_1's whereas, two rows each of F_2 progenies. All the recommended agronomical package of practices and plant protection measures were followed timely to raise a healthy crop. The observations were recorded on five randomly selected competitive plants of parents and F_1's while, 20 plants of F_2's from each replication for twelve characters *viz*., days to 50 % flowering, plant height (cm), number of effective branches per plant, number of capsules per plant, number of seeds per capsule, length of capsules (cm), days to 80 % maturity, yield per plant (g), 1000 seed weight (g), oil content (%), harvest index (%) and leaf area index. Data were statistically analyzed following Panse and Sukhatme (1978). The combining ability analysis was carried out according to Model-I, Method-2 of Griffing (1956_a). The gca and sca variances were estimated as per the technique suggested by Griffing (1956_b) and Gardner (1963).

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RESULTS AND DISCUSSION

Analysis of variance revealed significant differences among parents, F_1's, F_2's, parents *vs* crosses and F_1's *vs* F_2's, for all the traits except, for number of capsules per plant in F_2's and parents *vs* crosses for days to 50 % flowering, plant height, number of capsules per plant,

Table 1: Analysis of variance for combining ability for twelve characters in sesame

Source	Generation	d. f.	Days to 50 % flowering	Plant height (cm)	No. of effective branches per plant	No. of capsules per plant	No. of seeds per capsule	Length of capsule (cm)	Days to 80 % maturity	Yield per plant (g)	1000 seed weight (g)	Oil content (%)	Harvest index (%)	Leaf area index
			Mean squares											
gca	F_1	9	22.49**	525.85**	0.590**	84.90**	99.75**	0.046**	40.23**	2.76**	0.282**	3.49**	86.57**	0.068**
	F_2	9	25.29**	152.75**	0.476**	24.73*	36.38**	0.059**	21.32**	1.22**	0.210**	2.18**	17.39**	0.124**
sca	F_1	44	4.25**	40.64*	0.364**	48.10**	64.25**	0.012**	3.52**	1.92**	0.035**	2.56**	13.87**	0.033**
	F_2	44	9.96**	65.60**	0.127**	19.83**	33.27**	0.016**	5.74**	1.15**	0.029**	2.19**	13.72**	0.041**
Error	F_1	108	1.56	24.53	0.111	13.82	10.58	0.005	1.09	0.366	0.015	0.142	6.06	0.011
	F_2	108	1.11	15.15	0.043	9.78	6.32	0.003	1.44	0.185	0.012	0.074	3.79	0.016
σ^2_g	F_1		1.52	40.43	0.019	3.066	2.959	0.003	3.058	0.07	0.020	0.08	6.05	0.003
	F_2		1.28	7.26	0.029	0.408	0.259	0.004	1.29	0.026	0.015	0.0013	0.31	0.007
σ^2_s	F_1		2.69	16.11	0.253	34.28	53.67	0.007	2.43	1.35	0.020	2.41	7.80	0.022
	F_2		8.85	50.45	0.083	10.05	26.96	0.013	4.30	0.965	0.017	2.12	9.93	0.025
σ^2_g/σ^2_s	F_1		0.565	2.510	0.170	0.089	0.055	0.429	1.260	0.050	1.028	0.033	0.780	0.136
	F_2		0.145	0.144	0.349	0.041	0.009	0.308	0.300	0.026	0.880	0.006	0.030	0.270

* and ** indicate significance of values at P 0.05 and 0.01, respectively

number of seeds per capsule, days to maturity and leaf area index. Therefore, the data were subjected to combining ability analysis. The analysis of variance for combining ability (Table 1) exhibited that variances due to gca and sca were significant for all the traits in both the generations. This indicated that both additive as well as non-additive gene effects played an important role in the expression of all the characters. Similar findings were reported by Gawade *et al.* (2007). The magnitude of variances due to gca were lower than the magnitude of variances due to sca for all the characters in both the generations except for plant height and days to maturity in F_1 indicating preponderance of non-additive gene action in the expression of these characters. The predominance of non-additive gene action for most of the characters is suggestive of the high scope for exploitation of heterosis in sesamum. However, the additive gene action was important for plant height and days to maturity in F_1 generation. Same gene action was also observed for days to 50 % flowering and primary branches per plant (Prajapati *et al.*, 2006), days to maturity (Singh, 2004 and Toprope, 2008), number of capsules per plant (Durai *et al.*, 2007), 1000 seed weight and oil content (Vidyavathi *et al.*, 2005, Prajapati *et al.*, 2006 and Durai *et al.*, 2007). Whereas, non-additive gene action was preponderant for days to 50 % flowering and days to maturity (Vidyavathi *et al.*, 2005), primary branches per plant and plant height (Singh, 2004 and Toprope, 2008), number of capsules per plant and yield per plant (Singh, 2004, Vidyavathi *et al.*, 2005, Prajapati *et al.*, 2006 and Toprope, 2008).

An overall appraised of gca effects (Table 2) revealed in general, none of the parents was good general combiner for all the traits studied. However, parent ABT-22 was good general combiner along with high *per se* performance for number of effective branches per plant, length of capsule, 1000 seed weight, oil content and leaf area index. It was also average general combiner for yield and capsules per plant. It has, therefore, given consistent performance in both the generations. With respect to yield, two parents ABT-23 and AT-34 were found good general combiners in both F_1 and F_2 generations. In case of earliness (days to 50 % flowering and days to maturity), parents AT-90, AT-92, AT-104 and AT-114 were observed well to average general combiners in both the generations. The parents *viz.*, AT-90, AT-92 and G.Til-2 were identified as good general combiners for plant height in both F_1 and F_2 generations. Besides, for 1000 seed weight, AT-104 and ABT-22 were found as good general combiners in both the generations while, BAVJ-1 and AT-34 were good general combiners in F_1 set and average general combiners in F_2 set for this character. None of the parents

Table 2: Estimation of general combining ability (GCA) effects of parents for twelve characters in sesame

Parents	Days to 50 % flowering		Days to 80 % maturity		Plant height (cm)		Number of effective branches per plant		Number of capsule per plant		Number of seeds per capsule	
	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
AT 90	0.54	0.90**	1.82**	1.51**	7.47**	3.41**	0.21*	0.06	2.91**	0.16	3.72**	0.89
AT 92	1.07**	0.79**	1.66**	0.93**	3.69**	3.40**	0.08	0.15**	1.55	0.92	2.81**	1.70*
AT 104	0.73*	0.12	0.91**	0.18	0.81	0.68	0.32**	0.03	0.62	0.31	1.55	0.60
AT 114	2.01**	1.40**	1.43**	0.93**	2.16	0.56	0.14	0.12*	1.85	1.13	0.64	2.47**
BAVJ 1	0.02	0.15	0.16	0.57	2.85*	2.78**	0.22*	0.16**	0.84	1.20	2.88**	1.19
ABT 22	2.85**	2.29**	3.34**	2.66**	14.87**	6.25**	0.40**	0.33**	0.88	0.24	5.68**	0.56
ABT 23	1.07**	0.71*	2.04**	1.49**	0.64	3.19**	0.16	0.14*	4.71**	1.92*	0.78	3.68**
AT 34	0.99**	1.38**	1.84**	1.02**	6.78**	4.86**	0.13	0.38**	2.16*	1.27	1.71	1.27
G.TIL 1	0.18	1.41**	1.54**	0.10	5.38**	0.66	0.11	0.01	0.21	1.06	0.31	0.02
G.TIL 2	0.76*	2.43*	0.29	1.15**	5.47**	3.13**	0.07	0.13*	4.55**	2.90**	2.47**	0.47
S.E.(g_i)	0.342	0.289	0.286	0.329	1.360	1.070	0.091	0.057	1.018	0.857	0.891	0.689
S.E.(g_i-g_j)	0.510	0.430	0.426	0.491	2.020	1.590	0.136	0.085	1.518	1.277	1.328	1.026
C.D. (P=0.05)	0.680	0.572	0.566	0.651	2.690	2.110	0.181	0.113	2.016	1.696	1.763	1.364
C.D. (P=0.01)	0.880	0.745	0.738	0.885	3.500	2.750	0.236	0.147	2.627	2.209	2.229	1.776

Table 2 Contd...

Parents	Length of capsule (cm)		Yield per plant (g)		1000 seed weight (g)		Oil content (%)		Harvest index (%)		Leaf area index	
	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
AT 90	0.01	0.02	0.45**	0.43**	0.14**	0.14**	0.44**	0.25**	0.64	0.30	0.01	0.04
AT 92	0.01	0.03	0.27	0.10	0.14**	0.12**	0.50**	0.71**	3.52**	0.67	0.08**	0.02
AT 104	0.03	0.05**	0.09	0.37**	0.11**	0.16**	0.37**	0.01	0.94	0.65	0.02	0.02
AT 114	0.003	0.002	0.10	0.15	0.08*	0.01	0.60**	0.43**	0.91	0.56	0.06*	0.004
BAVJ 1	0.08**	0.01	0.53**	0.22	0.07*	0.04	0.40**	0.13	1.08	0.42	0.001	0.09
ABT 22	0.08**	0.06**	0.21	0.06	0.30**	0.25**	0.42**	0.23**	6.52**	3.03**	0.18**	0.20**
ABT 23	0.01	0.01	0.38*	0.31**	0.04	0.03	0.04	0.17*	0.04	0.44	0.04	0.001
AT 34	0.01	0.01	0.41*	0.23*	0.11**	0.01	1.16**	0.08	1.12	0.53	0.03	0.04
G.TIL 1	0.01	0.02	0.10	0.15	0.07*	0.05	0.01	0.86**	2.34**	0.90	0.02	0.07
G.TIL 2	0.14**	0.19**	1.06**	0.57**	0.19**	0.17**	0.04	0.18*	0.12	1.06*	0.079**	0.19**
S.E.(g_i)	0.200	0.016	0.166	0.116	0.034	0.030	0.103	0.075	0.674	0.533	0.029	0.034
S.E.(g_i-g_j)	0.029	0.023	0.246	0.175	0.051	0.045	0.154	0.111	1.005	0.796	0.043	0.051
C.D. (P=0.05)	0.038	0.031	0.328	0.229	0.067	0.060	0.205	0.148	1.340	1.050	0.057	0.068
C.D. (P=0.01)	0.050	0.040	0.427	0.304	0.087	0.078	0.267	0.193	1.740	1.370	0.074	0.089

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 3 : Estimates of means and sca effects of promising crosses in sesame

Characters	Cross	Mean	sca effect	gca effect
Days to 50 % flowering	AT-104 x ABT-22	F_1 44.00	-4.22**	(H x L)
		F_2 42.67	-4.03**	(M x L)
	AT-114 x ABT-22	F_1 43.00	-3.94**	(H x L)
		F_2 39.67	-5.76**	(H x L)
Plant height (cm)	AT-114 x ABT-22	F_1 99.40	-9.29**	(M x L)
		F_2 96.03	-3.33	(M x L)
No. of effective branches per plant	AT-104 x G.Til-2	F_1 5.07	1.37**	(H x M)
		F_2 2.40	-0.22	(M x L)
	ABT-22 x G.Til-2	F_1 5.10	1.32**	(H x M)
		F_2 2.80	-0.22	(H x L)
No. of capsules per plant	AT-104 x AT-34	F_1 56.30	15.14**	(M x H)
		F_2 30.27	1.38	(M x M)
	ABT-23 x AT-34	F_1 60.67	14.19**	(H x H)
		F_2 27.30	-3.81	(H x M)
No. of seeds per capsule	AT-104 x BAVJ-1	F_1 77.00	18.90**	(M x H)
		F_2 44.23	-3.66	(M x M)
	AT-90 x ABT-22	F_1 70.20	18.49**	(H x L)
		F_2 52.23	5.81*	(M x L)
Length of capsule (cm)	AT-104 x BAVJ-1	F_1 2.81	0.22**	(M x H)
		F_2 2.51	-0.04	(H x M)
	BAVJ-1 x ABT-22	F_1 2.89	0.20**	(H x H)
		F_2 2.56	-0.002	(M x H)
Days to 80 % maturity	ABT-23 x G.Til-2	F_1 90.33	-3.07**	(L x M)
		F_2 90.67	1.50	(L x H)
	AT-34 x G.Til-1	F_1 88.33	-3.05**	(L x H)
		F_2 90.67	0.72	(L x M)
Yield per plant (g)	AT-90 x AT-104	F_1 8.81	2.67**	(L x M)
		F_2 4.60	-0.23	(L x H)
	ABT-22 x G.Til-1	F_1 9.16	2.37**	(M x M)
		F_2 5.38	-0.80*	(M x M)
1000 seed weight (g)	ABT-23 x AT-34	F_1 4.08	0.37**	(M x H)
		F_2 3.29	-0.17*	(M x M)
	ABT-22 x G. Til.-1	F_1 4.11	0.32**	(H x L)
		F_2 3.88	0.25*	(H x M)
Oil content (%)	ABT-22 x G. Til.-1	F_1 50.73	3.40**	(H x M)
		F_2 47.85	0.11	(H x H)
	AT-92 x AT-34	F_1 50.76	3.18**	(L x H)
		F_2 44.84	-1.18**	(L x M)
Harvest index (%)	AT-104 x G.Til-1	F_1 39.57	7.47**	(M x H)
		F_2 37.51	4.04	(M x M)
	AT-104 x AT-23	F_1 36.75	7.03**	(M x M)
		F_2 34.23	1.22	(M x M)
Leaf area index	AT-92 x G.Til-1	F_1 1.12	0.37**	(L x M)
		F_2 0.86	0.08	(M x L)
	AT-92 x AT-34	F_1 1.01	0.25**	(L x M)
		F_2 0.93	0.04	(M x L)

* and ** indicate significance of values at P=0.05 and 0.01, respectively

was good general combiner in both the generations for number of seeds per capsule and harvest index.

A multiple crossing programme involving these parents would offer good scope for improving the yield by combining the positive effects of most of the yield attributing characters. A good degree of correspondence between gca estimates in F_1 and F_2 generations indicated the possibility of postponing combining ability studies to F_2 generation to obtained more reliable information where the problem of producing sufficient quantity of hybrid seed is evident.

Out of forty-five hybrids studied for specific combining ability effects, none of the cross combinations exhibited significant and consistent effects for all the characters. However, some of the crosses exhibited high *per se* performance and sca effect for more than one characters (Table 3). A perusal of the sca values and *per se* performance of hybrids indicated that the crosses AT-90 x AT-104, ABT-22 x G.Til.-1, ABT-23 x AT-34 and AT-104 x G.Til-2 produced superior and potential hybrids. Parents involved in these hybrids were either high x high (H x H) or medium x medium (M x M) or medium x low (M x L) or low x medium (L x M) with regard to gca effects. The cross combinations showed high sca effect indicating additive x additive type gene action between favourable alleles contributed by two parents, which were considered to be fixable type of nature. In case of M x L and L x M general combiners indicated the presence of genetic interaction of additive x dominance and dominance x additive types of gene actions.

In view of these studies, it can be concluded that yield and most of the yield contributing traits were dominantly controlled by non-additive gene effects. Under such situation, it would be worthwhile to resort by using breeding methodologies such as biparental mating, recurrent selection and diallel selective mating than to use conventional pedigree or backcross methods.

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