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Research Article

Combining ability for seed yield and its components in sesame (*Sesamum indicum* L.)

M. B. Virani, J. H. Vachhani*, V. H. Kachhadia, R. M. Chavadhari and Sureshkumar Sharma
Main Oilseeds Research Station, Junagadh Agricultural University, Junagadh-362001 (Gujarat)
E-mail: jhvachhani@jau.in

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Abstract

Fifty sesame crosses generated in line x tester (10 lines x 5 testers) mating method were studied to estimate combining ability for fourteen characters in sesame. Analysis of variance for combining ability revealed that the mean squares due to lines, testers and line x testers were significant for all the characters except mean squares due to lines for days to maturity. The results indicated the importance of both additive and non-additive genetic variances in the expression of these characters. The estimated ratio of $\hat{\sigma}^2$gca/$\hat{\sigma}^2$sca from analysis of combining ability revealed that non-additive gene action was predominant in the genetic control of all the characters studied except plant height. Among female parents, ES-246 was found to be good general combiner for eleven characters followed by Lalavadar-6 for five characters and Borda-2 for four characters. Among the testers, G.Til-4 was good general combiner for seven characters followed by G.Til-1-9-4, which gave desirable gca for five traits. The estimates of sca effects of the crosses indicated that twelve hybrids manifested significant and positive sca effects for seed yield per plant. Among these, the best three specific cross combinations were RMT-180 x G. Til-3, Borda-2 x G. Til-1-9-4 and Lalavadar-6 x J-68-3., which had high sca effects for seed yield per plant along with *per se* performance and other yield traits.

Keywords
Sesame, combining ability, L x T analysis, gene action

Introduction

Sesame (*Sesamum indicum* L.) is a principle oilseed crop for internal and export purposes. Selection of suitable parents for hybridization is an important aspect in the crop improvement programme and the performance of hybrids may give an idea of their relative superiority. Therefore, in any sound breeding programme, the proper choice of parents based on their combining ability is a pre-requisite. As studies indented to determine the combining ability not only provide necessary information regarding the choice of parents but also illustrate the nature and magnitude of gene action involved. Accordingly, the present investigation was undertaken to identify good general combiners and specific cross combinations which may be used to create a population with favourable genes for seed yield and its component characters.

Materials and Methods

Ten diverse pure lines *viz*., EC-41, U-76-22, ES-246, UCS-76-1, ES-139, JLSL-8, RMT-180, IC-74188, Lalavadar-6 and Borda-2 used as females were crossed with five male (tester) parents *viz*., G.Til-1-9-4, G.Til-2, G.Til-3, G.Til-4 and J-68-3 to develop 50 F_1 crosses using line x tester mating method during *kharif* season of 2015. The experimental material consisted of 66 entries including 15 parents (10 lines and 5 testers) and their resultant 50 hybrids along with one standard check variety (G. Til-4), was evaluated in Randomized Block Design with two replications at Main Oilseeds Research Station, Junagadh Agricultural University, Junagadh, Gujarat. All the agronomic management practices and plant protection measures were adopted timely to raise healthy crop. The observations on five randomly selected competitive plants were recorded from each replication for fourteen characters *viz*., days to 50 % flowering, days to maturity, plant height (cm), height to first capsule (cm), number of branches per plant, number of internodes per plant, length of capsule (cm), width of capsule (cm), number of capsules per plant, number of capsules per leaf axil, number of capsules per leaf axil, number of seeds per capsule, number of seeds per capsule, 1000-seed weight (g), seed yield per plant (g) and oil content (%). The days to 50% flowering and days to maturity were recorded on plot basis. The oil content was analysed by using Nuclear Magnetic Resonance Spectro Photometer as suggested by Tiwari *et al.* (1974). The analysis of variance was performed to test the significance of differences among the genotypes for all the characters as suggested by Panse and Sukhatme (1985). The analysis of variance for combining ability for all the fourteen characters was carried-out as suggested by Kempthorne (1957).

Results and Discussion

Analysis of variance for combining ability revealed that the mean squares due to lines were significant for all the characters except days to maturity, while for testers and lines x testers interaction, the mean squares were significant for all the characters. The estimates of σ^2gca were higher than the corresponding σ^2sca for only one character *i.e.* plant height, this indicated less influence of environment. While, in case of remaining characters the magnitude of σ^2sca was higher than σ^2gca, which was also confirmed by the ratio of σ^2gca/σ^2sca, which was less than unity for all the characters except plant height. The results indicated the importance of both additive and non-additive genetic variances in the expression of these characters. Predominance of non-additive gene action in the inheritance of seed yield per plant in sesame has been reported earlier by Mothilal and Manoharan (2004), El-Shakhess and Khalifa (2007), Yamanura *et al.* (2009), Prajapati *et al.* (2010) and Praveenkumar *et al.* (2012). Contrary to the present results, the preponderance of additive gene action was observed by Mansouri and Ahmadi (1998), Das and Gupta (1999) and Parameshwarappa and Salimath (2010).

In the study on gca effects of 15 parents (10 lines and 5 testers) for 14 traits (Table 2), the line, ES-246 gave desirable gca effect for eleven characters *viz.*, plant height, number of branches per plant, number of internodes per plant, length of capsule, width of capsule, number of capsules per plant, number of capsules per leaf axil, number of seeds per capsule, 1000-seed weight, seed yield per plant and oil content followed by Lalavadar-6 for five characters *viz*., days to 50% flowering, days to maturity, number of branches per plant, length of capsule, number of seeds per capsule and Borda-2 for four characters *viz*., number of branches per plant, number of internodes per plant, number of capsules per plant and seed yield per plant. Among the testers, G.Til-4 was good general combiner for seven characters *viz*., days to 50% flowering, days to maturity, length of capsule, width of capsule, number of capsules per plant, number of seeds per capsule and seed yield per plant followed by G.Til-1-9-4, which gave desirable gca effect for five traits *viz.*, plant height, number of branches per plant, number of capsules per plant, number of capsules per leaf axil and seed yield plant. Hence, from the present study, it can be concluded that in lines, ES-246, Lalavadar-6 and Borda-2 and the testers G. Til-4 and G. Til-1-9-4 were the good general combiners which could be preferred in breeding programme as these parents upon crossing, are expected to give desirable segregants in the succeeding generations.

The sca effect of the crosses indicated that twelve hybrids manifested significant and positive sca effect for seed yield per plant (Table 3). Among these, the best three specific combiners were RMT-180 x G.Til-3, Borda-2 x G.Til-1-9-4 and Lalavadar-6 x J-68-3 displayed high sca effect for seed yield per plant. The high sca status of the hybrids indicated the substantial role played by dominance and epistatic interaction (Table 3).

The best five crosses showing high sca effects for seed yield coupled with *per se* performance and gca effects of parents are presented in Table 4. These crosses exhibiting high sca effect involved either good x good, good x average and average x poor general combiners for majority of characters indicating the presence of additive x additive and additive x dominance types of gene interactions. Both additive and non-additive genetic components were important for seed yield per plant. The additive components of variations can be exploited by simple selection. However, the presence of non-fixable components *viz.*, additive x dominance and dominance x dominance types of interactions present, the improvement of seed yield could be made by using breeding methodology such as recurrent selection or bi-parental mating followed by recurrent selection may prove to be effective in simultaneous exploitation of both the type of gene actions for improvement of seed yield and its attributes in sesame.

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Table 1. Analysis of variance for combining ability for different fourteen characters in sesame

Source	d. f.	Days to 50 % flowering	Days to maturity	Plant height (cm)	Height to first capsule (cm)	Number of branches per plant	Number of internodes per plant	Length of capsule (cm)
		1	2	3	4	5	6	7
Replications	2	8.184	66.227*	32.643	39.405	0.877	0.145	0.146
Lines (L)	9	47.900**	40.893	1325.306**$^{++}$	312.092**	98.852**	24.098**	0.748**
Testers (T)	4	61.463**	485.920**$^{++}$	2146.546**$^{++}$	134.240**	41.259**	42.876**	0.539**
Lines x Testers (L x T)	36	52.616**	115.392**	368.712*	183.342**	18.791**	30.656**	0.961**
Error	98	16.109	20.873	184.698	33.323	0.469	2.164	0.091
<u>**Variance components**</u>								
$\hat{\sigma}^2{}_l$	-	2.119	1.335	76.041	18.585	6.559	1.468	0.044
$\hat{\sigma}^2{}_t$	-	1.512	15.502	65.395	3.364	1.360	1.357	0.015
$\hat{\sigma}^2{}_{lt}$	-	12.169	31.506	61.338	50.006	6.107	9.498	0.290
$\hat{\sigma}^2{}_{gca}$	-	1.714	10.779	68.943	8.437	3.093	1.392	0.025
$\hat{\sigma}^2{}_{sca}$	-	12.169	31.506	61.338	50.006	6.107	9.498	0.290
$\hat{\sigma}^2{}_{gca}/\hat{\sigma}^2{}_{sca}$	-	0.140	0.342	1.123	0.168	0.506	0.146	0.086

(Contd….)

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Table 1. ***(Contd….)***

Source	d. f.	Width of capsule (cm)	Number of capsules per plant	Number of capsules per leaf axil	Number of seeds per capsule	1000-seed weight (g)	Seed yield per plant (g)	Oil content (%)
		8	**9**	**10**	**11**	**12**	**13**	**14**
Replications	2	0.008	150.242	0.091	14.924	0.052	1.355	2.122
Lines (L)	9	0.027**	2254.336**	0.737**	279.034**	0.652**	59.016**	13.081*
Testers (T)	4	0.031*	2734.278**	0.932**	122.710**	0.579**	46.939**	15.374*
Lines x Testers (L x T)	36	0.019*	1108.969**	0.685**	236.788**	0.440**	37.412**	9.273*
Error	98	0.009	55.457	0.046	31.888	0.064	2.431	5.799
Variance components								
$\hat{\sigma}^2_l$	-	0.001	146.592	0.046	16.476	0.039	3.772	0.485
$\hat{\sigma}^2_t$	-	0.001	89.294	0.030	3.027	0.017	1.484	0.319
$\hat{\sigma}^2_{lt}$	-	0.003	351.171	0.213	68.300	0.125	11.660	1.158
$\hat{\sigma}^2_{gca}$	-	0.001	108.393	0.035	7.510	0.024	2.247	0.375
$\hat{\sigma}^2_{sca}$	-	0.003	351.171	0.213	68.300	0.125	11.660	1.158
$\hat{\sigma}^2_{gca}/\hat{\sigma}^2_{sca}$	-	0.333	0.308	0.164	0.109	0.192	0.193	0.323

*, ** Significant at 5 and 1 per cent levels, respectively

+, ++ Significant at 5 and 1 per cent levels, respectively against lines x testers interaction

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Table 2. Estimates of general combining ability (gca) of the parents for fourteen characters in sesame

S. N.	Parents	Days to 50% flowering	Days to maturity	Plant height (cm)	Height to first capsule (cm)	No. of branches/plant	No. of internodes/plant	Length of capsule (cm)
		1	**2**	**3**	**4**	**5**	**6**	**7**
Lines								
1	EC-41	0.608	-1.900	-2.401	0.028	-1.455**	-0.326	-0.301**
2	U-76-22	2.054*	0.434	16.240**	5.528**	2.631**	-0.833*	-0.048
3	ES-246	1.943	2.112	18.371**	6.054**	4.745**	2.994**	0.208**
4	UCS-76-1	-1.677	1.660	-0.476	5.194**	-1.829**	-0.899*	0.337**
5	ES-139	2.378**	0.451	-4.386	-3.266*	-1.122**	-1.286**	-0.402**
6	JLSL-8	-1.278	0.045	-8.441*	-5.832**	-2.615**	-0.006	0.016
7	RMT-180	0.955	-0.251	-6.404*	-4.259**	-0.362*	0.314	0.073
8	IC-74188	-1.140	-1.254	-5.411	-4.546**	-3.282**	-0.726	0.035
9	Lalavadar-6	-2.505*	-2.976*	-4.550	-1.570	1.611**	-0.426	0.158*
10	Borda-2	-1.337	1.678	-2.544	2.668	1.678**	1.194**	-0.074
	SE(g_i)	**1.036**	**1.179**	**3.509**	**1.490**	**0.177**	**0.379**	**0.077**
	SE(g_i-g_j)	**1.466**	**1.668**	**4.962**	**2.108**	**0.250**	**0.537**	**0.110**
Testers								
1	G.Til-1-9-4	-0.189	-1.617	12.228**	3.441**	2.011**	-1.793**	0.043
2	G.Til-2	0.246	1.953*	5.293*	-0.869	-0.009	0.694*	-0.126*
3	G.Til-3	0.375	1.213	-6.879**	-1.872	-0.515**	1.371**	-0.156**
4	G.Til-4	-2.199*	-6.051**	-3.785	0.531	-0.539**	-0.366	0.143*
5	J-68-3	1.767*	4.502**	-6.857**	-1.231	-0.949*	0.094	0.097
	SE(g_j)	**0.733**	**0.834**	**2.481**	**1.053**	**0.125**	**0.268**	**0.055**
	SE(g_i-g_j)	**1.036**	**1.179**	**3.509**	**1.490**	**0.177**	**0.379**	**0.077**

(Contd...)

Table 2. (*Contd...*)

S. N.	Parents	Width of capsule (cm)	No. of capsules/ plant	No. of capsules/leaf axil	No. of seeds/ capsule	1000-seed weight (g)	Seed yield per plant (g)	Oil content (%)
		8	9	10	11	12	13	14
Lines								
1	EC-41	-0.065*	-4.905*	-0.235**	-5.147**	-0.165*	-0.747	-0.095
2	U-76-22	0.019	0.441	0.152**	-2.587*	-0.065	-0.578	-0.203
3	ES-246	0.080**	26.428**	0.285**	4.346**	0.543**	3.439**	1.786**
4	UCS-76-1	0.025	-18.492**	-0.261**	-2.067	0.084	-3.432**	0.760
5	ES-139	0.009	1.775	0.419**	0.113	-0.012	0.392	0.748
6	JLSL-8	0.023	-7.305**	-0.115*	-1.027	0.032	-1.670**	-0.358
7	RMT-180	0.008	-4.719*	-0.101	-4.121**	-0.067	0.120	0.298
8	IC-74188	-0.045	-6.652**	0.019	8.386**	-0.032	-0.874*	-1.352*
9	Lalavadar-6	-0.044	0.601	-0.115*	4.253**	-0.168*	0.788	-0.501
10	Borda-2	-0.009	12.828**	-0.048	-2.147	-0.149*	2.564**	-1.084
	SE(g_i)	**0.025**	**1.922**	**0.055**	**1.458**	**0.065**	**0.402**	**0.621**
	SE(g_i-g_j)	**0.035**	**2.719**	**0.078**	**2.062**	**0.092**	**0.569**	**0.879**
Testers								
1	G.Til-1-9-4	-0.031	11.135**	0.225**	-0.647	-0.244**	0.755**	-0.905*
2	G.Til-2	-0.020	4.348**	-0.008	-1.527	0.027	0.264	0.415
3	G.Til-3	0.025	-8.725**	0.012	-2.107*	0.095	-1.597**	0.969*
4	G.Til-4	0.043*	4.455**	0.039	2.119*	0.054	1.494**	-0.192
5	J-68-3	-0.017	-11.212**	-0.268**	2.163*	0.069	-0.915**	-0.287
	SE(g_j)	**0.017**	**1.359**	**0.039**	**1.031**	**0.046**	**0.284**	**0.439**
	SE(g_i-g_j)	**0.025**	**1.922**	**0.055**	**1.458**	**0.065**	**0.402**	**0.621**

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

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Table 3. Estimates of specific combining ability (sca) effects of the best ten hybrids based on *per se* performance for fourteen characters in sesame

S. N.	Crosses	Days to 50% flowering	Days to maturity	Plant height (cm)	Height to first capsule (cm)	No. of branches/plant	No. of internodes/plant	Length of capsule (cm)
		1	2	3	4	5	6	7
1	Borda-2 x G.Til-1-9-4	9.135**	3.389	7.631	2.172	3.295**	0.806	-0.158
2	ES-246 x G.Til-4	2.636	0.769	-3.301	1.962	0.712	3.046**	-0.633**
4	ES-246 x G.Til-2	-0.682	0.008	2.188	-7.904*	1.049**	-0.081	0.489**
3	RMT-180 x G.Til-3	-0.264	-2.585	-2.865	-5.254	2.129**	1.189	-0.340
5	U-76-22 x G.Til-4	1.028	4.614	16.930*	11.922**	0.659	-1.727*	0.136
6	Lalavadar-6 x J-68-3	5.985*	1.638	12.463	7.295*	2.989**	3.139**	0.730**
7	ES-246 x G.Til-1-9-4	-4.428	-4.598	23.096**	11.619**	2.229**	5.673**	0.300
8	IC-74188 x G.Til-2	0.404	-7.969**	4.671	3.496	1.875**	2.439**	0.789**
9	Lalavadar-6 x G.Til-2	-7.028**	-12.547**	-13.064	2.586	2.115**	1.406	-0.167
10	ES-139 x G.Til-2	4.246	5.533*	8.762	10.716**	3.449**	3.799**	0.013
	SE (S_{ij})	**2.317**	**2.637**	**7.846**	**3.332**	**0.395**	**0.849**	**0.174**
	SE(S_{ij}-S_{kl})	**3.277**	**3.730**	**11.096**	**4.713**	**0.559**	**1.201**	**0.246**

Table 3. (*Contd…*)

S. N.	Crosses	Width of capsule (cm)	No. of capsules/plant	No. of capsules/leaf axil	No. of seeds/capsule	1000-seed weight (g)	Seed yield/ plant (g)	Oil content (%)	*per se* seed yield/plant (g)
		8	9	10	11	12	13	14	15
1	Borda-2 x G.Til-1-9-4	-0.046	46.972**	0.388**	1.434	-0.366*	7.680**	-1.314	25.02
2	ES-246 x G.Til-4	-0.044	-3.015	0.241	-5.626	0.054	2.372**	-0.424	21.33
3	ES-246 x G.Til-2	0.024	19.692**	0.288*	10.754**	-0.002	3.248**	-0.705	21.01
4	RMT-180 x G.Til-3	-0.042	33.245**	0.321*	10.934**	-0.063	8.463**	-2.200	20.97
5	U-76-22 x G.Til-4	-0.022	35.639**	0.375**	2.441	-0.140	4.150**	-0.248	19.09
6	Lalavadar-6 x J-68-3	0.119*	23.679**	-0.052	4.557	0.877**	5.131**	3.159*	19.03
7	ES-246 x G.Til-1-9-4	0.069	23.105**	0.055	-3.726	0.206	-0.082	1.583	18.13
8	IC-74188 x G.Til-2	0.155*	20.839**	0.555**	8.847**	0.407**	4.454**	2.751	17.87
9	Lalavadar-6 x G.Til-2	-0.100	4.385	-0.312*	-2.353	-0.637**	2.729**	-1.594	17.80
10	ES-139 x G.Til-2	0.017	18.612**	0.155	-1.213	-0.220	2.896**	-2.096	17.57
	SE (S_{ij})	**0.056**	**4.299**	**0.124**	**3.260**	**0.146**	**0.900**	**1.390**	-
	SE(S_{ij}-S_{kl})	**0.079**	**6.080**	**0.175**	**4.610**	**0.206**	**1.273**	**1.966**	-

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

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Table 4. Top ranking five specific combiners for seed yield per plant and their *per se* performance and its gca status of parents in sesame

S. N.	Crosses	sca effects	*per se* performance ($\bar{X}$)	gca status	
				Female	Male
1	RMT-180 x G. Til-3	8.463**	21.01	A	P
2	Borda-2 x G.Til-1-9-4	7.680**	25.02	G	G
3	Lalavadar-6 x J-68-3	5.131**	19.03	A	P
4	IC-74188 x G. Til-2	4.454**	17.87	P	A
5	U-76-22 x G. Til-4	4.150**	19.09	A	G

*, ** Significant at 5% and 1% levels of probability, respectively, against error mean squares.
G= Desired significant gca (good combiner)
A= Desired non-significant gca (average combiner)
P= Non-desired significant gca (poor combiner)