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Study of Combining Ability for Seed Yield and its Component in Sesame (*Sesamum indicum* L.)

Mungala, R. A.*, Bhatiya, V. J., Movaliya, H. M., Savaliya, P. G. and Virani, M. B.

Department of Genetics and Plant Breeding, Junagadh Agricultural University, Junagadh-362001,Gujarat, India

*Corresponding Author E-mail: patelrahul824@gmail.com

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ABSTRACT

Combining ability for seed yield and its component traits in sesame was studied using line x tester mating design involving 8 lines and 5 testers. Analysis of variance for combining ability revealed that the mean squares due to lines were significant for all the characters, while for testers were significant for all the characters except number of seeds per capsule and the mean squares for lines x testers interaction were also significant for all the characters except plant height and oil content. The analysis for combining ability revealed significant mean sum of squares of both general combining ability (GCA) and specific combining ability (SCA) for all the characters which indicated the presence of both additive and non-additive gene actions. The lines IC 96128, TC 66 and DPI 1484 and the testers Guj.Til-4 and Guj.Til-3 displayed high gca effect and good per se performance for seed yield per plant and some desirable traits like plant height, height to first capsule, number of branches per plant, number of internodes per plant, length of capsule, width of capsule, number of capsules per plant, number of seeds per capsule and 1000-seed weight. The crosses RT 33 x Guj.Til-10, LIMDI 9 x Guj.Til-1 and TC 66 x Guj.Til-2 displayed high sca effects for seed yield per plant and important yield components.

Key words: *Combining ability, GCA and SCA effects, Gene action, Sesame.*

INTRODUCTION

Sesame (*Sesamum indicum* L.) is a member of the order *Tubiflorae* and family *Pedaliaceae* with chromosome number 2n=2x=26. It is probably the most ancient known oilseed used by man and its domestication is lost in the mists of antiquity[20]. Although originated in Africa, it spread early through West Asia to India, China and Japan which themselves became secondary distribution centers[20]. Sesame 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 in a trial 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.

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Accordingly, the present investigation was undertaken on combining ability for seed yield and its components in sesame with a view 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 of some newly developed crosses through line x tester analysis in sesame.

MATERIALS AND METHODS

Experimental material consisting of 54 entries comprised of 8 lines (AT 351, AT 355, TC 66, DPI 1484, IC 96128, RT 33, LIMDI 9, RSE 3) and 5 testers (Guj.Til-1, Guj.Til-2, Guj.Til-3, Guj.Til-4, Guj.Til-10) and their 40 hybrids developed through line x tester mating design along with standard check Guj.Til-2 were evaluated in a Randomized Block Design with three replications. The 40 crosses made in line x tester mating design during *kharif* 2015 at Sagadividi Farm, Department of Seed Science and Technology, College of Agriculture, Junagadh Agricultural University, Junagadh, which were evaluated during summer 2016 also at the Sagadividi Farm, Department of Seed Science and Technology, College of Agriculture, Junagadh Agricultural University, Junagadh. Five competitive plants per each entry in each replication were randomly selected before flowering and tagged for the purpose of recording the observations of different characters *viz*., 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 seeds per capsule, 1000-seed weight (g), seed yield per plant (g) and oil content (%). The observations on days to 50 per cent 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*[18]. The mean values of recorded observations were finally subject to statistical analysis. The analysis of variance was performed to test the significance of differences among the genotypes for all the characters following fixed effect model as suggested by Panse and Sukhatme[12]. The analysis of variance for combining ability for all the fourteen characters was carried-out according to the method suggested by Kempthorne[8].

RESULTS AND DISCUSSION

The analysis of variance for combining ability that the mean squares due to lines, testers and lines x testers were first tested against the error mean squares. If, lines x testers interaction component was significant, the mean squares due to lines and testers were further tested against their respective interaction mean squares (Table 1.1).

The results obtained from the present study in respect to analysis of variance for combining ability (Table 1.1) are presented as under: Partitioning of variances due to the crosses showed under investigation that the mean squares due to lines were significant for all the characters, while for testers were significant for all the characters except number of seeds per capsule and the mean squares for lines x testers interaction were also significant for all the characters except plant height and oil content.

The mean squares due to lines were found significant for five character *i.e.* days to maturity, height to first capsule, number of branches per plant, number of internodes per plant and width of capsule, when tested against mean square due to lines x testers interaction. Similarly, the mean squares due to testers were also found significant for two characters *viz*., days to 50 per cent flowering and number of internode per plant, when tested against mean square due to lines x testers interaction.

The estimated variances due to lines (σ^2l) were higher than the corresponding variances due to testers (σ^2t) for all the characters except days to 50 per cent flowering, plant height, number of internode per plant, number of capsules per plant, number of capsules per leaf axil and seed yield per plant.

The estimates of σ^2gca were higher than the corresponding σ^2sca for plant height, number of internodes per plant and oil content. While in case of remaining characters *viz.*, days to 50 per cent flowering, days to maturity, height to first capsule, number of branches 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 and seed yield per plant, the magnitude of σ^2sca was higher than σ^2gca.

The ratio of σ^2gca/σ^2sca was less than unity for all the characters except plant height, number of internodes per plant and oil conent.

Analysis of variance for combining ability revealed that both additive and non-additive genetic variances played an important role in governing all the characters. The additive genetic component was predominant in the genetic control of plant height, number of internodes per plant and oil content, while non-additive genetic component was more important for 50 per cent flowering, days to maturity, height to first capsule, number of branches 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 and seed yield per plant. This was further substantiated by the ratio of σ^2gca/σ^2sca, which was more than unity for plant height, number of internodes per plant and oil content, whereas less than unity ratio of σ^2gca/σ^2sca were recorded for all the remaining character. Additive gene action is fixable and selection would be advantageous in segregating generations, while non-additive gene action can be exploited by adopting bi-parental mating in early segregating generations followed by pedigree selection.

The significance of mean squares due to lines, testers and lines x testers for seed yield per plant suggested the involvement of both additive and non-additive genetic variances in governing this character. The variance due to lines x testers (σ^2lt) was higher as compared to lines (σ^2l) and testers (σ^2t), suggesting the predominance of non-additive gene action in the control of seed yield per plant, which was also confirmed by lesser than one ratio of σ^2gca: σ^2sca. Predominance of non-additive gene action in the inheritance of seed yield per plant in sesame has been reported by Reddy *et al*[17]., Jayprakash and Subramanian[6], Manivannan[9], Das and Chaudhary[2], Devi *et al*[4]., Mothilal and Manoharan[11], El-Shakhess and Khalifa[5], Yamanura *et al*[21]., Prajapati *et al*[15]., and Praveenkumar *et al*[16]. Contrary to the present results, the preponderance of additive gene action was observed by Kadu *et al*[7]., Backiyarani *et al*[1]., Mansouri and Ahmadi[10], Das and Gupta[3], Parameshwarappa and Salimath[13], Pawar and Monpra[14] and Tripathy *et al*[19].

The estimates of gca effect for seed yield and its components indicated that among the lines, IC 96128 was found to be good general combiner simultaneously for seven characters *viz.*, height to first capsule, number of internodes per plant, length of capsule, width of capsule, number of capsules per plant, number of seeds per capsule and 1000-seed weight. Other good general combiners identified for different characters were TC 66 for number of branches per plant, length of capsule, width of capsule, number of seeds per capsule, seed yield per plant and oil content; DPI 1484 for days to maturity, number of internodes per plant, width of capsule, number of capsules per plant and seed yield per plant. Among the testers, Guj.Til-4 was good general combiner simultaneously for five characters *viz*., plant height, height to first capsule, width of capsule, 1000-seed weight and oil content, and Guj.Til-3 was good general combiner simultaneously for four traits *viz.,* days to 50 per cent flowering, plant height, length of capsule and 1000-seed weight (Table 1.2). The results indicated that the parents (lines and/or testers) showing desirable gca for more number of components possessed high concentration of favourable genes for more number of traits and should be utilized in multiple crossing programmes in order to combine important attributes and to develop high yielding types in sesame.

The estimates of sca effects of the crosses indicated (Table 1.5) that eleven hybrids manifested significant and positive sca effects for seed yield per plant. Among these, the best six specific combinations were RT 33 x Guj.Til-10, LIMDI 9 x Guj.Til-1, TC 66 x Guj.Til-2, DPI 1484 x Guj.Til-2, DPI 1484 x Guj.Til-1 and AT 355 x Guj.Til-4. The cross AT 355 x Guj.Til-4 was also found good specific combiner for height to first capsule, number of branches per plant, number of internodes per plant, number of capsules per plant and 1000-seed weight. The cross RT 33 x Guj.Til-10 also showed desirable sca effect for number of branches per plant, number of internodes per plant, length of capsule number of capsules per plant and 1000-seed weight. Another hybrid LIMDI 9 x Guj.Til-1 also showed desirable sca effect for number of branches per plant, number of internodes per plant, number of capsules per plant and number of capsules per leaf axil (Table 1.7). The high sca effects observed for seed yield per plant was associated with desirable sca effects manifested by its component characters like plant height, height to first capsule, number of branches per plant, length of capsule, number of internodes per plant, number of capsules per plant and 1000-seed weight. The high sca status of the hybrids indicated that substantial role was also played by dominance and epistatic interaction.

The most of the crosses exhibiting high sca effects involved either average x good, good x poor, average x poor, poor x average, poor x poor or good x good general combiners, in that order, for majority of the characters studied. The results suggested the presence of additive x dominance, dominance x dominance and additive x additive type of gene interactions. The presence of additive or additive x additive interaction effects would enhance the chances of making improvement through simple selection. The prevalence of both additive and non-additive genetic effects suggested the simultaneous exploitation of these gene actions by adopting selective inter-mating and recurrent selection, which would accumulate more of additive genetic variability. The non-additive gene effect can be exploited by the breeding procedures involving bi-parental mating followed by few cycles of recurrent selection. When epistasis is present, the recurrent selection followed by pedigree or bi-parental mating or diallel selective mating systems may prove to be effective in improvement of seed yield and its attributes in sesame.

Table 1.1: Analysis of variance for combining ability and variance components for different characters in sesame

Sour	d.f.	Days to 50 per cent 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)
Replications	2	1.633	7.233	65.320	2.188	0.013	0.140	0.019
Lines	7	12.608*	94.324**+	96.757**	334.508**++	4.517**++	67.749**++	0.491**
Testers	4	46.970**+	51.863*	1310.806**	19.544**	0.174*	112.239**++	0.259**
Lines x Testers	28	13.337**	35.910**	21.381	39.540**	0.878**	13.664**	0.289**
Error	78	4.752	18.131	31.698	1.629	0.054	1.719	0.020
Variance components								
σ^2l	-	0.524	5.079	4.337	22.192	0.298	4.402	0.031
σ^2t	-	1.759	1.405	53.296	0.746	0.005	4.605	0.010
σ^2lt	-	2.861	5.926	-3.439	12.637	0.275	3.982	0.089
σ^2gca	-	1.284	2.819	34.466	8.995	0.117	4.527	0.018
σ^2sca	-	2.861	5.926	-3.439	12.637	0.275	3.982	0.089
σ^2gca / σ^2sca	-	0.449	0.476	-10.022	0.712	0.428	1.137	0.203

Sour	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 (%)
Replications	2	0.008	3.490	0.005	12.497	0.053	0.762	2.915
Lines	7	0.029**++	364.389**	0.098**	119.382**	0.323**	9.560**	63.550**
Testers	4	0.009**	1722.636**	0.192**	13.055	0.235**	32.220**	11.033**
Lines x Testers	28	0.008**	665.481**	0.146**	59.896**	0.293**	15.192**	4.728
Error	78	0.002	21.400	0.006	9.094	0.026	0.661	2.994
Variance components								
σ^2l	-	0.0018	22.866	0.006	7.353	0.020	0.593	4.037
σ^2t	-	0.0003	70.885	0.008	0.165	0.009	1.315	0.335
σ^2lt	-	0.0019	214.694	0.047	16.934	0.089	4.844	0.578
σ^2gca	-	0.0009	52.416	0.007	2.929	0.013	1.037	1.759
σ^2sca	-	0.0019	214.694	0.047	16.934	0.089	4.844	0.578
σ^2gca / σ^2sca	-	0.4569	0.244	0.153	0.173	0.145	0.214	3.044

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

Table 1.2: General combining ability effects for days to 50 per cent flowering, days to maturity, plant height, height to first capsule and number of branches per plant in sesame

Sr. No.	Parents	Days to 50 per cent flowering	Days to maturity	Plant height (cm)	Height to first capsule (cm)	Number of branches per plant
Lines						
1	AT 351	0.308	1.200	-1.275	9.863**	-0.550**
2	AT 355	0.175	2.800*	-0.208	0.730*	1.023**
3	TC 66	-1.092	-1.267	-1.102	1.837**	0.597**
4	DPI 1484	0.175	-3.733**	-2.715	0.357	0.037
5	IC 96128	0.642	3.667**	1.165	-2.510**	-0.177**
6	RT 33	-1.492**	-0.867	5.552**	-2.803**	-0.377**
7	LIMDI 9	-0.092	-2.200*	0.218	-1.217	-0.083
8	RSE 3	1.375*	0.400	-1.635	-6.257**	-0.470**
	SE(g_i)	0.563	1.099	1.454	0.330	0.060
	SE(g_i-g_j)	0.796	1.555	2.056	0.466	0.085
Testers						
1	Guj.Til-1	2.225**	-2.425**	-1.917	0.880**	0.098*
2	Guj.Til-2	-0.650	-0.300	-1.508	-0.262	-0.018
3	Guj.Til-3	-1.567**	1.200	-5.308**	0.205	-0.118*
4	Guj.Til-4	-0.025	0.575	-4.183**	-1.420**	0.065
5	Guj.Til-10	0.017	0.950	12.917**	0.597*	-0.027
	SE(g_j)	0.445	0.869	1.149	0.261	0.047
	SE(g_i-g_j)	0.629	1.229	1.625	0.368	0.067

*, ** Significant at 5 per cent and 1 per cent levels of significance, respectively.

Table 1.3: General combining ability effects for number of internodes per plant, length of capsule, width of capsule, number of capsules per plant and number of capsules per leaf axil in sesame

Sr. No.	Parents	Number of internodes per plant	Length of capsule (cm)	Width of capsule (cm)	Number of capsules per plant	Number of capsules per leaf axil
Lines						
1	AT 351	-4.217**	-0.191**	-0.016	-1.565	0.060**
2	AT 355	0.943**	-0.286**	-0.019	3.715**	0.007
3	TC 66	0.063	0.142**	0.024*	1.115	-0.033
4	DPI 1484	3.263**	0.084	0.052**	5.755**	-0.113**
5	IC 96128	1.210**	0.156**	0.062**	4.462**	-0.113**
6	RT 33	-0.630	-0.020	0.003	-1.218	0.020
7	LIMDI 9	0.023	-0.102**	-0.060**	-2.752*	0.087**
8	RSE 3	-0.657	0.220**	-0.045**	-9.512**	0.087**
	SE(g_i)	0.339	0.037	0.011	1.194	0.021
	SE(g_i-g_j)	0.479	0.052	0.016	1.689	0.029
Testers						
1	Guj.Til-1	-0.992**	0.009	0.000	-3.265**	0.087**
2	Guj.Til-2	0.483	-0.134**	-0.022**	7.577**	0.095**
3	Guj.Til-3	-0.233	0.154**	0.008	-5.023**	-0.113**
4	Guj.Til-4	-2.558**	0.009	0.028**	-9.482**	-0.047**
5	Guj.Til-10	3.300**	-0.038	-0.015	10.193**	-0.022
	SE(g_j)	0.268	0.029	0.009	0.944	0.016
	SE(g_i-g_j)	0.379	0.041	0.013	1.335	0.023

*, ** Significant at 5 per cent and 1 per cent levels of significance, respectively.

Table 1.4: General combining ability effects for number of seeds per capsule, 1000-seed weight, seed yield per plant and oil content in sesame

Sr. No.	Parents	Number of seeds per capsule	1000-seed weight (g)	Seed yield per plant (g)	Oil content (%)
Lines					
1	AT 351	-4.162**	-0.174**	-0.745**	1.107*
2	AT 355	-0.042	0.004	0.750**	-4.441**
3	TC 66	2.745**	0.003	0.585**	1.283**
4	DPI 1484	-3.602**	-0.254**	1.284**	-1.629**
5	IC 96128	3.718**	0.108**	-0.186	0.171
6	RT 33	-0.775	0.018	-0.125	0.745
7	LIMDI 9	0.278	0.138**	-0.577**	1.403**
8	RSE 3	1.838*	0.157**	-0.985**	1.361**
	SE(g_i)	0.779	0.042	0.210	0.447
	SE(g_i-g_j)	1.101	0.059	0.297	0.632
Testers					
1	Guj.Til-1	1.052	-0.097**	-0.379*	0.131
2	Guj.Til-2	-0.690	-0.067*	0.884**	-0.299
3	Guj.Til-3	-0.432	0.071*	-0.714**	0.294
4	Guj.Til-4	0.485	0.136**	-1.294**	0.842*
5	Guj.Til-10	-0.415	-0.042	1.504**	-0.968**
	SE(g_j)	0.616	0.033	0.166	0.353
	SE(g_i-g_j)	0.871	0.046	0.235	0.500

*, ** Significant at 5 per cent and 1 per cent levels of significance, respectively.

Table 1.5: Specific combining ability effects for days to 50 per cent flowering, days to maturity, plant height, height to first capsule, number of branches per plant, number of internodes per plant and length of capsule in sesame

Sr. No.	Crosses	Days to 50 per cent 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	AT 351 x Guj.Til-1	2.108	0.425	2.517	0.520	-0.325*	-0.208	0.077
2	AT 351 x Guj.Til-2	2.317	0.633	3.108	4.395**	-0.808**	-1.683*	-0.046
3	AT 351 x Guj.Til-3	-0.100	-0.200	-0.492	-2.872**	0.025	3.700**	0.213*
4	AT 351 x Guj.Til-4	0.025	2.425	-1.217	5.887**	0.642**	2.358**	0.022
5	AT 351 x Guj.Til-10	-4.350**	-3.283	-3.917	-7.930**	0.467**	-4.167**	-0.266**
6	AT 355 x Guj.Til-1	-1.758	-5.175*	-1.483	3.453**	0.035	-3.035**	-0.094
7	AT 355 x Guj.Til-2	-1.550	-3.300	-1.225	-2.405**	0.018	1.823*	0.116
8	AT 355 x Guj.Til-3	4.033**	2.200	1.175	3.528**	0.185	-2.393**	-0.205*
9	AT 355 x Guj.Til-4	-2.175	6.158*	1.717	-3.180**	0.268*	2.465**	0.124
10	AT 355 x Guj.Til-10	1.450	0.117	-0.183	-1.397	-0.507**	1.140	0.060
11	TC 66 x Guj.Til-1	1.175	-2.775	-0.59	-2.120**	-0.005	-0.622	0.081
12	TC 66 x Guj.Til-2	1.717	-1.233	0.535	0.422	0.845**	0.370	0.328**
13	TC 66 x Guj.Til-3	-1.033	-0.067	-2.132	-3.112**	0.078	0.687	-0.207*
14	TC 66 x Guj.Til-4	-1.908	0.892	-1.590	-1.553*	-0.572**	-1.988*	-0.305**
15	TC 66 x Guj.Til-10	0.050	3.183	3.777	6.363**	-0.347*	1.553*	0.102
16	DPI 1484 x Guj.Til-1	1.908	-1.642	-1.643	0.160	0.888**	4.445**	0.389**
17	DPI 1484 x Guj.Til-2	-0.883	-1.100	-1.785	0.235	0.672**	-0.363	-0.027
18	DPI 1484 x Guj.Til-3	-0.633	1.067	-1.252	-2.632**	0.105	-0.713	-0.512**
19	DPI 1484 x Guj.Til-4	1.158	-0.975	-2.043	-1.340	-0.812**	-1.122	-0.157
20	DPI 1484 x Guj.Til-10	-1.550	2.650	6.723*	3.577**	-0.853**	-2.247**	0.306**

(***Contd…***)

Sr. No.	Crosses	Days to 50 per cent 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)
21	IC 96128 x Guj.Til-1	-1.225	1.625	0.877	-1.307	-0.232	1.498	0.327**
22	IC 96128 x Guj.Til-2	-1.683	-0.167	-1.998	-0.765	0.285*	-0.110	-0.226**
23	IC 96128 x Guj.Til-3	-1.100	-3.667	0.202	2.302**	-0.415**	-1.060	0.286**
24	IC 96128 x Guj.Til-4	3.358**	0.625	2.677	2.127**	0.068	-1.268	-0.295**
25	IC 96128 x Guj.Til-10	0.650	1.583	-1.757	-2.357**	0.293*	0.940	-0.092
26	RT 33 x Guj.Til-1	0.908	3.825	1.223	-1.280	-0.432**	-2.462**	-0.490**
27	RT 33 x Guj.Til-2	1.450	-0.633	1.215	-2.738**	-0.448**	0.263	-0.313**
28	RT 33 x Guj.Til-3	0.367	2.200	1.815	-1.338	-0.082	0.180	0.485**
29	RT 33 x Guj.Til-4	-2.175	-3.508	1.623	-1.313	0.402**	-0.295	0.008
30	RT 33 x Guj.Til-10	-0.550	-1.883	-5.877	6.670**	0.560**	2.313**	0.310**
31	LIMDI 9 x Guj.Til-1	-1.825	4.158	-1.51	2.467**	0.275*	1.818*	0.035
32	LIMDI 9 x Guj.Til-2	-1.283	0.700	-0.585	-0.458	-0.208	-0.857	0.269**
33	LIMDI 9 x Guj.Til-3	-1.367	4.533	0.615	3.342**	0.425**	0.593	-0.186*
34	LIMDI 9 x Guj.Til-4	0.758	-5.842*	-1.710	-0.433	-0.092	-0.815	0.380**
35	LIMDI 9 x Guj.Til-10	3.717**	-3.550	3.190	-4.917**	-0.400**	-0.740	-0.498**
36	RSE 3 x Guj.Til-1	-1.292	-0.442	0.610	-1.893*	-0.205	-1.435	-0.327**
37	RSE 3 x Guj.Til-2	-0.083	5.100*	0.735	1.315	-0.355**	0.557	-0.100
38	RSE 3 x Guj.Til-3	-0.167	-6.067*	0.068	0.782	-0.322*	-0.993	0.125
39	RSE 3 x Guj.Til-4	0.958	0.225	0.543	-0.193	0.095	0.665	0.224**
40	RSE 3 x Guj.Til-10	0.583	1.183	-1.957	-0.010	0.787**	1.207	0.077
	SE (S_{ij})	1.259	2.458	3.251	0.737	0.134	0.757	0.082
	SE(S_{ij}-S_{kl})	1.780	3.477	4.597	1.042	0.189	1.070	0.116

*, ** Significant at 5 per cent and 1 per cent levels of significance, respectively.

Table 1.6: Specific combining ability effects for number of capsules per plant, number of capsules per leaf axil, number of seeds per capsule, 1000-seed weight, width of capsule, seed yield per plant and oil content in sesame

Sr. No.	Crosses	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 (%)
1	AT 351 x Guj.Til-1	0.056*	7.065**	-0.260**	-0.505	0.303**	-0.058	1.326
2	AT 351 x Guj.Til-2	-0.032	-7.177**	0.265**	-1.563	-0.034	-0.894	0.962
3	AT 351 x Guj.Til-3	-0.009	0.690	-0.060	4.045*	0.128	2.030**	0.543
4	AT 351 x Guj.Til-4	0.008	15.082**	0.073	-3.738*	-0.384**	0.600	-0.845
5	AT 351 x Guj.Til-10	-0.023	-15.660**	-0.018	1.762	-0.013	-1.678**	-1.985*
6	AT 355 x Guj.Til-1	-0.005	-7.948**	-0.207**	0.708	-0.395**	-0.689	0.414
7	AT 355 x Guj.Til-2	0.014	-5.457*	-0.215**	5.317**	0.311**	-1.265**	0.413
8	AT 355 x Guj.Til-3	-0.023	5.743*	-0.007	-8.875**	-0.014	0.976*	-1.263
9	AT 355 x Guj.Til-4	0.027	15.868**	-0.073	-0.325	0.249**	2.526**	0.573
10	AT 355 x Guj.Til-10	-0.013	-8.207**	0.502**	3.175	-0.151	-1.548**	-0.137
11	TC 66 x Guj.Til-1	-0.021	-2.815	0.233**	4.922**	0.276**	-1.474**	0.859
12	TC 66 x Guj.Til-2	0.065*	17.010**	-0.175**	-2.537	-0.257**	3.200**	-0.941
13	TC 66 x Guj.Til-3	-0.022	10.010**	0.033	0.672	0.051	0.867	0.446
14	TC 66 x Guj.Til-4	-0.056*	-17.665**	-0.033	-0.845	0.493**	-1.519**	-1.452
15	TC 66 x Guj.Til-10	0.034	-6.540*	-0.058	-2.212	-0.563**	-1.074*	1.088
16	DPI 1484 x Guj.Til-1	-0.030	20.278**	-0.087	1.935	-0.341**	2.563**	-2.809**
17	DPI 1484 x Guj.Til-2	0.019	17.037**	-0.095*	-8.190**	-0.081	3.034**	-1.829
18	DPI 1484 x Guj.Til-3	0.046	-13.763**	0.113*	-2.848	-0.019	-2.672**	2.038
19	DPI 1484 x Guj.Til-4	0.009	-13.572**	0.047	0.968	0.137	-1.192*	2.140**
20	DPI 1484 x Guj.Til-10	-0.045	-9.980**	0.022	8.135**	0.304**	-1.733**	0.460

(***Contd…***)

Sr. No.	Crosses	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 (%)
21	IC 96128 x Guj.Til-1	0.051*	-2.495	-0.087	-3.118	0.141	0.220	-1.168
22	IC 96128 x Guj.Til-2	-0.107**	4.463	-0.095*	-1.110	0.241*	1.168*	1.458
23	IC 96128 x Guj.Til-3	0.053*	6.397*	0.113*	4.098*	-0.268**	-0.185	-1.461
24	IC 96128 x Guj.Til-4	-0.070**	-6.345*	0.047	3.648*	-0.106	-0.834	0.311
25	IC 96128 x Guj.Til-10	0.073**	-2.020	0.022	-3.518*	-0.008	-0.369	0.861
26	RT 33 x Guj.Til-1	0.003	-21.215**	-0.220**	-4.092*	0.281**	-2.518**	0.537
27	RT 33 x Guj.Til-2	0.049	-15.190**	0.438**	3.517*	-0.266**	-2.467**	0.437
28	RT 33 x Guj.Til-3	-0.065*	-0.923	-0.020	0.392	-0.341**	-0.143	-0.386
29	RT 33 x Guj.Til-4	0.022	-0.798	-0.087	4.008*	-0.076	-1.026*	0.046
30	RT 33 x Guj.Til-10	-0.009	38.127**	-0.112*	-3.825*	0.402**	6.153**	-0.634
31	LIMDI 9 x Guj.Til-1	-0.048	18.385**	0.247**	-0.012	0.127	3.481**	0.489
32	LIMDI 9 x Guj.Til-2	0.048	-5.857*	0.172**	-2.470	-0.023	-1.525**	-0.291
33	LIMDI 9 x Guj.Til-3	-0.042	0.943	-0.087	1.338	0.322**	-0.717	0.406
34	LIMDI 9 x Guj.Til-4	0.051*	-5.465*	-0.153**	2.422	-0.509**	-0.354	-0.772
35	LIMDI 9 x Guj.Til-10	-0.009	-8.007**	-0.178**	-1.278	0.082	-0.885	0.168
36	RSE 3 x Guj.Til-1	-0.006	-11.255**	0.380**	0.162	-0.392**	-1.524**	0.351
37	RSE 3 x Guj.Til-2	-0.057*	-4.830	-0.295**	7.037**	0.108	-1.250**	-0.209
38	RSE 3 x Guj.Til-3	0.060*	-9.097**	-0.087	1.178	0.140	-0.156	-0.322
39	RSE 3 x Guj.Til-4	0.010	12.895**	0.180**	-6.138**	0.195*	1.798**	0.000
40	RSE 3 x Guj.Til-10	-0.007	12.287**	-0.178**	-2.238	-0.051	1.133*	0.180
	SE (S_{ij})	0.025	2.671	0.046	1.741	0.093	0.470	0.999
	SE(S_{ij}-S_{kl})	0.036	3.777	0.065	2.462	0.131	0.664	1.413

*, ** Significant at 5 per cent and 1 per cent levels of significance, respectively.

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