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Heterosis and Combining Ability in Sesame (*Sesamum indicum* L.)

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The present study on heterosis and combining ability for seed yield and its components was carried out in a set of 15 F_1 hybrids of sesame involving five lines and three testers diverse parents at Agricultural college, Bapatla. The ratio of the genetic variance was less than the unity, which indicated the predominance of the non-additive gene action in all the characters studied. The analysis revealed that none of the parents was found as good general combiners for all the traits consistently, however two lines YLM 95, IS 355 and a tester Gowri were found to be good combiners for seed yield and its contributing traits. The hybrids IS 355 x Gowri followed by KMR x Madhavi, YLM 95 x Gowri and IS 355 x Madhavi have exhibited higher heterosis (Average heterosis and Heterobeltiosis) for seed yield. These crosses involved good x poor and poor x poor combiner parents. Further improvement in seed yield could be possible through the hybridization and selection of transgressive segregants.

Key words: Combining ability, Gene action, Heterosis, Line x tester, *Sesamum indicum* L.

Sesame (*Sesamum indicum* L.) is one of the most important and popular oil seed crop. The breeding method to be adopted for improvement of any crop depends primarily on the nature of gene action involved in the expression of quantitative traits of economic importance. Line x Tester design was followed by crossing each line with all the testers for studying the combining ability and the gene action involved. This approach has practical utility in breeding programme aimed at genetic improvement of yield.

Materials and Methods

An experiment was conducted during *Kharif* 2011 and *rabi* 2011-12 at Agricultural College Farm, Bapatla. The experimental materials comprised of five lines (females) namely; YLM 94, YLM 95, YLM 96, IS 355 and KMR 42 and three testers (males) namely; Madhavi, Gowri and RT 54. The complete set of 15 F_1 s and eight parents were grown in Randomized Complete Block Design (RCBD) with three replications. Row to row and plant to plant spacing were maintained at 30cm and 10cm, respectively. In each replication, randomly selected 10 plants in each parent and F_1 s were used for observation. Observations were recorded on nine important characters, *viz*., days to 50 per cent flowering, days to maturity, plant height (cm), number of primary branches per plant, number of capsules per plant, number of seeds per capsule, 1000-seed weight (g), oil content (%) and seed yield per plant (g). Combining ability analysis of parents and crosses was done by using the Line x Tester fashion as given by Kempthorne (1957). Heterosis was measured as deviation of F_1 mean from mid parent (average heterosis) and better parent (heterobeltiosis) mean.

Results and Discussion

The mean sum of square due to *gca* and *sca* were highly significant for all the nine characters except days to 50 per cent flowering, days to maturity, 1000-seed weight and oil content for *GCA* variance (Table 1). It indicated that both additive and non-additive gene action were involved in the expression of these traits. Similar results have been reported by Banerjee and Kole (2009) for plant height, number of capsules per plant, number of seeds per capsule and Gangadhar Rao (2006) for number of primary branches per plant and Gaikwad *et al*. (2009) for seed yield per plant. The estimates of *SCA* variance were higher than *GCA* variance. The ratio of *GCA* to total variance being lesser than unity for all the traits revealed preponderance of non additive gene effects in the inheritance of seed yield and its component traits.

The estimates of *gca* effects (Table 2) revealed that none of the parents exhibited significant *gca* for all the characters so it was difficult to pick good combiners for all the characters considered together. This shows that genes for different desirable characters would have to be combined from different sources. Among the five lines tested, YLM 95 and IS 355 were good general combiners for seed yield per plant. These lines also showed

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Table 1. Analysis of variance for combining ability for yield and yield contributing characters in sesame (*Sesamum indicum* L.)

Parents	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of primary branches per plant	No. of capsules per plant	No. of seeds per capsule	1000-seed weight (g)	Oil content (%)	Seed yield per plant (g)
GCA	0.2782	-0.5380	17.5393*	0.1896**	34.7792*	49.6250*	-0.0142	0.6604	2.5963*
SCA	13.4296**	2.0521**	31.2471**	0.2721**	69.5256**	93.5938**	0.1376**	1.8685*	5.7618**
2GCA/ 2GCA+SCA	0.0398	-1.1023	0.5289	0.5822	0.5001	0.5147	-0.2601	0.4141	0.4740

*, **Significant at P=0.05 and P=0.01 level, respectively.

significant general combining ability effects in desirable direction for various characters, YLM 95 for number of primary branches per plant, number of capsules per plant, number of seeds per capsule, 1000-seed weight and seed yield per plant, while IS 355 for plant height, number of capsules per plant, number of seeds per capsule and seed yield per plant.

Table 2. Estimates of general combining ability (gca) effects of lines and testers for different characters in sesame (*Sesamum indicum* L.)

Parents	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of primary branches per plant	No. of capsules per plant	No. of seeds per capsule	1000-seed weight (g)	Oil content (%)	Seed yield per plant (g)
Lines									
YLM 94	-3.000**	0.333	-9.082**	-0.762**	-15.440**	-17.827**	-0.160**	-0.067	-4.373**
YLM 95	0.444	0.000	1.529	0.338**	8.149**	4.440**	0.076*	-1.060	2.465**
YLM 96	0.444	0.333	4.918**	-0.029	-6.584**	6.040**	-0.131**	0.395	-0.573
IS 355	1.222*	-0.333	6.162**	0.693**	12.349**	14.496**	-0.061*	1.151	3.256**
KMR 42	0.889	-0.333	-3.527**	-0.240**	1.527	-7.149**	0.276**	-0.418	-0.774
SE	0.536	0.448	1.133	0.052	1.016	1.084	0.028	0.565	0.544
CD at 5%	1.098	0.918	2.321	0.107	2.081	2.222	0.059	1.158	1.115
Testers									
Madhavi	-2.089**	0.378	-2.718**	-0.480**	-3.511**	5.038**	0.136**	0.736	0.855
Gowri	-0.022	-0.022	4.916**	0.480**	1.816*	-0.536	-0.058*	0.800	0.443
RT 54	2.111**	-0.356	-2.198*	0.000	1.696*	-4.502**	-0.078**	-1.536**	-1.298**
SE	0.415	0.347	0.877	0.040	0.787	0.840	0.022	0.437	0.421
CD at 5%	0.851	0.711	1.797	0.083	1.612	1.721	0.0459	0.897	0.869

*, **Significant at P=0.05 and P=0.01 level, respectively.

The estimates of specific combining ability effects were found negatively significant in cross combinations YLM 94 x RT 54, YLM 95 x Madhavi and YLM 96 x Gowri for days to 50 per cent flowering, YLM 94 x Madhavi for days to maturity. Significant and positive specific combining ability effects were observed in the cross YLM 95 x Gowri for plant height, IS 355 x RT 54 for number of primary branches per plant, IS 355 x RT 54 for number of capsules per plant, KMR 42 x Madhavi for number of seeds per capsule and YLM 96 x Gowri for 1000-seed weight. The only hybrid KMR 42 x Madhavi exhibited significant *sca* effect for the seed yield per plant (Table 3). This suggests that high *sca* effect of any

Table 3. Estimates of specific combining ability (sca) effects of F_1s for different characters in sesame (*Sesamum indicum* L.)

Crosses	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of primary branches	No. of capsules / plant	No. of seeds / capsule	1000 Seed weight (g)	Oil content (%)	Seed yield/ plant (g)
YLM 94 X Madhavi	0.867	-1.600*	-5.504**	0.469**	2.067	-9.360**	0.290**	0.878	-0.558
YLM 94 X Gowri	4.133**	2.133*	2.462	-0.391**	0.873	5.080*	-0.115*	0.653	0.167
YLM 94 X RT 54	-5.000**	-0.533	3.042	-0.078	-2.940	4.280*	-0.175**	-1.531	0.391
YLM 95 X Madhavi	-4.578**	-1.267	-2.849	0.069	-1.422	1.207	-0.076	-2.179*	-1.123
YLM 95 X Gowri	2.022*	0.800	6.718**	0.276**	1.784	9.413**	-0.315**	0.416	1.259
YLM 95 X RT 54	2.556*	0.467	-3.869	-0.344**	-0.362	-10.620**	0.392**	1.762	-0.137
YLM 96 X Madhavi	1.089	0.733	-0.838	0.002	4.878**	-0.627	-0.385**	1.402	0.768
YLM 96 X Gowri	-4.311**	-1.200	3.929	0.576**	4.584*	-2.853	0.619**	-0.879	1.687
YLM 96 X RT 54	3.222**	0.467	-3.091	-0.578**	-9.462**	3.480	-0.234**	-0.523	-2.456*
IS 355 X Madhavi	1.644	2.400**	3.318	-0.553**	-12.722**	-5.782**	0.268**	1.373	-2.410*
IS 355 X Gowri	-0.089	-1.533	-5.549**	-0.047	2.684	-0.242	-0.124*	-1.495	1.295
IS 355 X RT 54	-1.556	-0.867	2.231	0.600**	10.038**	6.024**	-0.144**	0.121	1.116
KMR 42 X Madhavi	0.978	-0.267	5.873**	0.013	7.200**	14.562**	-0.096	-1.474	3.323**
KMR 42 X Gowri	-1.756	-0.200	-7.560**	-0.413**	-9.927**	-11.398**	-0.065	1.304	-4.408**
KMR 42 X RT 54	0.778	0.467	1.687	0.400**	2.727	-3.164	0.162**	0.170	1.086
SE	0.929	0.776	1.962	0.090	1.760	1.879	0.050	0.979	0.943
CD at 5%	1.903	1.591	4.020	0.186	3.606	3.849	0.103	2.006	1.932

*, **Significant at P=0.05 and P=0.01 level, respectively.

cross combination does not necessarily depend on the *gca* effects of the parental lines involved. This superiority of *sca* effects may be due to complementary type of gene action or involvement of non allelic interaction of fixable and non fixable genetic variance.

The hybrids varied in magnitude and direction of heterosis for most of the characters (Table 4). The significant average heterosis and heterobeltiosis observed for days to 50% flowering in cross combinations *viz.,* YLM 94 x RT 54, YLM 95 x Madhavi and YLM 94 x Madhavi, days to maturity in IS 355 x RT 54, YLM 94 x RT 54 and KMR 42 x RT 54. In general, heterosis for days to 50% flowering and days to maturity should be in negative direction, in order to develop early cultivars therefore, YLM 94 x RT 54 can be used in future crop improvement programme for development of early maturing types. These findings are in consonance with Gaikwad *et al*. (2009). The character that contribute to vegetative growth such as number of primary branches per plant expressed highest magnitude of heterosis (both average heterosis and heterobeltiosis) in cross combinations *viz.,* IS 355 x RT 54 and IS 355 x Gowri. Above findings are in accordance with the results of Mothilal and Ganesan (2005). Cross combinations *viz.,* YLM 95 x Gowri, IS 355 x RT 54 and IS 355 x Madhavi expressed positively significant heterosis for plant height. Similar results were reported by Mothilal and Ganesan (2005) in case of average heterosis and Shekhat *et al*. (2008) for heterobeltiosis. A desirable degree of vegetative growth is essential for realizing high capsule yield.

Table 4. The better performing F_1 over mid parent and better parent for different characters in sesamum (*Sesamum indicum* L.)

Characters	No. of crosses with significant heterosis		Three best cross comnations with hetetosis value (%)	
	Average heterosis	Hetero beltiosis	Average heterosis	Heterobeltiosis
Days to 50% flowering	3	3	YLM 94 x RT 54 (-20.45), YLM 95 x Madhavi (-9.17), YLM 94 x Madhavi (-8.71)	YLM 94 x RT 54 (-22.79), YLM 94 x Madhavi (-14.06), YLM 95 x Madhavi (-10.34)
Days to maturity	3	3	IS 355 x RT 54 (-5.79), YLM 94 x RT 54 (-3.33), KMR 42 x RT 54 (-2.94)	IS 355 x RT 54 (-8.27), YLM 94 x RT 54 (-7.14), KMR 42 x RT 54 (-6.77)
Plant height (cm)	5	4	YLM 95 x Gowri (22.24), IS 355 x RT 54 (16.18), IS 355 x Madhavi (16.16)	YLM 95 x Gowri (9.57), IS 355 x RT 54 (8.44), IS 355 x Madhavi (7.89)
Number of primary branches per plant	6	5	IS 355 x RT 54 (60.23), IS 355 x Gowri (51.96), YLM 95 x Gowri (41.36)	IS 355 x RT 54 (54.95), IS 355 x Gowri (44.68), YLM 96 x Gowri (40.00)
Number of capsules per plant	8	6	IS 355 x RT 54 (57.96), IS 355 x Gowri (49.22), YLM 95 x Gowri (31.82)	IS 355 x RT 54 (49.95), IS 355 x Gowri (44.99), YLM 95 x Gowri (27.68)
Number of seeds per capsule	5	2	KMR 42 x Madhavi (27.34), YLM 95 x Gowri (18.37), IS 355 x Gowri (16.99)	IS 355 x RT 54 (8.90), YLM 95 x Gowri (8.88)
1000-seed weight (g)	7	4	YLM 96 x Gowri (21.70), IS 355 x Madhavi (20.85), KMR 42 x Madhavi (14.22)	IS 355 x Madhavi (14.57), YLM 96 x Gowri (10.83), YLM 95 x RT 54 (7.10)
Oil content (%)	3	2	YLM 96 x Madhavi (8.57), IS 355 x Madhavi (8.16), YLM 94 x Madhavi (6.88)	IS 355 x Madhavi (7.98), YLM 96 x Madhavi (6.70)
Seed yield per plant (g)	7	5	IS 355 x Gowri (77.96), YLM 95 x Gowri (64.16), KMR 42 x Madhavi (63.03)	IS 355 x Gowri (62.88), KMR 42 x Madhavi (61.47), YLM 95 x Gowri (46.33)

Regarding the number of capsules per plant, IS 355 x RT 54, IS 355 x Gowri and YLM 95 x Gowri expressed positively significant average heterosis and heterobeltiosis. However, the cross combinations namely KMR 42 x Madhavi and YLM 95 x Gowri have recorded higher heterosis for number of seeds per capsule. The results are in close conformity with findings of Kar *et al.* (2002), Mothilal and Ganesan (2005) for average heterosis and Senthil Kumar and Ganesan (2004) for heterobeltiosis respectively. Number of capsules per plant as well as number of seeds per capsule had direct correlation with seed yield per plant. The highest value of heterosis for seed yield per plant was observed in IS 355 x Gowri, YLM 95 x Gowri and KMR 42 x Madhavi. These crosses showing desirable heterosis for seed yield per plant in addition to most of the yield contributing characters studied. Similar results were reported by Mothilal and Ganesan (2005), Prajapati *et al*. (2006) and Gaikwad *et al.* (2009).

The cross combinations *viz.,* YLM 96 x Gowri and IS 355 x Madhavi exhibited the highest heterosis for 1000- seed weight. This is similar with the findings of Mothilal and Ganesan (2005) for average heterosis and Shekhat *et al.* (2008) for heterobeltiosis. For oil content two crosses *viz.,* YLM 96 x Madhavi and IS 355 x Madhavi showed higher heterosis which are in accordance with the results reported by Bhuyan and Sarma (2003) and Shekhat *et al.* (2008) for average heterosis and heterobeltiosis respectively.

Considering the overall performance in respect of seed yield per plant these promising hybrids *viz.,* IS 355 x Gowri, YLM 95 x Gowri and KMR 42 x Madhavi exhibited high heterotic effects. The cross KMR 42 x Madhavi have higher *sca* effect even though poor x poor parents are involved. The higher *sca* effect observed in poor x poor general combiners cross might be due to non-additive gene effects and such could be exploited through the hybridization. The crosses, IS 355 x Gowri, YLM 95 x Gowri also have positive *sca* effects for seed yield per plant, which involved good x poor parents. The cross involved good x poor general combiners can produce transgressive segregants in later generation.

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