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Combining ability analysis and gene action for seed cotton yield and fibre quality traits in cotton (*Gossypium hirsutum* L.)

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ABSTRACT : In the present investigation, combining ability was studied with ten parents in half diallel crossing design along with their parents for fourteen characters in order to identify suitable parents/ crosses, which could be utilized for further improvement programme of American cotton (*Gossypium hirsutum* L.). The results indicated that general combining ability (*gca*) variances due to parents and specific combining ability (*sca*) variances due to parents *vs* hybrids were significant for all the characters except for days to 50 per cent flowering and uniformity ratio. The estimates of gca effects revealed that the parents SCS-1207, PBH-13 and GSHV 177 were found to be best general combiners for yield and fibre quality traits in desired direction. The cross combinations *viz.,* SCS 1207 × GSHV 177, SCS 1207 × PBH 13 and GSHV 177 × L1231 registered high *sca* effects along with high *per se* performance for seed cotton yield/plant and its component traits. However, the analysis of variance for combining ability revealed that, the *gca* variances were higher than *sca* variances for all the characters except for ginning outturn (%) indicating predominance of non additive gene action.

Key Words: Combining ability, half- diallel analysis, *Gossypium hirsutum* L.

Cotton is a major crop of global importance and has high commercial value. In India cotton is being grown over an area of 122 lakh ha with an annual production of 377 lakh bales (1bale = 170 kg of lint) and productivity of 524 kg lint/ha (Anonymous, 2018). There are four cultivated cotton species including two diploids (*Gossypium herbaceum* L. and *Gossypium arboreum* L.) and two tetraploids (*Gossypium hirsutum* L. and *Gossypium barbadense* L.). Approximately 95 per cent of the world cotton production is from *Gossypium hirsutum* L. Hybridization is the most potent technique for breaking yield barriers. Selection of parents on the basis of phenotypic performance alone is not a sound procedure, parents should be chosen on the basis of their combining ability and gene action and hence the concept of combing ability has been proposed. It plays a significant role in crop improvement as it helps the breeder to determine the nature and magnitude of gene action involved in the inheritance of traits. Combining ability is useful in selection of desirable parents for exploitation of hybrids and transgressive expressions and also to assess the ability of parents to generate potential hybrids with a reasonable level of stability.

The present investigation was carried out by crossing ten parents *viz.*, L788, HYPS 152, L770, L1493, L1231, SCS 1207, PBH 13, GJHV 497, GSHV 177 and GTHV 13/32 in half diallel fashion and forty five intra specific cross combinations were generated and evaluation of hybrids along with parents was done at Regional Agricultural Research Station, Lam, Guntur, Andhra Pradesh, during *kharif,* 2017-2018. Each entry was represented by following 105 cm × 60 cm spacing with one row for each entry with a row length of 6m. Recommended doses of fertilizers 120: 60: 40 (N: P: K) kg/ha were applied in split doses. Observations were recorded on five randomly selected plants from each genotype/ replication for the characters *viz.,* days to 50 per cent flowering, plant height (cm), monopodia/ plant, number of sympodia /plant, Bolls /plant, boll weight (g), seed index (g), lint index (g), ginning outturn (%), 2.5 per cent span length (mm), micronaire value (10^{-6}g/inch), bundle strength (g/tex), uniformity ratio and seed cotton yield /plant. The fibre quality parameters were studied at Central Institute for Research on Cotton Technology (CIRCOT), Regional Unit, RARS, Lam, Guntur, Andhra Pradesh by using HVT Expert 1201 high volume fibre tester instrument. The data were statistically analyzed.

The analysis of variance for combining ability recorded significant differences for most of the traits studied (Table1). The differences among the parents were significant for all the characters except for lint index (g). Whereas, the differences among the parents *vs* hybrids were significant for all the characters except for days to 50 per cent flowering and uniformity ratio. The analysis of variance for combining ability revealed that, the variance due to specific combining ability (*sca*) variances were lesser than general combining ability (*gca*) variances for all the characters except for ginning outturn (%), thus indicating predominance of non additive gene action for all the characters and additive gene action for ginning outturn (%). General combining ability effects of parents and specific combining ability effects of crosses were estimated and presented in Table 2 and 3, respectively. The *gca* effects revealed that none of the parents recorded significant *gca* effects for all the characters studied. Among the parents, the genotype SCS 1207 showed significant positive *gca* effects for eight traits *viz.*, plant height, sympodia /plant, bolls/plant, boll weight, seed index, lint index, uniformity ratio, micronaire value, bundle strength and seed cotton yield /plant followed by GSHV 177 which showed significant positive *gca* effects for four traits *viz.*, plant height, sympodia /plant, boll /plant and seed cotton yield /plant. The parent PBH 13 showed significant positive *gca* effects for seven traits namely, plant height, sympodia /plant, bolls /plant, boll weight, seed index, lint index, micronaire value and seed cotton yield /plant. These results are in agreement with the findings of Tuteja and Banga (2013), Deosarkar *et al.*, (2014) Bayyapureddy *et al.*, (2016) and Lingaraja *et al.,* (2017).

The cross combinations, HYPS 152 x SCS 1207 (12.58*), PBH 13 × GTHV 13/32 (1.84) and GSHV 177 × GTHV 13/32 (4.56) showed significant positive *sca* effects in desirable direction for plant height. Two hybrid combinations, HYPS 152 × GJHV 497 (3.11*) and SCS 1207 × GJHV 497 (2.75*) expressed positive and significant *sca* effects in desirable direction for days to 50 per cent flowering. Out of 45 cross combinations, three hybrid combinations *viz.,* GJHV 497 × GSHV 177 (0.97**), GJHV 497 × L1231 (0.67**) and SCS 1207 × GJHV 497 (1.02**) showed significant positive *sca* effects for monopodia /plant. Eight cross combinations *viz.*,

Table 1. Analysis of variance for combining ability for yield and its components in intra-specific hybrids of cotton

Source of variation	d. f.	Plant height (cm)	Days to 50 per cent flowering	Mono-podia/ plant	Sym-podia/ plant	Bolls/ plant	Boll weight (g)	Seed index (g)	Lint index (g)	Gin-ning outturn (%)	2.5 per cent span length (mm)	Uni-formity ratio	Micron-aire value (10^{-6}g/ inch)	Bundle strength (g/tex)	Seed cotton yield/ plant (g)
							Mean sum of squares								
Replicates	2	66.72	4.07	0.068	0.92**	11.84	0.01	1.53	0.27	2.44	0.19	0.26	0.02	0.02	22.23
Treatments	54	451.68**	12.23**	1.19**	11.68**	111.15**	0.51**	3.14**	1.17**	6.86**	8.49**	2.91**	0.18**	4.42**	1978.65**
Parents	9	886.32**	31.27**	0.28**	8.80**	102.48**	1.19**	2.51**	0.36	6.63**	19.74**	4.84**	0.362**	7.02**	811.47**
Hybrids	44	318.27**	8.48**	1.20**	9.89**	79.90**	0.20**	2.43**	1.28**	5.95**	5.43**	2.58	0.12**	3.18**	1816.34**
Parent *V/s* Hybrids	1	2410.38**	5.77	8.62**	116.37**	1563.93**	8.07**	39.78**	3.18*	49.04**	41.67**	0.21	1.24**	35.34**	19625.08**
Error	108	90.4	4.46	0.09	2.72	19.58	0.03	0.73	0.47	1.03	0.67	1.56	0.03	0.4	219.77
Total	164	209.07	7.02	0.45	5.65	49.64	0.19	1.53	0.69	2.97	3.24	1.99	0.08	1.72	796.51
GCA	9	551.63**	9.02**	0.75**	6.17**	80.89**	0.32**	2.01**	0.43**	2.02**	10.57**	1.12*	0.14**	4.06**	1544.50**
SCA	45	70.34**	3.08**	0.32**	3.44**	28.28**	0.14**	0.85**	0.38**	2.34**	1.28**	0.94**	0.04**	0.95**	482.56**
Error	108	30.13	1.48	0.03	0.91	6.52	0.01	0.24	0.15	0.34	0.22	0.52	0.01	0.13	73.25

Table 2. Estimates of general combining ability (*gca*) effects of parents for 14 traits in cotton

Sr. No.	Parents	Plant height (cm)	Days to 50 per cent flowering	Mono-podia/ plant	Sym-podia/ plant	Bolls/ plant	Boll weight (g)	Seed index (g)	Lint index (g)	Gin-ning outturn (%)	2.5 per cent span length (mm)	Uni-formity ratio	Micron-aire value (10^{-6}g/ inch)	Bundle strength (g/tex)	Seed cotton yield/ plant (g)
1	L788	-5.51**	-0.65	0.08	-0.86**	-3.661**	0.155**	-0.094	-0.123	-0.155	0.059	-0.133**	-0.320**	-0.072	-9.617**
2	HYPS 152	2.54	1.51**	-0.19**	0.38	-3.508**	0.201**	0.049	-0.238*	- 0.656**	1.801**	-0.188**	1.191**	-0.128	-10.236**
3	L770	-7.95**	-1.51**	-0.01	-0.64*	0.512	-0.205**	0.207	0.149	0.010	0.657**	-0.038	0.305**	-0.267	-8.203**
4	L 1493	-7.94**	-0.03	-0.17**	-1.04**	-2.330**	-0.103**	-0.009	-0.040	-0.060	1.012**	0.062*	0.327**	-0.572**	-9.041**
5	SCS 1207	4.68**	-0.78*	-0.23**	0.52*	2.884**	0.233**	0.867**	0.338**	-0.590**	-0.091	0.081**	0.227*	0.400*	17.230**
6	PBH 13	8.83**	-0.03	-0.08	1.12**	3.406**	0.119**	0.347*	0.275*	0.061	-0.504**	0.109**	-0.245*	0.039	13.107**
7	GJHV 497	3.81*	-0.06	0.62**	0.45	1.776*	-0.117**	-0.154	-0.055	0.138	-0.674**	0.153**	-0.309**	0.178	-1.813
8	GSHV 177	5.51**	0.40	-0.08	0.55*	1.923**	-0.015	-0.253	-0.124	0.100	-0.521**	-0.022	-0.309**	0.233	16.823**
9	GTHV13/37	4.99**	0.96**	-0.08	-0.06	-1.502*	-0.181**	-0.347*	-0.049	0.487**	-0.266*	-0.083**	0.136	-0.183	-7.523**
10	L 1231	-8.97**	0.21	0.14**	-0.42	0.501	-0.088**	-0.613**	-0.133	0.666**	-1.474**	0.059	-1.003**	0.372	-0.726
	SE (gj)	**2.24**	**0.49**	**0.07**	**0.38**	**1.04**	**0.04**	**0.20**	**0.16**	**0.24**	**0.19**	**0.04**	**0.15**	**0.29**	**3.49**

* Significant at 5% level ** Significant at 1% level

L788 x L 770 (3.28**), L770 x L1493 (2.36*), L1493 x PBH 13 (2.72**), L1493 x GJHV 497 (2.76**), SCS 1207 x PBH 13 (2.03*), SCS 1207 x GTHV 13/32 (1.97*), PBH 13 x GSHV 177 (2.69**) and GSHV 177 × L1231 (3.99**) exhibited significant positive *sca* effects for sympodia /plant. The top ten cross combinations based on *sca* effects identified for bolls /plant, were L788 x HYPS 152 (7.05**), L 788 x PBH 13 (6.27**), L788 x GJHV 497 (7.56**), L770 x L1493 (8.10**), L770 x GJHV 497 (6.66**), L1493 x PBH 13 (5.34*), SCS 1207 x GJHV 497 (6.35**), PBH 13 x GJHV 497 (6.76**), PBH 13 x GTHV 13/32 (4.77*), GJHV 497 x GSHV 177 (5.51*) and GSHV 177 x GTHV 13/32 (9.86**). For boll weight, the hybrid combinations *viz*., HYPS 152 x SCS 1207(0.28**), HYPS 152 x L1231 (0.46**), L770 x L1493 (0.20*), L770 x GTHV 13/32(0.41**), L1493 x SCS 1207 (0.64**), SCS 1207 x PBH 13 (0.45**) and GJHV 497 x GTHV 13/32 (0.31**) has recorded significant positive *sca* effects. Based on *sca* effects for seed index the superior hybrid combinations were HYPS 152 x PBH 13 (0.301**), L 770 x GSHV 177 (1.13*), L1493 x SCS 1207 (2.63**) and L1493 x GSHV 177 (0.92*).

The best six cross combinations identified among 45 crosses for lint index based on *sca* effects were HYPS 152 x PBH 13 (1.09**), L 770 x GSHV 177 (0.93*), L 1493 x GTHV 13/32 (0.94*), SCS 1207 x GTHV 13/32 (1.12**), PBH 13 x GSHV 177 (0.91*) and GSHV 177 x L1231 (0.85*). For ginning outturn (%), the cross combinations *viz*., L770 x SCS 1207 (1.17*), L 1493 x GTHV 13/32 (2.15**), SCS 1207 x L1231 (2.90**), L 770 x L1231 (1.46**) and GSHV 177 x L1231 (1.74**) registered significant positive *sca* effects. The promising eight cross combinations identified based on *sca* effects were significant for 2.5% span length are HYPS 152 × L 770 (0.91*), HYPS 152 × PBH 13 (1.54**), HYPS 152 × GSHV 177 (1.62**), PBH 13 × GJHV 497 (1.31**), PBH 13 × GSHV 177 (0.93*), L1493 × SCS 1207 (1.08*), L1493 × GSHV 177 (1.14**) and GTHV 13/32 × L1231 (1.04*). The best hybrid combinations for micronaire value were L 788 x SCS 1207 (0.27**), HYPS 152 x L770 (0.20*), HYPS 152 × SCS 1207 (0.42**), L770 × SCS 1207 (0.23*), SCS 1207 × GSHV 177 (0.28**), GJHV 497 × GTHV 13/32 (0.40**) and GTHV 13/32 x L1231 (0.37**). The top ten cross combinations identified based on *sca* effects for bundle strength were HYPS 152 x GSHV 177 (1.22**), HYPS 152 × L1231(0.82*), L770 x PBH 13(0.71*), L770 x GSHV 177 (1.74**), L770 x L1231(0.87*), L1493 x SCS 1207 (1.29**), L1493 x GJHV 497 (0.69*), L1493 x GSHV 177 (1.49**), L1493 x GTHV 13/32 (1.18**), PBH 13 x GJHV 497 (1.29**) and GJHV 497 x L1231 (1.29**). Among forty five cross combinations only one cross showed significant positive *sca* effects for uniformity ratio were L1493 x GTHV 13/32 (1.98**). The superior fourteen cross combinations for seed cotton yield /plant were L788 x GJHV 497 (21.05*), L788 x L1231 (16.91*), HYPS 152 x SCS 1207 (20.89*), L770 x GJHV 497 (26.43**), L770 x GSHV 177 (25.86**), L1493 x SCS 1207(37.53**), L1493 x GTHV 13/32 (21.52**), SCS 1207 x GSHV 177 (25.98**), SCS 1207 x GTHV 13/32 (37.37**), PBH 13 x GJHV 497 (24.07**), PBH 13 x L1231 (28.04**), GSHV 177 x GTHV 13/32 (24.07**) and GSHV 177 x L1231 (28.04**).

From the present study, it was observed that the hybrid combinations, SCS 1207 x GSHV 177, GSHV 177 × L1231 and SCS 1207 × PBH 13 recorded high per se performance (180.76, 175.00 and 167.81 g, respectively) for seed cotton yield

Table 3. Specific combining ability (*sca*) effects of 45 hybrids of cotton for yield and yield components in cotton during *kharif*, 2017-18.

Sr. No.	Parents	Plant height (cm)	Days to 50 per cent flowering	Mono-podia/ plant	Sym-podia/ plant	Bolls/ plant	Boll weight (g)	Seed index (g)	Lint index (g)	Gin-ning outturn (%)	2.5 per cent span length (mm)	Uni-formity ratio	Micron-aire value (10^{-6}g/ inch)	Bundle strength (g/tex)	Seed cotton yield/ plant (g)
1	L788 x HYPS-152	0.379	0.03	0.754**	0.857	7.051**	-0.249*	-0.131	0.015	0.195	-0.587	0.758	0.101	0.074	0.702
2	L788 x L770	2.279	-2.942*	0.032	3.282**	-1.569	-0.11	0.854	0.424	-0.348	-0.142	-0.104	-0.083	-0.373	-0.204
3	L788 x L1493	2.84	1.586	-0.193	-2.315*	-0.46	0.045	-0.747	-0.31	0.539	-0.031	0.202	-0.249*	0.538	-6.99
4	L788 x SCS-1207	-1.755	1.003	0.393*	-0.085	1.059	-0.114	-0.126	0.035	0.298	-1.328**	-0.437	-0.169	0.071	2.083
5	L788 x PBH-13	2.859	1.253	0.112	1.182	6.270*	-0.024	-0.589	-0.082	0.855	1.186**	-1.076	0.270**	0.277	2.002
6	L788 x GJHV-497	2.109	-0.72	0.337*	1.521	7.567**	-0.055	0.025	0.012	0.067	2.788**	-0.215	0.126	0.507	21.059*
7	L788 x GSHV-177	-12.488*	0.475	-0.052	-3.146**	-1.213	0.07	0.051	-0.853*	-2.292**	-0.231	0.396	0.034	0.24	-12.624
8	L788 x GTHV-13/32	-5.205	-0.747	-0.285	-0.499	-3.021	-0.227*	0.425	0.322	0.019	-0.587	0.48	0.162	-0.804*	-6.217
9	L788 x L1231	0.234	-0.997	-0.052	0.062	-1.558	0.07	0.827	0.477	-0.221	0.555	-0.076	-0.013	-0.365	16.919*
10	HYPS-152 × L770	1.418	0.225	-0.29	0.901	-2.888	0.054	0.867	-0.187	-1.797**	0.916*	0.952	0.206*	-0.285	13.898
11	HYPS-152 × L1493	5.745	0.086	0.085	0.037	4.054	-0.397**	-0.384	-0.161	0.183	-1.973**	-0.742	0.006	-0.34	2.313
12	HYPS-152 × SCS-1207	12.584*	-1.497	-0.463**	1.001	-3.227	0.287**	0.784	0.047	-1.031	-0.77	0.619	0.420**	-0.64	20.892*
13	HYPS-152 × PBH-13	-7.802	0.419	-0.477**	-1.265	-3.816	0.094	1.301**	1.097**	0.466	1.544**	1.313	-0.174	0.632	-5.169
14	HYPS-152 × GJHV-497	-6.152	3.114**	0.548**	0.673	0.548	-0.03	0.218	-0.183	-0.842	0.247	0.508	0.081	0.329	1.384
15	HYPS-152 × GSHV-177	3.551	-1.359	-0.074	0.173	1.201	-0.116	-0.88	-0.351	0.619	1.627**	-1.215	-0.011	1.229**	-3.271
16	HYPS-152 × GTHV13/32	5.868	-1.247	0.360*	0.587	3.226	-0.086	0.804	0.15	-1.064	0.472	-1.131	-0.116	-0.282	-0.405
17	HYPS-152 × L1231	9.373	-2.164	0.560**	0.882	1.99	0.467**	0.037	-0.815*	-2.187**	-0.22	1.313	0.176	0.824*	-13.426
18	L770 x L1493	7.912	0.447	0.562**	2.362*	8.101**	0.205*	-0.335	-1.319**	-2.822**	0.672	-1.604*	0.023	-0.821*	2.67
19	L770 x SCS-1207	0.284	-2.470*	-0.518**	-0.374	0.82	-0.037	-0.174	0.476	1.174*	0.841	0.091	0.237*	0.146	4.453
20	L770 x PBH-13	-1.268	0.114	-0.265	-1.307	-5.302*	0.07	0.643	-0.391	-1.883**	0.222	-1.215	-0.024	0.718*	-23.255**
21	L770 x GJHV-497	-0.452	1.808	0.826**	-2.635**	6.662**	0.105	-0.263	-0.354	-0.457	-1.009*	0.98	0.064	0.049	26.439**
22	L770 × GSHV-177	2.851	-1.664	-0.129	0.865	-1.285	0.367**	1.136*	0.932*	0.317	0.338	0.591	-0.094	1.749**	25.869**
23	L770 × GTHV-13/32	-6.966	0.447	-0.329*	-1.321	-1.794	0.410**	0.653	0.116	-0.856	-0.217	1.008	0.101	0.138	-23.104**
24	L770 × L1231	1.44	-0.47	0.404*	1.107	0.737	0.11	0.059	0.678	1.465**	0.124	1.119	-0.074	0.877*	8.529
25	L1493 × SCS-1207	3.612	0.058	0.390*	0.096	2.862	0.648**	2.636**	0.655	-2.223**	1.086*	0.73	-0.097	1.290**	37.537**
26	L1493 × PBH-13	10.226*	-1.692	0.243	2.729**	5.340*	-0.175	-1.195*	-0.795*	0.123	-1.367**	-0.242	0.076	-0.971**	9.149
27	L1493 × GJHV-497	9.143	-0.331	-0.465**	2.768**	-2.83	0.294**	0.55	0.602	0.379	-0.431	0.952	-0.236*	0.693*	-18.634*
28	L1493 × GSHV-177	1.979	-0.803	0.046	1.735	-2.377	0.466**	0.925*	0.511	-0.246	1.149*	0.563	0.006	1.493**	-27.856**
29	L1493 × GTHV13/32	-2.538	-0.359	0.179	-0.185	0.181	0.612**	-0.058	0.942*	2.151**	-0.373	1.980**	0.167	1.182**	21.520**
30	L1493 × L1231	1.001	-0.942	-0.054	-1.357	-1.555	0.205*	0.379	-0.4	-1.672**	0.236	0.758	0.126	0.421	3.776
31	SCS-1207 × PBH-13	0.332	1.391	0.296	-1.407	-2.274	0.452**	-0.147	0.373	1.056	-0.098	1.119	-0.244*	-0.071	5.446
32	SCS-1207× GJHV-497	0.315	2.753*	1.021**	2.032*	6.356**	0.005	0.864	-0.083	-1.555**	0.638	-0.02	0.012	0.293	3.789
33	SCS-12 07×GSHV-177	3.751	0.28	-0.502**	1.165	0.142	0.016	-0.587	-0.851*	-1.127*	-1.148*	-1.076	0.287**	-1.673**	25.983**
34	SCS-1207×GTHV13/32	15.668**	-1.275	-0.368*	1.979*	3.501	0.216*	0.884	1.127**	0.967	0.83	-0.659	-0.019	0.349	37.379**
35	SCS-1207 × L1231	5.24	0.141	0.198	0.807	1.598	-0.111	-1.354**	0.239	2.901**	0.172	-1.215	-0.061	0.254	-24.788**
36	PBH-13 × GJHV-497	0.829	1.669	-0.227	-0.535	6.767**	-0.101	0.027	0.287	0.582	1.319**	0.341	-0.016	1.299**	24.078**
37	PBH-13 × GSHV-177	3.598	0.53	0.151	2.698**	0.387	0.04	0.849	0.912*	0.63	0.933*	0.285	-0.141	0.432	-19.411*
38	PBH-13× GTHV-13/32	1.848	0.308	0.885**	0.779	4.779*	0.009	0.14	-0.08	-0.457	-0.856	-0.298	-0.147	-0.179	16.379*
39	PBH-13 × L1231	1.754	0.058	-0.615**	1.673	0.509	0.216*	-0.414	0.075	0.87	0.752	-0.52	0.078	0.593	28.045**
40	GJHV-497 × GSHV-177	0.082	-0.109	0.976**	-0.296	5.517*	0.122	0.09	-0.558	-1.591**	0.369	-1.187	0.014	-2.271**	8.759
41	GJHV497×GTHV13/32	-10.935*	0.669	0.576**	-1.149	-4.191	0.312**	0.208	-0.346	-1.308*	0.913*	-1.437*	0.409**	0.285	-11.095
42	GJHV-497 × L1231	1.904	2.419*	0.676**	-0.654	-1.194	-0.035	0.671	0.235	-0.59	0.388	-0.992	0.067	1.290**	-8.382
43	GSHV177×GTHV13/32	4.568	-0.47	0.087	-0.782	9.862**	0.027	0.31	0.129	-0.283	0.561	-0.826	-0.016	0.352	24.079**
44	GSHV-177 × L1231	-8.593	-1.053	-0.013	-0.821	1.092	0.267*	0.196	0.854*	1.741**	0.102	0.952	0.209*	0.257	38.172**
45	GTHV-13/32 × L1231	17.657**	-1.942	-0.479**	3.993**	7.684**	0.296**	0.387	-0.655	-2.309**	1.047*	-0.965	0.370**	0.013	2.879
	SE (s_{ij})	**5.05**	**1.12**	**0.16**	**0.87**	**2.35**	**0.1**	**0.45**	**0.36**	**0.54**	**0.43**	**0.66**	**0.1**	**0.34**	**7.88**

* Significant at 5% level   ** Significant at 1% level

/plant and significant positive *sca* effects (25.98, 38.17 and 37.37, respectively). These cross combinations also recorded high *per se* performance and significant positive *sca* effects for other important yield contributing characters such as boll weight (SCS 1207 x PBH 13), lint index (SCS 1207 × PBH 13), ginning outturn (GSHV 177 × L1231) and also for uniformity ratio (GSHV 177 × L1231) and (SCS 1207 × PBH 13). Similar results for these characters were earlier reported by Rajanna (2010), Imran *et al.*, (2012), Senthil Kumar *et al.*, (2013), Tuteja and Banga (2013), Rajamani *et al.*, (2014) and Bayyapu Reddy *et al.*, (2016). The ratio of general combining ability component of variance to specific combining ability component of variance indicated the preponderance of additive gene action for plant height and non additive gene action for remaining traits studied. The traits governed by additive gene action may be exploited through simple selection procedures in recombination breeding or pedigree method of breeding. Whereas, the traits governed by non additive gene action could be improved through breeding procedures such as hybridization, biparental mating and diallel selective mating system.

CONCLUSION

Based on the *per se* performance and *gca* effects the parents *viz.*, SCS 1207, PBH 13 followed by GSHV 177 were identified to be the best combiners for further utilization as parents in the crossing programme. Similarly, the hybrid combination SCS 1207 x PBH 13 was found to be the best hybrid with high *sca* effects for most of the traits studied followed by GSHV 177 × L1231. In majority of the hybrids, high *sca* was either due to high x low or low x low combining parents, which further substantiate the operation of non additive gene action be explored in one, where (additive dominance and dominance x dominance epistatic interaction). It could be inferred that the choice of parents for crossing programme should not be based only on the *per se* performance and *gca* effects but also on *sca* effects of the cross combinations. Parents with good individual performance and good *gca* effects may not nick well but the parents with poor *gca* effects may nick well due to complementary gene action. An ideal combination to be explored in one, where high magnitude of *gca* in both or at least one of the parents.

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