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Heterosis and Combining Ability for Seed Cotton Yield and Component Traits in Inter Specific Cotton Hybrids (*Gossypium hirsutum* L. x *Gossypium barbadense* L.)

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Forty five inter specific hybrids between *G. hirsutum* X *G. barbadense* derived from nine diverse female parents of *G. hirsutum* and five pollen parents of *G. barbadense* were evaluated to study heterosis and combining ability for seed cotton yield and its component traits. Significant heterosis was observed for the characters under study indicating the presence of genetic diversity among the parental lines. The hybrid (G. 67 x GSB 19) exhibited significant positive heterosis over the standard check hybrid for seed cotton yield per plant. Combining ability analysis suggested the preponderance of non-additive type of gene action for all the traits except average boll weight. The female parent G. 67 was found to be the best general combiner for majority of the traits; while, male parent GSB 19 was good general combiner for seed cotton yield per plant and its component characters *viz.,* average boll weight and lint yield per plant. The hybrid G. 247 x Suvin exhibited significant positive *sca* effect for seed cotton yield per plant and its attributing traits except plant height.

Key words: Cotton, Line x Tester analysis, Heterosis and Combining ability

The phenomenon of heterosis has proved to be the most important genetic tool in boosting the yield of self as well as cross pollinated crops and is considered as the most important breakthrough in the field of crop improvement. Shull (1914) coined the term heterosis. The exploitation of hybrid vigour in cotton on commercial scale has become feasible and economical due to easy hand emasculation and pollination. The identification of specific parental combination capable of producing the desired level of F_1 heterotic effect is important in improving the yield potential of this crop. Commercial exploitation of heterosis is considered to be an outstanding application of the principles of genetics into the field of plant breeding. Thus, heterosis can be useful only with marked superiority over the best checks. The present study was therefore, undertaken to determine the extent of heterosis in cotton and to identify most heterotic hybrids. In a crop improvement programme much success depends upon isolation of valuable cross combinations as determines in the form of parents with high combining ability. This emphasizes on the importance of testing the parents for their combining ability because many times the high yielding parents may not combine well to give good segregants. Combining ability analysis is a powerful tool to discriminate good as well as poor combiners and choose appropriate parental material in breeding programme. At the same time it also gives the information about the nature of gene effects involved in the inheritance of various characters. The concept of general and specific combining ability as a measure of gene effects was proposed by Sprague and Tatum (1942). The resulting total genetic variance is partitioned into the variance due to general combining ability and specific combining ability. This helps the breeder in knowing the relative proportion of additive and non additive genetic variances involved in the inheritance of various characters as well as deciding the appropriate breeding methods for effective exploitation of available genetic variation. The presence of non additive genetic variance is the primary justification for initiating the hybrid breeding programme. Combining ability analysis was carried out in the present study to obtain information on selection of better parents and cross combinations for their further use in hybrid breeding programme.

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Materials and Methods

The experimental material consisted of 60 genotypes, comprising of nine lines (Narsimha, G. Cot. 100, G. Cot. 10, G. Cot. 16, BC 68 2, MCU 11, AC 738, G. 247 and G. 67), five testers (GSB 19, GSB 21, GSB 24, GSB 43 and Suvin) and resultant forty five hybrids produced by line x tester mating design were evaluated along with one standard check hybrid G. Cot. Hy. 102. The experimental material was sown in a randomized block design with three replications during *kharif* 2010-11 at Regional Research Station, Anand Agricultural University, Anand (Gujarat). A single row of 4.5 meter length was assigned to each genotype with 10 plants having 45 cm intra row spacing and 120 cm inter row spacing. Five plants were randomly selected from each replication for each genotype and the average value per plot was computed for recording observations on plant height, total number of bolls, average boll weight, seed cotton yield, lint yield and ginning percentage. Analysis of variance technique suggested by Panse and Sukhatme (1978) was followed to test the differences between the genotypes for all the characters under study. Heterosis was estimated in terms of three parameters, i.e. relative heterosis (Turner, 1953), heterobeltiosis (Fonseca and Patterson, 1968) and standard heterosis (Meredith and Bridge, 1972). The variation among the hybrids was partitioned further into sources attributed to general combining ability (gca) and specific combining ability (sca) components in accordance with the procedure suggested by Kempthorne (1957).

Results and Discussion

Analysis of variance revealed that the mean squares due to genotypes were significant for all the characters under study. Mean squares due to genotypes were further partitioned into mean squares due to parents, hybrids, parents vs. hybrids and check vs. hybrids. The parents and hybrids differed significantly for all the characters. This revealed the existence of considerable genetic variability among the parents and hybrids for all the characters under study. The mean square due to parents vs. hybrids were significant for most of the traits except total number of bolls per plant and ginning percentage which suggested the presence of substantial amount of heterosis in crosses for most of the characters (Table 1). The estimates of relative heterosis (RH) and heterobeltiosis (BH) were ranged from 12.80 to 102.29% and -9.31 to 77.38% for plant height, -35.62 to 50.83% and -48.24 to 47.08% for total number of bolls/plant, -41.83 to 59.00% and -56.05 to 29.02% for average boll weight, -54.19 to 43.76% and - 71.71 to 14.65% for seed cotton yield/plant, -54.06 to 42.31% and -71.37 to 16.40% for lint yield per plant and -10.81 to 20.09% and -20.73 to 19.86% for ginning percentage, respectively. Out of 45F_1S hybrids, 43 and 24 hybrids were found significant and positive heterosis over mid and better parent for plant height, 14 and 8 hybrids recorded significant positive heterosis over mid and better parent for total number of bolls/plant, 8 and 1 hybrids recorded significant and positive relative heterosis and heterobeltiosis for average boll weight, 7 and 1 hybrids had significant positive relative heterosis and heterobeltiosis for lint yield per plant and 12 and 4 hybrids depicted significant and positive relative heterosis and heterobeltiosis for ginning percentage, respectively. The perusal of data on performance of hybrids with respect to heterosis revealed that seven hybrids manifested significant positive heterosis over their mid parent for seed cotton yield per plant; while none of the hybrids were depicted significantly positive heterobeltiosis for seed cotton yield per plant. The highest magnitude of mid and better parent heterosis for seed cotton yield per plant was exhibited by the hybrid G. 247 x Suvin. It was observed that hybrids showing high relative and better parent heterosis for seed cotton yield per plant in general also manifested heterotic effects for its contributing characters *viz.,* plant height, average boll weight and total number of bolls per plant (Table 2). This study thus substantiates the findings of Baloch *et al.* (1993), Ahmad *et al.* (2002), Soomro *et al.* (2006), Abdel-Hafez *et al.* (2007) and Saifullah Abro *et al.* (2009).

Table 1. Analysis of variance (mean squares) for seed cotton yield and its attributing traits

Sources of variation	Plant height	Total number of bolls per plant	Average boll weight	Seed cotton yield per plant	Lint yield per plant	Ginning percentage
Replications	52.09	58.14	0.02	181.62	21.10	0.705
Genotypes (G)	2323.08**	729.77**	1.16**	12302.82**	1220.46**	13.07**
Parents (P)	2033.34**	929.37**	2.62**	30676.54**	3058.16**	24.45**
Females (F)	533.30*	761.78**	0.65**	10175.49**	1004.75**	23.69**
Male (M)	27.09	271.56**	0.19**	1890.5**	194.85*	0.54
(F Vs M)	22058.7**	4901.32**	28.13**	309829.1**	30938.72**	126.18**
Hybrids (H)	1127.22**	702.28**	0.63**	5889.50**	594.73**	9.45**
Female	2617.22**	1033.3**	2.45**	11166.53**	1112.63**	16.64**
Male	802.80**	226.45**	0.62**	4454.91**	401.31**	3.87
F x M	795.28**	679.01**	0.17**	4749.57**	489.43**	8.36**
P Vs H	60682.75**	73.21	5.37**	61430.5**	5660.64**	0.11
Checks Vs Hybrids	1317.71*	3.002	1.55**	9648.52**	670.42**	37.47**
Error	231.09	51.731	0.029	440.15	44.55	2.07

*, ** significant at 5 % and 1 % levels, respectively.

Improvement in yield is one of the important objectives, so the superiority of hybrids over best cultivated hybrid is essential for increasing its commercial value. In present study, G. Cot. Hy. 102 which is a promising hybrid released for general cultivation in Gujarat has been used as standard check hybrid in order to obtain information on superiority of hybrids. The estimates of standard heterosis (SH) was ranged from -12.22 to 49.17% for plant height, -40.38 to 51.78% for total number of

Table 2. Magnitude of Relative heterosis (RH), Heterobeltiosis (HB) and Standard heterosis (SH) for plant height and total number of bolls per plant.

Sr.	Hybrids	Plant height			Total number of bolls per plant		
No.		RH	HB	SH	RH	HB	SH
1	Narsimha X GSB 19	15.07	-1.58	-12.22	21.72**	15.52	9.87
2	Narsimha X GSB 21	38.54**	19.37*	6.46	42.91**	25.99**	19.83**
3	Narsimha X GSB 24	52.27**	32.54**	18.21*	-0.05	-0.19	-4.80
4	Narsimha X GSB 43	29.89**	13.92	1.61	24.69**	4.1	-0.98
5	Narsimha X Suvin	26.98**	11.96	-0.14	-0.63	- 3.96	-8.65
6	G. Cot. 100 X GSB 19	48.96**	28.75**	12.00	-33.8**	-40.71**	-35.98**
7	G. Cot. 100 X GSB 21	42.72**	24.27**	8.10	9.32	-8.6	-1.31
8	G. Cot. 100 X GSB 24	42.64**	25.5**	9.17	1.96	-3.99	3.67
9	G. Cot. 100 X GSB 43	39.36**	23.56*	7.49	-30.55**	-44.79**	-40.38**
10	G. Cot. 100 X Suvin	37.8**	22.83*	6.85	-14.89*	-22.48**	-16.29*
11	G. Cot. 10 X GSB 19	20.27*	-4.03	2.07	4.82	-3.12	-2.46
12	G. Cot. 10 X GSB 21	38.29**	11.08	18.14*	20.92**	4.06	4.75
13	G. Cot. 10 X GSB 24	26.8**	2.79	9.32	34.69**	31.15**	32.03**
14	G. Cot. 10 X GSB 43	36.04**	11.04	18.09*	12.06	-8.51	-7.90
15	G. Cot. 10 X Suvin	41.57**	16.10*	23.47**	50.83**	41.89**	42.84**
16	G. Cot. 16 X GSB 19	20.35*	0.47	-4.89	47.62**	47.08**	26.55**
17	G. Cot. 16 X GSB 21	42.56**	19.84*	13.46	17.65*	8.45	-6.69
18	G. Cot. 16 X GSB 24	31.95**	12.03	6.06	-26.41**	-30.01**	-33.24**
19	G. Cot. 16 X GSB 43	25.38**	7.22	1.51	43.68**	25.03**	7.58
20	G. Cot. 16 X Suvin	45.27**	24.87**	18.22*	5.18	3.59	-8.08
21	BC682 X GSB 19	35.44**	9.79	12.03	-11.05	-21.35**	-12.56
22	BC682 X GSB 21	51.17**	23.36**	25.47**	-7.62	-23.65**	-15.11
23	BC682 X GSB 24	26.19**	3.95	6.07	-25.67**	-30.95**	-23.24**
24	BC682 X GSB 43	20.76*	0.18	2.22	11.29	-12.47	-2.69
25	BC682 X Suvin	17.58*	-1.98	0.01	-17.41*	-25.75**	-17.46*
26	MCU 11 X GSB 19	12.80	-9.31	-5.47	-4.99	-17.52**	-4.31
27	MCU 11 X GSB 21	39.97**	13.29	18.08*	9.07	-11.35	2.85
28	MCU 11 X GSB 24	29.89**	6.12	10.61	43.59**	30.82**	51.78**
29	MCU 11 X GSB 43	42.88**	17.54*	22.51**	37.84**	6.77	23.86**
30	MCU 11 X Suvin	18.23*	-2.27	1.86	-13.85*	-23.98**	-11.80
31	AC 738 X GSB 19	45.12**	15.77*	23.22**	20.16**	3.25	22.75**
32	AC 738 X GSB 21	26.22**	1.35	7.88	-16.54*	-32.79**	-20.09*
33	AC 738 X GSB 24	43.18**	16.04*	23.50**	5.75	-4.75	13.23
34	AC 738 X GSB 43	35.16**	10.28	17.38*	5.75	-18.79**	-3.46
35	AC 738 X Suvin	41.53**	16.04*	23.50**	-11.75	-22.94**	-8.38
36	G. 247 X GSB 19	38.3**	15.01	9.92	-14.56*	-22.83**	-18.26*
37	G. 247 X GSB 21	56.58**	31.12**	25.32**	46.02**	23.04**	30.32**
38	G. 247 X GSB 24	57.18**	32.92**	27.04**	-2.34	-7.2	-1.71
39	G. 247 X GSB 43	58.24**	34.80**	28.83**	-18.17*	-34.48**	-30.59**
40	G. 247 X Suvin	54.47**	32.26**	26.41**	39.80**	28.46**	36.07**
41	G. 67 X GSB 19	102.29**	77.38**	49.17**	-29.07**	-45.81**	-12.34
42	G. 67 X GSB 21	96.65**	73.73**	46.11**	-15.93*	-39.1 **	-1.48
43	G. 67 X GSB 24	61.97**	44.61**	21.62**	-35.62**	-48.84**	-17.23*
44	G. 67 X GSB 43	62.53**	46.26**	23.00**	-21.49**	-45.29**	-11.48
45	G. 67 X Suvin	35.92**	22.98*	3.43	-28.40**	-44.56**	-10.32
RangeMax.		102.29	77.38	49.17	50.83	47.08	51.78
	Min.	12.80	-9.31	-12.22	-35.62	-48.24	-40.38
S.E. (±)		10.80	12.47	12.47	5.08	5.87	5.87

bolls/plant, -54.26 to 34.07% for average boll weight, -59.21 to 17.50% for seed cotton yield/plant, -57.76 to 19.18% for lint yield/plant and -21.01 to 1.75% for ginning percentage. Out of 45 F_1S hybrids, 20, 9, 2 and 1 hybrids were found positive and significant standard heterosis for plant height, total number of bolls/plant, lint yield /plant and average boll weight, respectively; while none of the hybrids were out yielded over standard check hybrid for ginning percentage. The hybrid G. 67 x GSB 19 exhibited maximum seed cotton yield (276.54 gm) and highest Standard heterosis (17.50 per cent) for seed cotton yield over the check G. Cot. Hy. 102. Several workers (Punitha *et al.*, 1999; Desalegn *et al.,* 2004 and Patel *et al.,* 2009) have also reported the presence of considerable degree of standard heterosis for seed

Table 2. (Continued) Magnitude of Relative heterosis (RH), Heterobeltiosis (HB) and Standard heterosis (SH) for average boll weight and seed cotton yield per plant.

Sr. No.	Hybrids	Average boll weight			Seed cotton yield per plant		
		RH	HB	SH	RH	HB	SH
1	Narsimha X GSB 19	-14.20**	-32.97**	-22.71**	3.00	-22.62**	-15.03*
2	Narsimha X GSB 21	5.74	-25.11**	-13.88**	43.06**	-5.65	3.60
3	Narsimha X GSB 24	13.73**	-19.45**	-7.26	13.25	-19.65**	-11.77
4	Narsimha X GSB 43	-15.11**	-37.9 **	-28.39**	-1.70	-35.68**	-29.37 **
5	Narsimha X Suvin	-9.54*	-29.95**	-19.24**	-10.99	-32.67**	-26.07**
6	G. Cot. 100 X GSB 19	-23.04**	-42.82**	-23.66**	-50.85**	-66.02**	-51.0 **
7	G. Cot. 100 X GSB 21	-20.53**	-45.98**	-28.08**	-20.31**	-50.48**	-28.59**
8	G. Cot. 100 X GSB 24	-26.22**	-49.84**	-33.12**	-26.79**	-51.71**	-30.38 **
9	G. Cot. 100 X GSB 43	-26.31**	-48.42**	-31.23**	-54.19**	-71.71**	-59.21 **
10	G. Cot. 100 X Suvin	-26.59**	-45.9 **	-27.76**	-39.93**	-58.23**	-39.37 **
11	G. Cot. 10 X GSB 19	-13.78**	-35.38**	-16.09**	-12.16	-37.57**	-18.27*
12	G. Cot. 10 X GSB 21	-20.40**	-45.51**	-29.34**	-10.86	-43.51**	-26.03**
13	G. Cot. 10 X GSB 24	-9.05*	-37.73**	-19.24**	20.32**	-18.7 **	6.45
14	G. Cot. 10 X GSB 43	-23.54**	-46.07**	-29.97**	-21.89**	-50.83**	-35.62**
15	G. Cot. 10 X Suvin	-28.98**	-47.21**	-31.55**	5.21	-24.77**	-1.50
16	G. Cot. 16 X GSB 19	-5.61	-22.33**	-22.08**	38.40**	13.43	-2.08
17	G. Cot. 16 X GSB 21	-6.81	-31.13**	-30.91**	6.15	-25.39**	-35.39**
18	G. Cot. 16 X GSB 24	0.14	-26.00**	-25.87**	-24.95**	-42.47**	-50.34**
19	G. Cot. 16 X GSB 43	-0.48	-23.79**	-23.66**	36.70**	-4.82	-17.83*
20	G. Cot. 16 X Suvin	-15.63**	-31.24**	-30.91**	-11.40	-26.8**	-36.81**
21	BC682 X GSB 19	-5.86	-25.47**	-17.35**	-19.12**	-41.47**	-27.81**
22	BC682 X GSB 21	-3.44	-30.87**	-23.34**	-17.49*	-47.03**	-34.67**
23	BC682 X GSB 24	-7.14	-33.52**	-26.18**	-33.13**	-54.09**	-43.38**
24	BC682 X GSB 43	1.73	-24.72**	-16.40**	3.35	-34.12**	-18.75**
25	BC682 X Suvin	-17.68**	-35.42**	-28.39**	-34.12**	-52.02**	-40.82**
26	MCU 11 X GSB 19	-34.45**	-46.88**	-44.48**	-39.73**	-56.11**	-46.95**
27	MCU 11 X GSB 21	-10.64*	-34.78**	-31.86**	-10.03	-41.98**	-29.87**
28	MCU 11 X GSB 24	-22.24**	-43.25**	-40.69**	8.20	-25.31**	-9.72
29	MCU 11 X GSB 43	-41.83**	-56.05**	-54.26**	-26.39**	-52.88**	-43.04**
30	MCU 11 X Suvin	-34.97**	-47.78**	-45.43**	-45.57**	-60.11**	-51.77**
31	AC 738 X GSB 19	11.98*	-6.52	-9.46*	29.90**	-3.89	10.52
32	AC 738 X GSB 21	3.34	-22.72**	-25.24**	-20.49**	-48.14**	-40.36**
33	AC 738 X GSB 24	4.94	-21.52**	-23.97**	6.67	-25.32**	-14.13
34	AC 738 X GSB 43	2.31	-20.65**	-23.34**	-0.96	-35.88**	-26.87**
35	AC 738 X Suvin	-12.82*	-27.93**	-30.28**	-25.17**	-44.26**	-35.91**
36	G. 247 X GSB 19	17.90**	1.77	-9.15*	-0.82	-21.5 **	-25.70**
37	G. 247 X GSB 21	0.15	-23.00**	-31.23**	38.45**	-5.16	-10.23
38	G. 247 X GSB 24	-4.91	-26.89**	-34.70**	-8.47	-31.99**	-35.62**
39	G. 247 X GSB 43	6.57	-14.86**	-23.97**	-19.14**	-45.09**	-48.03**
40	G. 247 X Suvin	4.21	-10.97*	-20.50**	43.76**	14.65	8.51
41	G. 67 X GSB 19	59.00**	29.02**	34.07**	5.34	-30.02**	17.50*
42	G. 67 X GSB 21	39.24**	1.72	5.68	2.95	-37.79**	4.46
43	G. 67 X GSB 24	20.55**	-11.93**	-8.52	-29.01**	-54.78**	-24.07**
44	G. 67 X GSB 43	24.33**	-5.97	-2.21	-14.04	-48.35**	-13.27
45	G. 67 X Suvin	17.61**	-5.46	-1.58	-21.20**	-47.39**	-11.65
Range	Max.	59.00	29.02	34.07	43.76	14.65	17.50
	Min.	-41.83	-56.05	-54.26	-54.19	-71.71	-59.21
S.E. (±)		0.12	0.14	0.14	14.87	17.18	17.18

cotton yield per plant. The hybrid G. 67 x GSB 19 was found promising as they exhibited positive significant heterosis over G. Cot. Hy. 102 with respect to yield contributing traits *viz.,* plant height, average boll weight, lint yield per plant and ginning percentage. The analysis of variance for combining ability was carried out for seed cotton yield and its attributing characters *viz.,* plant height, total number of bolls, average boll weight, ginning percentage and lint yield per plant which presented in Table 3. The variation present in the hybrids was partitioned into portions attributable to lines, testers and line x tester and error components. Analysis of variance for combining ability revealed that mean squares due to lines (females) were highly significant for all the traits while mean squares due to testers (males)

Table 2. (Continued) Magnitude of Relative heterosis (RH), Heterobeltiosis (HB) and Standard heterosis (SH) for lint yield per plant and ginning percentage.

Sr. No.	Hybrids	Lint yield per plant			Ginning percentage		
		RH	HB	SH	RH	HB	SH
1	Narsimha X GSB 19	3.08	-21.93**	-11.91	-2.77	-6.68	-16.45**
2	Narsimha X GSB 21	40.75**	-4.80	6.52	-1.77	-6.85	-16.61**
3	Narsimha X GSB 24	14.18	-18.93**	-8.32	-6.84	-11.0 **	-20.34**
4	Narsimha X GSB 43	-1.12	-35.10**	-26.52**	0.34	-5.09	-15.02**
5	Narsimha X Suvin	-11.26	-32.07**	-23.06**	3.06	-0.65	-11.08**
6	G. Cot. 100 X GSB 19	-51.14**	-65.61**	-49.65**	-1.82	-11.54**	-9.20 *
7	G. Cot. 100 X GSB 21	-19.79**	-49.88**	-25.18	0.63	-10.35**	-7.96*
8	G. Cot. 100 X GSB 24	-24.86**	-51.14**	-26.44**	-0.21	-10.48**	-8.08*
9	G. Cot. 100 X GSB 43	-54.06**	-71.37**	-57.76**	-10.81**	-20.73**	-18.62**
10	G. Cot. 100 X Suvin	-39.12**	-57.73**	-36.49**	-5.30	-14.33**	-12.06**
11	G. Cot. 10 X GSB 19	-11.05	-36.32**	-14.89*	-5.08	-12.79**	-14.29**
12	G. Cot. 10 X GSB 21	-8.78	-42.37**	-21.65**	-0.33	-9.48*	-11.01**
13	G. Cot. 10 X GSB 24	21.09**	-17.07**	9.60	-5.96	-13.98**	-15.44**
14	G. Cot. 10 X GSB 43	-19.16*	-49.84**	-31.66**	-8.73*	-17.3**	-18.71**
15	G. Cot. 10 X Suvin	8.44	-23.26**	5.10	-2.49	-10.04**	-11.58**
16	G. Cot. 16 X GSB 19	40.18**	14.23	2.83	6.62	4.32	-14.13**
17	G. Cot. 16 X GSB 21	8.16	-24.86**	-31.23**	2.73	1.78	-18.30**
18	G. Cot. 16 X GSB 24	-22.77**	-42.07**	-47.33**	9.53*	7.68	-12.22**
19	G. Cot. 16 X GSB 43	40.18**	-4.14	-12.78	4.15	3.46	-17.41**
20	G. Cot. 16 X Suvin	-12.55	26.28**	-34.76**	9.42*	6.59	-11.46**
21	BC682 X GSB 19	-17.73*	-40.93**	-23.93**	-2.04	-8.14*	-13.62**
22	BC682 X GSB 21	-16.39*	-46.54**	-30.87**	-2.01	-9.19*	-14.61**
23	BC682 X GSB 24	-33.59**	-53.67**	-42.03**	-7.12*	-13.3 **	-18.46**
24	BC682 X GSB 43	4.82	-33.51**	-14.76*	12.43**	3.94	-2.26
25	BC682 X Suvin	-32.88**	-51.57**	-37.11**	0.04	-5.8	-11.43**
26	MCU 11 X GSB 19	-38.85**	-55.46**	-44.44**	-7.53*	-12.26**	-19.54**
27	MCU 11 X GSB 21	-10.92	-41.13**	-27.78**	11.10**	4.16	-4.46
28	MCU 11 X GSB 24	11.58	-24.22**	-4.39	14.39**	8.04**	-0.92
29	MCU 11 X GSB 43	-24.62**	-52.19**	-39.91**	1.73	-4.86	-12.73**
30	MCU 11 X Suvin	-44.86**	-59.53**	-49.22**	-3.31	-7.87	-15.50**
31	AC 738 X GSB 19	32.53**	-2.71	16.56*	11.71**	6.08	-2.86
32	AC 738 X GSB 21	-23.15**	-47.51**	-39.93**	-8.06*	-13.73**	-21.01**
33	AC 738 X GSB 24	9.60	-24.41**	-9.25	7.02	1.16	-7.38
34	AC 738 X GSB 43	1.51	-35.10**	-22.03**	3.51	-3.12	-11.30**
35	AC 738 X Suvin	-25.79**	-43.58**	-33.80**	2.00	-2.72	-10.95**
36	G. 247 X GSB 19	1.01	-20.29**	-21.94**	8.35*	8.08	-10.57**
37	G. 247 X GSB 21	37.80**	-3.70	-6.98	14.22**	12.5**	-6.91
38	G. 247 X GSB 24	-9.08	-30.94**	-34.43**	11.79**	10.96*	-8.18*
39	G. 247 X GSB 43	-16.81*	-44.25**	-44.97**	9.17*	7.24	-11.27**
40	G. 247 X Suvin	42.31**	16.40*	11.76	20.09**	19.86**	-0.45
41	G. 67 X GSB 19	3.64	-28.90**	19.18**	7.51*	-4.86	1.75
42	G. 67 X GSB 21	3.27	-36.79**	8.66	0.27	-12.24**	-6.14
43	G. 67 X GSB 24	-27.49**	-54.06**	-20.36**	-6.45	-17.57**	-11.84**
44	G. 67 X GSB 43	-11.68	-47.52**	-8.27	-2.70	-15.03**	-9.13*
45	G. 67 X Suvin	-19.39**	-46.54**	-6.29	2.62	-8.83*	-2.51
Range	Max.	42.31	16.40	19.18	20.09	19.86	1.75
	Min.	-54.06	-71.37	-57.76	-10.81	-20.73	-21.01
S.E. (±)		4.74	5.48	5.48	1.00	1.16	1.16

were significant for all the traits except ginning percentage. The mean squares due to hybrids were highly significantly for all the characters. However, the ratio of variance components suggested the preponderance of non-additive type of gene action for most of the traits except average boll weight. This study thus substantiates the findings of many workers *viz.,* Kadapa *et al.* (1990), Kiani *et al.*(2007), and Patel *et al.*(2009).

Estimates of general and specific combining ability

The estimates of gca and sca effects were ranged from -16.86 to 23.39% and -35.96 to 38.25%

Table 3. Analysis of variance (mean squares) and variance estimates of combining ability for seed cotton yield and its component traits.

Sources of variation	Plant height	Total number of bolls per plant	Average boll weight	Seed cotton yield per plant	Ginning percentage	Lint yield per plant
Replication	14.45	13.24	0.0019	52.38	0.30	2.42
Hybrids (H)	1127.22**	702.28**	0.63**	5889.50**	9.45**	594.73**
Line effect (L)	2617.22**	1033.3**	2.45**	11166.52**	16.64**	1112.63**
Tester effect (T)	802.80*	226.45**	0.62**	4454.91**	3.87	401.31**
L x T	795.28**	679.01**	0.17**	4749.57**	8.36**	489.43**
Error	269.60	50.45	0.031	402.45	2.13	40.58
Estimates						
σ_2 gca (Line)	121.46**	23.62**	0.15**	427.80**	0.55**	41.55**
σ_2 gca (Tester)	0.28*	-16.76**	0.02**	-10.91**	-0.17	-3.26**
σ_2 gca (pooled)	81.06**	10.16**	0.10**	281.56**	0.31**	26.61**
σ_2 sca	175.22**	209.52**	0.05**	1449.04**	2.07**	149.62**
σ_2 A	174.24	9.36	0.26	583.08	0.36	50.96
σ_2 D	700.90	838.08	0.20	5796.17	8.30	598.46
$[\sigma_2 D/\sigma_2 A]_{1/2}$	2.00	9.46	0.87	3.15	4.80	3.42
σ_2 *gca /d.f.*						
σ_2*sca /d.f.*	0.47	0.048	2.13	0.19	0.14	0.17

*, ** significant at 5% and 1% levels, respectively.

for plant height, -12.40 to 11.30% and - 25.34 to 26.49% for total number of bolls/plant, -0.65 to 0.90% and -0.40 to 0.65% for average boll weight, -41.02 to 44.62% and -52.98 to 76.65% for seed cotton yield/ plant, -13.12 to 14.09% and -16.81 to 23.67% for lint yield/plant and -1.42 to 1.82% and -3.08 to 3.57% for ginning percentage, respectively. Out of 14 parents (9 females and 5 males), 3 females and 1 male parents exhibited significant positive gca effects for plant height, seed cotton yield per plant and lint yield per plant; whereas 2 females and 1 male manifested significant positive gca effects for average boll weight and ginning percentage, while 4 females and 1 male manifested significant and positive gca effects for total number of bolls/plant. The estimates of general combining ability effects of parents for seed cotton yield and its component characters were presented in Table 4. However, an overall appraisal of general combining ability effects revealed that G. 67 among the females was found to be the good and consistent general combiners for seed cotton yield and its attributing traits *viz.,* plant height, average boll weight, ginning percentage and lint yield per plant. Among males, good and consistent general combining ability effect was displayed by the parent GSB 19 for average boll weight, seed cotton yield per plant and lint yield per plant. In general, it was evident from the parents

Table 4. Estimates of general combining ability (gca) effects of parents for seed cotton yield and its component traits

Parents	Plant height	Total number of bolls per plant	Average boll weight	Seed cotton yield per plant	Ginning percentage	Lint yield per plant
Females						
Narsimha	-16.86**	3.28*	0.14**	20.32**	-1.42**	5.98**
G. Cot. 100	-7.62*	-12.40**	-0.19**	-41.02**	0.06	-13.12**
G. Cot. 10	0.92	11.30**	-0.07	22.04**	-0.89**	7.39**
G. Cot. 16	-10.50**	-1.05	-0.12**	-9.81*	-1.04**	-2.69*
BC682	-6.82	-9.55**	0.02	-20.53**	-0.22	-6.36**
MCU 11	-6.38	10.28**	-0.65**	-28.03**	0.24	-8.82**
AC 738	8.51*	1.61	0.01	7.37	0.21	2.34
G. 247	15.36**	3.36*	-0.04	5.05	1.23**	1.17
G. 67	23.39**	-6.84**	0.90**	44.62**	1.82**	14.09**
S. E. (lines)	3.49	1.51	0.04	4.26	0.31	1.35
CD@5%	6.84	2.95	0.07	8.34	0.60	2.64
Males						
GSB 19	-6.36*	-1.20	0.26**	15.80**	0.12	4.83**
GSB 21	8.09**	2.09	-0.01	5.74	-0.16	1.61
GSB 24	1.55	2.70*	-0.05	1.65	-0.01	0.44
GSB 43	0.00	-4.44**	-0.10**	-18.87**	-0.49*	-5.64**
Suvin	-3.28	0.84	-0.11**	-4.33	0.54*	-1.24
S.E. (testers)	2.47	1.07	0.03	3.02	0.22	0.96
CD@5%	4.84	2.09	0.05	5.91	0.43	1.88

*, ** significant at 5% and 1% levels, respectively.

Table 5. Estimates of specific combining ability (sca) effects of hybrids for seed cotton yield and its component traits

Crosses	Plant height	Total number of bolls per plant	Average boll weight	Seed cotton yield per plant	Ginning percentage	Lint yield per plant
Narsimha X GSB 19	-16.97*	6.26*	-0.40**	-14.16	-0.3	-4.29
Narsimha X GSB 21	-2.36	10.38**	0.15	39.74**	-0.06	12.24**
Narsimha X GSB 24	22.44**	-8.54**	0.40**	7.67	-1.38*	2.69
Narsimha X GSB 43	-1.83	1.44	-0.22**	-13.25	0.76	-4.37
Narsimha X Suvin	-1.27	-9.54**	0.08	-20.01*	0.98	-6.27*
G. Cot. 100 X GSB 19	11.46	-12.12**	-0.10	-37.48**	0.5	-12.45**
G. Cot. 100 X GSB 21	-9.05	10.36**	0.03	25.32**	1.17	8.45**
G. Cot. 100 X GSB 24	-0.85	13.44**	-0.09	25.22**	0.99	8.71**
G. Cot. 100 X GSB 43	-1.93	-12.15**	0.02	-22.13**	-1.85**	-7.84**
G. Cot. 100 X Suvin	0.37	0.47	0.14	9.07	-0.81	3.12
G. Cot. 10 X GSB 19	-12.53	-10.93**	0.03	-23.50**	-0.15	-7.86**
G. Cot. 10 X GSB 21	-1.99	-8.85**	-0.12	-31.72**	1.16	-9.51**
G. Cot. 10 X GSB 24	-9.16	10.80**	0.24**	48.83**	-0.37	14.22**
G. Cot. 10 X GSB 43	6.02	-11.72**	-0.05	-29.69**	-0.93	-9.50**
G. Cot. 10 X Suvin	17.68*	20.70**	-0.09	36.08**	0.29	12.65**
G. Cot. 16 X GSB 19	-11.93	22.99**	-0.12	46.45**	0.06	15.02**
G. Cot. 16 X GSB 21	2.16	-5.00**	-0.13	-22.37**	-0.97	-6.35*
G. Cot. 16 X GSB 24	-2.82	-25.34**	0.08	-52.98**	0.8	-16.81**
G. Cot. 16 X GSB 43	-8.34	12.13**	0.20*	44.05**	-0.36	14.21**
G. Cot. 16 X Suvin	20.93**	-4.78	-0.03	-15.15	0.48	-6.06*
BC682 X GSB 19	10.69	2.42	-0.10	-3.39	-0.61	-0.64
BC682 X GSB 21	17.78*	-2.76	-0.02	-9.47	-0.64	-2.42
BC682 X GSB 24	-6.48	-9.41**	-0.07	-25.87**	-2.00**	-9.31**
BC682 X GSB 43	-10.92	13.00**	0.28**	52.60**	3.57**	16.45**
BC682 X Suvin	-11.06	-3.25	-0.08	-13.88	-0.34	-4.08
MCU 11 X GSB 19	-16.95*	-11.27**	-0.30**	-40.93**	-2.92**	-12.99**
MCU 11 X GSB 21	5.23	-9.24**	0.37**	9.33	2.10**	2.27
MCU 11 X GSB 24	0.14	26.49**	0.13	60.84**	3.07**	20.33**
MCU 11 X Suvin	-8.62	-18.88**	0.04	-32.18**	-2.07**	-10.36**
AC 738 X GSB 19	12.76	17.50**	0.15	58.92**	2.34**	19.90**
AC 738 X GSB 21	-25.53**	-17.62**	-0.08	-50.77**	-3.08**	-17.66**
AC 738 X GSB 24	5.30	6.53*	0.00	15.06	1.06	5.65*
AC 738 X GSB 43	-2.67	1.27	0.07	7.00	0.3	2.5
AC 738 X Suvin	10.14	-7.67*	-0.14	-30.21**	-0.62	-10.40**
G. 247 X GSB 19	-14.77*	-14.72**	0.21**	-24.01**	-1.1	-6.73*
G. 247 X GSB 21	-5.26	18.09**	-0.22**	22.46**	0.34	7.30**
G. 247 X GSB 24	3.95	-6.32*	-0.29**	-33.21**	-0.21	-11.35**
G. 247 X GSB 43	8.28	-20.65**	0.10	-41.89**	-0.7	-12.89**
G. 247 X Suvin	7.80	23.61**	0.22**	76.65**	1.67**	23.67**
G. 67 X GSB 19	38.25**	-0.12	0.65**	38.11**	2.18**	10.04**
G. 67 X GSB 21	19.04**	4.66	0.02	17.48*	-0.02	5.67*
G. 67 X GSB 24	-12.51	-7.65*	-0.39**	-45.57**	-1.96**	-14.12**
G. 67 X GSB 43	-8.81	3.76	-0.15	0.37	-0.63	0.69
G. 67 X Suvin	-35.96**	-0.65	-0.12	-10.38	0.42	-2.28
S.E. (Sij) ±	6.98	3.02	0.08	8.53	0.62	2.71
CD at 5%	13.68	5.91	0.15	16.71	1.21	5.31

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

which were good general combiners for seed cotton yield per plant also were good combiners for most of its yield contributing characters (Table 4). The further use of parents G. 67 and GSB 19 would be more rewarding for boosting yield in cotton. This study thus substantiates the findings of many workers *viz.,* Kadapa *et al.* (1990), Stoilova *et al.* (2004), Ahuja *et al.* (2007), Preetha *et al.* (2008) and Singh *et al.* (2010). Out of 45F_1S hybrids, 7, 6 and 15 hybrids registered positively significant sca effects for plant height, ginning percentage and total number of bolls/plant as well as lint yield/plant, respectively. The perusal of data on sca effects (Table 5) revealed that none of the hybrid was consistently superior for all traits under study. Out of 45F_1S hybrids studied, 14 cross combinations exhibited significant positive sca effects for seed cotton yield per plant. The hybrids G. 247 x Suvin, MCU 11 x GSB 24 and AC 738 x GSB 19 were found promising due to their significant positive sca effects for seed cotton yield per plant. These hybrids also exhibited significant positive sca effects for majority of yield attributing traits *viz.,* total number of bolls per plant, average boll weight, lint yield per plant and ginning percentage. This study thus coincides with the findings of many workers *viz.,* Ahuja *et al.* (2007), Preetha *et al.* (2008) and Singh *et al.* (2010).

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