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Research Article

Heterosis studies for yield and fibre quality traits in American cotton (*Gossypium hirsutum* L.)

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Abstract
In the present study forty five intra-hirsutum hybrids along with their parents and standard check were evaluated to estimate the magnitude of heterosis for yield and fibre quality traits at Regional Agricultural Research Station, Lam, Guntur during *Kharif*, 2017-18. The standard heterosis was calculated over check hybrid, LAHH 5. The hybrid combinations, SCS-1207 × GSHV-177, GSHV-177 × L1231 and SCS-1207 × PBH-13 were found to be promising for seed cotton yield plant^{-1} along with majority of yield components and fibre quality traits in terms of standard heterosis. These genotypes may be evaluated over locations for further confirmation of their superiority for exploiting them commercially.

Key words
Heterosis, *Gossypium hirsutum,* seed cotton yield, fibre quality.

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is a major crop of global importance and has high commercial value. In India cotton is being grown over an area of 125.84 lakh ha with an annual production of 360 lakh bales (1bale = 170kg of lint) and productivity of 486 kg lint ha^{-1} (AICCIP, Annual Report, 2019). Cotton is designated as “White Gold” and is an important economic crop worldwide. There are four cultivated cotton species including two diploids (*Gossypium herbaceum* L. and *G. arboreum* L.) and two tetraploids (*Gossypium hirsutum* L. and *Gossypium barbadense* L.). Approximately 95 per cent of the world’s cotton production is from *Gossypium hirsutum* L. There is a need to improve the productivity of cotton crop by developing a high yielding adaptable cotton variety or hybrid. Hybridization is the most potent technique for breaking yield barriers and evolving genotypes with higher yield potential. The study of heterosis shows the percentage of increase or decrease of the F_1 performance in terms of yield and yield traits including quality traits over the mid parent or better parent or standard check. Hence, the present experiment was carried out with the objective of finding out the extent of heterosis over mid parent, better parent and standard check for seed cotton yield and fibre quality attributes.

MATERIALS AND METHODS

The present study was carried out by selecting ten parents *viz*., L788, HYPS-152, L770, L1493, L1231, SCS-1207, PBH-13, GJHV-497, GSHV-177 and GTHV-13/32 and forty five intra-specific cross combinations which were generated in half-diallel fashion. The evaluation of hybrids along with the parents and standard check (LAHH-5) was done at Regional Agricultural Research Station, Lam, Guntur during *Kharif*, 2017-18. Observations were recorded on five randomly selected plants from each genotype per replication. The data were recorded on 2.5% span length (mm), micronaire value (10^{-6}g/inch), bundle strength (g/tex), uniformity ratio and seed cotton yield plant $^{-1}$ (g) were used for statistical analysis for estimation of heterosis. The heterotic effects were measured as deviation of F_1 mean from mid parent (relative heterosis), better parent (heterobeltiosis) and the standard check (standard heterosis). Heterosis over mid parent, better parent and standard check was estimated as per the formula given by Liang *et al* (1971).

Table 1. Estimates of heterosis over mid parent (MP), better parent (BP) and standard check (SC) for seed cotton yield and fibre quality traits in intra-specific cotton hybrids (*Gossypium hirsutum* L.) during *kharif*, 2017-18

S. No.	Character	2.5% span length (mm)			Micronaire value (10^{-6} g/inch)			Bundle strength (g/tex)		
		MP	BP	SH	MP	BP	SH	MP	BP	SH
1	L788 × HYPS-152	0.43	-5.20*	0.43	8.30*	3.33	-10.14**	2.05	-2.61	12.86**
2	L788 × L770	2.36	0.44	-1.84	1.23	0.00	-10.87**	0.93	0.43	6.81**
3	L788 × L1493	0.38	-4.65*	-0.32	-5.84	-11.68**	-12.32**	6.30**	5.46*	11.04**
4	L788 × SCS-1207	-2.96	-3.62	-8.10**	-0.80	-4.62	-10.14**	0.49	-1.92	8.47**
5	L788 × PBH-13	8.94**	4.94*	-1.30	5.34	-2.82	0.00	4.42*	1.87	7.26**
6	L788 × GJHV-497	16.42**	9.87**	3.35	7.14*	2.27	-2.17	5.15*	2.59	8.02**
7	L788 × GSHV-177	3.94	0.00	-5.94**	3.67	1.60	-7.97*	3.22	1.44	6.81**
8	L788 × GTHV-13/32	0.93	-0.34	-6.26**	11.21**	7.50	-6.52	-2.13	-3.10	4.08
9	L788 × L1231	6.45**	-0.57	-6.48**	6.22	5.79	-7.25*	3.33	-4.17	0.91
10	HYPS-152 × L770	5.30**	1.22**	7.24**	12.07**	5.69	-5.80	2.65	-1.57	14.07**
11	HYPS-152 × L1493	-5.90**	-6.52**	-0.97	3.25	-7.30*	-7.97*	3.79*	-1.70	13.92**
12	HYPS-152 × SCS1207	-1.29	-6.22**	-0.65	17.15**	7.69*	1.45**	-1.00	-3.26	12.10**
13	HYPS-152 × PBH-13	9.28**	0.41**	5.51*	-1.99	-13.38**	-10.87**	7.14**	-0.13	15.73**
14	HYPS-152 × GJHV-497	6.39**	-4.89*	0.76	9.54**	0.00	-4.35	5.60**	-1.57	14.07**
15	HYPS-152 × GSHV177	9.63**	-0.20	5.72**	5.98	-0.80	-10.14**	8.62**	1.96	18.15**
16	HYPS152×GTHV13/32	4.04*	-2.96	2.81	7.69*	6.25	-13.77**	1.49	-2.22	13.31**
17	HYPS-152 × L1231	3.05	-8.77**	-3.35	14.78**	9.09*	-4.35	9.92**	-2.35	13.16**
18	L770 × L1493	2.72	-0.62	3.89	1.54	-3.65	-4.35	2.59	1.28	7.72**
19	L770 × SCS-1207	4.47*	3.20	0.86	9.88**	6.92	0.72	2.93	0.96	11.65**
20	L770 × PBH-13	5.49**	-0.22	-2.48	-0.38	-7.04*	-4.35	8.57**	5.41*	12.10**
21	L770 × GJHV-497	2.62	-4.86*	-7.02**	6.67*	3.03	-1.45	5.35**	2.28	8.77**
22	L770 × GSHV-177	5.96*	0.11	-2.16	1.61	0.80	-8.70*	12.00**	9.53**	16.49**
23	L770 × GTHV13/32	2.28	-0.88	-3.13	10.64**	5.69	-5.80	4.03*	3.52	11.20**
24	L770 × L1231	4.88*	-3.76	-5.94**	5.74	4.88	-6.52	11.40**	2.84	9.38**
25	L1493 × SCS-1207	2.86	-1.65	2.81	-1.12	-3.65	-4.35	9.18**	5.75**	16.94**
26	L1493 × PBH-13	2.42**	-10.54**	6.48**	-1.08	-2.82	0.00	2.60	0.88	4.54
27	L1493 × GJHV-497	2.13	-8.16**	-4.00	-3.35	-5.11	-5.80	9.73**	7.88**	11.80**
28	L1493 × GSHV-177	6.15**	-2.79	1.62	0.76	-3.65	-4.35	12.45**	11.39**	15.43**
29	L1493 × GTHV13/32	-0.61	-6.71**	-2.48	8.43**	-1.46	-2.17	9.96**	8.03**	16.04**
30	L1493 × L1231	2.67	-8.57**	-4.43*	6.98*	0.73	0.00	10.94**	3.65	7.41**
31	SCS-1207 × PBH-13	3.08	-1.36	-5.94**	-5.15	-9.15**	-6.52	2.66	-2.19	8.17**
32	SCS-1207× GJHV-497	7.25**	0.57	-4.10	5.34	4.55	0.00	3.95*	-0.96	9.53**
33	SCS-1207×GSHV-177	-0.59	-4.98*	-9.40**	10.59**	8.46*	2.17**	-5.20**	-9.03**	0.61
34	SCS-1207×GTHV13/32	4.62*	2.60	-2.16	7.44*	0.00	-5.80	2.57	1.09	11.80**
35	SCS-1207 × L1231	3.72	-3.74	-8.21**	5.98	2.31	-3.62	5.88**	-3.97	6.20*
36	PBH-13 × GJHV-497	13.42**	11.03**	-3.24	0.73	-2.82	0.00	11.78**	11.78**	11.95**
37	PBH-13 × GSHV-177	10.30**	10.16**	-4.00	-3.37	-9.15**	-6.52	7.05**	6.25**	8.02**
38	PBH-13× GTHV-13/32	1.81	-0.71	-8.96**	0.00	-10.56**	-7.97 *	3.35	-0.14	7.26**
39	PBH-13 × L1231	9.40**	5.95*	7.67**	4.94	-2.82	0.00	11.06**	5.44*	5.60*
40	GJHV-497 × GSHV-177	9.89**	7.70**	6.37**	5.06	2.27	-2.17	-5.40**	-6.10*	-4.54
41	GJHV497×GTHV13/32	9.86**	4.95**	-3.78	18.85**	9.85**	5.07**	5.10*	1.55	9.08**
42	GJHV-497 × L1231	9.74**	8.54**	9.40**	9.88**	5.30	0.72	14.08**	8.31**	8.47**
43	GSHV177×GTHV13/32	7.01**	4.24	-4.43*	7.17*	1.60	-7.97 *	4.63*	1.83	9.38**
44	GSHV-177 × L1231	6.98**	3.73	-9.83**	12.20**	10.40**	0.00	8.29**	2.08	3.78
45	GTHV-13/32 × L1231	8.54**	2.59	-5.94**	21.03**	16.53**	2.17*	6.05**	-2.54	4.69
	Mean	4.81	- 0.47	- 1.60	5.59	0.66	-4.46	5.32	1.46	9.56
	Range Min	-5.90	-10.54	-9.83	-5.84	-13.38	-13.77	-5.40	-9.03	-4.54
	Max	16.42	11.03	9.40	21.03	16.53	5.07	14.08	11.78	18.15

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

Table 1 (cont.)

S.No.	Character	Uniformity ratio			Seed cotton yield plant^{-1} (g)		
		MP	BP	SH	MP	BP	SH
1	L788 × HYPS-152	2.80	1.38	4.26	9.86	9.07	-14.25
2	L788 × L770	0.70	-0.69	2.13	14.24	10.28	-13.30
3	L788 × L1493	1.77	-0.69	2.13	3.33	2.09	-19.74
4	L788 × SCS-1207	-1.36	-2.68	2.84	35.91**	32.01*	10.10
5	L788 × PBH-13	-2.41	-2.74	0.71	14.00	-1.63	6.55
6	L788 × GJHV-497	-1.02	-2.03	2.84	39.77**	39.56**	10.04
7	L788 × GSHV-177	0.00	-1.34	4.26	5.96	-7.40	-2.66
8	L788 × GTHV-13/32	0.00	-0.68	3.55	15.84	4.55	-17.81
9	L788 × L1231	0.00	-0.68	3.55	36.49**	36.28**	7.46
10	HYPS-152 × L770	4.26*	4.26	4.26	30.20*	26.57	-1.92
11	HYPS-152 × L1493	1.08	0.00	0.00	13.59	13.04	-12.41
12	HYPS-152 × SCS1207	2.07	-0.67	4.96*	55.94**	50.42**	25.45*
13	HYPS-152 × PBH-13	3.83*	2.05	5.67*	7.61	-7.70	-0.03
14	HYPS-152 × GJHV-497	1.73	-0.68	4.26	18.86	17.84	-7.09
15	HYPS-152 × GSHV177	-2.07	-4.70 *	0.71	14.68	-0.39	4.71
16	HYPS152×GTHV13/32	-2.08	-4.08	0.00	23.00	11.73	-13.42
17	HYPS-152 × L1231	4.17*	2.04	6.38**	4.03	3.13	-18.67
18	L770 × L1493	-1.08	-2.13	-2.13	19.56	16.78	-10.39
19	L770 × SCS-1207	0.69	-2.01	3.55	44.72**	35.84**	13.29
20	L770 × PBH-13	-1.74	-3.42	0.00	-4.76	-20.21*	-13.58
21	L770 × GJHV-497	2.42	0.00	4.96*	52.32**	46.83**	15.77
22	L770 × GSHV-177	1.38	-1.34	4.26	46.99**	24.65*	31.02**
23	L770 × GTHV13/32	2.08	0.01	4.26	1.33	-5.51	-30.87**
24	L770 × L1231	3.47	1.36	5.67*	33.63**	28.81*	1.57
25	L1493 × SCS-1207	2.44	-1.34	4.26	75.49**	68.47**	40.51
26	L1493 × PBH-13	0.70	-2.05	1.42	22.20*	4.39	13.07
27	L1493 × GJHV-497	2.80	-0.68	4.26	-0.99	-2.32	-22.98*
28	L1493 × GSHV-177	1.74	-2.01	3.55	-6.55	-19.17	-15.03
29	L1493 × GTHV13/32	4.56*	1.36	5.67*	51.54**	38.26**	6.09
30	L1493 × L1231	3.16	0.00	4.26	24.50*	22.83	-3.15
31	SCS-1207 × PBH-13	1.69	0.67	6.38**	37.83**	21.98*	32.12**
32	SCS-1207× GJHV-497	-1.01	-1.34	4.26	45.61**	41.63**	18.12**
33	SCS-12 07×GSHV-177	-3.36	-3.36	2.13	61.88**	45.16**	52.59**
34	SCS-1207×GTHV13/32	-2.70	-3.36	2.13	93.14**	69.85**	41.66**
35	SCS-1207 × L1231	-2.70	-3.36	2.13	17.00	13.81	-5.08
36	PBH-13 × GJHV-497	0.00	-0.68	4.26	40.81**	21.66*	31.77**
37	PBH-13 × GSHV-177	-0.34	-1.34	4.26	3.82	2.29	10.79
38	PBH-13× GTHV-13/32	-1.71	-2.04	2.13	40.38**	11.21	20.45
39	PBH-13 × L1231	-1.02	-1.36	2.84	45.36**	25.60**	36.04**
40	GJHV-497 × GSHV-177	3.70*	-4.03	1.42	32.61**	16.04	21.98*
41	GJHV497×GTHV13/32	-4.41*	-4.73 *	0.00	19.13	7.38	-15.33
42	GJHV-497 × L1231	-2.37	-2.70	2.13	17.55	17.55	-7.31
43	GSHV177×GTHV13/32	-3.38	-4.03	1.42	54.49**	23.76*	30.09**
44	GSHV-177 × L1231	1.35	0.67	6.38**	60.59**	40.53**	47.72**
45	GTHV-13/32 × L1231	-2.72	-2.72	1.42	37.01**	23.49	-2.62
	Mean	**0.38**	**-1.28**	**3.11**	**29.12**	**19.13**	**6.25**
	Range **Min**	**-4.41**	**-4.73**	**-2.13**	**-6.55**	**-20.21**	**-30.87**
	Range **Max**	**4.56**	**4.26**	**6.38**	**93.14**	**69.85**	**52.59**

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

RESULTS AND DISCUSSION

The heterosis observed over the mid parent, better parent and standard check for seed cotton yield and fibre quality traits are presented in **Table 1** and best heterotic combinations are represented in **Table 2**. The results have indicated that the phenomenon of heterosis was observed for all the characters, however, its magnitude varied with the characters.

Table 2. The best heterotic combinations identified for yield and yield contributing characters in intra-specific hybrids of cotton (*Gossypium hirsutum* L.) during *kharif*, 2017-18

S.No.	Characters	Cross combinations	*Per se* performance	*sca* effect	Standard heterosis
		HYPS-152 × L770	33.10	0.916**	7.24**
1.	2.5% span length (mm)	HYPS-152 × GSHV-177	32.63	1.627**	5.72*
		HYPS-152 × PBH-13	32.56	1.544**	5.51*
		GJHV-497 × GTHV-13/32	4.83	0.409**	5.07
2.	Micronaire value (10^{-6}g/inch)	SCS-1207 × GJHV-497	4.70	0.287**	3.00
		GSHV-177 × L1231	4.70	0.370**	3.97
		HYPS-152 × GSHV-177	26.03	1.229**	18.15**
3	Bundle strength (g/tex)	L1493 × SCS-1207	25.76	1.290**	16.94**
		L1493 × GTHV-13/32	25.56	1.182**	16.04**
		HYPS-152 × L1231	50.00	1.313	6.38**
4.	Uniformity ratio	SCS-1207 × PBH-13	50.00	1.119	6.38**
		GSHV-177 × L1231	50.00	0.952	6.38**
		SCS-1207 × GSHV-177	180.76	25.983**	52.59**
5.	Seed cotton yield plant^{-1} (g)	GSHV-177 × L1231	175.00	38.172**	47.72**
		SCS-1207 × PBH-13	167.81	37.379**	32.12**

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

The extent of heterosis is the indication of genetic diversity among the parents involved in the cross combination. By through study of heterosis, a breeder would able to decide the possibility and scope of exploitation of hybrid vigour in the material breeding studied. The estimate of heterosis over better parent (Heterobeltiosis) and standard parent (Standard heterosis) are more rational for practical applicability. Positive heterosis is considered for all the quality traits studied except for micronaire value.

Heterosis for seed cotton yield^{-1} over mid parent, better parent and standard check ranged from -6.55 (L1493 × GSHV-177) to 93.14 (SCS-1207 × GTHV 13/32), -20.21 (L770 × PBH-13) to 69.85 (SCS-1207 × GTHV 13/32) and -30.87 (L770 × GTHV-13/32) to 52.59 (SCS-1207 × GSHV-177) with the mean values of 29.12, 19.13 and 6.25, respectively. The hybrid combinations, *viz*., HYPS-152 × SCS-1207,(L770 × GSHV-177, SCS-1207 × PBH-13, SCS-1207 × GJHV-497, SCS-1207 × GSHV-177, SCS-1207 × GTHV 13/32, PBH-13 × GJHV-497, PBH-13 × L1231, GSHV-177 × GTHV-13/32 and GSHV-177 × L1231 exhibited a significant positive heterosis over mid parent, better parent and standard check. These results are in agreement with the findings of Balu *et al.* (2012), Sekhar *et al.* (2012), Maria *et al.*(2012), Patel *et al.*(2012), Kumar *et al.*(2013), Nassar (2013), Srinivas and Bhadru (2015), Abdul *et al.*(2016) and Jayshankar (2017) who had reported a significant positive heterosis for seed cotton yield plant^{-1}.

The mean values of heterosis for 2.5 % span length over mid parent, better parent and standard check were found to be 4.70, -0.49 and -2.92, respectively. Heterosis over mid parent ranged from -5.90 (HYPS-152 × L1493) to 16.42 (L788 × GJHV-497), over better parent from -10.54 (L1493 × PBH-13) to 11.03 (PBH-13 × GJHV-497) and over standard check from -9.83 (GSHV-177 × L1231) to 9.40 (GJHV-497 × L1231). Out of 45 hybrids, seven cross combinations, HYPS 152 x L 770, HYPS 152 x PBH 13, HYPS 152 x GSHV 177, L 1493 x PBH 13, PBH 13 x L 1231, GJHV 497 x GSHV 177 and GJHV 497 x L1231 exhibited a significant positive heterosis over mid parent, better parent and standard check. The best heterotic combinations identified to exploit for 2.5% span length were HYPS-152 × L770, HYPS-152 × GSHV-177 and HYPS-152 × PBH-13. These results found to be in agreement with the findings of Sekhar *et al.*(2012), Kumar *et al.* (2013), Srinivas and Bhadru (2015) and Jayshankar (2017).

Heterosis for micronaire value over mid parent, better parent and superior check ranged from -5.84 (L788 × L1493) to 21.03 (GTHV-13/32 × L1231); -13.38 (HYPS-152 × PBH-13) to 16.53 (GTHV-13/32 × L1231) and -13.77 (HYPS-152 × GTHV-13/32) to 5.07 (GJHV-497 × GTHV-13/32) with mean values of 5.59, 0.66 and -4.46 respectively. The hybrid combinations *viz*., HYPS-152 × GTHV-13/32, L788 x L1493, L788 x HYPS-152, L788 x L770 and L788 xSCS1207 exhibited a significant negative heterosis over mid parent, better parent and standard check. These results are in accordance with the research findings of Sekhar *et al.* (2012), Kumar *et al.* (2013), Srinivas and Bhadru (2015) and Jayshankar (2017).

The mean value of heterosis for bundle strength over mid parent, better parent and standard check were found to be 5.32, 1.46 and 9.56, respectively. The relative heterosis ranged from -5.40 (GJHV-497 × GSHV-177) to 14.08 (GJHV-497 × L1231), heterobeltiosis -9.03 (SCS-1207 × GSHV-177) to 11.78 (PBH-13 × GJHV-497) while the standard heterosis stretched between -4.54 (GJHV-497 × GSHV-177) and 18.15 (HYPS-152 × GSHV-177).

The crosses *viz*., L788 × L1493, L770 × PBH-13, L770 × GSHV-177, L1493 × SCS-1207, L1493 × GJHV-497, L1493 × GSHV-177, L1493 × GTHV-13/32, PBH-13 × GJHV-497, PBH-13 × GSHV-177, PBH-13 × L1231 and GJHV-497 × L1231 exhibited a significant positive heterosis over mid parent and better parent and standard check. The best heterotic combinations identified were HYPS-152 × GSHV-177, L1493 × SCS-1207 and L1493 × GTHV-13/32 over mid parent, better parent and standard check for bundle strength. These results are in conformity with the reports of Sekhar *et al.* (2012), Kumar *et al.* (2013) and Srinivas and Bhadru (2015).

Heterosis for uniformity ratio over mid parent, better parent and superior check ranged from -4.41 (GJHV-497 × GTHV-13/32) to 4.56 (L1493 × GTHV-13/32), -4.73 (GJHV-497 × GTHV-13/32) to 4.26 (HYPS-152 × L770) and -2.13 (L770 × L1493) to 6.38 (GSHV-177 × L1231) with mean value of 0.21, -1.28 and 3.06, respectively. None of the crosses exhibited significant positive heterosis over mid parent, better parent and standard check for uniformity ratio. The best heterotic combinations identified were HYPS-152 × 1231, SCS-1207 × PBH-13 and GSHV-177 × L1231 over mid parent, better parent and standard check. These results were in agreement with the findings of Sekhar *et al*. (2012) and Kumar *et al.* (2013).

In the present study based on *per se* performance and significant standard heterosis the crosses, SCS-1207 × GSHV-177, GSHV-177 × L1231 and SCS-1207 × PBH-13 were found to be promising for seed cotton yield plant^{-1}. These hybrids can be exploited for commercial cultivation after thorough testing in large number of environments.

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