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Studies on heterosis in cotton (*Gossypium hirsutum* L.) for yield and fibre quality traits

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Abstract

The present study was undertaken to assess the extent of heterosis for seed cotton yield, yield traits and fibre quality traits in 40 intra-hirsutum hybrids of cotton developed by crossing 8 lines with 5 testers in line x tester fashion during *kharif*, 2016-17 at Regional Agricultural Research Station, Lam Farm, Guntur. The standard heterosis was calculated over check hybrid, LAHH 5. The hybrid combinations viz., LH 2220 × GTHV 13/32, L 1384 x HYPS 5152 and L 1060 × GTHV 13/32, were found to be promising based on *per se* performance and significant standard heterosis for seed cotton yield per plant, important yield contributing traits including fibre quality traits in terms of standard heterosis. These genotypes may be evaluated over locations for further confirmation of their superiority before they are being exploited commercially.

Keywords: Heterosis, *Gossypium hirsutum,* seed cotton yield, fibre quality

Introduction

Cotton is one of the major fibre crops of the world having the global importance and has high commercial value. It is native to tropical and sub-tropical regions of the world and is being cultivated in more than 77 countries across the world. In *Gossypium,* 49 species are identified and among them only four species are being exploited for commercial cultivation. Among these species, *Gossypium hirsutum* is the most preferred for its growth habit and quality traits.

In India, cotton is being grown in an area of 105 lakh ha with an annual production of 351 lakh bales (1 bale = 170 kg) with a productivity of 568 kg lint ha^{-1}. In Andhra Pradesh, it occupies an area of about 4.49 lakh ha with an annual production of 13.10 lakh bales and productivity of 719 kg lint ha^{-1} (AICCIP Annual Report, 2016-17) [1].

The development of high yielding varieties is one of the important objective in cotton breeding programmes and heterosis is exploited in cotton in the form of hybrids. Most of the hybrids contributed for the yield advantage in cotton are intra-specific hybrids i.e., intra-hirsutum hybrids. In India, hybrids are commonly used by the farming community and the development of hybrids using diverse parents, evaluation of these hybrids for their yield advantage forms the prime importance. The study of heterosis gives the percentage of increase or decrease of the F$_1$ performance in terms of yield and yield traits including quality traits over the parents or better parent or standard check. Keeping this in view, the present investigation was proposed with the evaluation of 40 intra-hirsutum hybrids generated in the form of Line x Tester design using diverse parents.

Material and Methods

In the present study, forty cotton intra-specific cross combinations were made in a Line x Tester fashion using 8 lines and 5 testers during *kharif*, 2015-16 and the forty F$_1$'s along with 13 parents and check hybrid (LAHH 5) were evaluated during *kharif*, 2016-17 at Regional Agricultural Research Station, Lam, Guntur. Observations were recorded on five randomly selected plants from each genotype per replication. The data were recorded on 10 traits *viz.,* plant height (cm), number of bolls per plant, boll weight (g), seed index (g), ginning out turn (%), 2.5% span length (mm), micronaire value (10^{-6}g/inch), bundle strength (g/tex), uniformity ratio and seed cotton yield per plant (g) and 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 were estimated as per the formula given by Liang *et al.* (1971) [6].

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Results and Discussion

The heterosis with respect to mid parent, better parent and standard check for seed cotton yield, yield traits and fibre quality traits are presented in Table-1 The results indicated that heterosis was observed for all the characters, however, its magnitude varied with the characters.

Heterosis for seed cotton yield over mid parent, better parent and standard check ranged from -14.99 (SCS 1001 × MCU 5) to 89.22 (LH 2220 × GTHV 13/32), -31.18 (SCS 1001 × MCU 5) to 76.57 (LH 2220 × GTHV 13/32) and -14.94 (L 1493 × L 788) to 112.08 (LH 2220 × GTHV 13/32) with mean values of 20.72, 11.38 and 31.18, respectively. The hybrid combinations, *viz.*, (L 1060 × GTHV 13/32), (L 1060 × L 788), (L 1231 × L 788), (L 1384 × GTHV 13/32), (L 1384 × HYPS 152), (LH 2220 × GTHV 13/32), (LH 2220 × HYPS 152), (LH 2220 × MCU 5), (LH 2220 × SURAJ), (NDLH 1938 × L 788), (NDLH 2010 × HYPS 152) and (SCS 1001 × SURAJ) exhibited significant positive heterosis over mid parent, better parent and standard check, respectively. The best heterotic combinations identified over mid parent, better parent and standard check were LH 2220 × GTHV 13/32, L 1060 × GTHV 13/32 and L 1384 × HYPS 152. The similar significant positive heterosis was also observed by Maisuria *et al.* (2007) [7], Rajamani *et al.* (2009) [10], Deosarkar *et al.* (2009) [4], Basamma *et al.* (2010) [3], Balu *et al.* (2012) [2] and Sekhar *et al.* (2012) [11].

Heterosis for plant height over mid parent, better parent and superior check stretched between -8.63 (L 1231 × L 788) and 22.33 (SCS 1001 × GTHV 13/32), -16.08 (L 1231 × L 788) to 20.65 (SCS 1001 × GTHV 13/32) and -4.52 (L 1231 × L 788) to 25.04 (LH 2220 × HYPS 152) with mean values of 3.60, -0.26 and 8.14 per cent, respectively. The crosses *viz.,* SCS 1001× GTHV 13/32, NDLH 1938 × GTHV 13/32, L 1493 × SURAJ, LH 2220 × GTHV 13/32 and L 1493 × GTHV 13/32 showed positive significant heterosis over mid parent, better parent and standard check. The top three heterotic cross combinations for plant height were LH 2220 × HYPS 152, NDLH 2010 × SURAJ and NDLH 2010 × L 788. These results are in agreement with the research findings of Deosarkar *et al.* (2009) [4], Patel *et al.* (2012) [8], Sekhar *et al.* (2012) [11] and Kumar *et al.* (2013) [5].

The mean values of heterosis for number of bolls per plant over mid parent, better parent and standard check were found to be 15.75, 9.83 and 8.62, respectively. Heterosis over mid parent ranged from -17.55 (L 1493 × L 788) to 55.71 (LH 2220 × GTHV 13/32); over better parent -22.41 (SCS 1001 × MCU 5) to 51.62 (NDLH 1938 × L 788) and over standard check -26.88 (L 1493 × L 788) to 56.78 (LH 2220 × GTHV 13/32). The crosses, LH 2220 × GTHV 13/32, L 1060 × GTHV 13/32 and NDLH 2010 × SURAJ were identified as the best heterotic combinations over mid parent, better parent and standard check. Similar results for number of bolls per plant were reported by Pole *et al.* (2008) [9], Deosarkar *et al.* (2009) [4], Patel *et al.* (2012) [8], Sekhar *et al.* (2012) [11] and Kumar *et al.* (2013) [5].

The mean values of heterosis for boll weight over mid parent, better parent and standard check were found to be 5.60, -1.37 and 6.12, respectively. Heterosis over mid parent ranged from -8.96 (NDLH 2010 × MCU 5) to 19.05 (LH 2220 × GTHV 13/32), over better parent -19.32 (L 1493 × L 788) to 15.65 (LH 2220 × GTHV 13/32) and over standard check -6.35 (L 1493 × MCU 5) to 32.29 (L 1384 × L 788). Significant positive heterosis of all types was exhibited by L 1060 × GTHV 13/32, L 1231 × HYPS 152 and L 1231 × L 788. The crosses, L 1384 × L 788 and L 1384× HYPS 152, recorded significant and positive heterosis over mid parent, better parent and standard check. Similar findings with regard to boll weight were reported by Patel *et al.* (2012) [8] and Sekhar *et al.* (2012) [11].

Heterosis for ginning outturn over mid parent, better parent and superior check ranged between -7.04 (SCS 1001 × L 788) to 6.01 (SCS 1001 × SURAJ), -9.76 (L 1231 × SURAJ) to 5.14 (SCS 1001 × SURAJ) and -8.26 (SCS 1001 × L 788) to 3.56 (L 1493 × L 788) with mean performance of -0.52, -1.92 and -2.08, respectively. The hybrid combinations, L 1384 × L 788, NDLH 2010 × MCU 5 and L 1231 × MCU 5 and L 1493 × L 788 were found to be superior as they exhibited significant positive heterosis over mid parent, better parent and standard check. Similar superiority over mid parent, better parent and standard check for ginning outturn was reported by Deosarkar *et al.* (2009) [4] and Sekhar *et al.* (2012) [11].

Heterosis for seed index over mid parent, better parent and standard check ranged from -11.00 (NDLH 2010 × L 788) to 18.55 (LH 2220 × GTHV 13/32), -14.46 (NDLH 2010 × L 788) to 18.26 (LH 2220 × GTHV 13/32) and 2.98 (L 1493 × SURAJ) to 42.09 (L 1384 × HYPS 152) with mean values of 3.29, -0.61 and 20.27, respectively. Out of forty crosses, SCS 1001 × MCU 5, SCS 1001 × GTHV 13/32, LH 2220 × MCU 5, LH 2220 × HYPS 152, L 1384 × SURAJ and L 1060 × MCU 5 crosses exhibited significant positive heterosis over mid parent, better parent and standard check. Deosarkar *et al.* (2009) [4] also reported significant positive heterosis over mid parent, better parent and standard check for seed index.

The mean values of heterosis for 2.5 % span length over mid parent, better parent and standard check were found to be 4.17, -0.78 and -10.05, respectively. Heterosis over mid parent ranged from -10.51 (LH 2220 × MCU 5) to 18.24 (NDLH 1938 × HYPS 152), over better parent from -14.79 (NDLH 2010 × MCU 5) to 13.16 (L 1384 × L 788) and over standard check from -20.35 (L 1384 × SURAJ) to 0.51 (L 1384 × HYPS 152). The best heterotic combinations over mid, better and standard check were L 1384 × HYPS 152, NDLH 1938 × HYPS 152 and L 1060 × MCU 5. These results of heterosis for 2.5% span length are in agreement with the findings of Maisuria *et al.* (2007) [7], Rajamani *et al.* (2009) [10], Sekhar *et al.* (2012) [11] and Kumar *et al.* (2013) [5].

Heterosis for micronaire value over mid parent, better parent and superior check ranged from -26.48 (NDLH 2010 × GTHV 13/32) to 25.00 (NDLH 1938 × L 788); -29.01 (NDLH 2010 × GTHV 13/32) to 20.75 (L 1384 × HYPS 152) and -18.02 (NDLH 2010 × L 788) to 30.63 (NDLH 1938 × L 788) with mean values of 2.30, -3.27 and 3.90, respectively. The crosses which exhibited positive significant heterosis over mid parent, better parent and standard check were NDLH 1938 × L 788, L 1493 × L 788, L 1384 × HYPS 152, L 1231 × SURAJ, L 1231 × L 788 and L 1060 × L 788. The best heterotic significant combination identified over mid parent, better parent and standard check was L 1493 × L 788. These results are in accordance with the research findings of Rajamani *et al.* (2009) [10] and Sekhar *et al.* (2012) [11] who had reported significant positive heterosis for this trait.

Table 1a: Estimates of heterosis over mid parent (MP), better parent (BP) and standard check (SH) for seed cotton yield, yield traits and fibre quality traits in intra-specific cotton hybrids (*Gossypium hirsutum* L.) during *kharif*, 2016-17

S. No.	Genotype/ Cross Combination	Plant height (cm)			Number of bolls per plant			Boll weight (g)			Seed index (g)			Ginning outturn (%)		
		MP	BP	SH	MP	BP	SH	MP	BP	SH	MP	BP	SH	MP	BP	SH
1	L 1060 × GTHV 13/32	14.05**	53.67**	46.74**	51.74**	53.67**	46.74**	12.40**	8.33*	10.11**	3.84	3.09	16.20**	-0.43	-3.43**	-2.31
2	L 1060 × HYPS 152	2.27	6.35	3.52	7.05	6.35	3.52	3.85	-6.46*	10.03**	-0.46	-4.37	15.31**	0.48	-0.48	0.68
3	L 1060 × L 788	-0.6	33.49**	23.90**	28.12**	33.49**	23.90**	8.21**	-1.83	13.64**	4.37	-4.02	27.04**	-3.23**	-4.16**	-3.04*
4	L 1060 × MCU 5	1.37	16.57	2.77	6.27	16.57	2.77	16.10**	10.89**	4.55	13.17**	11.14**	23.47**	-0.89	-1.15	0.52
5	L 1060 × SURAJ	-3.06	17.34*	10.19	13.94	17.34*	10.19	-1.09	-6.96*	-0.47	4.31	0.86	19.98**	0.93	-1.76	-0.62
6	L 1231 × GTHV 13/32	7.31	8.46	5.21	-1.01	8.46	5.21	6.78*	2.54	4.23	8.04*	5.21	18.58**	2.39*	-1.05	0.85
7	L 1231 × HYPS 152	6.09	10.64	5.3	3.1	10.64	5.3	-3.97	-13.79**	1.41	8.15**	1.97	22.96**	-4.10**	-5.37**	-3.55**
8	L 1231 × L 788	-8.63*	29.63**	29.57**	14.72	29.63**	29.57**	7.00*	-3.25	11.99**	5.14	-5.01	25.72**	-5.25**	-6.50**	-4.70**
9	L 1231 × MCU 5	-4.35	-1.53	-6.83	-17.58	-1.53	-6.83	10.53**	5.95	-0.86	3	2.86	10.16*	0.65	0.53	2.46*
10	L 1231 × SURAJ	-1.05	14.08	12.61	2.25	14.08	12.61	-6.60*	-12.45**	-6.35	2.41	-2.82	15.60**	-6.95**	-9.76**	-8.03**
11	L 1384 × GTHV 13/32	9.22*	34.81**	30.83**	30.83**	34.81**	30.83**	8.71**	3.11	16.85**	6.35*	0.17	27.76**	1.46	-0.79	-1.31
12	L 1384 × HYPS 152	6.29	28.53**	27.19**	27.19**	28.53**	27.19**	11.30**	9.26**	28.53**	14.53**	11.40**	42.09**	-4.53**	-4.64**	-5.14**
13	L 1384 × L 788	2.62	-7.15	-12.47	-12.47	-7.15	-12.47	15.50**	14.29**	32.29**	0.54	-1.28	30.65**	3.96**	3.83**	3.28**
14	L 1384 × MCU 5	10.04**	8.31	-3.1	-3.1	8.31	-3.1	16.33**	2.21	15.83**	1.07	-7.03*	18.58**	0.37	-0.71	0.95
15	L 1384 × SURAJ	-1.85	20.33*	14.79	14.79	20.33*	14.79	-1.96	-4.7	7.99*	15.25**	11.37**	42.05**	1.78	-0.12	-0.64
16	L 1493 × GTHV 13/32	17.78**	3.99	1.09	-4.88	3.99	1.09	9.84**	-0.15	1.49	0.96	-2.6	9.78*	0.32	-1.67	-2.65*
17	L 1493 × HYPS 152	3.28	-2.2	-6.72	-8.68	-2.2	-6.72	-5.46	-19.32**	-5.09	-5.89	-12.06**	6.04	2.58*	2.45*	1.67
18	L 1493 × L 788	-2.9	-17.55*	-17.7	-26.88**	-17.55*	-17.7	5.91*	-9.00**	5.33	2.67	-8.03**	21.73**	4.49**	4.37**	3.56**
19	L 1493 × MCU 5	-0.76	12.65	6.36	-5.5	12.65	6.36	10.85**	9.13*	-6.35	-0.66	-1.75	5.23	-2.89**	-4.17**	-2.56*
20	L 1493 × SURAJ	-2.97	1.16	0.07	-9.14	1.16	0.07	0.41	-10.77**	-4.55	-7.94*	-13.44**	2.98	-3.41**	-4.98**	-5.94**
21	LH 2220 × GTHV 13/32	16.80**	55.71**	46.14**	56.78**	55.71**	46.14**	19.05**	15.65**	17.55**	18.55**	18.26**	33.29**	1.09	-1.71	-1.09
22	LH 2220 × HYPS 152	18.02**	11.59	6.71	14.48	11.59	6.71	2.2	-7.26*	9.09**	-3.91	-7.26*	11.82**	-2.27*	-2.95*	-2.34
23	LH 2220 × L 788	-4.52	-7.91	-15.96	-9.84	-7.91	-15.96	6.00*	-3.11	12.15**	6.49*	-1.64	30.19**	-0.42	-1.11	-0.49
24	LH 2220 × MCU 5	-5.38	37.85**	19.64*	28.35**	37.85**	19.64*	14.67**	8.67*	4.15	17.24**	14.59**	28.53**	-0.81	-1.32	0.33
25	LH 2220 × SURAJ	1.45	19.97*	10.76	18.82*	19.97*	10.76	9.66**	3.96	11.21**	-0.4	-3.25	15.09**	-0.08	-2.49*	-1.88
26	NDLH 1938 × GTHV 13/32	14.49**	11.63**	14.56**	41.39**	34.60**	26.65**	4.61	-1.08	0.55	2.09	1.22	16.07**	2.77	2.05	-1.6
27	NDLH 1938 × HYPS 152	-3.75	-4.2	-0.75	4.83	-2.06	-4.11	10.88**	-1.87	15.44**	-6.63*	-8.92**	9.82*	-1.95	-3.34**	-4.07**
28	NDLH 1938 × L 788	-5.62	-10.25*	2.12	54.66**	51.62**	34.24**	10.52**	-1.49	14.03**	5.54*	-1.51	30.36**	-0.86	-2.26	-3.02*
29	NDLH 1938 × MCU 5	-5.37	-8.07	0.06	16.3	12.11	-4.65	14.62**	11.59**	1.1	-1.46	-4.71	9.27*	2.31*	-0.34	1.34
30	NDLH 1938 × SURAJ	1.41	-3.83	10.07*	20.87*	17.04	6.27	2.74	-5.13	1.49	1.58	-0.25	18.66**	-0.44	-0.78	-4.33**
31	NDLH 2010 × GTHV 13/32	7.75*	5.31	7.54	5.63	3.82	1.16	7.05*	3.08	4.78	6.30*	2.23	24.79**	-2.27*	-2.55*	-7.36**
32	NDLH 2010 × HYPS 152	-3.7	-4.39	-0.95	35.21**	34.89**	32.07**	-4.22	-13.79**	1.41	-8.95**	-9.51**	10.46*	1	-1.39	-2.15
33	NDLH 2010 × L 788	10.88**	5.2	19.69**	-3.87	-8.27	-10.61	-8.96**	-17.47**	-4.47	-11.00**	-14.46**	13.22**	-4.10**	-6.38**	-7.10**
34	NDLH 2010 × MCU 5	-1.47	-4.51	3.93	-11.73	-20.11*	-22.15*	15.42**	10.32**	3.84	8.09**	1.46	23.85**	4.54**	0.86	2.56*
35	NDLH 2010 × SURAJ	11.41**	5.41	20.64**	50.44**	45.31**	41.60**	8.81**	2.27	9.40**	1.11	-0.17	21.85**	0.77	0.12	-4.12**
36	SCS 1001 × GTHV 13/32	22.33**	20.65**	17.62**	7.28	0.14	8.68	3.28	3.16	4.86	-4.37	-6.55	10.37*	-1.28	-2.45*	-5.01**
37	SCS 1001 × HYPS 152	4.01	-0.4	3.18	10.17	4.78	13.71	-5.26*	-11.79**	3.76	9.41**	8.29*	30.57**	-3.10**	-4.01**	-4.74**
38	SCS 1001 × L 788	0.37	-7.99*	4.68	-8.57	-16.99	-9.91	-7.69**	-13.41**	0.24	-4.12	-9.28**	20.07**	-7.04**	-7.91**	-8.62**
39	SCS 1001 × MCU 5	6.61	-0.26	8.56	-10.17	-22.41	-15.8	0.63	-7.11*	-5.8	14.25**	8.93**	28.66**	-2.50*	-4.56**	-2.96*
40	SCS 1001 × SURAJ	4.1	-4.82	8.92*	28.79	18.27	28.35	-4.7	-7.18*	-0.71	2.91	2.54	21.98**	6.01**	5.14**	2.38*
	Mean	3.6	-0.26	8.14	15.75	9.83	8.62	5.6	-1.37	6.12	3.29	-0.61	20.27	-0.52	-1.92	-2.08
	Range	-8.63 to	-16.08 to	-4.52 to	-17.55 to	-22.41 to	-26.88 to	-8.96 to	-19.32 to	-6.35 to	-11.00 to	-14.46 to	2.98 to	-7.04 to	-9.76 to 5.14	-8.26 to
		22.33	20.65	25.04	55.71	51.62	56.78	19.05	15.65	32.29	18.55	18.26	42.09	6.01		3.56

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

Table 1b: Estimates of heterosis over mid parent (MP), better parent (BP) and standard check (SH) for seed cotton yield, yield traits and fibre quality traits in intra-specific cotton hybrids (*Gossypium hirsutum* L.) during *kharif*, 2016-17

S. No.	Genotype/ Cross Combination	2.5% span length (mm)			Micronaire value (10^{-6} g/inch)			Bundle strength (g/tex)			Uniformity ratio			Seed cotton yield per plant (g)		
		MP	BP	SH	MP	BP	SH	MP	BP	SH	MP	BP	SH	MP	BP	SH
1	L 1060 × GTHV 13/32	1.14	-1.52	-14.24**	-6.33*	-15.27**	0	11.84**	11.09**	-1.7	1.39	0	6.57**	78.26**	69.63**	95.44**
2	L 1060 × HYPS 152	1.67	-4.74*	-10.07**	9.52**	8.49*	3.6	4.86	4.63	-8.25**	-0.7	-2.74	3.65	9.93	2.02	37.29**
3	L 1060 × L 788	-4.57*	-6.82**	-19.33**	18.14**	16.51**	14.41**	-4.62	-11.64**	-9.55**	1.37	1.37	8.03**	55.21**	47.64**	70.10**
4	L 1060 × MCU 5	10.11**	1.56	-0.81	-5.16	-5.61	-9.01*	13.81**	10.97**	1.96	-3.78	-4.11	2.19	31.31**	10.86	27.72**
5	L 1060 × SURAJ	15.98**	12.67**	-1.42	13.86**	8.49*	3.6	-5.59*	-14.30**	-8.25**	-2.44	-4.11	2.19	18.15*	17.1	34.91**
6	L 1231 × GTHV 13/32	-3.73	-3.85	-16.07**	-2.48	-9.92**	6.31	-6.82*	-7.57*	-16.88**	1.74	0.69	6.57**	18.98*	13.03	17.62
7	L 1231 × HYPS 152	0	-3.77	-9.16**	4.19	0.9	0.9	14.08**	12.66**	1.31	-1.75	-3.45	2.19	0.79	-14.53	15.01
8	L 1231 × L 788	0.06	-0.35	-13.02**	18.18**	17.12**	17.12**	-3.88	-9.72**	-7.59**	-1.03	-1.37	5.11	54.90**	47.21**	53.06**
9	L 1231 × MCU 5	6.16**	0.52	-1.83	-8.26**	-9.91**	-9.91**	14.04**	12.82**	3.66	-4.14*	-4.14	1.46	7.68	-0.55	-6.87
10	L 1231 × SURAJ	-5.82**	-5.93**	-17.70**	18.84**	10.81**	10.81**	-18.67**	-25.18**	-19.90**	-0.7	-2.07	3.65	7.21	-2.03	10.87
11	L 1384 × GTHV 13/32	-4.73*	-8.18**	-20.04**	-2.95	-12.21**	3.6	-9.57**	-10.68**	-18.98**	2.42	0.68	8.03**	42.93**	27.74**	68.80**
12	L 1384 × HYPS 152	14.75**	6.47**	0.51	21.90**	20.75**	15.32**	7.41**	5.63	-4.19	-3.14	-5.44*	1.46	42.52**	41.23**	90.06**
13	L 1384 × L 788	17.08**	13.16**	-2.03	9.77**	8.26*	6.31	6.17*	0.13	2.49	-6.48**	-6.80**	0	2.29	-8.61	20.76*
14	L 1384 × MCU 5	-3.53	-11.87**	-13.94**	7.98*	7.48*	3.6	-0.93	-1.57	-9.55**	-2.74	-3.4	3.65	0.8	-19.34*	6.58
15	L 1384 × SURAJ	-5.32**	-8.95**	-20.35**	10.89**	5.66	0.9	-16.88**	-23.23**	-17.80**	-1.39	-3.4	3.65	15.37*	7.09	41.51**
16	L 1493 × GTHV 13/32	17.85**	12.62**	-1.93	7.38	0	18.02**	6.11*	3.99	-7.98**	-4.14*	-6.08**	1.46	0.93	-7.85	-4.11
17	L 1493 × HYPS 152	4.92*	-3.45	-8.85**	4.15	0	1.8	16.15**	14.33**	0.26	-4.17*	-6.76**	0.73	-11.09	-27.15**	-1.97
18	L 1493 × L 788	12.57**	7.87**	-6.61**	20.72**	18.58**	20.72**	2.87	-5.88*	-3.66	-4.76*	-5.41*	2.19	-10.42	-18.19	-14.94
19	L 1493 × MCU 5	-3.79*	-12.81**	-14.85**	-6.36*	-8.85*	-7.21*	-1.26	-4.99	-12.70**	-1.71	-2.7	5.11	25.00*	20.19	3.3
20	L 1493 × SURAJ	13.29**	8.02**	-5.49**	12.92**	4.42	6.31	2.93	-7.70**	-1.18	-3.11	-5.41	2.19	6.37	-6.43	5.9
21	LH 2220 × GTHV 13/32	-5.60**	-6.73**	-16.79**	-13.28**	-15.27**	0	4.71	3.55	-8.38**	1.41	1.41	5.11	89.22**	76.57**	112.08**
22	LH 2220 × HYPS 152	-7.92**	-10.45**	-15.46**	16.16**	6.40*	19.82**	-0.53	-1.19	-13.35**	-0.71	-1.41	2.19	39.31**	31.82**	77.39**
23	LH 2220 × L 788	4.17*	2.62	-8.44**	-6.84*	-12.80**	-1.8	6.44*	-1.79	0.52	-4.17*	-5.48*	0.73	6.96	-0.23	19.84
24	LH 2220 × MCU 5	-10.51**	-14.38**	-16.38**	11.21**	3.2	16.22**	-6.53*	-9.26**	-16.62**	3.14	2.07	8.03**	66.09**	37.90**	65.63**
25	LH 2220 × SURAJ	2.82	1.82	-9.16**	9.50**	-3.2	9.01*	-8.99**	-17.73**	-11.91**	0.35	0	3.65	32.10**	28.28**	54.08**
26	NDLH 1938 × GTHV 13/32	9.63**	1.75	-11.39**	-2.36	-5.34	11.71**	8.10**	2.66	-9.16**	-2.1	-2.78	2.19	42.28**	39.01	44.65**
27	NDLH 1938 × HYPS 152	18.24**	5.82**	-0.1	-3.08	-10.57**	-0.9	22.07**	16.42**	2.09	-2.11	-3.47	1.46	7.88	-6.27	26.14*
28	NDLH 1938 × L 788	-0.25	-7.17**	-19.63**	25.00**	17.89**	30.63**	-0.86	-11.89**	-9.82**	-1.38	-2.05	4.38	76.09**	72.11**	78.95**
29	NDLH 1938 × MCU 5	3.25	-8.96**	-11.09**	3.48	-3.25	7.21*	6.11*	-1	-9.03	-0.35	-0.69	5.11*	25.97**	13.32	12.5
30	NDLH 1938 × SURAJ	10.23**	2.09	-10.68**	10.50**	-1.63	9.01*	1.54	-11.49**	-5.24	-3.16	-4.17	0.73	16.32*	9.18	23.56
31	NDLH 2010 × GTHV 13/32	14.22**	12.62**	-1.93	-26.48**	-29.01**	-16.22**	6.04*	-2.95	3.4	-3.5	-4.17	0.73	13.36	11.83	19.6
32	NDLH 2010 × HYPS 152	1.36	-3.88	-9.26**	3.54	-4.1	5.41	-16.31**	-23.71**	-18.72**	-1.41	-2.78	2.19	29.56**	16.26*	56.46**
33	NDLH 2010 × L 788	12.54**	11.28**	-3.66	-21.21**	-25.41**	-18.02**	4.51	2.46	9.16**	-5.52**	-6.16**	0	-14.37	-15.56	-9.7
34	NDLH 2010 × MCU 5	-8.71**	-14.79**	-16.79**	-10.04**	-15.57**	-7.21*	-4.09	-10.69**	-4.84	-3.11	-3.45	2.19	-2.8	-15.35	-9.47
35	NDLH 2010 × SURAJ	0.47	-1.16	-13.53**	-12.84**	-22.13**	-14.41**	-8.95**	-9.17**	-2.75	0.35	-0.69	4.38	6.92	3.98	17.68
36	SCS 1001 × GTHV 13/32	8.77**	4.32	-9.16**	-5.82*	-6.11*	10.81**	9.42**	3.11	-8.77**	-0.35	-0.7	3.65	1.07	-8.42	17.34
37	SCS 1001 × HYPS 152	8.05**	-0.22	-5.80**	-7.77**	-17.05**	-2.7	22.87**	16.27**	1.96	-1.06	-2.1	2.19	-4.03	-6.33	26.05*
38	SCS 1001 × L 788	5.93**	1.88	-11.80**	-5.52	-13.21**	1.8	8.12**	-4.6	-2.36	-6.57**	-7.53**	-1.46	-8.26	-16.90*	6.47
39	SCS 1001 × MCU 5	8.13**	-1.67	-3.97*	-17.37**	-24.73**	-11.71**	23.08**	13.96**	4.71	-2.78	-3.45	2.19	-14.99	-31.18**	-11.82
40	SCS 1001 × SURAJ	7.90**	3.26	-9.66**	-1.86	-14.75**	0	10.73**	-4.16	2.62	-1.41	-2.1	2.19	23.18**	16.00*	48.62**
	Mean	4.17	-0.78	-10.05	2.3	-3.27	3.9	2.99	-2.44	-5.87	-1.84	-2.86	3.05	20.72	11.38	31.18
	Range	-10.51 to	-14.79 to	-20.35 to	-26.48 to	-29.01 to	-18.02 to	-18.67 to	-15.18 to	-19.90 to	-6.57 to	-7.53 to	-1.46 to	-14.99 to	-31.18 to	-14.94 to
		18.24	13.16	0.51	25	20.75	30.63	23.08	16.42	9.56	3.14	2.07	8.03	89.22	76.57	112.08

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

Table 2: The best heterotic combinations identified for yield and yield contributing characters in intra-specific hybrids of cotton (*Gossypium hirsutum* L.) during *kharif*, 2016-17

S. No	Characters	Cross combinations	*Per se* performance	Standard heterosis
1.	Plant height (cm)	LH 2220 × HYPS 152	149.47	25.04**
		NDLH 2010 × SURAJ	144.20	20.64**
		NDLH 2010 × L788	143.07	19.69**
		LH 2220 × GTHV 13/32	151.47	26.09**
2.	Number of bolls per plant	LH 2220 × GTHV 13/32	67.47	56.78**
		L 1060 × GTHV13/32	65.30	51.74**
		NDLH 2010 × SURAJ	60.93	41.60**
3.	Boll weight (g)	L 1384 × L788	5.63	32.29**
		L 1384 × HYPS 152	5.47	28.53**
		LH2220 × GTHV 13/32	5.00	17.55
4.	Seed index (g)	L 1384 × HYPS 152	11.14	42.09**
		LH 2220 × GTHV 13/32	10.45	33.28**
		L 1384 × L788	10.24	30.65**
		LH 2220 × GTHV 13/32	5.52	31.22**
		NDLH 2010 × MCU 5	5.42	28.76**
5.	Ginning outturn (%)	L 1493 × L 788	36.17	3.56**
		NDLH 2010 × MCU 5	35.82	2.56**
		L 1231× MCU 5	35.79	2.46**
6.	2.5% span length (mm)	L 1384 × HYPS 152	32.93	0.51
		NDLH 1938 × HYPS 152	32.73	-0.10
		L 1060 × MCU 5	32.50	-0.81
7.	Micronaire value (10 $^{-6}$g/inch)	NDLH 1938 × MCU 5	4.83	30.63**
		L 1493 × L 788	4.47	20.72**
		LH 2220 × HYPS 152	4.43	19.82
8	Bundle strength (g/tex)	NDLH 2010 × L 788	27.80	9.16**
		SCS 1001 × MCU 5	26.67	4.71
		L 1232 × MCU5	26.40	3.66
9.	Uniformity ratio	L 1060 × L788	49.33	8.03**
		L 1231 × GTHV 13/32	48.67	6.57**
		L 1231 × SURAJ	47.33	3.65
10	Seed cotton yield per plant (g)	LH 2220 × GTHV 13/32	249.73	112.08**
		L 1060 × GTHV 13/32	230.13	95.44**
		L 1384 × HYPS 152	223.80	90.06**

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

The mean value of heterosis for bundle strength over mid parent, better parent and standard check was found to be 2.99, -2.44 and -5.87, respectively. Heterosis over mid parent ranged from -18.67 (L 1231 × SURAJ) to 23.08 (SCS 1001 × MCU 5), over better parent -25.18 (L 1231 × SURAJ) to 16.42 (NDLH 1938 × HYPS 152) and over standard check -19.90 (L 1231 × SURAJ) to 9.16 (NDLH 2010 × L 788). The crosses, L 1060 × GTHV 13/32, L 1060 × MCU 5, L 1231 × HYPS 152, L 1231 × MCU 5, L 1493 × HYPS 152, NDLH 1938 × HYPS 152, SCS 1001 × HYPS 152 and SCS 1001 × MCU 5, exhibited significant positive heterosis over mid parent and better parent. None of the cross exhibited significant positive heterosis over standard check. The best heterotic combination identified over mid parent was NDLH 2010 × L 788, over better parent was SCS 1001× MCU 5 and over standard check was L 1231 × MCU 5. These results of heterosis for bundle strength are in conformity with the reports of Maisuria *et al.* (2007) [7] and Sekhar *et al.* (2012) [11].

Heterosis for uniformity ratio over mid parent, better parent and superior check ranged from -6.57 (SCS 1001 × L 788) to 3.14 (LH 2220 × MCU 5), -7.53 (SCS 1001 × L 788) to 2.07 (LH 2220 × MCU 5) and -1.46 (SCS 1001 × L 788) to 8.30 (LH 2220 × MCU 5) with mean value of -1.84, -2.86 and 3.05, respectively. None of the crosses exhibited significant positive heterosis over mid parent and over better parent. The crosses viz., L 1060 × GTHV 13/32, L 1231 × GTHV 13/32, L 1060 × L 788, L 1384 × GTHV 13/32, LH 2220 × MCU 5 and NDLH 1938 × MCU 5, exhibited significant positive heterosis over standard check. The best heterotic combinations identified was L 1060 × L 788 over mid parent, better parent and standard check.

The best heterotic combinations for various traits based on per se performance and standard heterosis are represented in Table 2. The cross, LH 2220 × GTHV 13/32, recorded higher seed cotton yield with other important traits like plant height, number of bolls per plant boll weight and seed index while the crosses L 1384 x HYPS 5152 and L 1060 × GTHV 13/32 showed higher yield with significant values for boll weight. The cross, L1384 x HYPS 5152, also showed the superiority for seed index and 2.5% span length. The cross, NDLH 2070 x MCU 5, performed better for seed index, ginning outturn and micronaire value.

Thus, the present study identified the promising crosses viz., LH 2220 × GTHV 13/32, L 1384 x HYPS 5152 and L 1060 × GTHV 13/32, based on *per se* performance and significant standard heterosis for seed cotton yield per plant along with important yield contributing traits. These hybrids can be exploited for commercial cultivation after thorough testing in large number of environments for further confirmation of their yield advantage over the standard check.

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