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Heterosis study for yield and yield attributes in cotton (*Gossypium hirsutum* L.)

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Abstract
The present study was undertaken by thirteen parents (4 lines and 9 testers) and their thirty-six resultant crosses with a check GN. Cot. Hy-14 was evaluated in a randomized block design with three replications in line × tester manner during *kharif* 2019-20 at Main Cotton Research Station, Navsari Agricultural University, Surat. The heterobeltiosis for seed cotton yield per plant ranged from -37.78 to 46.51 per cent, while the standard heterosis for grain yield per plant ranged from -45.25 to 34.77 per cent. The highest value of heterobeltiosis and standard heterosis were PBH-116 × TCH-1828 (46.51%) and GISV-171 × GJHV-523 (34.77%). For seed cotton yield four crosses *viz*., PBH-116 × TCH-1828, PBH-116 × SCS-1061, GSHV-172 × TCH-1828, and GISV-171 × GJHV-523 recorded positive and significant heterobeltosis and standard heterosis. These four crosses also exhibited significant heterobeltosis and standard heterosis for yields contributing character like Bolls per plant, boll weight and seed index.

Keywords: Replication, line × tester, hybrids, heterosis, heterobeltiosis

Introduction
Cotton is a major fibre crop of global importance value. Cotton is known as the king of fibre. India was established as the leading country in terms of area under cotton in the world. As per USDA estimate in India, cotton is covered about 12.60 million ha of land and it occupies the second position in production with 25.80 million bales (each of 170 kg) next to China among all cotton-producing countries in the world. An average productivity of India is 446 kg/ha. Gujarat is the second largest cotton growing state after Maharashtra with 26.60 lakh ha and the largest cotton producing state of India with a production of 87.50 lakh bales (Anon., 2018-19) [1]. Simpson (1954) [12] classified cotton as an often cross-pollinated crop that is amenable for heterosis breeding. Heterosis in cotton has been known since 1970. India resides a pioneer in the commercialization of heterosis in cotton. For better exploitation of heterosis in cotton, development of simple and economically viable hybrid seed production techniques should be strengthened. Noticeable heterosis is reported in cotton by many workers. The present investigation was carried out to identify superior hybrids based on better parent and standard heterosis.

Materials and Methods
The experimental material consisted of thirteen parents (4 lines and 9 testers) and their thirty-six resultant crosses with a check GN. Cot. Hy-14 was evaluated in a randomized block design with three replications during kharif 2019-20 at Main Cotton Research Station, Navsari Agricultural University, Surat. The hybrid (F1) seeds were produced by Dock, J. W., and Moll, R. H. (1934) [4] method. The present investigation was carried out to study heterosis in the inheritance of the majority of yield traits, fiber quality, and biochemical traits of cotton *viz*., days to 50% flowering, bolls per plant, boll weight (g), seed cotton yield per plant (g), ginning outturn (%), seed index (g), fiber length (mm), fiber strength (g/tex), fiber fineness (mv), oil content (%), gossypol content (mg/100g) and protein content (mg /g). The observations were recorded from randomly selected 5 plants from each genotype in each replication.
The mean performance of parents, as well as hybrids, were subjected to statistical analysis. Analysis of variance was carried out to test the significance for each character as per the methodology suggested by Panse and Sukhatme (1985) [8]. Heterobeltiosis (BH) was calculated using the method given by Fonseca and Patterson (1968) [5]. and Standard heterosis by Meredith and Bridge (1972) [7].

Results and Discussion

The analysis of variance showed highly significant differences among the genotypes for all the traits revealed that a considerable amount of variability was observed among experimental material. Analysis of variance depicting the mean sum of squares for twelve quantitative traits is presented in Table 1. The genotypic variance was further partitioned into parents, hybrids, and parents vs hybrids. The differences among parents were highly significant for all characters under investigation except days to 50% flowering, boll weight (g), and oil content (%). Hybrids were also found highly significant for all characters. Differences due to parents vs hybrids were also found significant for all the traits under study.

Concerning heterosis over better parent and commercial or standard check, out of 36 hybrids, hybrids exhibited significant heterosis in the desired direction for days to 50% flowering (3,0), bolls per plant (15,9), boll weight (9,8), seed cotton yield per plant (12,6), ginning outturn (1,5), seed index (14,13), fiber length (4,0), fiber strength (8,5), fiber fineness (1,4), oil content (6,5), gossypol content (0,35) and protein content (12,19).

For Seed cotton yield per plant, the range of heterobeltiosis was -37.78 (H-1452 × TCH-1828) to 46.51% (PBH-116 × TCH-1828). Total twelve F1 s exhibited positive and significant heterobeltiosis. The highest value was observed by the cross PBH-116 × TCH-1828 (46.51%) followed by PBH-116 × SCS-1061 (43.31%) and GSHV-172 × TCH-1828 (42.03%). The standard heterosis over GN. Cot. Hy -14 varied from -45.25 (H-1452 × TCH-1828) to 34.77% (GISV-171 × GJHV-523). Six cross combinations manifested significant and positive standard heterosis in the desired direction, the highest value was observed for the cross GISV-171 × GJHV-523 (34.77%) followed by PBH-116 × TCH-1828 (28.93%) and GSHV-172 × TCH-1828 (25.00%). Similar findings of useful heterosis have also been reported by Bilwal *et al.* (2018) [3] and Pavitra *et al.* (2019) [9] for seed cotton yield per plant. The per se performance of the top five crosses along with standard heterosis and better parent heterosis for seed cotton yield and the yield attributing traits that registered significant and desirable standard heterosis for the particular cross is summarized in Table 4.

The hybrid, PBH-116 × SHJ-23 for days to 50% flowering, GSHV-172 × 8401 for bolls per plant, PBH-116 × SCS-1061 for boll weight, PBH-116 × TCH-1828 for seed cotton yield per plant, PBH-116 × TCH-1828 for ginning outturn, GISV-171 × 8401 for seed index, PBH-116 × TCH-1761 for fiber length, PBH-116 × TCH-1705 for fiber strength, GSHV-172 × GSHV-199 for fiber fineness, GSHV-172 × 8401 for oil content, H-1452 × SHJ-23 for gossypol content and H-1452 × GISV-267 for protein content showed significant and maximum heterosis over better parent in the desirable direction.

The hybrid, PBH-116 × SHJ-23 for days to 50% flowering, GSHV-172 × 8401 for bolls per plant PBH-116 × GSHV-199 for boll weight, GISV-171 × GJHV-523 for seed cotton yield per plant, PBH-116 × SCS-1061 for ginning outturn, PBH-116 × TCH-1828 for seed index, PBH-116 × TCH-1828 for fiber length, GSHV-172 × SHJ-23 for fiber strength, GSHV-172 × GSHV-199 for fiber fineness, H-1452 × GSHV-199 for oil content, GSHV-172 × 8401 for gossypol content and H-1452 × GISV-267 for protein content showed significant and maximum heterosis over standard check-in desirable direction. Similar results were also reported by Basal *et al.* (2011) [2], Linga Swami *et al.* (2013) [6], Solanki *et al.* (2014) [13], Sawarkar *et al.* (2015) [11], Sonawan *et al.* (2016) [14], Vekariya *et al.* (2017) [15], Bilwal *et al.* (2018) [3], Pinki *et al.* (2018) [10] and Pavitra *et al.* (2019) [9].

It was noted that the top-ranking crosses based on per se performance and standard heterosis were almost the same, whereas ranking based on heterobeltiosis and per se performance varied slightly. This indicated that ranking based on standard heterosis is more reliable as compared to better parent heterosis. The top three cross combinations *viz.*, GISV-171 × GJHV-523, PBH-116 × TCH-1828, and GSHV-172 × TCH-1828 manifested significant and positive standard heterosis over check GN. Cot. Hy-14. The above-mentioned highly heterotic crosses also occupied top ranks in per se performance for seed cotton yield per plant. The crosses which showed significant and positive standard heterosis for seed cotton yield also manifested significant standard heterosis in the desired direction for one or more yield attributing characters like bolls per plant and boll weight.

Table 1: Analysis of variance (mean sum of square) for experimental design for different traits in *G. hirsutum* L

Source of variation	Df	Days to 50% flowering	Bolls per plant	Boll weight (g)	Seed cotton yield per plant (g)	Ginning outturn (%)	Seed index (g)	Fiber length (mm)	Fiber Strength (g/tex)	Fiber fineness (mv)	Oil content (%)	Gossypol content (mg/100g)	Protein content (mg/g)
Replications	2	7.61	9.50	0.10	62.46	7.31	0.16	1.47	1.56	0.04	0.01	18.73	31.63
Treatments	48	15.97**	176.60**	0.54**	2777.50**	11.57**	2.19**	4.07**	13.60**	0.45**	1.19**	18269.18**	1823.60**
Parents	12	10.33	78.37**	0.18	1997.19**	15.98**	2.30**	5.82**	17.80**	0.27**	0.45	24018.71**	2981.19**
Parents *vs* Crosses	1	39.00*	951.57**	3.26**	18168.59**	31.02**	6.44**	15.17**	26.48**	2.68**	17.16**	65724.01**	1399.46**
Crosses	35	17.25**	188.14**	0.59**	2605.29**	9.50**	2.03**	3.16**	11.79**	0.45**	0.98**	14942.06**	1438.83**
Error	96	6.81	12.58	0.10	255.80	2.69	0.06	0.61	0.86	0.03	0.52	137.83	45.76

* and ** indicates significance at 5% and 1% levels of probability, respectively

Table 2: Per cent heterobeltiosis (H_1) and standard heterosis (H_2) for days to 50% flowering, bolls per plant, boll weight and seed cotton yield per plant in *G. hirsutum* L.

Sr. No.	Crosses	Days to 50% flowering		Bolls per plant		Boll weight (g)		Seed cotton yield per plant (g)	
		H_1 (%)	H_2 (%)	H_1 (%)	H_2 (%)	H_1 (%)	H_2 (%)	H_1 (%)	H_2 (%)
1	PBH-116 × TCH-1828	0.00	-3.41	39.78**	21.50*	21.67**	16.90*	46.51**	28.93**
2	PBH-116 × GJHV-523	-7.65*	-3.98	19.19*	10.28	7.32	-3.10	9.59	5.77
3	PBH-116 × SHJ-23	-8.74*	-5.11	30.99*	-13.08	3.86	1.14	31.09*	-5.07
4	PBH-116 × GSHV-199	-2.78	-0.57	-36.96**	-45.79**	21.02**	17.96**	-29.65**	-37.30**
5	PBH-116 × 8401	0.00	3.98	-18.37*	-25.23**	7.05	-3.35	14.07	-7.30

6	PBH-116 × SCS-1061	2.94	-0.57	36.17**	19.63*	30.47**	17.80**	43.31**	23.19*
7	PBH-116 × TCH-1705	0.00	0.57	36.14**	5.61	-8.26	-15.67*	35.19**	7.26
8	PBH-116 × TCH-1761	-3.89	-1.70	36.56**	18.69*	26.04**	13.80*	24.36*	21.74*
9	PBH-116 × GISV-267	-7.65*	-3.98	30.14*	-11.21	15.13*	13.06*	34.70**	6.55
10	GSHV-172 × TCH-1828	3.53	0.00	39.78**	21.50*	21.07**	16.33*	42.03**	25.00**
11	GSHV-172 × GJHV-523	1.11	3.41	12.12	3.74	0.46	-10.69	0.08	-3.42
12	GSHV-172 × SHJ-23	-1.11	1.14	37.68**	-11.21	-8.55	-10.94	25.14*	-9.38
13	GSHV-172 × GSHV-199	8.33*	10.80**	38.04**	18.69*	-9.72	-12.00	12.83	0.56
14	GSHV-172 × 8401	-3.33	-1.14	54.08**	41.12**	8.52	-10.61	29.40*	5.15
15	GSHV-172 × SCS-1061	5.88	2.27	4.26	-8.41	12.78	-7.10	10.57	-4.95
16	GSHV-172 × TCH-1705	7.91*	8.52*	-18.07	-36.45**	-8.61	-16.00*	-25.53*	-40.92**
17	GSHV-172 × TCH-1761	-5.56	-3.41	1.08	-12.15	9.84	-1.55	-5.01	-7.01
18	GSHV-172 × GISV-267	6.11	8.52*	21.92	-16.82*	17.87**	15.76*	36.45**	7.94
19	H-1452 × TCH-1828	3.53	0.00	-43.01**	-50.47**	-7.65	-11.27	-37.78**	-45.25**
20	H-1452 × GJHV-523	1.68	3.41	26.26**	16.82*	0.99	-8.73	5.31	1.64

* and ** indicates significance at 5% and 1% levels of probability, respectively

Table 2: Continue…….

Sr. No.	Crosses	Days to 50% flowering		Bolls per plant		Boll weight (g)		Seed cotton yield per plant (g)	
		H_1 (%)	H_2 (%)	H_1 (%)	H_2 (%)	H_1 (%)	H_2 (%)	H_1 (%)	H_2 (%)
21	H-1452 × SHJ-23	-0.56	1.14	6.58	-24.30**	-4.78	-7.27	1.61	-24.58**
22	H-1452 × GSHV-199	3.35	5.11	5.43	-9.35	0.59	-1.96	-2.65	-13.23
23	H-1452 × 8401	-1.12	0.57	-10.20	-17.76*	-0.18	-9.80	-2.62	-20.87*
24	H-1452 × SCS-1061	-0.59	-3.98	7.45	-5.61	-2.35	-11.76	8.63	-6.62
25	H-1452 × TCH-1705	-3.95	-3.41	33.73**	3.74	-4.44	-12.16	17.02	-7.16
26	H-1452 × TCH-1761	-0.56	1.14	0.00	-13.08	15.18*	4.08	4.66	2.46
27	H-1452 × GISV-267	6.15	7.95*	-1.32	-29.91**	11.22	9.22	-4.46	-24.42**
28	GISV-171 × TCH-1828	0.00	-3.41	11.83	-2.80	5.18	1.06	15.14	1.33
29	GISV-171 × GJHV-523	-3.95	-3.41	35.35**	25.23**	23.45**	16.90*	39.64**	34.77**
30	GISV-171 × SHJ-23	-3.95	-3.41	10.47	-11.21	-3.77	-6.29	15.89	-1.11
31	GISV-171 × GSHV-199	0.56	1.14	-9.78	-22.43**	-4.27	-6.69	13.50	1.16
32	GISV-171 × 8401	0.56	1.14	-22.45*	-28.97**	7.84	2.12	-7.75	-21.28*
33	GISV-171 × SCS-1061	0.00	-3.41	-12.77	-23.36**	-2.07	-7.27	-29.08**	-39.04**
34	GISV-171 × TCH-1705	0.56	1.14	-31.40**	-44.86**	-0.95	-6.20	-33.63**	-43.37**
35	GISV-171 × TCH-1761	-3.39	-2.84	38.71**	20.56*	12.33	6.37	22.27*	19.70*
36	GISV-171 × GISV-267	-4.52	-3.98	16.28	-6.54	-4.41	-6.12	18.93	1.49
SE(d) ±		2.13	2.13	2.90	2.90	0.26	0.26	13.06	13.06
CD @ 5%		4.25	4.25	5.78	5.78	0.52	0.52	26.05	26.05
Range		-8.74 to 8.33	-5.11 to 10.80	-43.01 to 54.08	-50.47 to 41.12	-9.72 to 30.47	-16.00 to 17.96	-37.78 to 46.51	-45.25 to 34.77

* and ** indicates significance at 5% and 1% levels of probability, respectively

Table 3: Per cent heterobeltiosis (H1) and standard heterosis (H2) for ginning outturn, seed index, fiber length and fiber strength in *G. hirsutum* L.

Sr. No.	Crosses	Ginning outturn (%)		Seed index (g)		Fiber length (mm)		Fiber strength (g/tex)	
		H_1 (%)	H_2 (%)	H_1 (%)	H_2 (%)	H_1 (%)	H_2 (%)	H_1 (%)	H_2 (%)
1	PBH-116 × TCH-1828	-0.14	-1.38	17.57**	23.37**	0.99	1.97	2.08	5.32*
2	PBH-116 × GJHV-523	-0.56	-1.07	3.23	1.23	3.88	-0.33	8.78**	5.74*
3	PBH-116 × SHJ-23	-2.10	-3.33	4.04	15.56**	-3.17	-3.50	-0.50	3.29
4	PBH-116 × GSHV-199	-4.61	-5.80	5.17*	4.73	0.82	0.67	7.10**	7.02**
5	PBH-116 × 8401	-2.80	-4.02	6.64*	-0.82	4.60	-2.64	-1.28	-2.46
6	PBH-116 × SCS-1061	5.53	11.37**	14.42**	-0.41	-0.61	-10.68**	-5.75*	-16.09**
7	PBH-116 × TCH-1705	-5.87	-7.05	20.44**	11.52**	6.57**	-0.17	14.60**	3.72
8	PBH-116 × TCH-1761	-0.24	-1.49	-4.80*	11.73**	7.50**	-2.95	1.19	1.16
9	PBH-116 × GISV-267	-4.62	2.38	3.83	17.28**	-6.23**	-9.82**	5.72*	0.42
10	GSHV-172 × TCH-1828	-1.95	-2.61	6.67**	11.93**	-2.72	-1.78	-7.64**	-4.71
11	GSHV-172 × GJHV-523	2.54	2.02	1.13	-0.82	2.57	-1.59	4.51	1.59
12	GSHV-172 × SHJ-23	-3.51	-4.16	0.56	11.69**	-1.76	-2.09	3.71	7.66**
13	GSHV-172 × GSHV-199	5.02	4.31	-7.02**	-7.41**	-6.09**	-6.23**	-9.11**	-9.17**
14	GSHV-172 × 8401	2.81	2.12	6.64*	-0.82	0.01	-6.91**	-12.50**	-13.54**
15	GSHV-172 × SCS-1061	2.34	8.00*	6.86*	-7.00**	4.41	-7.15**	-3.74	-12.26**
16	GSHV-172 × TCH-1705	-8.43*	-9.05*	6.62*	-1.28	3.08	-3.43	9.47**	-0.22
17	GSHV-172 × TCH-1761	-2.95	-3.61	-4.98*	11.52**	-0.82	-10.46**	-4.56	-4.59
18	GSHV-172 × GISV-267	-4.40	2.62	3.93	17.41**	3.04	-0.90	7.75**	2.34
19	H-1452 × TCH-1828	3.94	3.19	0.00	4.94	-5.29*	-4.37*	-15.08**	-12.38**
20	H-1452 × GJHV-523	-0.33	-0.84	-5.79*	-7.61**	0.47	-3.60	-5.92*	-8.55**

* and ** indicates significance at 5% and 1% levels of probability, respectively

Table 3: Continue…….

Sr. No.	Crosses	Ginning outturn (%)		Seed index (g)		Fiber length (mm)		Fiber Strength (g/tex)	
		H_1(%)	H_2(%)	H_1(%)	H_2(%)	H_1(%)	H_2(%)	H_1(%)	H_2(%)
21	H-1452 × SHJ-23	2.32	1.59	-7.41**	2.84	-4.38*	-4.70*	-4.08	-0.43
22	H-1452 × GSHV-199	-0.11	-0.83	-13.43**	-13.79**	-4.48*	-4.62*	-9.96**	-10.03**
23	H-1452 × 8401	-4.99	-5.67	10.58**	2.84	5.63*	-1.69	-2.25	-3.42
24	H-1452 × SCS-1061	4.81	10.61**	5.66	-7.82**	4.25	-8.10**	6.77*	-7.68**
25	H-1452 × TCH-1705	-3.06	-3.76	-5.78*	-12.76**	4.70*	-1.91	3.87	-5.99*
26	H-1452 × TCH-1761	-0.14	-0.86	-21.00**	-7.28**	-0.45	-10.12**	-7.01**	-7.04**
27	H-1452 × GISV-267	-4.75	2.24	-7.29**	4.73	1.51	-2.37	8.30**	2.87
28	GISV-171 × TCH-1828	-8.40*	-9.23*	-11.76**	-7.41**	0.47	1.44	-2.98	0.10
29	GISV-171 × GJHV-523	-1.12	-1.63	-5.37*	-7.20**	-0.06	-4.10	-1.08	-1.19
30	GISV-171 × SHJ-23	-3.34	-4.21	10.97**	23.25**	1.07	0.73	3.50	7.45**
31	GISV-171 × GSHV-199	-0.47	-1.37	10.74**	10.29**	-2.58	-2.72	3.05	2.97
32	GISV-171 × 8401	8.90*	7.91*	26.64**	17.78**	2.81	-4.27	1.39	1.27
33	GISV-171 × SCS-1061	2.61	8.28*	2.03	-6.79**	-2.70	-9.41*	-9.28**	-9.39**
34	GISV-171 × TCH-1705	-4.81	-5.67	6.67*	-1.23	3.68	-2.87	-1.60	-1.72
35	GISV-171 × TCH-1761	-2.14	-3.02	-5.33*	11.11**	-0.16	-7.04**	0.02	-0.01
36	GISV-171 × GISV-267	-8.48*	-1.77	-12.20**	-0.82	-1.24	-5.01*	-1.71	-1.82
SE(d) ±		1.34	1.34	0.21	0.21	0.64	0.64	0.76	0.76
CD @ 5%		2.67	2.67	0.41	0.41	1.27	1.27	1.51	1.51
Range		-8.48 To 8.90	-9.23 to 11.37	-21.00 to 26.64	-13.79 to 23.37	-6.23 to 7.50	-10.68 to 1.97	-15.08 to 14.60	-16.09 to 7.66
* and ** indicates significance at 5% and 1% levels of probability, respectively									

Table 4: Per cent heterobeltiosis (H_1) and standard heterosis (H_2) for fiber fineness, oil content, gossypol content, and protein content in *G. hirsutum* L.

Sr. No.	Crosses	Fiber fineness (mv)		Oil content (%)		Gossypol content (mg/100g)		Protein content (mg/g)	
		H_1 (%)	H_2 (%)	H_1 (%)	H_2 (%)	H_1 (%)	H_2 (%)	H_1 (%)	H_2 (%)
1	PBH-116 × TCH-1828	26.36**	15.64**	-0.90	-2.66	117.46**	-18.16**	-4.36	-1.26
2	PBH-116 × GJHV-523	7.83*	3.16	1.40	-0.34	38.95**	-47.71**	-28.38**	11.66**
3	PBH-116 × SHJ-23	-0.88	-6.82	1.47	1.36	124.39**	-15.56**	-18.34**	5.08
4	PBH-116 × GSHV-199	-2.61	-6.82	-3.31	-5.17	67.85**	-36.83**	8.72**	20.36**
5	PBH-116 × 8401	36.56**	5.66	5.46	-0.77	116.02**	-18.71**	3.49	6.86
6	PBH-116 × SCS-1061	28.09**	22.55**	3.75	-0.26	134.43**	-11.78**	10.68**	14.27**
7	PBH-116 × TCH-1705	18.26**	13.14**	8.11*	6.99*	134.62**	-11.70**	3.35	12.66**
8	PBH-116 × TCH-1761	15.65**	10.65**	5.20	1.91	130.63**	-13.21**	1.16	4.46
9	PBH-116 × GISV-267	15.65**	10.65**	2.03	-2.15	53.89**	-42.09**	-18.38**	-15.73**
10	GSHV-172 × TCH-1828	13.64**	3.99	2.73	0.91	126.34**	-13.63**	22.78**	18.77**
11	GSHV-172 × GJHV-523	2.70	-1.75	-3.21	-4.87	44.02**	-45.04**	-42.18**	-9.85**
12	GSHV-172 × SHJ-23	8.05*	1.58	2.55	2.44	111.00**	-19.48**	-11.79**	13.51**
13	GSHV-172 × GSHV-199	-12.17**	-15.97**	-2.56	-4.44	54.02**	-41.22**	-12.16**	-2.75
14	GSHV-172 × 8401	21.51**	-5.99	10.11**	3.46	10.72*	-57.75**	26.76**	19.34**
15	GSHV-172 × SCS-1061	18.26**	13.14**	4.40	0.36	128.70**	-12.73**	-3.35	-5.91
16	GSHV-172 × TCH-1705	2.61	-1.83	0.15	-0.89	128.50**	-12.81**	11.83**	21.91**
17	GSHV-172 × TCH-1761	4.43	-0.08	3.80	0.55	101.06**	-23.28**	0.42	3.70
18	GSHV-172 × GISV-267	8.00*	3.33	6.06	1.72	23.45**	-52.89**	47.26**	22.44**
19	H-1452 × TCH-1828	13.18**	3.58	3.97	3.23	11.61**	-11.78**	12.72**	17.98**
20	H-1452 × GJHV-523	10.70**	3.24	7.70*	6.93*	10.65**	-12.83**	-20.59**	23.80**

* and ** indicates significance at 5% and 1% levels of probability, respectively

Table 4: Continue……

Sr. No.	Crosses	Fiber fineness (mv)		Oil content (%)		Gossypol content (mg/100g)		Protein content (mg/g)	
		H_1 (%)	H_2 (%)	H_1 (%)	H_2 (%)	H_1 (%)	H_2 (%)	H_1 (%)	H_2 (%)
21	H-1452 × SHJ-23	-5.35	-11.73**	6.86*	6.74*	6.14*	-16.10**	-9.78**	16.08**
22	H-1452 × GSHV-199	-1.69	-8.32*	8.43*	7.65*	26.43**	-34.51**	-13.32**	-4.03
23	H-1452 × 8401	43.12**	10.73**	5.86	5.10	22.66**	-11.51**	9.71**	14.83**
24	H-1452 × SCS-1061	17.13**	9.23*	0.40	-0.32	14.29**	-13.86**	-5.23	-0.80
25	H-1452 × TCH-1705	8.30*	1.00	2.42	1.68	11.00**	-12.26**	-7.83*	0.48
26	H-1452 × TCH-1761	24.09**	15.72**	4.81	4.06	27.73**	0.96	5.29	10.20**
27	H-1452 × GISV-267	8.03*	0.75	3.67	2.93	55.42**	-22.02**	52.28**	59.40**
28	GISV-171 × TCH-1828	-6.27	-14.23**	1.43	0.60	11.03**	-26.83**	23.60**	32.86**
29	GISV-171 × GJHV-523	21.19**	18.97**	0.32	-0.49	31.01**	-13.66**	-38.47**	-4.08
30	GISV-171 × SHJ-23	12.48**	5.74	2.19	2.08	32.34**	-12.78**	-23.94**	-2.13
31	GISV-171 × GSHV-199	5.00	3.08	3.60	2.76	32.00**	-31.62**	-3.98	6.31
32	GISV-171 × 8401	33.55**	3.33	1.14	0.32	16.97**	-22.92**	-15.55**	-9.23*
33	GISV-171 × SCS-1061	23.73**	21.46**	1.09	0.26	27.98**	-15.66**	13.37**	21.86**
34	GISV-171 × TCH-1705	13.76**	10.73**	3.48	2.64	38.36**	-8.82**	6.98*	16.63**
35	GISV-171 × TCH-1761	20.34**	18.14**	7.63*	6.76*	32.55**	-12.65**	-9.43**	-2.65
36	GISV-171 × GISV-267	7.63*	5.66	3.41	2.57	36.15**	-31.69**	2.53	10.21**
SE(d) ±		0.14	0.14	0.59	0.59	9.59	9.59	5.52	5.52
CD @ 5%		0.29	0.29	1.18	1.18	19.12	19.12	11.02	11.02
Range		-12.17 to 43.12	-15.97 to 22.55	-5.17 to 10.11	-5.17 to 7.65	6.14 to 134.62	-57.75 to 0.96	-42.18 to 52.28	-15.73 to 59.40

* and ** indicates significance at 5% and 1% levels of probability, respectively

Table 5: Best heterotic crosses and their performance for seed cotton yield and related parameters in *G. hirsutum* L.

Best crosses (P_1 x P_2)	Mean yield/ plant (g)	Better parent heterosis (%)	Standard heterosis (%)	Significant standard heterosis of other yield attributing traits in desired direction
GISV-171 × GJHV-523	194.10	39.64**	34.77**	Bolls per plant, boll weight (g)
PBH-116 × TCH-1828	185.70	46.51**	28.93**	Bolls per plant, boll weight (g), seed index (g)
GSHV-172 × TCH-1828	180.03	42.03**	25.00**	Bolls per plant, boll weight (g), seed index (g)
PBH-116 × SCS-1061	177.43	43.31**	23.19*	Bolls per plant, boll weight (g)
PBH-116 × TCH-1761	175.34	24.36*	21.74*	Bolls per plant, boll weight (g), seed index (g)

* and ** indicates significance at 5% and 1% levels of probability, respectively

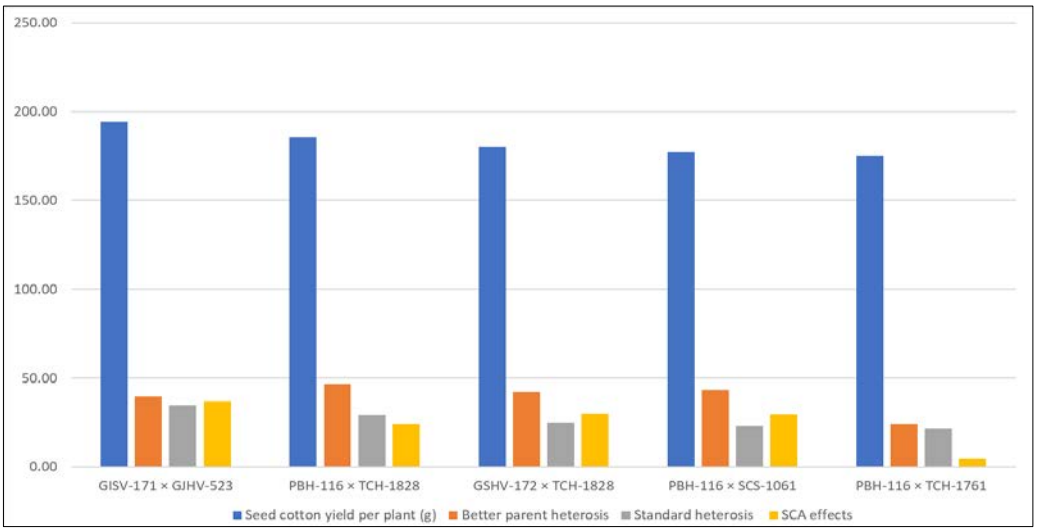

Fig 1: The top five crosses in terms of *per se* performance along with better parent heterosis, standard heterosis and SCA effects for seed cotton yield in *G. hirsutum* L.

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