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Heterosis Study for Seed Cotton Yield and its Related Attributes in Cotton (*Gossypium hirsutum* L.)

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ABSTRACT: A line × tester crossing technique was undertaken for the identification of best heterotic crosses for seed cotton yield and its components traits in upland cotton (*Gossypium hirsutum* L.) using thirteen parents (3 lines and 10 testers) and their thirty resultant crosses along with a check GN. Cot. Hy-18 in a randomized block design with three replications during *kharif* 2020-21 at Main Cotton Research Station, Navsari Agricultural University, Surat. The highest heterobeltiosis and standard heterosis found in cross GSHV-01/1338 × ARBC-1351(81.45%) and GJHV-566 × GSHV-213 (51.16%) for seed cotton yield per plant respectively. Among the 30 hybrids, eight hybrids showed significantly positive heterobeltiosis and four hybrids showed significant positive heterosis over standard check GN. Cot. Hy. 18 for seed cotton yield per plant. Four crosses *viz.*, GJHV-566 × GSHV-213, GSHV-01/1338 × ARBC-1351, GISV-323 × G. Cot-16 and GISV-323 × ARBC-1351 recorded positive and significant heterobeltiosis and standard heterosis for seed cotton yield per plant along with yields contributing characters like Plant height, bolls per plant, sympodia per plant, boll weight, ginning outturn and seed index. Therefore, such cross combinations may be recommended for commercial cultivation as hybrids or further production of more desirable recombinants and superior varieties.

Keywords: Cotton, Line × Tester, Heterosis, Heterobeltiosis, standard heterosis.

INTRODUCTION

Cotton is a soft, fluffy staple fiber that grows in a boll or protective capsule, around the seed of cotton plants of the genus *Gossypium*. Cotton is known as "King of fiber crop" and "White gold". There are about 50 species of cotton in the world from which *Gossypium arboreum, Gossypium herbaceum, Gossypium hirsutum* and *Gossypium barbadense* are cultivated. India is ranked 1st place in the world with estimated production of 362.18 lakh bales (6.16 million MT) during cotton season 2021- 22 *i.e*., 23% of world cotton production of 1555 lakh bales (26.44 million MT). India got 1st place in the world in cotton acreage with 120.69 Lakh Hectares area under cotton cultivation *i.e*., around 36% of world area of 333 Lakh Hectares. India is also the 2nd largest consumer of cotton in the world with estimated consumption of 338 lakh bales (5.75 million MT) *i.e*., 22% of world cotton consumption of 1507 lakh bales (25.63 million MT). 3rd largest exporter of cotton with estimated export of 45 lakh bales (0.76 million MT) *i.e*., 8% of world export of 597 lakh bales (10.15 million MT) in 2021-22 (Anonymous, 2022). Cotton is often cross-pollinated crop, which is accessible to the development of homozygous genotypes as varieties and at the same time amenable to commercial exploitation of heterosis by exploitation of additive as well as non-additive genetic variance. Heterosis, commonly referred to as hybrid vigour, is the superiority of an F_1 over its parents in terms of any trait and the term given by Shull (Richika *et al.*, 2021). Hybrids have occupied nearly 90% of the area of cotton cultivated in India. There is a continuous need to develop more potential hybrids and adopt novel approaches for improving hybrid performance.

MATERIALS AND METHODS

The experimental materials comprised of thirteen diverse genotypes of cotton including three lines (females) *viz*., GSHV-01/1338, GJHV-566, GISV-323 as well as ten testers (males) *viz*., ARBC-1351, Phule Yamuna, GSHV 213, TCH-1716, H-1452, BS-27, H 401/2014, GISV-216, G. Cot-16, DELTA-15 of *Gossypium hirsutum* L. and their thirty resultant crosses along with a check GN. Cot. Hy-18 were evaluated in a randomized block design with three replications during *kharif* 2021-22 at Main Cotton Research Station, Navsari Agricultural University, Surat. The hybrid (F_1) seeds were produced by Doak (1934) method and parent seeds were obtained by selfing of parents. Observations were recorded for 15 different characters *viz*., plant height (cm), days to 50% flowering, sympodia per plant, 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 (%), protein content (%) and phenol content (%). The experimental plot wise mean values of five randomly selected plants were used in each statistical analysis.

The mean performance of parents, as well as hybrids, were subjected to statistical analysis for different characters. Analysis of variance was carried out to test the significance for each character as per the methodology suggested by Panse and Sukhatme (1985). Heterobeltiosis (BH) was calculated using the method given by Fonseca and Patterson (1968) and Standard heterosis by Meredith and Bridge (1972).

RESULTS AND DISCUSSION

The analysis of variance showed highly significant differences among the genotypes for all the traits except for sympodia per plant and revealed that a considerable amount of variability was observed among experimental material. Analysis of variance depicting the mean sum of squares for fifteen 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 for sympodia per plant, bolls per plant, seed cotton yield per plant (g) and protein content (%). Hybrids were also found highly significant for all characters except sympodia per plant. Differences due to parents *vs* hybrids were also found significant for all the traits under study except for sympodia per plant, fiber strength (g/tex), fiber fineness (mv) and phenol content (%).

For days to 50% flowering, the parent which took minimum days was considered to be a better parent. For fiber fineness and gossypol content, the parent with minimal value was considered to be a better parent and accordingly heterosis were calculated. For these characters heterotic effects in the negative direction were desirable. The heterotic effects were desirable in a positive direction for all the remaining characters except mentioned above.

Plant Height. According to better parent heterosis, none of the hybrids showed significant and positive heterobeltiosis. While, as per the standard heterosis, best performing positively significant hybrids were GISV-323 × ARBC-1351 (19.16%), GJHV-566 × GSHV-213 (18.64%) and GJHV-566 × H 401/2014 (16.17%). Similar findings have also been reported by Ashokkumar and Ravikesavan (2013); Chhavikant *et al.* (2017); Gohil *et al.* (2017); Vavdiya *et al.* (2019); Richika *et al.* (2021) for standard heterosis only.

Days to 50% Flowering. The best performing negatively significant hybrids for days to 50% flowering as per better parent heterosis were GISV-323 × H-1452 (-8.80%), GISV-323 × GISV-216 (-8.00%) and GISV-323 × ARBC-1351 (-7.11%). Out of 30 hybrids, the best performing negatively significant hybrids for standard heterosis were GISV-323 × H 401/2014 (-12.44%), GISV-323 × GISV-216 (-11.33%) and GISV-323 × H-1452 (-10.78%). Similar findings have also been reported by Gohil *et al*. (2017).

Sympodia per Plant. For this trait, none of the hybrids showed significant positive heterosis over the better parent and only one hybrid GSHV-01/1338 × ARBC-1351 (28.35%) showed positively significant standard heterosis. It shows similarity for standard heterosis with the results of Ashokkumar and Ravikesavan (2013); Chhavikant *et al.* (2017); Gohil *et al*. (2017); Khokhar *et al*. (2018); Vavdiya *et al.* (2019).

Bolls per Plant. GJHV-566 × GSHV-213 (71.11%) had significant heterobeltiosis among 30 cross combinations, followed by GISV-323 × ARBC-1351 (67.88%) and GSHV-01/1338 × ARBC-1351 (59.44%) while for standard heterosis only two hybrids *viz* ., GSHV-01/1338 × ARBC-1351 (51.19%) and GJHV-566 × GSHV-213 (42.50%) exhibited significant heterosis for this trait. The present findings are in fidelity with the reports of Ashokkumar and Ravikesavan (2013); Chhavikant *et al.* (2017); Khokhar *et al*. (2018); Vavdiya *et al.* (2019); Richika *et al*. (2021).

Boll Weight (g). Hybrid GSHV-01/1338 × Phule Yamuna (21.51%) and GISV-323 × BS-27 (10.06%) exhibited significant heterobeltiosis. GISV-323 × BS-27 (28.52%), GISV-323 × GISV-216 (18.46%) and GISV-323 × H 401/2014 (16.95%) were the top three hybrids with positive and significant standard heterosis. Similar results also reported by Ashokkumar and Ravikesavan (2013); Chhavikant *et al.* (2017); Khokhar *et al*. (2018); Richika *et al*. (2021).

Seed Cotton Yield per Plant. For Seed cotton yield per plant, eight hybrids exhibited positive and significant heterobeltiosis. The hybrid GSHV-01/1338 × ARBC-1351 has the highest heterobeltiosis (81.45%), followed by GSHV-01/1338 × H 401/2014 (51.08%) and GJHV-566 × GSHV-213 (50.75%). Four cross combinations exhibited significant and positive standard heterosis *viz.*, GJHV-566 × GSHV-213 (51.16%), GSHV-01/1338 × ARBC-1351 (48.11%), GISV-323 × G. Cot-16 (39.07%) and GISV-323 × ARBC-1351 (36.26%). Similar results also reported by Ashokkumar and Ravikesavan (2013); Chhavikant *et al.* (2017); Gohil *et al.* (2017); Khokhar *et al*. (2018); Pavitra *et al.* (2019); Rani *et al*. (2020); Richika *et al*. (2021).

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 5.

Ginning Outturn (%). Five crosses, GISV-323 × GISV-216 (11.41%), GISV-323 × G. Cot-16 (11.19%), GISV-323 × H 401/2014 (10.28%), GISV-323 × Phule Yamuna (8.98%) and GISV-323 × GSHV-213 (5.56%), showed considerable and positive heterobeltiosis. Out of 30 cross combinations, GSHV-01/1338 × G. Cot-16 (17.72%) exhibited the highest desirable heterosis followed by GISV-323 × GISV-216 (17.38%) and GISV-323 × G. Cot-16 (17.06%). Similar results were also reported by Richika *et al.* (2021).

Seed Index (g). The GISV-323 × GSHV- 213 cross had the largest heterosis over the better parent (21.68%), followed by GJHV-566 × GISV-216 (14.78%) and

GISV-323 × BS-27 (12.93%). The top three hybrids, GISV-323 × GSHV-213 (16.30%), GISV-323 × BS-27 (9.85%) and GJHV-566 × GISV-216 (7.75%), showed considerable and positive standard heterosis in the desired direction among the 30 hybrids. Chhavikant *et al.* (2017); Gohil *et al.* (2017); Pavitra *et al.* (2019); reported similar results.

Fiber Length (mm). Only one cross (GSHV-01/1338 × BS-27) outperformed both the superior parent and the standard check in terms of heterosis. Ashokkumar and Ravikesavan (2013); Lingaraja *et al*. (2017); Khokhar *et al*. (2018); Pavitra *et al.* (2019) also recorded similar results.

Fiber Strength (g/tex). Among 30 hybrids, significant heterobeltiosis was observed only in one cross GSHV-01/1338 × GSHV-213 (4.14%). None of the hybrids showed significant and positive standard heterosis for this trait. Lingaraja *et al*. (2017); Khokhar *et al*. (2018); also recorded similar results.

Fiber Fineness (mv). GJHV-566 × BS-27 (-9.49%) revealed significant and negative heterosis over the better parent out of 30 hybrids. None of the hybrids possesses significant and negative value for fiber fineness as per standard heterosis. Similar results have been reported by Ashokkumar and Ravikesavan (2013); Lingaraja *et al.* (2017).

Oil Content (%). Eleven crosses out of 30 exhibited positive and significant heterosis over the superior parent. Among them, the top three were GSHV-01/1338 × H-1452 (29.71%), GSHV-01/1338 × GISV-216 (28.48%) and GJHV-566 × ARBC-1351 (23.97%). Nineteen hybrids out of the thirty exhibited positive and significant value for this trait. Among them, the top three were GISV-323 × Phule Yamuna (44.56%), GJHV-566 × ARBC-1351 (44.54%) and GSHV-01/1338 × Phule Yamuna (44.14%). Ashokkumar and Ravikesavan (2013); Vekariya *et al.* (2017) also recorded similar results.

Gossypol Content (%). Nine crosses showed significant and negative heterosis for both over better parent and standard check for gossypol content. Out of 30 hybrids, top three hybrids for heterobeltiosis were GISV-323 × ARBC-1351 (-19.05%), GISV-323 × H-1452 (-11.94%) and GISV-323 × GSHV-213 (-8.59%). The cross GISV-323 × H 401/2014 (-5.77%) had the greatest desirable standard heterosis, followed by cross GSHV-01/1338 × GSHV-213 (-5.16%) and GSHV-01/1338 × DELTA-15 (-5.00%). Ramani *et al*. (2017); Vekariya *et al.* (2017) also recorded similar results.

Protein Content (%). Out of the thirty crosses, eleven were significant and positive for heterobeltiosis, while ten were significant and positive for standard heterosis for this trait. Top three hybrids, *viz.*, GISV-323 × TCH-1716 (29.04%), GSHV-01/1338 × H 401/2014 (28.13%) and GJHV-566 × H 401/2014 (24.51%) recorded positive and significant heterobeltiosis. Hybrids GSHV-01/1338 × H 401/2014 (24.64%) followed by GISV-323 × TCH-1716 (22.93%) and GJHV-566 × H 401/2014 (21.11%) exhibited positive standard heterosis. Ashokkumar and Ravikesavan (2013); Vekariya *et al.* (2017) also recorded similar results.

Phenol Content (%). The cross GISV-323 ×G. Cot-16 (36.57%), followed by GJHV-566 × H-1452 (33.99%) and GISV-323 × Phule Yamuna (16.66%) had significant heterobeltiosis. The cross GISV-323 × G. Cot-16 had the highest standard heterosis (33.14%), followed by GJHV-566 × H-1452 (32.84%) and GSHV-01/1338 × H-1452 (31.71%). Balakrishnan (2006) reported similar findings.

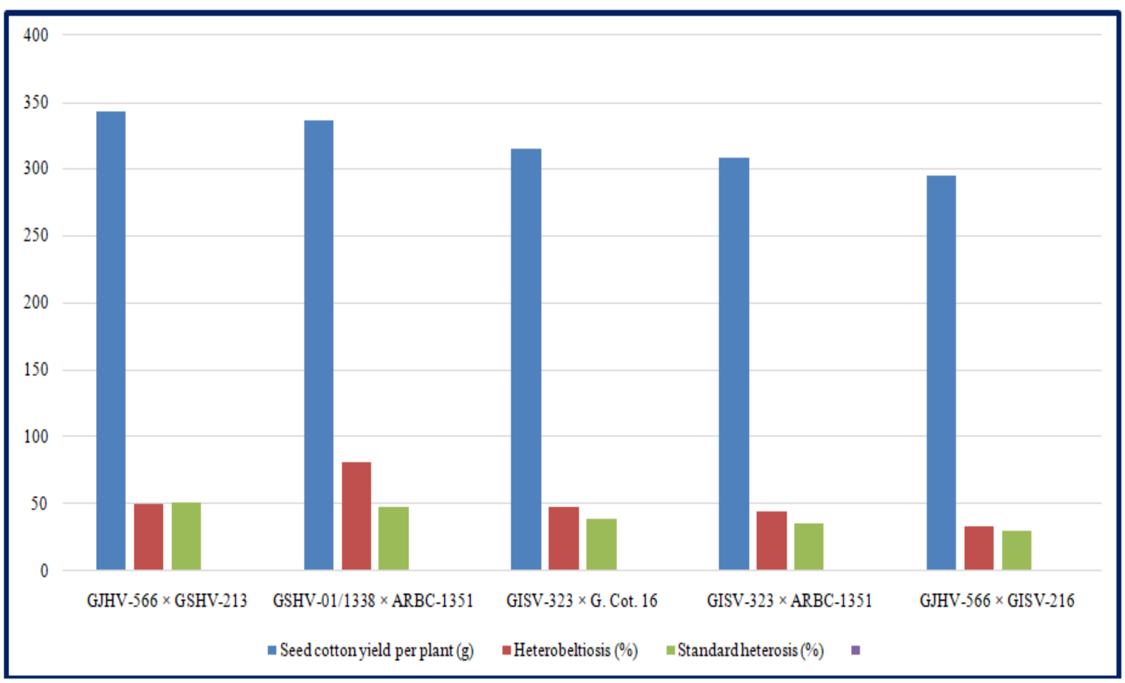

Fig. 1. Heterobeltiosis and standard heterosis of top five crosses for seed cotton yield per plant.

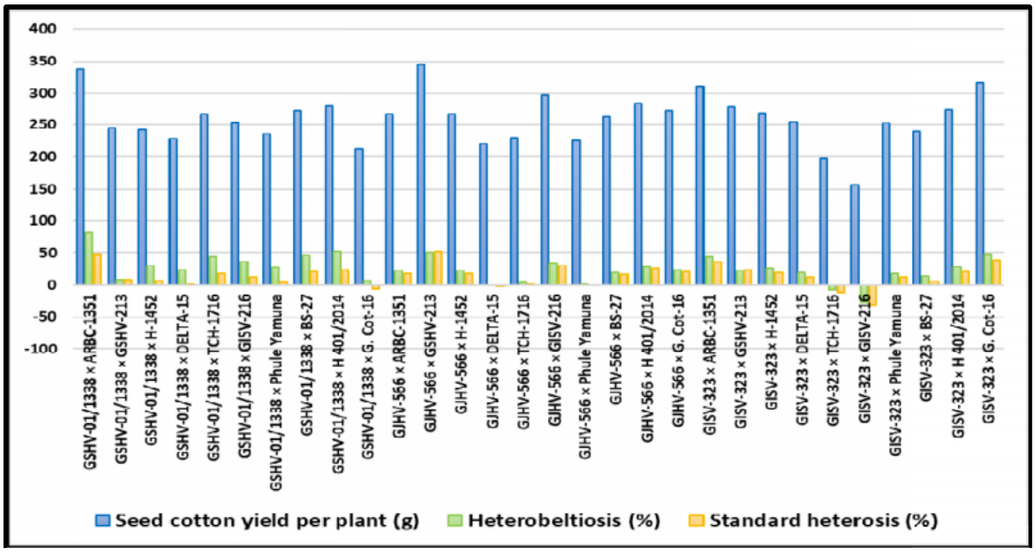

Fig 2. Heterobeltiosis and standard heterosis of all hybrids for seed cotton yield per plant.

Table 1: Analysis of variance for experimental design for different traits in cotton.

Source of variation	df	Plant height (cm)	Days to 50% flowering	Sympodia per plant	Bolls per plant	Boll weight (g)	Seed cotton yield per plant (g)	Ginning outturn (%)
Replications	2	85.90	8.85	26.44*	323.54	0.46**	1689.65	2.74
Treatments	42	956.36**	13.43**	11.30	683.73**	0.72**	8724.60**	9.86**
(a) Parents	12	1726.66**	10.92*	12.11	232.01	0.96**	3211.23	13.39**
i Females	2	243.69	4.46	31.70*	98.36	1.98**	1086.19	7.65**
ii Males	9	1252.36**	13.12**	8.31	213.70	0.82**	2749.01	14.19**
iii Females *vs* Males	1	8961.23**	4.03	7.11	664.12*	0.13	11621.36*	17.66**
Parents *vs* Crosses	1	6124.53**	118.91**	7.13	15689.96**	2.35**	191987.27**	99.12**
Crosses	29	459.41**	10.83**	11.11	353.19**	0.56**	4686.60**	5.32**
Error	84	183.51	4.55	8.40	124.98	0.07	2021.66	1.37

Source of variation	df	Seed index (g)	Fiber length (mm)	Fiber strength (g/tex)	Fiber fineness (mv)	Oil content (%)	Gossypol content (%)	Protein content (%)	Phenol content (%)
Replications	2	0.03	7.65**	38.85**	1.81**	0.06	0.00**	11.27**	0.01**
Treatments	42	3.07**	1.64**	1.31**	0.3**	17.46**	0.00**	16.05**	0.02**
(a) Parents	12	1.48**	1.44*	2.16**	0.53**	10.08**	0.01**	2.93	0.00**
i Females	2	1.02**	1.55	5.62**	0.58**	9.02**	0.02**	5.73	0.03**
ii Males	9	1.54**	1.48	1.62**	0.58**	11.33**	0.01**	0.60	0.00**
iii Females *vs* Males	1	1.86**	0.81	0.11	0.00	0.94	0.01**	18.21**	0.00**
Parents *vs* Crosses	1	1.81**	6.26**	0.13	0.04	20.32**	0.03**	30.97**	0.00
Crosses	29	3.77**	1.57**	1.00**	0.21**	20.41**	0.00**	20.97**	0.03**
Error	84	0.06	0.76	0.42	0.07	0.55	0.00	1.86	0.00

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

Table 2: Estimation of heterobeltiosis (HB) and standard heterosis (SH) for plant height (cm), days to 50% flowering, sympodia per plant, bolls per plant and boll weight (g) in cotton.

Sr. No.	Crosses	Plant height (cm)		Days to 50% flowering		Sympodia per plant		Bolls per plant		Boll weight (g)	
		HB	SH	HB	SH	HB	SH	HB	SH	HB	SH
1.	GSHV-01/1338 × ARBC-1351	-10.23	6.69	-4.52	-6.93*	2.66	28.35*	59.44**	51.19**	0.00	-1.34
2.	GSHV-01/1338 × GSHV-213	-8.06	9.27	-5.68	-8.58**	-12.52	9.37	20.59	14.35	-12.84*	-2.01
3.	GSHV-01/1338 × H-1452	-10.83	5.97	-2.26	-4.73	-7.65	15.46	31.66	24.85	-3.02	-13.76*
4.	GSHV-01/1338 × DELTA-15	-11.96*	4.63	-1.13	-3.62	-18.44	1.97	30.43	23.68	7.59	-14.43*
5.	GSHV-01/1338 × TCH-1716	-6.67	10.92	-1.73	-6.38*	-17.23	3.48	29.79	23.07	1.24	-4.19
6.	GSHV-01/1338 × GISV-216	-15.68**	0.21	-5.71	-9.13**	-19.33*	0.85	34.01*	27.08	-12.12*	-12.42*
7.	GSHV-01/1338 × Phule Yamuna	-5.98	11.74	1.79	-5.83*	-9.15	13.58	23.39	17.01	21.51**	-8.05
8.	GSHV-01/1338 × BS-27	-25.04**	-10.92	-6.21*	-8.58**	-20.30*	-0.35	9.13	3.48	-2.16	14.26*
9.	GSHV-01/1338 × H 401/2014	-5.63	12.15	-0.59	-6.93*	-16.87	3.94	35.65*	28.63	3.01	-2.52
10.	GSHV-01/1338 × G. Cot-16	-10.40	6.49	-4.52	-6.93*	-17.13	3.61	21.51	15.22	-6.40	-17.79**
11.	GJHV-566 × ARBC-1351	-4.21	3.19	-1.17	-6.93*	2.38	9.35	48.31*	23.51	-7.63	-4.53
12.	GJHV-566 × GSHV-213	8.88	18.64*	7.60*	1.33	-5.33	-0.73	71.11**	42.50**	-4.18	7.72

13.	GJHV-566 × H-1452	-2.29	5.25	4.68	-1.42	0.65	10.83	49.02**	24.10	-7.63	-4.53
14.	GJHV-566 × DELTA-15	-8.41	-1.34	4.68	-1.42	-1.77	-5.07	11.60	-7.06	3.08	6.54
15.	GJHV-566 × TCH-1716	-1.72	5.87	2.92	-3.07	-1.73	-5.03	14.90	-4.31	1.30	4.70
16.	GJHV-566 × GISV-216	-5.07	2.27	3.51	-2.52	-6.47	-9.61	41.12*	17.53	8.77	12.42*
17.	GJHV-566 × Phule Yamuna	-5.83	1.44	0.00	-7.48*	-7.43	5.89	19.05	8.22	-6.01	-2.85
18.	GJHV-566 × BS-27	-10.42	-3.50	0.58	-5.28	-3.77	-7.00	21.71	1.36	-0.57	16.11**
19.	GJHV-566 × H 401/2014	7.84	16.17*	-1.18	-7.48**	3.03	5.47	40.02*	16.61	2.11	5.54
20.	GJHV-566 × G. Cot-16	1.05	8.86	-1.17	-6.93*	7.12	3.52	41.09*	22.88	-6.98	-3.86
21.	GISV-323 × ARBC-1351	4.71	19.16**	-7.11*	-9.13**	8.36	15.74	67.88**	26.11	-5.95	8.72
22.	GISV-323 × GSHV-213	0.18	14.01*	0.57	-2.52	15.13	20.72	34.78	7.43	-0.73	14.77**
23.	GISV-323 × H-1452	-5.16	7.93	-8.80**	-10.78**	-16.42	-7.96	44.94*	8.88	-6.53	8.05
24.	GISV-323 × DELTA-15	-2.26	11.23	-3.17	-5.28	1.84	-3.45	39.91	5.10	-8.85	5.37
25.	GISV-323 × TCH-1716	-13.48*	-1.54	-1.73	-6.38*	-4.03	-9.14	7.26	-19.43	-7.69	6.71
26.	GISV-323 × GISV-216	-18.82**	-7.62	-8.00**	-11.33**	-0.28	-5.59	-23.69	-42.68**	2.47	18.46**
27.	GISV-323 × Phule Yamuna	-11.31	0.93	4.76	-3.07	-23.17*	-12.12	25.35	13.95	-15.09**	-1.85
28.	GISV-323 × BS-27	-19.10**	-7.93	-1.48	-3.62	7.30	1.58	10.18	-17.23	10.06*	28.52**
29.	GISV-323 × H 401/2014	-8.78	3.81	-6.47*	-12.44**	15.07	17.80	35.44	1.74	1.16	16.95**
30.	GISV-323 × G. Cot-16	0.90	14.83*	-4.30	-6.38*	21.63	15.94	48.52**	29.35	-7.11	7.38
SEd ±		11.33		1.72		2.36		9.09		0.22	
CD @ 5%		22.52		3.42		4.69		18.07		0.44	
CD@1%		29.84		4.54		6.21		23.94		0.59	
Range	Minimum	-25.4	-10.92	-8.80	-12.44	-23.17	-12.12	-23.69	- 42.68	-15.09	-17.79
	Maximum	8.88	19.16	7.60	1.33	21.63	28.35	71.11	51.19	21.51	28.52
Signi. crosses		06	05	06	18	03	01	12	00	05	11
Positive		00	05	01	00	00	01	12	02	02	07
Negative		06	00	05	18	03	00	00	01	03	04

Table 3: Estimation of heterobeltiosis (HB) and standard heterosis (SH) for seed cotton yield per plant (g), ginning outturn (%), seed index (g), fiber length (mm), fiber strength (g/tex) in cotton.

Sr. No.	Crosses	Seed cotton yield per plant(g)		Ginning outturn (%)		Seed index (g)		Fiber length (mm)		Fiber strength (g/tex)	
		HB	SH	HB	SH	HB	SH	HB	SH	HB	SH
1.	GSHV-01/1338 × ARBC-1351	81.45**	48.11*	-0.53	13.43**	1.91	-13.21**	1.43	-0.15	2.40	-1.84
2.	GSHV-01/1338 × GSHV-213	7.16	7.45	-2.34	14.40**	-6.51**	-13.04**	-1.19	-2.73	4.14*	-1.50
3.	GSHV-01/1338 × H-1452	30.59	6.59	0.20	16.01**	-11.50**	-25.02**	-2.05	-3.57	0.12	-2.30
4.	GSHV-01/1338 × DELTA-15	22.66	0.12	-0.39	13.58**	-2.64	-16.47**	-2.81	-4.10	2.82	-3.34
5.	GSHV-01/1338 × TCH-1716	44.20*	17.70	0.55	14.95**	-10.61**	-15.04**	-1.96	-3.49	0.73	-4.15*
6.	GSHV-01/1338 × GISV-216	36.28	11.23	1.45	15.68**	8.87**	-7.75**	-2.42	-3.94	0.61	-4.49*
7.	GSHV-01/1338 × Phule Yamuna	27.00	3.66	-3.04	10.56**	0.39	-14.94**	-4.93*	-2.63	-1.62	-1.96
8.	GSHV-01/1338 × BS-27	46.60*	19.66	-7.51**	5.47	0.21	-2.53	7.74**	6.06*	-2.48	-4.95**
9.	GSHV-01/1338 × H 401/2014	51.08**	23.32	1.76	16.03**	-9.24**	-21.92**	-3.69	-5.19*	-4.88**	-3.34
10.	GSHV-01/1338 × G. Cot-16	6.15	-6.29	3.23	17.72**	-12.78**	-24.65**	1.19	-0.39	-0.61	-5.76**
11.	GJHV-566 × ARBC-1351	20.80	17.70	-1.35	12.27**	-2.37	-8.35**	3.80	-0.86	0.60	-3.57
12.	GJHV-566 × GSHV-213	50.75**	51.16*	0.40	11.29**	-3.58	-9.48**	3.35	1.14	0.49	-4.95**
13.	GJHV-566 × H-1452	20.80	17.70	-0.43	10.36**	-7.73**	-13.37**	-1.47	-5.89*	0.00	-2.42
14.	GJHV-566 × DELTA-15	-0.63	-3.17	1.11	12.07**	-3.12	-9.05**	0.89	-0.45	1.85	-4.72**
15.	GJHV-566 × TCH-1716	3.38	0.73	-11.49**	1.19	-4.76*	-9.48**	0.94	-2.03	-2.30	-7.03**
16.	GJHV-566 × GISV-216	33.46*	30.04	-2.71	7.83**	14.78**	7.75**	2.12	-1.56	-2.06	-7.03**
17.	GJHV-566 × Phule Yamuna	1.58	-1.03	-2.82	7.71**	-22.82**	-27.54**	-1.26	1.14	-0.81	-1.15
18.	GJHV-566 × BS-27	18.90	15.85	-2.30	8.29**	4.86*	2.00	4.01	0.90	-0.24	-2.76
19.	GJHV-566 × H 401/2014	27.94	24.66	3.43	14.64**	-3.19	-9.12**	-0.41	-4.16	-5.33**	-3.80*
20.	GJHV-566 × G. Cot-16	23.06	19.90	-2.15	8.45**	-11.27**	-16.70**	3.04	-0.74	0.12	-5.07**
21.	GISV-323 × ARBC-1351	44.56*	36.26*	0.00	13.81**	-31.64**	-34.66**	-3.55	-3.02	-6.24**	-4.84**
22.	GISV-323 × GSHV-213	22.02	22.34	5.56*	10.99**	21.68**	16.30**	-1.03	-0.48	-5.68**	-4.26*
23.	GISV-323 × H-1452	25.52	18.32	-0.12	8.49**	-0.59	-4.99*	-2.97	-2.44	-2.61	-1.15
24.	GISV-323 × DELTA-15	18.65	11.84	0.94	5.46	-12.15**	-16.03**	0.93	1.49	-3.63	-2.19
25.	GISV-323 × TCH-1716	-7.58	-12.88	-2.71	11.23**	7.66**	2.89	-0.47	0.08	-4.77**	-3.34
26.	GISV-323 × GISV-216	-27.33	-31.50*	11.41**	17.38**	-5.01*	-9.21**	-0.47	0.08	-1.36	0.12

27.	GISV-323 × Phule Yamuna	17.72	10.96	8.98**	13.85**	4.94*	0.30	-0.92	1.49	0.68	2.19
28.	GISV-323 × BS-27	12.05	5.62	4.25	8.91**	12.93**	9.85**	0.47	1.02	-3.29	-1.84
29.	GISV-323 × H 401/2014	27.46	20.15	10.28**	16.45**	-0.97	-5.36*	-0.12	0.43	-5.78**	-4.26*
30.	GISV-323 × G. Cot-16	47.54**	39.07*	11.19**	17.06**	-7.45**	-11.54**	1.17	1.72	-5.90**	-4.49*
SEd ±		36.42		0.95		0.22		0.72		0.53	
CD @ 5%		72.41		1.90		0.43		1.43		1.05	
CD@1%		95.95		2.52		0.57		1.89		1.40	
Range	Minimum	-27.33	-31.50	-11.49	1.19	-31.64	-34.66	-4.93	-5.89	-6.24	-7.03
	Maximum	81.45	51.16	11.41	17.72	21.68	16.30	7.74	6.06	4.14	2.19
Signi. crosses		09	05	07	27	20	26	02	03	09	14
Positive		08	04	05	27	07	00	01	01	01	00
Negative		01	01	02	00	13	23	01	02	08	14

Table 4: Estimation of heterobeltiosis (HB) and standard heterosis (SH) for fiber fineness (mv), Oil content (%), Gossypol content (%), Protein content (%) and Phenol content (%) in cotton.

Sr. No.	Crosses	Fiber fineness (mv)		Oil content (%)		Gossypol content (%)		Protein content (%)		Phenol content (%)	
		HB	SH	HB	SH	HB	SH	HB	SH	HB	SH
1.	GSHV-01/1338 × ARBC-1351	6.06	-1.41	13.40**	12.96**	-5.85**	-3.43*	-17.77**	-18.77**	-28.00**	-15.62**
2.	GSHV-01/1338 × GSHV-213	6.06	-1.41	-23.75**	-0.32	-7.54**	-5.16**	-22.03**	-21.87**	-27.98**	-15.60**
3.	GSHV-01/1338 × H-1452	-0.76	-7.75	29.71**	43.73**	-5.71**	-3.29*	-11.78*	-13.15*	12.39**	31.71**
4.	GSHV-01/1338 × DELTA-15	15.45**	0.00	-11.25**	14.04**	-7.38**	-5.00**	-13.85*	-12.03*	-31.31**	-19.50**
5.	GSHV-01/1338 × TCH-1716	10.61*	2.82	22.84**	21.37**	-0.04	-4.11**	18.17**	12.57*	-24.37**	-11.38**
6.	GSHV-01/1338 × GISV-216	21.21**	12.68**	28.48**	40.79**	3.89**	-1.10	-20.71**	-21.92**	-30.86**	-18.97**
7.	GSHV-01/1338 × Phule Yamuna	10.32	-2.11	19.22**	44.14**	2.78*	2.10	19.86**	18.04**	-22.50**	-9.18**
8.	GSHV-01/1338 × BS-27	9.09	1.41	-13.17**	12.57**	2.29*	-1.75	-11.80	-14.86*	-29.01**	-16.81**
9.	GSHV-01/1338 × H 401/2014	12.12*	4.23	-5.54	16.96**	0.55	-0.85	28.13**	24.64**	-12.51**	2.53
10.	GSHV-01/1338 × G. Cot-16	4.55	-2.82	-1.45	-2.63	11.70**	10.45**	-13.37*	-10.86	-31.36**	-19.57**
11.	GJHV-566 × ARBC-1351	6.77	0.00	23.97**	44.54**	0.56	0.27	-3.20	-4.38	-16.53**	-17.25**
12.	GJHV-566 × GSHV-213	-2.63	4.23	7.78*	40.89**	-1.26	-1.55	-6.00	-5.80	-8.17*	-8.96**
13.	GJHV-566 × H-1452	-5.26	1.41	-13.77**	0.53	2.63*	2.33**	-5.87	-7.33	33.99**	32.84**
14.	GJHV-566 × DELTA-15	30.08**	12.68**	-18.84**	4.30	-0.09	-0.38	-9.01	-7.09	-12.98**	-8.55**
15.	GJHV-566 × TCH-1716	3.45	5.63	17.30**	36.75**	1.83	-2.32*	5.16	2.18	-31.50**	-32.08**
16.	GJHV-566 × GISV-216	-0.63	10.56*	-12.74**	1.73	1.95	-2.95*	9.51	7.84	-11.90**	-12.66
17.	GJHV-566 × Phule Yamuna	7.94	-4.23	6.69	28.99**	0.08	-0.58	9.35	7.68	-22.81**	-23.47
18.	GJHV-566 × BS-27	-9.49*	0.70	5.35	36.57**	4.46**	0.34	24.50**	20.97**	-3.70	-3.86
19.	GJHV-566 × H 401/2014	15.94**	12.68**	-17.52**	2.13	0.90	-0.51	24.51**	21.11**	-6.16	-6.97*
20.	GJHV-566 × G. Cot-16	-5.48	-2.82	-16.25**	-2.36	-2.00	-3.09*	-5.38	-2.64	3.98	3.08
21.	GISV-323 × ARBC-1351	3.01	-3.52	-3.82	17.05**	-19.05**	-1.51	14.44*	13.05*	11.02**	-0.83
22.	GISV-323 × GSHV-213	9.93*	9.15	9.33**	42.92**	-8.59**	-2.03	16.36**	16.61**	11.79**	7.85*
23.	GISV-323 × H-1452	9.22	8.45	6.83	30.01**	-11.94**	-0.65	3.69	2.08	-4.74	-15.81**
24.	GISV-323 × DELTA-15	6.50	-7.75	-23.58**	-1.80	-2.59*	0.67	5.11	7.33	-15.96**	-11.68**
25.	GISV-323 × TCH-1716	-2.13	-2.82	-16.12**	2.08	2.55*	-1.62	29.04**	22.93**	-8.54*	-16.68**
26.	GISV-323 × GISV-216	0.00	-0.70	-14.14**	4.48	3.26*	-1.71	15.59**	13.83**	7.67*	0.32
27.	GISV-323 × Phule Yamuna	13.49*	0.70	18.79**	44.56**	-0.87	-1.53	4.86	3.27	16.66**	8.07*
28.	GISV-323 × BS-27	2.13	1.41	9.82**	42.37**	11.57**	7.17**	12.52*	8.61	-2.23	-2.39
29.	GISV-323 × H 401/2014	5.80	2.82	6.31	31.62**	-4.43**	-5.77**	17.52**	14.32*	11.14**	2.55
30.	GISV-323 × G. Cot-16	3.55	2.82	-19.06**	-1.50	-0.07	-1.18	-4.84	-2.08	36.57**	33.14**
SEd ±		0.23		0.63		0.01		1.11		0.02	
CD @ 5%		0.45		1.26		0.02		2.21		0.05	
CD@1%		0.59		1.67		0.03		2.93		0.06	
Range	Minimum	-9.49	-7.75	-23.75	-2.63	-19.05	-5.77	-22.03	-21.92	-31.50	-32.08
	Maximum	30.08	12.68	29.71	44.56	11.70	10.45	29.04	24.64	36.57	33.14
Signi. cross		09	04	23	19	18	04	17	16	25	23
Positive		08	04	11	19	09	04	11	10	08	05
Negative		01	00	12	00	09	00	06	06	17	18

* 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 cotton.

Best crosses ($P_1 \times P_2$)	Mean yield/plant (g)	Better parent heterosis (%)	Standard heterosis (%)	Significant standard heterosis of other yield attributing traits in desired direction
GJHV-566 × GSHV-213	343.89	50.75**	51.16**	Plant height, Bolls per plant, Ginning outturn, Oil content
GSHV-01/1338 × ARBC-1351	336.94	81.45**	48.11**	Days to 50% flowering, Sympodia per plant, Bolls per plant, Ginning outturn, Oil content, Gossypol content
GISV-323 × G. Cot-16	316.39	47.54**	39.07*	Plant height, Days to 50% flowering, Ginning outturn, Phenol content
GISV-323 × ARBC-1351	310.00	44.56*	36.26*	Plant height, Days to 50% flowering, Ginning outturn, Oil content, Protein content
GJHV-566 × GISV-216	295.83	33.46*	30.04	Boll weight, Ginning outturn, Seed index, Gossypol content

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

CONCLUSIONS

The current analysis revealed significant amounts of both desired heterobeltiosis and standard heterosis for various traits. These imply the potential for cotton improvement through heterosis breeding. Top-ranking crosses based on per se performance and standard heterosis were nearly identical, although heterobeltiosis resulted in a slight difference. Since better parent heterosis is less reliable, ranking based on standard heterosis is more reliable.

FUTURE SCOPE

Out of 30 crosses, four crosses *viz*., GJHV-566 × GSHV-213, GSHV-01/1338 × ARBC-1351, GISV-323 × G. Cot-16 and GISV-323 × ARBC-1351 recorded positive and significant standard heterosis for seed cotton yield per plant. Therefore, such cross combinations may be recommended for commercial cultivation as hybrids or further production of more desirable recombinants and superior varieties.

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