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Estimation of heterobeltiosis and standard heterosis for seed cotton yield and its component traits in upland cotton (*Gossypium hirsutum* L.)

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Abstract

A diallel analysis was designed aiming towards the identification of best heterotic crosses for seed cotton yield and its component traits in upland cotton (*Gossypium hirsutum* L.). The present study was conducted at Cotton Research Station, Junagadh Agricultural University, Junagadh during *kharif* 2017 in a randomized block design with three replications. Forty five crosses obtained by crossing 10 x 10 half diallel were evaluated for 6 biometric traits with their parents and check (GN.Cot.Hy-14). The analysis of variance revealed significant differences among the mean squares due to genotypes, parents, hybrids and parents Vs hybrids for all the characters except parents Vs hybrids for days to 50 per cent boll bursting, plant height and seed index suggesting the presence of considerable amount of genetic variability among the parents and the material which was most useful for the study of manifestation of heterosis and genetic parameters involved in the inheritance of different traits studied. Based on study of heterobeltiosis, it was found that number of sympodia per plant and numbers of bolls per plant were main contributors towards increase in heterotic effects for seed cotton yield per plant. Four crosses *viz.*, GJHV-503 x GJHV-515, GISV-267 x GJHV-517, GJHV-517 x GJHV-522 and GJC-101 x Deviraj were best heterotic crosses over standard check for seed cotton yield per plant. These cross combination may utilize for further improvement to develop high yielding genotypes after due testing.

Keywords: Cotton, diallel, *Gossypium hirsutum*, heterobeltiosis, standard heterosis, seed cotton yield

Introduction

Cotton is a multipurpose crop that supplies five basic products *viz.*, seed, lint, oil, hulls and linters. The seeds are being used for growing crop and also as feed for animal, lint is used in textile industry, linters for various industrial uses, refined cotton seed oil is used for human consumption and cotton seed meal as fertilizer as well as livestock feed. Cotton is commercially cultivated in nearly 77 countries across the globe with India, China, United States, Pakistan and Brazil being five of the largest producers of cotton. India is the only country where all the four cultivated species of cotton are grown on commercial scale and covers cultivated area about 122.35 lakh hectares. It occupies first position in production with 377.00 lakh bales (each of 170 kg) among all cotton producing countries. Average productivity of India is 524 kg per ha which is much lower as compared to the world average productivity of 792 kg per ha. Gujarat is the second largest cotton growing state with acreage of 26.18 lakh hectares and largest cotton producing state of India with production of 104.00 lakh bales. The average productivity of cotton in the state is 675 kg per ha which is higher than national productivity (Anon., 2017-18).

To meet challenges of increasing productivity, *Gossypium hirsutum* offers better scope for genetic improvement among four cultivated species of cotton. Majority of cotton produced by *Gossypium hirsutum* species is of medium and long staple length. This species has a very high adaptability with rich diversity for yield and yield related components. On account of its versality, the area under cultivation has increased tremendously in most cotton growing countries in the world with no exception to India and has created and increased in research on cultivation of *Gossypium hirsutum* species.

Exploiting hybrid vigour in a single cross hybrid depends on the two parents complementing each other with special reference to desirable characters. However, it is often noticed that all the desirable characters need not to be distributed between only these two parents. Therefore, it might be necessary to involve multiple cross combinations of parents to have wider genetic content and thus broaden the genetic base. Therefore, the exploitation of hybrid vigour in cotton has been recognized as a practical tool in providing the breeder a means of increasing yield and other economic characters. Most of the local varieties which are grown by farmers in India have not been fully utilized in any genetic improvement programme on scientific line.

The development of an effective heterosis breeding programme in cotton needs to elucidate the genetic nature and magnitude of quantitatively inherited traits and judge the potentiality of parents in hybrid combinations.
The intent of present study is to exploit the heterosis for seed cotton yield and component traits by using half diallel mating design in *hirsutum* cotton for meet the future challenges.

Materials and methods
The experimental materials comprised of ten promising genotypes of *hirsutum* cotton *viz.,* G.Cot-10, GISV-267, GJHV-503, GJHV-515, GJHV-517, GJHV-522, GJC-101, Deviraj, GJHV-510 and 76IH20. Which was were used in diallel mating design to prepare forty five hybrids at Cotton Research Station, Junagadh Agricultural University, Junagadh during *kharif*-2016. Thus the experimental material consisted of 56 entries, comprising of ten genotypes, their forty five hybrids and one check *viz.* GN.Cot.Hy-14. This was evaluated for heterosis analysis in *kharif*-2017 at same place with single row length of 6 meter, consisting 14 plants in each row with 45 centimeter intra row spacing and 120 centimeter inter row spacing. All the agronomic and plant protection practices were uniformly applied throughout the crop growth period to raise a good crop.
Five competitive plants from each entry excluding border plants were randomly selected to record the observations on plant height, number of monopodia per plant, number of sympodia per plant, number of bolls per plant, boll weight and seed cotton yield per plant. Analysis of variance technique suggested by [9] was followed to test the difference between genotypes for all the characters under study. Heterosis was estimated in terms of two parameters, *i.e.* heterobeltiosis [3] and standard heterosis [6].

Result and discussion
The character-wise data of parents and hybrids were subjected to analysis of variance for the experimental design. Analysis of variance for different characters is presented in Table1. Perusal of data revealed highly significant mean squares due to genotypes for all the characters indicating that experimental material had sufficient genetic variability for all the characters under investigation. The genotypic variance was further partitioned into variance due to parents, hybrids and parents Vs hybrids. The mean square due to parents as well as hybrids was also highly significant for all the characters except mean square due to plant height for hybrids.
Mean square due to parents Vs hybrids were highly significant for all the traits except plant height, indicating that the performance of hybrids as a group was different than that of parents for most of the characters. This revealed the presence of considerable heterosis due to directional dominance. The estimates of heterobeltiosis (HB) was ranged from -38.33 per cent (GISV-267 x Deviraj) to 14.86 per cent (GJC-101 x 76IH20) for plant height, -86.67 per cent (GJHV-522 x 76IH20) to 20.00 per cent (G.Cot-10 x GISV-267) for number of monopodia per plant, -15.83 per cent (GJHV-515 x Deviraj) to 46.86 per cent (Deviraj x 76IH20) for number of sympodia per plant, -32.12 per cent (GJC-101 x 76IH20) to 92.63 per cent (GJHV-503 x GJHV-522) for number of bolls per plant, -21.09 per cent (GJHV-510 x 76IH20) to 19.78 per cent (G.Cot-10 x GJC-101) for average boll weight and -42.86 per cent (GJHV-510 x 76IH20) to 96.06 per cent (GJHV-503 x GJHV-522) for seed cotton yield per plant (Table 2,3,4 and 5). Several hybrids exhibited significant and desirable (positive) heterobeltiosis in desirable direction for studied characters *i.e.* number of monopodia per plant (4), number of sympodia per plant (20), number of bolls per plant (10), boll weight (3) and for seed cotton yield per plant (23). While, none of the hybrids registered significant and positive heterobeltiosis for plant height. The heterotic response over better parent was also reported by [2,4,5,6,7,8,10,11,12,13,14,15].
Improvement in seed cotton yield in one of most important breeding objective of plant breeder. So the superiority of hybrids over best cultivated hybrid is essential for increasing its commercial value. The estimates of standard heterosis (SH) was ranged from -21.69 per cent (GJHV-522 x 76IH20) to 3.10 per cent (GISV-267 x GJHV-515) for plant height, -95.65 per cent (GJHV-522 x 76IH20) to 43.48 per cent (GJC-101 x Deviraj) for number of monopodia per plant, -25.63 per cent (GISV-267 x Deviraj) to 13.29 per cent (GJHV-503 x GJHV-515) for number of sympodia per plant, -51.47 per cent (GJHV-510 x 76IH20) to 31.16 per cent (GJC-101 x Deviraj) for number of bolls per plant, -15.22 per cent (GJHV-510 x 76IH20) to 12.54 per cent (GISV-267 x 76IH20) for average boll weight and -70.00 per cent (GJHV-510 x 76IH20) to 25.00 per cent (GJHV-503 x GJHV-515) for seed cotton yield per plant. Out of 45 hybrids, several hybrids exhibited significant and desirable (positive) standard heterosis for studied characters *i.e.* number of monopodia per plant (8), number of sympodia per plant (3), number of bolls per plant (6), boll weight (4) and seed cotton yield per plant (4). While, none of the hybrids registered significant and desirable (positive) standard heterosis for plant height. As observed in present investigation, several workers [2,4,5,6,7,8,10,11,12,13,14,15] had also reported considerable degree of standard heterosis for seed cotton yield per plant and its component traits.

Conclusion
On the basis of heterosis analysis, four hybrids depicted significant and desirable (positive) heterosis over check (GN.Cot.Hy-14) for seed cotton yield per plant *viz.*, GJHV-503 x GJHV-515 (25.00%), GISV-267 x GJHV-517 (18.54%), GJHV-517 x GJHV-522 (17.92%) and GJC-101 x Deviraj (17.92%). These hybrids also depicted significant and desirable (positive) heterosis over their respective better parent. The high heterotic response of these hybrids was resulted due to positive heterosis of yield attributing character number of bolls per plant. The heterotic effect for seed cotton yield per plant can be considered as outcome of direct effect of this attributes and indirect effects of the other yield contributing characters like, plant height, number of monopodia per plant, number of sympodia per plant and boll weight. Therefore, heterotic effects for seed cotton yield per plant could be a result of combinational heterosis. Therefore, these four crosses could be exploited for heterosis breeding programme to boost the seed cotton yield in cotton after due testing.

Table 1: Analysis of variance (mean squares) for various characters in cotton

Source of variation	d. f.	PH	NMP	NSP	NBP	BW	SCYP
Replications	2	820.19*	0.01	0.74	4.13	0.05	222.32
Treatment	54	284.79*	2.99**	12.04**	234.54**	0.33**	3918.50**
Parents	9	1112.17**	3.28**	9.85**	314.58**	0.60**	3501.86**
Hybrids	44	118.57	2.98**	9.08**	169.67**	0.25**	2721.40**
Parent Vs Hybrid	1	152.04	0.85**	161.79**	2368.40**	1.80**	60340.66**
Error	108	183.05	0.06	1.22	31.75	0.06	289.71
Total	164	224.32	1.02	4.78	98.19	0.15	1483.76

*, ** significant at 5 per cent and 1 per cent levels of probability, respectively

PH = plant height (cm)	NMP = Number of monopodia per plant
NSP = Number of sympodia per plant	NBP = Number of bolls per plant
BW = Boll weight (g)	SCYP = Seed cotton yield per plant (g)

Table 2: The estimates of heterosis over BP and SC for different character in cotton

S. No.	Crosses	Plant height (cm)		Number of monopodia per plant	
		H (%)	SH (%)	H (%)	SH (%)
1	G.Cot-10 x GISV-267	-30.83**	-6.48	20.00**	17.39*
2	G.Cot-10 x GJHV-503	2.32	-0.56	0.00	-2.17
3	G.Cot-10 x GJHV-515	-0.31	-8.45	-4.17	0.00
4	G.Cot-10 x GJHV-517	1.54	-7.32	-8.89	-10.87
5	G.Cot-10 x GJHV-522	0.00	-8.73	-40.00**	-41.30**
6	G.Cot-10 x GJC-101	2.16	-6.76	5.26	30.43**
7	G.Cot-10 x Deviraj	-8.33	-16.34	-2.17	-2.17
8	G.Cot-10 x GJHV-510	0.30	-6.76	-31.11**	-32.61**
9	G.Cot-10 x 76IH20	8.33	-1.13	-60.00**	-60.87**
10	GISV-267 x GJHV-503	-31.67**	-7.61	-26.67**	-28.26**
11	GISV-267 x GJHV-515	-23.75**	3.10	0.00	4.35
12	GISV-267 x GJHV-517	-30.42**	-5.92	-11.11	-13.04*
13	GISV-267 x GJHV-522	-31.67**	-7.61	-15.56*	-17.39**
14	GISV-267 x GJC-101	-37.08**	-14.93	5.26	30.43**
15	GISV-267 x Deviraj	-38.33**	-16.62	-8.70	-8.70
16	GISV-267 x GJHV-510	-31.46**	-7.32	-8.89	-10.87
17	GISV-267 x 76IH20	-33.33**	-9.86	-40.00**	-41.30**
18	GJHV-503 x GJHV-515	-1.16	-3.94	-35.42**	-32.61**
19	GJHV-503 x GJHV-517	-6.67	-9.30	20.00	-21.74**
20	GJHV-503 x GJHV-522	-2.61	-5.35	-30.00**	-54.35**
21	GJHV-503 x GJC-101	-4.06	-6.76	-26.32**	-8.70
22	GJHV-503 x Deviraj	-7.25	-9.86	15.22*	15.22*
23	GJHV-503 x GJHV-510	-5.51	-8.17	-20.00	-47.83**
24	GJHV-503 x 76IH20	-6.67	-9.30	-13.33	-43.48**
25	GJHV-515 x GJHV-517	-5.20	-12.68	-17.78*	-19.57**
26	GJHV-515 x GJHV-522	-7.65	-14.93	-2.22	-4.35
27	GJHV-515 x GJC-101	-1.53	-9.30	5.26	30.43**
28	GJHV-515 x Deviraj	-1.83	-9.58	17.39*	17.39*
29	GJHV-515 x GJHV-510	-1.21	-8.17	-20.00**	-21.74**
30	GJHV-515 x 76IH20	-14.68	-21.41*	-73.33**	-73.91**
31	GJHV-517 x GJHV-522	6.23	-3.94	-36.67**	-58.70**
32	GJHV-517 x GJC-101	-0.93	-10.42	-14.04*	6.52
33	GJHV-517 x Deviraj	1.56	-8.17	10.87	10.87
34	GJHV-517 x GJHV-510	2.73	-4.51	3.33	-32.61**
35	GJHV-517 x 76IH20	9.66	-0.85	10.00	-28.26**
36	GJHV-522 x GJC-101	-8.81	-18.31*	-15.39**	4.35
37	GJHV-522 x Deviraj	-5.03	-14.93	17.39*	17.39*
38	GJHV-522 x GJHV-510	-3.03	-9.86	-85.19**	-91.30**
39	GJHV-522 x 76IH20	-12.58	-21.69*	-86.67**	-95.65**
40	GJC-101 x Deviraj	0.00	-17.18	10.00	43.48**
41	GJC-101 x GJHV-510	2.42	-9.30	-18.33**	6.52
42	GJC-101 x 76IH20	14.86	-4.23	-40.00**	-21.74**
43	Deviraj x GJHV-510	-1.21	-8.17	-2.22	-4.35
44	Deviraj x 76IH20	2.36	-14.65	-31.11**	-32.61**
45	GJHV-510 x 76IH20	-5.76	-12.39	-60.00**	-73.91**
	S.E. (d) ±	11.04	11.04	0.20	0.20

*, ** significant at 5 per cent and 1 per cent levels of probability, respectively

Table 3: The estimates of heterosis over BP and SC for different character in cotton

S. No.	Crosses	Number of sympodia per plant		Number of bolls per plant	
		H (%)	SH (%)	H (%)	SH (%)
1	G.Cot-10 x GISV-267	0.93	-16.38**	24.91*	12.71
2	G.Cot-10 x GJHV-503	1.38	-14.84**	27.78*	6.98
3	G.Cot-10 x GJHV-515	-6.12	-11.37*	-7.21	9.77
4	G.Cot-10 x GJHV-517	14.98*	0.58	9.26	-8.53
5	G.Cot-10 x GJHV-522	4.42	-9.06	20.00	0.47
6	G.Cot-10 x GJC-101	14.07*	-12.52*	-8.58	-7.44
7	G.Cot-10 x Deviraj	10.26	-17.15**	-4.16	-17.83
8	G.Cot-10 x GJHV-510	15.38*	-13.29*	-4.07	-19.69
9	G.Cot-10 x 76IH20	10.26	-17.15**	-32.04*	-43.10**
10	GISV-267 x GJHV-503	15.14*	-3.28	7.69	-2.33
11	GISV-267 x GJHV-515	4.08	-1.73	-17.30	-2.17
12	GISV-267 x GJHV-517	23.79**	8.29	39.49**	26.51**
13	GISV-267 x GJHV-522	5.31	-8.29	16.92	6.05
14	GISV-267 x GJC-101	3.81	-15.99**	-8.88	-7.75
15	GISV-267 x Deviraj	-8.10	-25.63**	12.14	1.71
16	GISV-267 x GJHV-510	10.95	-10.21*	20.85	9.61
17	GISV-267 x 76IH20	-7.14	-24.86**	-0.51	-9.77
18	GJHV-503 x GJHV-515	20.00**	13.29*	8.52	28.37**
19	GJHV-503 x GJHV-517	26.43**	10.60*	45.00**	12.40
20	GJHV-503 x GJHV-522	27.88**	11.37*	92.63**	21.55*
21	GJHV-503 x GJC-101	16.00**	0.58	9.95	11.32
22	GJHV-503 x Deviraj	15.11*	-0.19	33.45**	14.42
23	GJHV-503 x GJHV-510	-3.11	-15.99**	66.51**	8.68
24	GJHV-503 x 76IH20	7.11	-7.13	29.07	-24.96*
25	GJHV-515 x GJHV-517	15.42**	6.74	-0.52	17.98
26	GJHV-515 x GJHV-522	6.67	-1.35	-20.26	-5.43
27	GJHV-515 x GJC-101	7.92	-0.19	-9.15	7.75
28	GJHV-515 x Deviraj	-15.83**	-22.16**	-28.50**	-15.19
29	GJHV-515 x GJHV-510	7.92	-0.19	5.62	25.27*
30	GJHV-515 x 76IH20	2.71	-5.01	-25.36**	-11.47
31	GJHV-517 x GJHV-522	22.57**	6.74	59.39**	22.33*
32	GJHV-517 x GJC-101	1.78	-11.75*	4.59	5.89
33	GJHV-517 x Deviraj	-2.67	-15.61**	18.26	1.40
34	GJHV-517 x GJHV-510	3.56	-10.21*	21.62	-6.67
35	GJHV-517 x 76IH20	-5.78	-18.30**	13.33	-13.02
36	GJHV-522 x GJC-101	16.00**	0.58	6.58	7.91
37	GJHV-522 x Deviraj	8.44	-5.97	19.89	2.79
38	GJHV-522 x GJHV-510	15.56*	0.19	64.61**	7.44
39	GJHV-522 x 76IH20	-2.22	-15.22**	70.12**	6.82
40	GJC-101 x Deviraj	41.03**	5.97	28.18	31.16**
41	GJC-101 x GJHV-510	29.23**	-2.89	-11.82	-9.77
42	GJC-101 x 76IH20	31.28**	-1.35	-32.12**	-30.54**
43	Deviraj x GJHV-510	18.45**	-23.31**	23.06	5.89
44	Deviraj x 76IH20	46.86**	-0.96	17.12	0.78
45	GJHV-510 x 76IH20	40.57**	-5.20	-25.48	-51.47**
	S.E. (d) ±	0.90	0.90	4.60	4.60

*, ** significant at 5 per cent and 1 per cent levels of probability, respectively

Table 4: The estimates of heterosis over BP and SC for different character in cotton

S. No.	Crosses	Boll weight (g)		Seed cotton yield per plant (g)	
		H (%)	SH (%)	H (%)	SH (%)
1	G.Cot-10 x GISV-267	-15.08**	-10.54*	6.31	-5.21
2	G.Cot-10 x GJHV-503	-5.83	-6.19	71.97**	-5.42
3	G.Cot-10 x GJHV-515	10.28	-1.00	1.02	3.13
4	G.Cot-10 x GJHV-517	9.17	-0.84	35.25*	-16.88
5	G.Cot-10 x GJHV-522	-12.10*	-8.86	49.82**	-12.92
6	G.Cot-10 x GJC-101	19.78**	-9.20*	8.55	-23.33**
7	G.Cot-10 x Deviraj	1.97	-4.52	-3.99	-29.79**
8	G.Cot-10 x GJHV-510	-3.64	-10.37*	17.05	-35.63**
9	G.Cot-10 x 76IH20	-1.56	5.18	-7.58	-49.17**
10	GISV-267 x GJHV-503	10.83*	11.54*	17.25	4.79
11	GISV-267 x GJHV-515	9.17	9.20	0.82	2.92
12	GISV-267 x GJHV-517	-3.33	-3.01	32.63**	18.54*
13	GISV-267 x GJHV-522	7.26	11.04*	19.81	7.08
14	GISV-267 x GJC-101	6.67	6.69	3.50	-7.50

15	GISV-267 x Deviraj	-4.17	-4.01	3.03	-7.92
16	GISV-267 x GJHV-510	-1.67	-1.51	14.92	2.71
17	GISV-267 x 76IH20	5.47	12.54**	7.69	-3.75
18	GJHV-503 x GJHV-515	0.83	1.00	22.45**	25.00**
19	GJHV-503 x GJHV-517	4.17	4.85	85.08**	13.75
20	GJHV-503 x GJHV-522	-5.65	-2.17	96.06**	13.96
21	GJHV-503 x GJC-101	-5.83	-5.52	41.00**	-0.42
22	GJHV-503 x Deviraj	1.67	2.34	55.56**	13.75
23	GJHV-503 x GJHV-510	-6.67	-6.19	84.92**	-2.92
24	GJHV-503 x 76IH20	-8.59	-2.17	38.03**	-32.71**
25	GJHV-515 x GJHV-517	-2.50	-1.84	9.20	11.25
26	GJHV-515 x GJHV-522	-0.81	3.51	-10.84	-9.17
27	GJHV-515 x GJC-101	-0.83	0.50	3.07	5.00
28	GJHV-515 x Deviraj	8.33	8.70	-15.13	-13.54
29	GJHV-515 x GJHV-510	-9.17	-9.53*	6.34	8.33
30	GJHV-515 x 76IH20	-2.34	5.02	-14.11	-12.50
31	GJHV-517 x GJHV-522	-3.23	0.33	92.52**	17.92*
32	GJHV-517 x GJC-101	4.17	4.01	45.72**	2.92
33	GJHV-517 x Deviraj	0.83	1.17	32.19**	-3.33
34	GJHV-517 x GJHV-510	8.33	9.36	57.48**	-3.54
35	GJHV-517 x 76IH20	2.34	8.86	42.86**	-12.50
36	GJHV-522 x GJC-101	-6.67	-6.02	33.33**	-5.83
37	GJHV-522 x Deviraj	10.83*	10.54*	49.29**	9.17
38	GJHV-522 x GJHV-510	7.50	7.53	87.81**	9.17
39	GJHV-522 x 76IH20	-16.41**	-10.03*	55.91**	-9.38
40	GJC-101 x Deviraj	-0.89	-7.02	61.25**	17.92**
41	GJC-101 x GJHV-510	1.82	-6.02	8.85	-23.13
42	GJC-101 x 76IH20	-0.78	6.69	-6.49	-33.96**
43	Deviraj x GJHV-510	2.50	2.84	39.60**	2.08
44	Deviraj x 76IH20	1.56	8.36	41.31**	3.33
45	GJHV-510 x 76IH20	-21.09**	-15.22**	-42.86*	-70.00**
	S.E. (d) ±	0.20	0.20	13.89	13.89

*, ** significant at 5 per cent and 1 per cent levels of probability, respectively

Table 5: range of H and SH, number of significant crosses and total significant cross for various characters in cotton.

Character		**Plant height (cm)**		**Number of monopodia per plant**		**Number of sympodia per plant**	
		H (%)	**SH (%)**	**H (%)**	**SH (%)**	**H (%)**	**SH (%)**
Range	Minimum value	-38.33	-21.69	-86.67	-95.65	-15.83	-25.63
	Maximum value	14.86	3.10	20.00	43.48	46.86	13.29
Significant crosses	Positive crosses	0	0	4	8	20	3
	Negative crosses	9	3	21	23	1	19
	Total crosses	9	3	25	31	21	22
Character		**Number of bolls per plant**		**Boll weight (g)**		**Seed cotton yield per plant (g)**	
		H (%)	**SH (%)**	**H (%)**	**SH (%)**	**H (%)**	**SH (%)**
Range	Minimum value	-32.12	-57.47	-21.09	-15.22	-42.86	-70.00
	Maximum value	92.63	31.16	19.78	12.54	96.06	25.00
Significant crosses	Positive crosses	10	6	3	4	23	4
	Negative crosses	4	4	4	6	1	7
	Total crosses	14	10	7	10	24	11

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