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Research Note

Estimation of heterosis and dominance deviation for seed cotton yield, its components characters in upland cotton

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Abstract
A line x tester analysis was undertaken to estimates the magnitude of heterosis and dominance deviation in *Gossypium hirsutum* L. for yield, its components and other matricate characters in 60 test entries including (44 F_1s along with 15 parents and 1 standard check hybrid). Analysis of variance indicated the significant difference among the parents and hybrids for all 12 characters studied which revealed existence of variability among the genotypes. Studies revealed that out of 44 cross combinations, only 3 hybrids *viz.*, BC-68-2 x MCU 11, BC-68-2 x AC 738 and BN 1 x Reba-B-50 depicted significant and positive heterosis over standard check hybrid G. Cot. Hy. 12. The hybrid BC-68-2 x MCU 11 exhibited significant positive standard heterosis for seed cotton yield per plant and other attributing characters i.e. total number of bolls per plant, average boll weight, lint yield per plant and lint index. The mean values of potence ratio in all twelve characters suggested that degree of dominance was governed by over dominance genes for the expression of all the characters under study.

Key words:
Cotton, Dominance estimates, Heterosis and Line x Tester analysis

"Cotton" the king of fibre is one of the momentous and important cash crop exercising profound influence on economics and social affairs of the world. Any other fibre crops cannot compare with cotton for its fibre quality. It belongs to family Malvaceae and series Hibisceae. India has been the traditional home of cotton, therefore it is popularly known as the "White Gold". The existence of cotton thread is traced back to the Rigveda about 4000 B.C. and it is not only the birth place of cotton, but also of the cotton industry. Exploitation of heterosis was first achieved in maize, which was followed subsequently in many crops like bajra, cotton, castor, sorghum, etc. The term heterosis was first coined by Shull (1914), who referred this phenomenon as the stimulus of heterozygosis. Later on Fonseca and Patterson (1968) suggested a new term "Heterobeltiosis" to describe the increase or decrease in the mean value of F_1 over its better parent. Considering the importance of Upland cotton, the present investigation was undertaken with a view to study heterosis and dominance estimates with the following objectives: a) to study the extent of heterosis over better parent and standard check hybrid G. Cot. Hy. 12 for yield, yield attributes along with other matricate characters and b) to study the average degree of dominance based on potence ratio of twelve different characters.

The experimental material consisted of 60 genotypes, comprising of four lines (G. Cot. 16, BC-68-2, BN 1, 76 IH-20), eleven testers (American Nectariless, MCU 11, AC 738, Surat Dwarf, Reba-B-50, Khandwa 2, LRA 5166, G. Cot. 100, G. Cot. 10, Narasimha, G. 247) and resultant forty four hybrids developed by line x tester mating design and these hybrids were evaluated with one standard check hybrid G. Cot. Hy. 12. The experimental material was sown in a randomized block design with three replications during *kharif* 2010-11 at Regional Research Station, Anand Agricultural University, Anand (Gujarat). A single row of 4.5 meter length was assigned to each genotype with 10 plants having 45 cm intra row spacing and 120 cm inter row spacing. Five plants were randomly selected from each replication for each genotype and the average value per plot was computed for recording observations on plant height, number of monopodia, number of sympodia, total number of bolls, seed cotton yield and seed index; whereas, average boll weight, ginning percentage, lint yield and lint index were calculated on formula basis. While, days to 50 per cent flowering was recorded on plot basis and oil content was estimated by NMR (Nuclear Magnetic Resonance) machine. Analysis of variance technique suggested by Panse and Sukhatme (1978) was followed to test the differences between the genotypes for all the characters under study. Heterosis was estimated in terms of two parameters, i.e. heterobeltiosis (Fonseca and Patterson, 1968) and standard heterosis (Meredith and Bridge, 1972). While, the dominance estimates was carried out as per following formula given by Griffing (1950) and Petr and Frey (1966).

$$\text{Dominance estimates} = \frac{\overline{F_1} - \overline{MP}}{\overline{BP} - \overline{MP}}$$

Where,

$\overline{F_1}$ = Mean performance of F_1 hybrid

$\overline{MP}$ = Mean performance of parents

$\overline{BP}$ = Mean performance of better parent in desired direction

The degree of dominance (h) is classified as per following six different conditions:

When, degree of dominance (h) = 0 there is no dominance; h=1 or h= -1 complete dominance or complete recessive; 0<h<1 : partial dominance; -1<h<0 partial recessive; h>1 or h< -1 : over dominance

Analysis of variance revealed that the mean squares due to genotypes were significant for all the characters under study (Table 1). Mean squares due to genotypes were further partitioned into mean squares due to parents, hybrids, parents *vs.* hybrids and check *vs*. hybrids. The parents and hybrids differed significantly for all the characters which revealed that the existence of considerable genetic variability among the parents and hybrids for all the characters. The mean square due to parents *vs.* hybrids were significant for all the characters except for plant height suggested that the presence of substantial amount of heterosis among the different crosses. Several hybrids exhibited significant heterosis over better parent in desirable direction for different component characters such as days to 50% flowering (13), plant height (7), number of monopodia per plant (3), number of sympodia per plant (19), total number of bolls per plant (8), average boll weight (21), lint yield per plant (19), ginning percentage (4), seed index (4), lint index (6) and oil content (11). The heterotic response over better parent in cotton was also reported by Desai *et al.* (1982); Singh and Narayanan (1990); Siddiqui and Patil (1994); Rauf *et al*. (2005); Ganpathy and Nadarajan (2008) and Abro *et al.* (2009).

Improvement in yield is one of the most important objectives, so there is a need to be a developed superior hybrids over best cultivated check for increasing its commercial value. In present study, G. Cot. Hy. 12 which is a promising hybrid released for general cultivation in Gujarat has been used as standard check hybrid in order to obtain information on superiority of hybrids. Out of 44 F_1 hybrids, 28 F_1 hybrids depicted significant standard heterosis in desired direction for days to 50 % flowering; where as, 21, 5, 16, 4 and 34 F_1 hybrids registered significant with positive standard heterosis for plant height, number of sympodia/plant, average boll weight, seed index and oil content, respectively. While, 3 F_1 hybrids i.e. BC-68-2 x MCU 11, BC-68-2 x AC 738 and BN 1 x Reba-B-50 depicted the significant and positive standard heterosis for seed cotton yield and total number of bolls/plant; where as, none of the hybrids registered significantly positive heterosis over standard check for number of monopodia/plant, lint yield/plant, ginning percentage and lint index. The best three hybrids, BC-68-2 x MCU 11 (14.55%), BC-68-2 x AC 738 (13.91%) and BN 1 x Reba-B-50 (11.53%) depicted significant with positive heterosis over check hybrid G. Cot. Hy. 12. As observed in the present investigation, several workers have also reported the standard heterosis for seed cotton yield per plant in cotton (Singh and Narayanan 1990; Patil *et al.*, 1991; Soomro, 2000; Muthu *et al.*, 2005 and Kaliyaperumal *et al.*, 2010). In general, the crosses which had higher estimates of heterobeltiosis (HB) and standard heterosis (SH) for seed cotton yield/plant also had significant with positive heterotic effects for plant height, total number of bolls per plant, average boll weight and lint yield per plant (Table 2). Therefore, heterotic effects for seed cotton yield per plant could be outcome of direct effects of the above stated component characters. Therefore, heterotic effects for seed cotton yield per plant could be result of combinational heterosis. However, positive and negative estimates of heterosis for rest of the characters could have checked each other for expression of heterotic effects. Hence, to obtain maximum heterotic effects for seed cotton yield desired level of heterosis of each component character should be worked out to identify superior cross combinations.

Dominance estimates (h): The level of dominance estimates is also called as degree of dominance and potence ratio. Generally, two types of heterosis, average heterosis (MP) and heterobeltiosis (HB) were used to determined the potence ratio.

Several hybrids depicted greater magnitude of dominance estimates in desirable direction for different characters *viz.*, days to 50% flowering (22), plant height (22), number of monopodia/plant (12), number of sympodia/plant (33), total number of bolls/plant (31), average boll weight (30), lint yield/plant (31), ginning percentage (31), seed index (34), lint index (36) and oil content (27) (Table 3). The mean values of potence ratio in all characters suggested that degree of dominance was governed by over dominance genes for the expression of the characters i.e. days to 50% flowering, plant height, number of monopodia/plant, number of sympodia/plant, total number of bolls/plant, average boll weight, seed cotton yield/plant, lint yield/plant, ginning percentage, seed index, lint index and oil content.

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Table 1. Analysis of variance for seed cotton yield, its components and other matricate characters in upland cotton.

Source of variation	d.f.	Days to 50 % flowering	Plant height (CM)	Number of monopodia per plant	Number of sympodia per plant	Total no. of bolls per plant	Average boll weight (g)
Replications	2	0.42	62.98	0.16	2.56	48.13	0.01
Genotypes	59	50.71**	1318.47**	0.69**	50.20**	682.79**	0.97**
Parents (P)	14	39.78**	716.98**	0.82**	18.81**	328.98**	0.33**
Females (F)	3	25.44**	1944.64**	0.727**	7.60	344.55**	0.39**
Males (M)	10	46.98**	414.85**	0.93**	23.13**	340.20**	0.27**
F Vs M	1	10.76*	55.31	0.06	9.20	170.09	0.77**
Hybrids (H)	43	54.42**	1566.40**	0.57**	49.58**	787.73**	1.02**
P Vs H	1	36.20**	33.00	3.11**	539.40**	1253.59**	8.53**
Checks Vs Hybrids	1	65.55**	337.45	1.61**	11.82	431.62*	0.04
Error	118	2.02	90.55	0.06	4.40	73.762	0.03

*, ** indicate level of significance at 5% and 1%, respectively.

Table 1. Contd…

Source of variation	d.f.	Seed cotton yield per plant (g)	Lint yield per plant (g)	Ginning percentage	Seed Index	Lint index	Oil Content (%)
Replications	2	260.65	41.08	2.74	2.76	1.00	0.04
Genotypes	59	18815.66**	2016.20**	6.03**	5.08**	1.34**	7.70**
Parents (P)	14	4448.85**	554.81**	2.89	3.88**	1.04**	7.04**
Females (F)	3	6939.07**	996.92**	7.01*	3.25*	1.23**	5.18**
Males (M)	10	3400.03**	385.20**	1.90	4.37**	1.04**	8.05**
F Vs M	1	7466.62**	924.48**	0.49	0.91	0.38	2.44**
Hybrids (H)	43	20739.96**	2118.51**	6.64**	5.23**	1.27**	8.13**
P Vs H	1	112228.00**	13502.81**	16.83**	20.57**	9.00**	1.34**
Checks Vs Hybrids	1	33674.15**	5214.96**	10.75*	0.01	0.60	5.29**
Error	118	449.34	54.51	1.79	1.03	0.31	0.11

*, ** indicate level of significance at 5% and 1%, respectively.

Table 2. Manifestation of heterobeltiosis (HB) and standard heterosis (SH) for different characters in five top ranking heterotic crosses for seed cotton yield per plant.

Characters	Heterobeltiosis (HB)					Standard heterosis (SH)				
	BC-68-2 X AC 738	BC-68-2 X Guj-247	BC-68-2 X MCU 11	BC-68-2 X Reba B -50	BC-68-2 X Surat Dwarf	BC-68-2 X MCU 11	BC-68-2 X AC 738	BN 1 X Reba B - 50	BN 1 X G Cot 100	76 IH-20 X Guj-247
Seed cotton yield / plant (g)	104.78**	98.36**	68.24**	63.93**	54.91**	14.55**	13.91**	11.53*	5.96	2.94
Days to 50 % flowering	7.69**	5.92**	12.43**	14.79**	12.05**	-2.07	-6.19**	-5.16**	-13.41**	-1.55
Plant height (cm)	25.18**	6.41	4.09	15.53**	-2.62	16.74**	17.80**	20.40**	17.78**	17.58**
Number of monopodia/ plant	-6.00	-33.00**	-32.50**	-29.00**	-18.00**	-13.74*	0.11	-11.61	-23.32**	-29.71**
Number of sympodia/ plant	41.45**	36.84**	33.06**	-11.51	0.30	10.84	17.82*	17.82*	-5.60	20.02**
Total number of bolls / plant	49.60**	31.60**	21.83**	37.91**	15.33	31.86**	24.22**	3.33	7.78	13.11
Average boll weight (g)	42.41**	27.70**	44.97**	38.03**	27.33**	28.40**	25.97**	30.34**	24.27**	22.09**
Lint yield per plant (g)	97.73**	107.83**	69.15**	59.06**	51.40**	3.19	3.63	4.09	4.32	3.24
Ginning percentage	-3.33	4.35	0.44	-2.69	-2.04	-10.21**	-9.03**	-6.85*	-1.97	-0.09
Seed Index	-6.54	8.49	-24.35**	15.27	-2.18	-16.27*	-11.20	-1.72	-14.55	12.44
Lint index	1.21	23.69*	-23.84**	10.19	2.83	-29.02**	-22.92**	-11.46	-16.27*	12.01
Oil Content (%)	14.05**	-6.82**	4.28**	-5.70**	-27.75**	10.40**	7.69**	15.50**	1.86	8.11**

* Significant at 5% probability level, ** Significant at 1% probability level

Table 3. Magnitude of dominance deviation fort various traits

Sr. No.	Hybrids	Days to 50% flowering	Plant height (cm)	No. of monopodia/plant	No. of sympodia/ plant	Total number of bolls/plant	Average boll weight (g)
1	G.Cot-16 x American nectariless	-63.49	-471.39	-472.09	-75.36	-360.29	-2.70
2	G.Cot-16 x MCU 11	500.00	63.47	-108.24	1382.71	-160.53	325.00
3	G.Cot-16 x AC 738	219.76	-11.10	325.53	281.74	5177.78	715.38
4	G.Cot-16 x Surat Dwarf	-41.09	-1261.69	161.54	-459.59	-12272.09	11500.0
5	G.Cot-16 x Reba B -50	330.95	-252.20	4100.00	287.35	957.78	442.86
6	G.Cot-16 x Khandwa 2	1500.00	-258.35	487.88	100.00	-326.09	52.63
7	G.Cot-16 x LRA 5166	400.30	-123.46	-135.00	531.21	278.67	833.33
8	G.Cot-16 x G Cot 100	-43.35	-108.54	53.33	379.25	-317.15	617.65
9	G Cot-16 x G Cot 10	-22.86	-3320.34	50.00	1834.25	-39.39	74.36
10	G.Cot-16 x Narasimha	177.67	-82.67	-115.56	388.21	-391.58	238.10
11	G.Cot-16 x Guj – 247	500.00	-721.99	957.14	117.70	571.70	263.64
12	BC-68-2 x American nectariless	-28.06	-23.18	-133.33	-82.38	586.68	435.14
13	BC-68-2 x MCU 11	-82.53	134.35	-288.06	1440.00	205.56	1466.67
14	BC-68-2 x AC 738	-189.33	646.08	73.33	347.42	520.53	2469.23
15	BC-68-2 x Surat Dwarf	-1234.00	77.76	-33.33	106.19	229.60	19900.0
16	BC-68-2 x Reba B -50	-85.33	242.22	-92.00	-18.78	414.03	4042.86
17	BC-68-2 x Khandwa 2	-158.91	588.93	-222.86	-69.45	-18.42	863.16
18	BC-68-2 x LRA 5166	-91.75	13.87	-258.73	-291.43	175.62	3600.00
19	BC-68-2 x G Cot 100	-90.57	286.18	-45.21	1309.30	34.13	1170.59
20	BC-68-2 x G Cot 10	-4217.65	83.76	-258.73	465.00	200.41	494.87
21	BC-68-2 x Narasimha	-1504.51	269.30	-1284.62	322.39	211.05	-147.62
22	BC-68-2 x Guj – 247	12.91	154.32	-100.00	1965.00	360.12	559.09
23	BN 1 x American nectariless	85.87	-259.38	-48.15	-43.93	-181.01	540.00
24	BN 1 x MCU 11	100.00	191.82	-206.00	204.29	-148.59	100.00
25	BN 1 x AC 738	-1989.55	124.51	65.81	213.90	441.09	-134.29
26	BN 1 x Surat Dwarf	-271.31	-889.47	-29.82	-24.46	157.14	-248.28
27	BN 1 x Reba B -50	50.09	215.56	31.34	731.17	591.23	459.38
28	BN 1 x Khandwa 2	700.00	58.32	208.11	273.83	310.36	-89.47
29	BN 1 x LRA 5166	-7.62	-374.51	-186.67	520.00	144.94	-107.84
30	BN 1 x G Cot 100	340.24	120.08	-200.00	212.88	1176.92	550.00
31	BN 1 x G Cot 10	320.42	-1348.56	-166.67	-117.00	212.12	777.78
32	BN 1 x Narasimha	-193.20	-137.24	-630.00	-7.32	-9.37	-740.00
33	BN 1 x Guj – 247	-100.00	-1390.32	-159.74	-383.75	-772.03	-74.26
34	76 IH-20 x American nectariless	347.76	-954.92	-627.27	203.45	2100.00	-196.77
35	76 IH-20 x MCU 11	2983.58	190.45	-125.00	330.09	-25.99	26.09
36	76 IH-20 x AC 738	516.50	416.30	-226.32	222.73	67.90	23.46
37	76 IH-20 x Surat Dwarf	183.25	-316.18	-4566.67	42.80	56.42	-82.61
38	76 IH-20 x Reba B -50	333.00	368.75	300.00	279.62	125.54	65.33
39	76 IH-20 x Khandwa 2	-0.75	924.01	-273.91	307.19	133.08	179.25
40	76 IH-20 x LRA 5166	-368.00	121.62	-233.33	596.24	937.61	-3.23
41	76 IH-20 x G Cot 100	0.00	-2365.31	-770.00	455.56	121.51	-33.33
42	76 IH-20 x G Cot 10	100.00	-147.03	-700.00	241.88	1239.09	-51.72
43	76 IH-20 x Narasimha	35.89	-5250.00	-150.00	172.59	1135.65	-30.77
44	76 IH-20 x Guj – 247	-1.49	231.03	-135.29	1038.83	500.76	225.00
	Average	-23.80	-330.57	-140.20	357.53	98.92	1160.64
	Number of positive crosses	22	22	12	33	31	30
	Number of negative crosses	22	22	32	11	13	14

Table 3. contd.

Sr. No.	Hybrids	Seed cotton yield/plant (g)	Lint yield/plant (g)	Ginning percentage	Seed index	Lint index	Oil content (%)
1	G.Cot-16 x American nectariless	-475.14	-482.10	200.00	102.62	105.31	-100.00
2	G.Cot-16 x MCU 11	-145.14	-550.00	-87.50	30.26	15.38	100.00
3	G.Cot-16 x AC 738	163.58	94.48	0.00	398.41	180.00	-100.00
4	G.Cot-16 x Surat Dwarf	-593.91	-320.90	706.00	1158.82	964.00	100.00
5	G.Cot-16 x Reba B -50	12.54	97.96	374.00	81.43	287.23	95.33
6	G.Cot-16 x Khandwa 2	-181.06	-85.50	233.00	100.00	1480.00	-21.26
7	G.Cot-16 x LRA 5166	228.88	188.38	-332.84	1947.62	636.36	570.59
8	G.Cot-16 x G Cot 100	-355.70	-264.73	432.00	163.11	196.61	-121.43
9	G Cot-16 x G Cot 10	294.68	233.07	-100.00	1566.67	0.00	146.46
10	G.Cot-16 x Narasimha	-952.13	-1282.06	0.00	-7.92	-83.16	-13.48
11	G.Cot-16 x Guj – 247	268.41	282.17	306.02	-370.27	-785.71	7.34
12	BC-68-2 x American nectariless	950.73	483.31	28.08	140.45	64.71	361.36
13	BC-68-2 x MCU 11	636.03	596.32	123.64	-243.90	-160.22	173.79
14	BC-68-2 x AC 738	2491.49	1318.74	20.74	35.96	124.39	2862.50
15	BC-68-2 x Surat Dwarf	826.35	623.14	25.88	73.25	166.67	-328.57
16	BC-68-2 x Reba B -50	957.55	711.76	2.35	0.00	355.56	44.08
17	BC-68-2 x Khandwa 2	1424.70	1722.00	1528.57	9.09	22900.00	141.94
18	BC-68-2 x LRA 5166	710.46	2059.64	310.84	186.96	851.52	102.00
19	BC-68-2 x G Cot 100	252.30	197.86	15.63	-114.12	-38.32	-202.93
20	BC-68-2 x G Cot 10	759.07	580.67	144.33	397.35	2500.00	107.87
21	BC-68-2 x Narasimha	40.40	18.16	-35.56	374.19	92.86	9140.00
22	BC-68-2 x Guj – 247	67819.35	5257.51	294.16	357.58	5000.00	46.74
23	BN 1 x American nectariless	-108.31	-79.62	19600.00	-336.73	50.00	162.64
24	BN 1 x MCU 11	269.47	269.58	225.56	-88.71	300.00	796.88
25	BN 1 x AC 738	26.75	26.21	0.00	206.17	202.52	129.92
26	BN 1 x Surat Dwarf	-201.52	-149.50	345.00	-275.63	-170.18	-1853.85
27	BN 1 x Reba B -50	447.87	393.87	11.67	70.00	47.62	52.76
28	BN 1 x Khandwa 2	65.55	55.95	20.91	173.97	89.87	580.00
29	BN 1 x LRA 5166	2.33	30.40	589.66	27.36	121.62	-111.43
30	BN 1 x G Cot 100	950.69	1161.56	653.33	-722.22	-355.17	-738.71
31	BN 1 x G Cot 10	31.71	19.70	-106.90	259.48	185.39	112.61
32	BN 1 x Narasimha	-247.84	-263.96	-770.00	-763.64	-1866.67	-24.53
33	BN 1 x Guj – 247	-139.18	-132.38	-86.93	-224.53	-160.98	-308.99
34	76 IH-20 x American nectariless	14.10	48.96	504.17	644.44	509.09	-57.58
35	76 IH-20 x MCU 11	-12966.67	-290.37	39.13	457.89	467.74	-470.00
36	76 IH-20 x AC 738	141.24	112.36	-137.14	203.23	166.67	261.48
37	76 IH-20 x Surat Dwarf	87.39	15.89	-147.06	133.33	60.00	-300.00
38	76 IH-20 x Reba B -50	364.49	205.51	-150.59	268.22	77.27	92.79
39	76 IH-20 x Khandwa 2	-36.93	-44.75	-60.74	145.71	37.60	50.00
40	76 IH-20 x LRA 5166	284.83	309.24	337.96	81.34	133.12	176.74
41	76 IH-20 x G Cot 100	-834.55	-1043.19	-1470.00	1845.45	700.00	91.49
42	76 IH-20 x G Cot 10	653.58	617.04	289.78	130.00	168.15	-293.68
43	76 IH-20 x Narasimha	58455.00	4046.99	-320.00	766.67	255.00	45.20
44	76 IH-20 x Guj – 247	509.92	489.01	225.12	186.71	209.38	-133.47
	Average	2793.26	392.69	540.51	217.64	820.03	258.47
	Number of positive crosses	31	31	31	34	36	27
	Number of negative crosses	13	13	13	10	8	17