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Research Note

Heterosis for seed cotton yield and its contributing characters in cotton (*Gossypiumhirsutum*L.)

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Abstract
A line x tester crossing programme was taken up with ten lines and five testers with a view to identify the best heterotic crosses for seed cotton yield and its attributing traits in upland cotton. The analysis of variance revealed significant differences among genotypes, parents, hybrids and parents Vs hybrids for all the eight traits except parents Vs hybrids for seed index suggesting the presence of considerable amount of genetic variation with respect to various traits studied.Heterosis was worked out over better parent and standard hybrid,G.Cot Hy-12. Based on study of heterobeltiosis, it was found that number of sympodia per plant, number of bolls per plant, boll weight and lint yield per plant were main contributors towards increase in heterotic effects for seed cotton yield per plant. Five crosses *viz.*,G.cot-12 x H 1316 (35.27%), 76 IH 20 x GBHV 170 (33.67%), LRA 5166 x GJHV 503 (24.39%), 76 IH 20 x BS 27 (23.04%) and G.cot-12 x GJHV 460 (20.95%) were best heterotic crosses over standard check for seed cotton yield per plant and could be exploited.

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

Cotton (*Gossypium spp*.), popularly known as “King of fibre’’and “White Gold”,is one of the most important commercial cash crops and plays a key role in economic, political and social affairs of the world. Cotton enjoys a pre-eminent status among all the cash crops in the country, being the principal material for flourishing textile industries. The predominant species cultivated in India is *G. hirsutum*which cover about 90% of the total area.

India is pioneer in commercialization of heterosis in cotton and noticeable heterosis is also reported in cotton by many workers (Khadi *et al.*, 1993; Wu *et al.*, 2004;Tuteja *et al.*,2005). Heterosis breeding is useful to identify the cross combinations which are promising in conventional breeding programme. Therefore,the present investigation was undertaken to find out the extent of heterobeltiosis and standard heterosis for seed cotton yield and its contributing traits in upland cotton.

Five diverse parents (G.cot-18, G.cot-12, LRA 5166, BC 68-2, 76 IH 20) and ten good combiners (MR 786, GISV 254, GTHV 95/145, GBHV 148, GJHV 503, GBHV 170, BS 27, BS 279, H 1316, GJHV 460) were used to generate 50 cross combinations by using line x tester mating design. These crosses along with 15 parents and one check (G. Cot. Hy. 12) were evaluated in randomized block design with three replications. One row of each hybrid and parent was sown at spacing of120 x 45 cm during 2010-11 at Cotton Research Station, Junagadh Agricultural University, Junagadh, Gujarat. Five plants were randomly chosen from each row to record observations on seed cotton yield and its seven contributing traits (Table 1). Heterosis was estimated over better parent as per the standard procedure of Meredith and Bridge (1972) and useful heterosisas suggested by Rai (1978).

The analysis of variance for parents and their hybrids (Table 1) revealed significant differences among genotypes, parents and hybrids for all the eight traits suggesting the presence of considerable genetic variation with respect to various traits studied. Variance due to parents vs. hybrids as a group was significant for all the characters except seed index.

Heterosis over better parent and standard check for eight characters are presented in Table 2. For sympodia per plant, 34 and 13 crosses showed significant and positive heterobeltiosis and standard heterosis with range of -23.88 to 101.39% and -41.72 to 32.43%, respectively. The cross combination BC 68-2 x GJHV 503 recorded the highest heterobeltiosis (101.39%) and third highest standard heterosis (31.52%) along with high *per se* performance, while the cross combination LRA 5166 x GJHV 503 showed the maximum standard heterosis(32.43%) and the second highest heterobeltiosis (82.50%) for this trait. Similar findings were also reported by Bharad*et al*. (2000), Muthu*et al*. (2005), Tuteja*et al*. (2005), Verma*et al*. (2006), Abro*et al*. (2009) and Geddam*et al*. (2011) for this trait.

In cotton, the number of bolls per plant and boll weight are two important yield attributing components which are mostly positively associated with seed cotton yield. Among hybrids, LRA 5166 x GJHV 503 (80.12%) and 76 IH 20 x GBHV 170 (41.86%) showed highest, significant and positive heterobeltiosis and standard heterosis, respectively for bolls per plant. Thirteen hybrids showed significant and positive heterosis over better parent with range of -47.96 to 80.12% and eight hybrids exhibited significant and positive heterosis over standard check with range of -44.51 to 41.86%. Such high heterotic response would be useful for obtaining more number of bolls per plant which ultimately results in higher seed cotton yield (Bhatade*et al.*, 1994). Likewise, out of fifty hybrids studied for boll weight, 14 and 13 hybrids exhibited significant and positive heterosis over better parent and standard check with range of -23.56 to 35.32% and -24.00 to 31.10%,respectively.The cross combinationG.cot-12 x GBHV 170 (80.12%) and G.cot-12 x BS 279 (31.10%) showed highest, significant and positive heterobeltiosis and standard heterosis, respectively for boll weight.

The extent of heterosis for seed cotton yield per plant ranged from -42.02 to 92.67% and -40.12 to 35.27% over better parent and standard check, respectively. Among hybrids, seventeen and six hybrids showed significant and positive heterosis over better parent and standard heterosis, respectively. The cross combinations G.cot-12 x BS 279,G.cot-12 x GJHV 460, 76 IH-20 x GBHV 170, G.cot-12 x H 1316 and 76 IH 20 x BS 27 showed significant and positive heterobeltiosis and standard heterosis for seed cotton yield per plant. The results reported in the present investigation are in agreement with earlier workers (Pole *et al.*, 2008;Abro*et al*., 2009; Patel *et al*., 2009a; Khan *et al*., 2009;Jyotiba*et al*., 2010; Basal *et al*., 2011;Geddam*et al*., 2011; Kaushik and Shastry, 2011;Patil*et al*., 2011). While considering lint yield per plant, 16 and eight crosses showed significant and positive heterobeltiosis and standard heterosis with range of -41.00 to 101.39% and -36.16 to 49.14%, respectively. The highest, significant and positive heterobeltiosis(101.39 %)and standard heterosis (49.14%) was reported by BC 68-2 x BS 27 and 76 IH 20 x GBHV 170, respectively along with maximum *per se* performance. Similar findings have been reported by Desalegn and Ratanadilok (2004), Tuteja*et al*. (2006) and Basal *et al*. (2011) for lint yield per plant.

The heterotic expression for ginning percentage ranged from -7.28 to 5.52% over better parent and -1.10 to 15.05% over standard check, respectively. Among hybrids, LRA 5166 x GISV 254 (5.52%) and G.cot-12 x GBHV 170 (15.05%) showed highest, significant and positive heterobeltiosis and standard heterosis, respectively for ginning percentage.Tuteja (2001), Singh *et al*. (2003), Nirania*et al*. (2004), Rauf*et al*. (2005),Preetha and Raveendaran (2008), Patel*et al*. (2009b) and Geddam*et al*. (2011) also reported varying magnitude of heterosis for this character.

The cross combination, BC 68-2 x GBHV 170 (27.59%) and G.cot-12 x BS 27 (18.98%) exhibited highest, significant and positive heterosis over better parent and standard check, respectively for seed index. The extent of heterosis for seed index ranged from -31.47 to 27.59 % and -23.93 to 18.98% over better parent and standard check, respectively. Among hybrids, nine and seven hybrids showed significant and positive heterosis over better parent and standard heterosis, respectively.Pole *et al.* (2008) and Jyotiba*et al*. (2010) also reported high heterosis for seed index. For lint index, heterobeltiosis and standard heterosis ranged from -22.36 % (LRA 5166 x BS 279) to 30.20% (BC 68-2 x GISV 254) and -17.93% (LRA 5166 x GBHV 148) to 39.29 % (G.cot-12 x BS 27) with significant and positive cross combinations of 12 and 18 crosses, respectively. Similar findings have also been reported by Singh *et al*. (2003), Nirania*et al*. (2004), Khosla*et al*. (2007), Pole *et al*. (2008) and Jyotiba*et al*. (2010) for lint index.

Seed cotton yield in cotton is one of the most important economic characters and is the final product of the multiplicative interaction of contributing traits.It is imperative to know the causes of heterosis for seed cotton yield. Whitehouse *et al.* (1958) and Grafius (1959) suggested that there may not be any gene system for yield *per se* as yield is an end product of the multiplicative interaction between the yield components. This would indicate that the heterosis for yield should be through heterosis for the individual yield components or alternatively due to the multiplicative effects of partial dominance of component characters. William and Gilbert (1960) reported that even simple dominance in respect of yield components may lead to expression of heterosis for yield. Hagberg (1952) observed similar effects and termed it “Combinational heterosis”. In order to see whether similar situation exists in cotton or not, a comparison of ten most heterobeltiotic crosses for seed cotton yield was made with other yield related traits along with seed cotton yield per plant (Table 3).

It was revealed that high, significant and positive heterobeltiosis for seed cotton yield per plant in ten crosses were not accompanied by single unique trait (Table 3). High, significant and positive heterobeltiosis for seed cotton yield per plant in crosses G.cot-12 x BS 279, BC 68-2 x BS 27, G.cot-12 x GJHV 460, G.cot-12 x H 1316 and 76 IH 20 x BS 27 were accompanied by significant and positiveheterobeltiosis for number of bolls per plant, boll weight, lint yield per plant. Besides, the cross combination G.cot-12 x GJHV 460 had also significant and positive heterobeltiosis for number of sympodia per plant, seed index and lint index. Likewise, crosses G.cot-12 x H 1316 and 76 IH 20 x BS 27 had also significant and positive heterobeltiosis for number of sympodia per plant, ginning percentage only in later cross and lint index. Similarly, three cross combinations *viz.*, 76 IH 20 x GBHV 170, BC 68-2 x GJHV 503 and LRA 5166 x GJHV 503 had also significant and positive heterobeltiosis for number of sympodia per plant, number of bolls per plant and lint yield per plant. The cross G.cot-12 x GJHV 503 had desirable rating for number of sympodia per plant, boll weight and lint yield per plant as well as cross BC 68-2 x BS 279 for lint yield per plant only.

This indicated that in different crosses, the pathway for realising heterotic effect varied from cross to cross. This results revealed that number of sympodia per plant, number of bolls per plant, boll weight and lint yield per plant were the main contributors toward increased in heterotic effects for seed cotton yield per plant. While ginning percentage, seed index and lint index were secondary contributors toward increased heterotic effects for seed cotton yield per plant in specific cross combinations only. Similar findings have been reported by Tuteja (2001),Nirania*et al*. (2004), Muthu*et al*. (2005), Tuteja*et al*. (2005), Soomro*et al*. (2006), Verma*et al*. (2006), Ganapathy and Nadarajan (2008), Abro*et al*. (2009), Khan *et al*. (2009), Jyotiba*et al*. (2010), Kaushik and Shastry (2011) and Patil*et al*. (2011).

Based on data of standard heterosis, it can be concluded that, five cross combinations namely G.cot-12 x H 1316, 76 IH 20 x GBHV 170, LRA 5166 x GJHV 503, 76 IH 20 x BS 27 and G.cot-12 x GJHV 460 appeared to be the most heterotic crosses for seed cotton yield per plant to exploit heterosis in cotton.

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Table 1.Analysis of variance for different characters in cotton

Source	d.f.	Number of sympodia per plant	Number of bolls per plant	Boll weight (g)	Seed cotton yield per plant (g)	Lint yield per plant (g)	Ginning percentage (%)	Seed index (g)	Lint index (g)
Replications	2	33.43**	100.86**	0.20*	1008.31	122.41	0.49	0.23	0.03
Genotypes	64	101.71**	348.19**	0.57**	4003.17**	625.87**	8.15**	2.41**	1.17**
Parents (P)	14	36.88**	414.33**	0.27**	3062.76**	441.40**	14.82**	3.27**	0.99**
Hybrids (H)	49	86.80**	332.22**	0.62**	4057.11**	630.37**	5.69**	2.21**	1.19**
P. Vs H.	1	1739.94**	204.62**	2.13**	14525.67**	2988.20**	35.54**	0.16	2.41**
Error	128	2.94	13.08	0.06	345.77	46.16	0.47	0.23	0.09

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

Table 2.Range of *per se* performance, heterobeltiosis (H) and standard heterosis(SH), best five crosses and number of significant crosses in desirable direction for different characters in cotton

Character	Range of			Best five crosses				No. of significant crosses in desirable direction	
	Per se	H (%)	SH (%)	Heterobeltiosis	Value (%)	Standard Heterosis	Value (%)	H (%)	SH (%)
No. of sympodia per plant	17.13 to 38.39	-23.88 to 101.39	-41.72 to 32.43	BC 68-2 x GJHV 503	101.39	LRA 5166 x GJHV 503	32.43	34	13
				LRA 5166 x GJHV 503	82.50	G.cot-18 x H 1316	32.20		
				G.cot-18 x H 1316	66.10	BC 68-2 x GJHV 503	31.52		
				76 IH 20 x GJHV 503	57.29	LRA 5166 x GBHV 170	31.07		
				G.cot-18 x GISV 254	54.07	76 IH 20 x GBHV 170	27.66		
No. of bolls per plant	30.67 to 78.40	-47.96 to 80.12	-44.51 to 41.86	LRA 5166 x GJHV 503	80.12	76 IH 20 x GBHV 170	41.86	13	8
				BC 68-2 x GJHV 503	49.83	LRA 5166 x GJHV 503	41.01		
				G.cot-12 x GJHV 460	42.12	LRA 5166 x GBHV 170	19.54		
				76 IH 20 x GJHV 460	38.03	G.cot-12 x H 1316	13.57		
				76 IH 20 x BS 27	36.80	G.cot-12 x GJHV 460	13.15		
Boll weight (g)	2.58 to 4.45	-23.56 to 35.32	-24.00 to 31.10	G.cot-12 x GBHV 170	35.32	G.cot-12 x BS 279	31.10	14	13
				G.cot-12 x BS 27	34.49	G.cot-12 x BS 27	28.61		
				G.cot-12 x H 1316	32.45	76 IH 20 x BS 27	19.25		
				BC 68-2 x GBHV 170	31.38	BC 68-2 x BS 27	18.93		
				G.cot-18 x GBHV 170	29.26	G.cot-12 x GJHV 503	17.23		
Seed cotton yield per plant (g)	112.42 to 253.93	-42.02 to 92.67	-40.12 to 35.27	G.cot-12 x BS 279	92.67	G.cot-12 x H 1316	35.27	17	6
				BC 68-2 x BS 27	82.29	76 IH 20 x GBHV 170	33.67		
				G.cot-12 x GJHV 460	70.16	LRA 5166 x GJHV 503	24.39		
				76 IH 20 x GBHV 170	62.40	76 IH 20 x BS 27	23.04		
				G.cot-12 x H 1316	60.71	G.cot-12 x GJHV 460	20.95		

Table 2 Contd….

Character	Range of			Best five crosses				No. of significant crosses in desirable direction	
	Per se	H (%)	SH (%)	Heterobeltiosis	Value (%)	Standard Heterosis	Value (%)	H (%)	SH (%)
Lint yield per plant(g)	42.76 to 99.93	-41.00 to 101.39	-36.18 to 49.14	BC 68-2 x BS 27	101.39	76 IH 20 x GBHV 170	49.14	16	8
				G.cot-12 x BS 279	97.42	G.cot-12 x H 1316	46.05		
				76 IH 20 x BS 27	83.96	76 IH 20 x BS 27	37.36		
				G.cot-12 x GJHV 460	66.61	LRA 5166 x GJHV 503	34.39		
				G.cot-12 x H 1316	60.86	G.cot-12 x GJHV 460	26.52		
Ginning percentage (%)	35.9 to 41.8	-7.28 to 5.52	-1.10 to 15.05	LRA 5166 x GISV 254	5.52	G.cot-12 x GBHV 170	15.05	11	38
				G.cot-12 x BS 27	4.52	G.cot-18 x MR 786	13.85		
				G.cot-18 x GTHV 95/145	4.49	G.cot-18 x GBHV 170	11.56		
				G.cot-18 x GJHV 460	4.37	LRA 5166 x GBHV 170	11.19		
				G.cot-18 x BS 27	4.26	LRA 5166 x MR 786	10.64		
Seed index(g)	6.09 to 9.53	-31.47 to 27.59	-23.93 to 18.98	BC 68-2 x GBHV 170	27.59	G.cot-12 x BS 27	18.98	9	7
				BC 68-2 x GISV 254	23.64	76 IH 20 x BS 279	17.31		
				G.cot-12 x MR 786	22.34	BC 68-2 x GBHV 170	14.11		
				G.cot-12 x GISV 254	21.62	G.cot-18x MR 786	13.03		
				G.cot-18 x MR 786	17.69	G.cot-12 x GISV 254	12.36		
Lint index (g)	3.75 to 6.37	-22.36 to 30.20	-17.93 to 39.29	BC 68-2 x GISV 254	30.20	G.cot-12 x BS 27	39.29	12	18
				BC 68-2 x GBHV 170	22.31	BC 68-2 x GBHV 170	31.05		
				G.cot-12 x BS 27	19.96	76 IH 20 x BS 279	30.25		
				BC 68-2 x GBHV 148	18.40	76 IH 20 x BS 27	30.10		
				G.cot-12 x GISV 254	16.76	G.cot-18 x MR 786	26.90		

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

Table 3. Performance of promising hybrids for seed cotton yield per plant

Crosses	n yield per plant	f monopodia per plant	of Sympodia per plant	f bolls per plant	weight	l per plant	g percentage	index	index	ed cotton yield per plant
G.cot-12 x BS 279	92.67**	-25.00**	-17.89*	27.93**	22.62**	97.42**	-0.61	-11.50**	-12.08**	
BC 68-2 x BS 27	82.29**	-14.71	8.04	33.16**	24.37**	101.39**	2.26	0.47	4.71	
G.cot-12 x GJHV 460	70.16**	-16.67*	30.64**	42.12**	27.79**	66.61**	-2.01	12.70**	13.63**	
76 IH 20 x GBHV 170	62.40**	-9.09	37.32**	32.73**	-7.30	57.55**	-2.92*	-23.61**	1.96	
G.cot-12 x H 1316	60.71**	-12.50	33.33**	14.12*	32.45**	60.86**	-0.17	5.41	11.27*	
76 IH 20 x BS 27	53.25**	-24.24*	32.98**	36.80**	11.94*	83.96**	3.74**	-9.73**	12.05**	
BC 68-2 x GJHV 503	50.61**	47.06**	101.39**	49.83**	-0.26	51.97**	1.19	1.76	3.53	
LRA 5166 x GJHV 503	47.82**	-10.81	82.50**	80.12**	-3.50	47.38**	1.18	-16.42**	-14.68**	
G.cot-12 x GJHV 503	41.23**	-4.17	35.46**	10.60	27.25**	45.10**	1.35	-2.05	3.96	
BC 68-2 x BS 279	36.33**	-35.29**	-1.63	9.01	1.52	48.23**	0.78	-10.45**	-9.38*	

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