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## Research Article

### Estimation of combining ability of yield and different agronomic traits in interspecific cotton hybrids

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#### Abstract

The experiment was carried out to investigate the general combining ability of elite genotypes of seven *hirsutum* and six *barbadense* lines and the heterotic values and specific combining ability of 42 interspecific hybrids obtained by line x tester mating design for twelve characters. The analysis of variance revealed the presence of sufficient genetic variability for all the characters in the experimental material. The seed cotton yield and yield attributing characters exhibited non-additive gene action and also their hybrid mean were significantly higher than parental mean. The parents MERREL-1, BCS-9, G.Cot.20, GSB 41 and DB 1602 were good general combiners for seed cotton yield and important yield contributing characters. The hybrids G.Cot.20 × DB 1602, G.Cot.20 × GSB 41 and BCS-9 × DB 1602 noted for their high *per se* performance, *sca* estimates and having both parents of good *gca* effects for seed cotton yield per plant and may recommended for future breeding programme.

#### Key words

Cotton, Combining ability, Interspecific hybrids, *G. hirsutum* L., *G. barbadense* L.

#### INTRODUCTION

Cotton, the king of fibres is arguably the world's most renewable natural textile fiber and sixth largest source of vegetable oil. The word 'cotton' comes from the Arabic word 'quṭn' and generally refers to species that produce spinnable fibers (lint) on their seed coat (Lee, 1984). It is popularly known as 'White Gold'. Cotton hybrids had played a significant role in taking India into a self-reliant cotton producer in the world. A number of interspecific hybrids (*G. Hirsutum* L. × *G. barbadense* L.) having high yield potentiality with Extra Long Staple and other desirable fibre traits have been released for commercial cultivation. Due to the divergent evolution of the two species, upland and pima cotton each has accumulated different genes alleles with opposite effect. The combination of these alleles exhibit remarkable heterosis in vegetative growth of the  $F_1$  hybrids (e.g., plant height, leaf number, boll set and fibre development). The recognition of specific parental combination to produce the desired level of  $F_1$  heterotic effect is important in improving the yield potential of this crop. Even though release of several hybrids during the last decade contributed to quantum jump in cotton productivity, the yield levels of hybrids appear to reach

stagnation. This might be due to the lack of identification or development of specific combiners for important yield contributing characters in hybrid populations and use of less diversified genotypes in hybridization programme. Line × tester analysis (Kempthorne, 1957) provides a systematic approach for the detection of appropriate parents and crosses superior in terms of the studied traits and present study was used to determine the extent of heterosis in cotton and to identify the most heterotic hybrids.

#### MATERIALS AND METHODS

Experimental material of the study included 56 test entries comprising of seven *G. Hirsutum* female lines viz., G.89, MERREL-1, BCS 9, GJHV-507, G.Cot.12, G.Cot.20 and G.247 and six *G. Barbadense* male parents viz., GSB 40, GSB 41, DB 1602, ARBB-1501, ARBB-27 and GSB 44 and 42 resultant hybrids and one standard H × B check hybrids G. Cot Hy.102. The crosses were made using a conventional hand emasculation and pollination method developed by Doak (1934) during *Kharif* 2017 through line × tester mating design and evaluation was carried out in a randomized block design with three replications

during the *Kharif* 2018-19 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 45cm intra row spacing and 120cm inter row spacing. All recommended agronomic practices like irrigation, fertilizer application, and weed and pest control were carried out to raise the healthy plant growth. The observations were recorded on five randomly selected competitive plants of each genotype in each replication for 11 characters viz., plant height (PH) (cm), the number of monopodia per plant (NMP), the number of sympodia per plant (NSP), average boll weight (AB) (g), the total number of bolls per plant (TNBP), seed cotton yield per plant (g) (SCYP), lint yield per plant (LYP) (g), ginning percentage (GP), seed index (SI) (g), lint index (LI) and oil content (OC)(%). The phenological character days to 50 per cent flowering was recorded on plot basis. The replication wise mean values for all the characters were

subjected to statistical analysis. Heterobeltiosis was calculated using the method given by Fonseca and Patterson (1968). Standard Heterosis (SH) expressed over best check hybrid G.Cot.Hy.102 and designated as SH. It was measured as suggested by Meredith and Bridge (1972). Test of significance was according to the formulae suggested by Turner (1953). Total genetic variance is partitioned into the variance due to general combining ability and specific combining ability as per procedure suggested by Kempthorne (1957). This helps the breeder in knowing the relative proportion of additive and non additive genetic variances involved in the inheritance of various characters as well as deciding the appropriate breeding methods for effective exploitation of available genetic variations. The presence of non-additive genetic variance is the primary justification for initiating the hybrid breeding programme. The degree of dominance [ $\sigma^2_D/\sigma^2_A$ ] was also estimated.

**Table 1. Analysis of variance for seed cotton yield and its component traits in cotton**

Source of variation	Df	DF	PH	NMP	NSP	ABW	TNBP	SCYP	LYP	GP	SI	LI	OC
Replication	2	13.16*	224.5	0.09	8.26	0.03	95.88	1454.16*	107.19	2.28	0.09	0.37	6.65**
Genotypes	55	67.87**	4947.8**	0.76**	40.53**	0.65**	1596.98**	10383.99**	1132.13**	24.25**	6.71**	1.38**	4.3**
Parents	12	135.53**	1349.98**	0.72**	11.47**	0.94**	2746.11**	13118.77**	1764.71**	20.7**	7.13**	1.24**	3.19**
Females	6	50.83**	1069.16**	1.03**	4.54	1.18**	425.29**	3715.91**	547.1**	15.07**	3.22**	1.93**	3.28**
Males	5	3.29	1871.79**	0.06	11.3**	0.22**	2770.1**	6356.43**	655.93**	9.31*	1.63**	0.46	1.22**
Females vs. Males	1	1304.91**	425.91	2.2**	53.85**	3.14**	16551.07**	103347.6**	14614.23**	111.46**	58.02**	1.03	12.49**
Hybrids	41	49.04**	1581.49**	0.45**	22.99**	0.57**	880.46**	7805.01**	902.31**	19.57**	1.82**	1.39**	2.92**
Parents vs. Hybrids	1	0.19	186945.2**	14.67**	1103.8**	0.56**	15269.61**	84465.12**	2758.3**	272.63**	208.3**	3.48**	76.18**
Check vs. Hybrids	1	95.78**	4142.9**	0.004	45.16**	0.59**	3511.87**	9223.37**	1337.74**	10.04	0.16	0.78	2.39*
Error	110	3.94	125.38	0.1	2.89	0.04	51.09	396.65	53.75	3.16	0.17	0.38	0.37
<b>Components of gene action</b>													
$\sigma^2_{gca}$ (female)		4.17**	154.22**	0.07**	2.24**	0.08**	-3.09	359.69	74.19*	2.45**	0.2**	0.15**	0.08
$\sigma^2_{gca}$ (male)		0.45	-6.08	0.01	0.17	-0.01	4.47	89.16	3.42	0.31	0.03	0.03	0.15*
$\sigma^2_{gca}$		2.17	67.91	0.04*	1.13*	0.03*	0.98	214.02	36.08	1.3*	0.11*	0.08*	0.12
$\sigma^2_{sca}$		10.96*	355.81*	0.05	4.62*	0.11*	271.27*	2089.64*	216.75*	3.11*	0.34*	0.18*	0.668*
$\sigma^2_{gca}/\sigma^2_{sca}$		0.20	0.19	0.65	0.24	0.29	0.00	0.10	0.17	0.42	0.33	0.46	0.18
$\sigma^2_A$		4.34	135.81	0.07	2.26	0.06	1.96	428.03	72.17	2.60	0.23	0.17	0.24
$\sigma^2_D$		10.96	355.81	0.05	4.62	0.11	271.27	2089.64	216.75	3.11	0.34	0.18	0.66
$(\sigma^2_D/\sigma^2_A)^{0.5}$		1.59	1.62	0.85	1.43	1.35	11.76	2.21	1.73	1.09	1.22	1.03	1.66

DF: Days to 50 % flowering, NMP: Number of monopodia /plant, NSP: Number of sympodia/plant, ABW: Average boll weight, TNBP: Total number of bolls/ plant, SCYP : Seed cotton yield per plant, LYP: Lint yield per plant, GP: Ginning percentage, LI: Lint index, SI: Seed index, OC: Oil content

## RESULTS AND DISCUSSION

The analysis of variance (Table 1.) revealed that there was significant difference among genotypes as well as parents and hybrids, as mean square value found significant for all traits which indicated the existence of sufficient variability in the experimental material. Similarly,

the lines and testers exhibited remarkable differences for all characters except the number of sympodia in lines and days to 50 per cent flowering, the number of monopodia and lint index in testers. Parent vs. hybrids also exhibited worthiness for all characters except days to 50 per cent flowering provided the existence of high

heterotic response for these traits among at least some of the hybrids and parents. The significance of variance in hybrid vs. check provides adequacy for comparing the heterotic expression for most of the characters excluding the number of monopodia per plant, ginning percentage, seed index and lint index.

For the number of monopodia per plant, GCA variance alone was only significant suggesting importance of only additive genetic variance for inheritance of the character. However, in contrast to this, genetic variance due to *sca* effects ( $\sigma^2_{sca}$ ) was significant for days to 50 per cent flowering, plant height, total number of bolls per plant, seed cotton yield per plant and lint yield per plant, which suggested the importance of non-additive genetic variance for those traits. The characters such as number

of sympodia, average boll weight, ginning percentage, seed index and lint index exhibited significance of both  $\sigma^2_{gca}$  and  $\sigma^2_{sca}$  variance suggesting the importance of both genetic variances with preponderance of non-additive genetic variance. Alkuddsi *et al.* (2013), Patel *et al.* (2014), Kannan *et al.* (2016), Komala *et al.* (2018), Rajeev *et al.* (2018) and Utpal *et al.* (2018) reported preponderance of non additive gene action for seed cotton yield and its attributing characters in cotton. All the characters except the number of monopodia, ginning percentage and lint index had above one value of average degree of dominance which revealed over dominance gene action was involved for inheritance suggesting heterosis breeding would be most effective approach to enhance the seed cotton yield potential of hybrids.

**Table 2. Mean performance and *gca* values of parents for important characters of cotton.**

Parents	Number of sympodia per plant		Average boll weight		Total number of bolls per plant		Seed cotton yield per plant		Ginning percentage	
	Mean	GCA value	Mean (g)	GCA value	Mean	GCA value	Mean (g)	GCA value	Mean (%)	GCA value
<b>Females</b>										
<b>G. 89</b>	18.33	3.31**	2.89	-0.33**	92.10	3.02*	219.27	-15.12**	33.38	-2.60**
<b>MERREL -1</b>	20.00	-0.36	2.73	-0.09*	107.10	7.21**	253.84	17.76**	34.32	1.52**
<b>BCS-9</b>	20.00	-0.19	4.21	0.59**	75.30	-2.38	228.07	37.59**	34.39	0.33
<b>GJHV- 507</b>	20.00	-1.97**	2.92	0.09*	91.20	-4.78**	241.94	-14.03**	33.37	-1.61**
<b>G.Cot -12</b>	19.00	0.48	3.55	-0.29**	92.70	-5.61**	251.80	-44.96**	33.67	-1.07**
<b>G.Cot -20</b>	17.00	0.59	3.05	0.20**	74.30	-7.38**	158.29	12.27**	29.65	1.68**
<b>G.247</b>	17.67	-1.86**	2.25	-0.17**	99.10	9.92**	189.64	6.47	37.26	1.76**
<b>Males</b>										
<b>GSB 40</b>	18.67	0.67*	2.33	-0.03	34.20	2.76*	107.13	-0.39	30.71	-0.25
<b>GSB 41</b>	15.33	-1.29**	2.65	0.12**	91.60	4.3**	186.12	25.21**	31.16	0.04
<b>DB 1602</b>	14.33	1.24**	2.13	-0.11**	27.90	8.84**	74.11	16.83**	32.49	0.45
<b>ARBB -1501</b>	14.67	0.19	2.48	0.01	23.10	-1.03	70.54	3.96	27.46	-0.49
<b>ARBB -27</b>	17.67	-1.05**	2.60	-0.05	83.80	-4.67**	157.41	-17.86**	30.99	1.53**
<b>GSB 44</b>	18.33	0.24	2.92	0.06	33.00	-10.2**	107.57	-27.75**	29.17	-1.28**

Knowledge of combining ability allows the breeders to use additive effects to match their practical production situation and gain further increases in productivity through non-additive gene action (Su *et al.*, 2013). A high *gca* value negative or positive implies that the parental mean is superior or inferior to the general mean respectively. *i.e.* there is desirable gene flow from the parent to progenies. It also indicates higher heritability and low environmental effect or its large adaptability. **Table 2.** shows, the mean value and *gca* effects of parents for seed cotton yield and important desirable characters such as the number of sympodia per plant, average boll weight, total number of bolls per plant, ginning percentage and lint yield per plant. Analysis of data indicated that to improve sympodia per plant, use of G.89, DB 1602 and GSB 40 as parents would be ideal as they were found to be good general combiners for the number of sympodia per plant even though they

were not good performers. The parents BCS-9, GJHV-507, GSB 41 showed positive and significant GCA value indicating good combiner for average boll weight. For the total number of bolls per plant G.247, MERREL-1, G.89, DB 1602, GSB 41, GSB 40 found to be good general combiners among which DB 1602 exhibited a poor mean performance with respect to most of the characters. The MERREL-1, BCS-9, G.Cot.20, GSB 41 and DB 1602 were good general combiners for seed cotton yield. The MERREL-1 and ARBB-27 showed a desirable *gca* value for ginning percentage.

Selection of hybrids based on *sca* effect has less scope in breeding programs. SCA effect should be used consecutive with high performance *per se* hybrid, favourable *sca* estimates and involving at least one parent with high GCA effect. The top three hybrids for important



Fig. 1. Top three high yielding hybrids. A: G. Cot.20 x DB 1602, B: G. Cot. 20 x GSB-41, C: BCS-9 x DB 1602

**Table 3. Promising hybrids for seed cotton yield per plant with heterosis over better parent, standard heterosis, their sca effects, and component characters showing significant desired standard heterosis in cotton**

Sr. No.	Hybrids	Seed cotton yield per plant(g)	Heterosis over		sca effects	gca effects of parents	Significant and desirable heterosis over G.Cot. Hy.102 for component traits	Significant and desirable sca effects for component traits
			BP	SH				
1.	G. Cot. 20 × DB 1602	317.26	100.44**	17.78**	62.15*	Good × Good	PH, ABW	PH, ABW, TNBP, LYP
2.	G. Cot. 20 × GSB 41	308.88	65.96**	14.67*	45.39*	Good × Good	ABW, LYP, SI	DF, NMP, ABW, LYP, GP, SI, LI
3.	BCS- 9 × DB 1602	305.47	33.94**	13.40 *	25.04*	Good × Good	ABW, SI	TNBP

DF: Days to 50 % flowering, NMP: Number of monopodia /plant, NSP: Number of sympodia/plant, ABW: Average boll weight, TNBP: Total number of bolls/ plant, SCYP : Seed cotton yield per plant,LYP: Lint yield per plant, GP: Ginning percentage, LI: Lint index, SI: Seed index, OC: Oil content

characters of cotton are shown (Table 3.) with their sca value, parental gca status and heterosis estimates. The hybrids G. Cot. 20 × DB 1602, followed by G.Cot.20 × GSB 41 and BCS- 9 × DB 1602 ( Fig. 1.) revealed statistically superior performance for seed cotton yield over the standard check. The parental performance of good x good gca effect ascribed to additive × additive gene action for this trait. The favourable sca estimates and higher performance per se and involving both parents with good gca effect assured the superior heterotic combinations. The three hybrids are statistically at par however G.Cot.20 × GSB 41 with significant standard heterosis for average boll weight, lint yield per plant and seed index and significant sca effects for days to fifty per cent flowering, the number of monopodia per plant, average boll weight, Lint yield per plant, ginning percentage, seed index and lint index in desirable direction could propose as the desirable heterotic cross combination. The line G.Cot.20 and male DB 1602 was good general combiners for seed cotton yield. The crosses on the basis of their per se performance, heterobeltiosis, standard heterosis and sca effects for different characters displayed differences in their ranking, which suggest that crosses exhibit high sca effect would not necessarily give either higher mean value or high heterotic effect or vice versa; therefore while selecting a cross for exploiting heterotic effects and or advancing for development of parental lines plant breeder has to consider all the aspects independently.

The character seed cotton yield per plant was under the influence of non-additive genetic variance; therefore, hybridization programme in respect to commercial exploitation of heterosis breeding would be more useful. Among the female and male parents, the highest seed cotton yield per plant was observed with MEREL-1, G.Cot.12 and GJHV-507 but the last two found to be poor combiner for seed cotton yield. This suggests that a parent good in per se performance may not necessarily produce better hybrids when used in hybridization.

The parents MERREL-1, BCS-9, G.Cot.20, GSB 41 and DB 1602 which were good general combiners for seed cotton yield and important yield contributing characters may be used in breeding programme. The top three high yielding hybrids viz., G.Cot.20 × DB 1602, followed by G.Cot.20 × GSB 41 and BCS- 9 × DB 1602 had favourable sca estimates and higher performance per se than standard check. . Also the parents of these three hybrids exhibited good gca effect ascribed for the additive × additive gene action, promising they can be further evaluated in multi-location trials for commercial breeding programme.

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