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Research Article

Combining ability analysis for yield and yield attributing traits in interspecific *(G. hirsutum* L. X *G. barabdense* L.) hybrids of cotton

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Abstract
Combining ability studies were carried out in interspecific (*G. hirsutum* L. X *G. barabdense* L.) hybrids of cotton for plant height, number of monopodia, number of sympodia, number of bolls per plant, boll weight, lint index, seed index, ginning out turn and seed cotton yield by following the line x tester analysis, involving 17 hirsutum lines and three barbadense testers with their 51 hybrids. The analysis revealed predominance of non-additive gene action for most of the characters except for number of monopodia and number of sympodia. This suggests the possibility of exploiting heterosis in the present material. Superior parents HBS-1, FQT-37 and HBS-146 in lines while BCS-23 in testers are having high *gca* effects for yield and its components and can be used to develop multiple crosses leading to further selection. Top five cross combinations *viz*., FQT-37 X SB-YF-425, 543403A03N106 X BCS-23, CSHH-243M X BCS-23, HBS-1 X Suvin and HAG-1055 X SB-YF-425 exhibited high mean value with high *sca* effects for seed cotton yield. These crosses were found to involve at least one parent with high *gca* effect and the other parent having either high or low *gca* effect indicating the involvement of additive as well as non-additive gene action operating in these crosses except one cross where both the parents having high *sca* effects indicating the involvement of additive gene action.

Keywords
General and specific combining ability, Interspecific hybrid, Line X Tester.

Introduction

Cotton, the "king of fibre", is an important cash crop having profound influence on economics and social affairs of the country. In India, cotton is the most important commercial crop, belonging to the family Malvaceae and the genus *Gossypium.* It has diversity in categories of cultivated species such as diploids and tetraploids, of which only four species *viz., Gossypium arboreum* L., *Gossypium herbaceum* L., *Gossypium hirsutum* L. and *Gossypium barbadense* L. are cultivated. Among the four cultivated species, upland cotton (*Gossypium hirsutum* L.) is known for its production potential, as demonstrated by the release of a number of stable varieties and hybrids while sea island cotton (*Gossypium barbadense* L.) is known for high fibre quality.

The interspecific hybrids between *G. hirsutum* L. X *G. barbadense* L. have good fibre properties as well as higher yields than barbadense varieties. Combining ability analysis is a powerful tool to discriminate good and poor combiners and also to choose appropriate parental material in breeding programs. The concept of general and specific combining ability as a measure of gene effects was proposed by Sprague and Tatum (1942). The resulting total genetic variance is partitioned into the variance due to general combining ability and specific combining ability. 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 variation. The presence of non-additive genetic variance is the primary justification for initiating a hybrid breeding program. The present study was aimed at evaluating combining ability of 17 hirsutum lines and 3 barbadense testers.

Material and Methods

The present study was conducted at Agricultural Research Station, Dharwad Farm, University of Agricultural Sciences, Dharwad during *Kharif* 2014-15. The parent material used in the study comprised of 17 hirsutum lines and 3 barbadense testers which generated 51 interspecific hybrids using Line X Tester mating design (Table 1). The resulting 51 F_1s and 20 parents were grown in randomized complete block design with two replications during *kharif* 2014-15. Here, spacing in between rows and plant to plant was 90 cm and 60 cm, respectively. Other recommended agronomic practices were followed. Data were recorded on randomly selected five plants in each replication for plant height, number of monopodia, number of sympodia, number of bolls per plant, boll weight, lint index, seed index, ginning out turn and seed cotton yield. Combining ability analysis was carried out according to the formulae given by Kempthorne (1957). The data were analyzed in the computer generated program, WINDOSTAT, Indostat services, Hyderabad Ram *et. al.(*2015); Kumar *et. al.* (2017).

Results and Discussion

Analysis of variance showed highly significant differences among crosses for all the characters studied except plant height. The female lines exhibited significant differences for seed cotton yield, ginning out turn and seed index. The males were highly significant for all the characters except plant height and lint index. However, line x tester interaction was highly significant for all the characters except number of sympodia per plant. The magnitude of SCA variance was greater than GCA variance for all the characters (Table 2) except number of monopodia and number of sympodia. The GCA and SCA variance ratio was less in the characters *viz.*, plant height, number of bolls per plant, boll weight, seed cotton yield, ginning out turn, seed index and lint index indicating that dominance variance was more than additive variance. It suggested that dominant and epistatic gene actions were important for controlling these traits. Hence, heterosis breeding is an appropriate and suitable approach for yield improvement. Similar results were aslo observed by Bhatade *et al.* (1992), Tausif (2008), Alkuddsi *et al.* (2013) and Patel *et al*. (2014). Additive variance was more than dominance variance for the two characters *viz.*, number of monopodia and number of sympodia. Lines and testers showed significant *gca* effects for most of the traits studied (Table 3). Out of the 17 lines studied, FQT-37, HBS-1, HAG-1055, 543403A03N106, FQT-26, and HBS-146 showed better general combining ability for seed cotton yield (kg/ha). Two testers *viz*., BCS-23 and SB-YF-425 with high *gca* effects were also good general combiners. These promising testers could be used in further cotton breeding programs.

Specific combining ability effects revealed the usefulness of a cross in the exploitation of heterosis. Table 4 shows the top five cross combinations based on mean seed cotton yield with significant *sca* effects along with *gca* effects of their parents. FQT-37 X SB-YF-425 (169.37) for seed cotton yield, followed by 543403A03N106 X BCS-23 (159.56), CSHH-243M X BCS-23 (247.75), HBS-1 X Suvin (223.97) and HAG-1055 X SB-YF-425 (167.83) were the top crosses with their *sca* effects in parentheses. Out of five, four crosses *viz.*, FQT-37 X SB-YF-425, CSHH-243M X BCS-23, HBS-1 X Suvin and HAG-1055 X SB-YF-425 involved the parents with high x low *gca* effects, indicating the involvement of additive x dominance interaction, Krishnaswami and Gunaseelan(1985) also reported similar findings. The cross 543403A03N106 X BCS-23 involved both the parents having high *gca* effect, such a behavior has been attributed to additive gene action Patel *et al*. (2014).

The results presented in Table 4 showed that out of five cross combinations showing significant SCA for yield, involved one parent having high *gca* effects and the other having low *gca* effects indicating additive as well as non-additive genetic interactions in the crosses studied. Krishnaswami and Gunaseelan (1985) also found similar results. The high yield potential of cross combinations with high x low *gca* effects was attributed to interactions between positive alleles from good general combiner and negative alleles from poor combiner Dubey(1975). Remaining one cross involved high x high general combiners may be advanced by pedigree method of breeding for improving yield, since it involves additive genes and additive X additive gene interaction Patel *et. al.(*2014).

There is a preponderance of non-additive gene action for grain yield and most of the yield components in the hybrids, which was reponsible for the high amount of heterosis seen. The cross, FQT-37 X SB-YF-425 revealed the highest heterosis over better parent and commercial check DHB-915 for seed cotton yield, followed by HBS-1 X Suvin and 543403A03N106 X BCS-23. Keeping in view the mean performance and standard heterosis for practical exploitation of hybrid vigour under rainfed condition, the hybrid combinations *viz.*, FQT-37 X SB-YF-425, 543403A03N106 X BCS-23 and HBS-1 X Suvin could be further evaluated in large *sca*le and multilocation trials for commercial utilization.

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Table 1. Experimental material used in the study

Lines (*G. hirsutum* L.)		**Testers (*G. barbadense* L.)**
1. HBS-1	**10**. FQT-26	**1**.BCS-23-18-7
2. HBS-137	**11**. FQT-37	**2**.Suvin
3. HBS-144	**12**. HAG-1055	**3**.SB-YF-425
4. HBS-146	**13.** CSHH-198M	
5. HBS-157	**14**. CSHH-243M	
6. HBS-176	**15**. RDT-8	
7. HBS-183	**16**. EC560413	
8. 543403A03N106	**17**. EC560436	
9.FQT-21		

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Table 2. Analysis of variance for combining ability involving interspecific crosses (HXB) with respect to yield and its component characters

Source of variation	Mean sum of squares									
	d.f	Plant height (cm)	Number of monopodia per plant	Number of sympodia per plant	Number of bolls per plant	Boll weight (g)	Lint index(g)	Seed index(g)	Ginning outturn (%)	Seed cotton yield (kg/ha)
Replication	1	126.29	0.20	18.89	0.42	0.02	0.07	0.01	5.11	3800.66
Crosses	50	68.95	0.72**	8.94**	11.73**	0.35**	0.30**	0.87**	6.00**	51294.61**
Line	16	77.78	0.47	7.96	13.74	0.40	0.43	1.22*	8.55*	64837.62*
Tester	2	34.31	9.25**	56.05**	32.75*	1.18*	0.02	2.96*	14.07*	252417.60**
Line x Tester	32	66.69*	0.31**	6.50	9.41**	0.28**	0.25**	0.56**	4.22**	31953.02**
Error	50	33.08	0.08	4.77	0.85	0.07	0.08	0.07	1.35	1063.77
s^2_{gca}		0.26	0.23**	1.36**	1.11**	0.03**	0.008	0.10**	0.49**	7885.71**
s^2_{sca}		7.96	0.11**	0.92	4.23**	0.10**	0.09**	0.24**	1.41**	15519.92**
s^2_{gca}/s^2_{sca}		0.03	2.03	1.48	0.26	0.34	0.08	0.41	0.35	0.51

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

Table 3. Estimates of general combining ability (*gca*) effects of parents involved in interspecific crosses (HXB) for different quantitative characters

Sl. No.	Parents	Plant height (cm)	Number of monopodia per plant	Number of sympodia per plant	Number of bolls per plant	Boll weight (g)	Lint index (g)	Seed index (g)	Ginning outturn (%)	Seed cotton yield (kg/ha)
1	HBS-1	1.59	-0.40*	1.24	2.00**	0.21	0.17	0.68**	-0.27	167.33**
2	HBS-137	2.13	-0.20	-0.51	-1.52**	0.21	0.29**	0.22	0.91	-74.29**
3	HBS-144	-0.90	-0.03	0.01	-1.09**	-0.20	-0.19	0.13	-0.95	-113.97**
4	HBS-146	3.73	-0.43**	-0.98	0.32	0.24*	-0.23*	0.09	-0.88	42.99**
5	HBS-157	0.69	-0.10	0.88	-2.12**	-0.31**	-0.05	-0.36**	0.36	-139.54**
6	HBS-176	-1.62	-0.46**	0.71	-0.76	-0.01	-0.20	-015	-0.60	-42.56**
7	HBS-183	-2.17	0.03	0.14	-2.26**	-0.21*	-0.06	-0.59**	1.25*	-124.99**
8	543403A03N106	-7.13*	-0.10	-1.68	2.40**	-0.25*	-0.15	-0.47**	0.10	88.84**
9	FQT-21	-0.53	0.00	2.08*	-0.21	-0.50**	0.18	0.02	0.65	-80.02**
10	FQT-26	-8.13**	0.56**	0.04	1.35**	0.11	-0.33**	-0.37**	-1.04*	87.96**
11	FQT-37	-2.37	0.10	-1.15	2.60**	0.19	0.26*	0.57**	0.23	198.19**
12	HAG-1055	1.26	-0.06	0.38	0.57	0.44**	-0.001	-0.23	0.52	137.56**
13	CSHH-198M	-0.10	0.03	1.11	-0.91*	-0.003	-0.38**	-0.33**	-1.88**	-55.80**
14	CSHH-243M	3.53	0.23	0.09	0.02	0.13	-0.01	0.91**	-1.52**	-11.24
15	RDT-8	2.86	0.40**	-1.85*	1.22**	-0.20	0.11	0.53**	-0.30	3.75
16	EC-560413	5.43	0.23	1.08	-0.36	0.28*	0.69**	-0.43**	3.20**	-24.91*
17	EC-560436	1.73	0.20	-1.61	-1.22**	-0.10	-0.07	-0.21	0.23	-59.30**
	SE (g_i)	**2.90**	**0.11**	**0.88**	**0.39**	**0.11**	**0.10**	**0.11**	**0.48**	**12.33**
	CD (g_i) 5%	**5.84**	**0.23**	**1.76**	**0.79**	**0.22**	**0.21**	**0.23**	**0.97**	**24.77**
	SEd (gi-gj)	**4.11**	**0.16**	**1.24**	**0.56**	**0.16**	**0.15**	**0.16**	**0.68**	**17.44**
1	BCS-23	1.11	0.32**	0.39	0.87**	0.20**	0.02	-0.33**	0.74**	89.11**
2	Suvin	-0.27	0.28**	-1.43**	-1.06**	-0.05	0.01	0.21**	-0.35	-82.87**
3	SB-YF-425	-0.83	-0.62**	1.04**	0.19	-0.15**	-0.03	0.12*	-0.38	-6.23
	SE (g_i)	**1.22**	**0.04**	**0.37**	**0.16**	**0.04**	**0.04**	**0.04**	**0.20**	**5.18**
	CD (g_i) 5%	**2.45**	**0.09**	**0.74**	**0.33**	**0.09**	**0.09**	**0.09**	**0.40**	**10.40**
	SEd (gi-gj)	**1.72**	**0.06**	**0.52**	**0.23**	**0.06**	**0.06**	**0.06**	**0.28**	**7.32**

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

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Table 4. Top five interspecific (HXB) hybrids based on seed cotton yield (kg/ha) along with *sca* effects and *gca* effects of their parents.

Sl. No.	Crosses	Seed cotton yield (kg/ha)	*sca* effects	*gca* effects		% Heterosis over	
				Female	Male	Better parent	Check (DHB-915)
1.	FQT-37 X SB-YF-425	718.25	169.37**	198.19** (H)	-6.23 (L)	190.38**	59.71**
2.	543403A03N106 X BCS-23	694.44	159.56**	88.84** (H)	89.11** (H)	77.83**	54.41**
3.	CSHH-243M X BCS-23	682.54	247.75**	-11.24 (L)	89.11** (H)	92.23**	51.76**
4.	HBS-1 X Suvin	665.34	223.97**	167.33** (H)	-82.87** (L)	122.57**	47.94**
5.	HAG-1055 X SB-YF-425	656.08	167.83**	137.56** (H)	-6.23 (L)	79.06**	45.88**

*, ** significant at 5% and 1% levels, respectively H- High L-Low