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Research Article

Heterosis and combining ability analysis in tetraploid cotton (*G.hirsutum* L. and *G.barbadense* L.)

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Abstract
The present investigation was carried out with a view to study the heterosis, combining ability and gene action for seed cotton yield, yield attributing traits, ginning outturn and important fibre quality parameters in tetraploid cotton (*G. hirsutum* L. and *G.barbadense* L.). A set of 38 genotypes, including six parents of which three each belonged to *G .hirsutum* and *G. barbadense*, 30 crosses and two check hybrids were grown at three Cotton Research Stations *viz.*, Surat, Hansot and Achhalia during *kharif* 2011-12. The hybrids were developed adopting complete diallel mating design. Analysis of variance showed significant differences amongst parents and hybrids for all the characters indicating presence of genetic variability. The cross G.Cot.20 x G.Cot.16 recorded the highest heterobeltiosis and standard heterosis for seed cotton yield. Combining ability analysis indicated that both additive and non additive gene effects were important in the inheritance of all the traits. The ratio of variance due to GCA to that of SCA was greater than one for plant height, boll weight, seed cotton yield per plant and fibre strength indicating preponderance of additive effects in the inheritance of these characters. On the other hand, σ^2GCA**:**σ^2SCA was less than unity for number of sympodia per plant, number of bolls per plant, ginning outturn and 2.5% span length indicating importance of dominance gene effects in the inheritance of these characters. Mean squares due to reciprocal effects were significant for number of sympodia per plant, plant height, bolls per plant, boll weight, seed cotton yield per plant, ginning outturn and 2.5% span length. In general, parents belonging to *G.hirsutum* species showed good general combining ability for yield and yield components while *G.barbadense* parents found to be good general combiners for fibre quality traits. Two crosses BC-68-2 x G.Cot.20 and G.Cot.20 x GSB-39 registered significant and positive SCA effects along with significant and positive standard heterosis for seed cotton yield and majority of yield components and fibre quality traits.

Key words:
Cotton, Full diallel analysis, heterosis, combining ability, gene action, reciprocal effects

Introduction

Cotton, the king of fibre, is one of the most momentous and important cash crops having profound influence on economics and social affairs of the country. It is also called “White Gold” due to its global importance in agriculture as well as industrial economy. It is the most important commercial crop contributing nearly 65 per cent of the total raw material needs of the textile industry in our country. Simpson (1954) classified cotton as predominantly self pollinated and often cross pollinated crop amenable for both heterosis breeding as well as hybridization followed by selection in subsequent generations. Exploitation of heterosis on commercial scale and systemic varietal improvement through hybridization are the main tools to increase cotton production. Besides yield, improvement in the fibre quality has also become increasingly important. *G.barbadense* cottons are well known for their quality of fibres particularly with regards to fibre length and fibre strength. On the other hand, *G.hirsutum* cottons possess early maturity, bigger bolls, good boll opening and high seed cotton yield. In order to derive high yielding cotton varieties or hybrids with superior fibre quality, there must be an involvement of *G.barbadense* lines as one of the parents in hybridization programme with *G.hirsutum*.

Combining ability described by Sprague and Tatum (1942) elucidates the nature and magnitude of gene action involved in the inheritance of various characters. For estimation of combining ability of parents, several biometrical tools have been developed for identifying desirable parents. Among these, diallel analysis (Griffings, 1956) has been extensively used to assess the combining ability of parents and crosses for different quantitative characters as well as to study the extent of heterosis for yield, yield contributing characters and fibre quality traits in cotton. The knowledge of nature and magnitude of gene action controlling yield, yield contributing characters and fibre quality characters are very useful for development of the breeding procedures to be followed for cotton improvement. The present study was therefore planned and executed to examine the extent of heterosis and combining ability in various environments for different characters utilizing full diallel mating design (Griffings, 1956).

Material and Methods

The present investigation was carried out at Main Cotton Research Station, Surat, Cotton Research Sub Station, Achhalia and Cotton Research Sub Station, Hansot of Navsari Agricultural University during *kharif* 2011-12. The experimental material consisted of six parents, of which three belongs to *G.hirsutum viz.,* G.Cot.16, BC-68-2 and G.Cot.20 while other three belongs to *G.barbadense viz.*, Suvin, GSB-39 and GSB-41 and their resultant 30 crosses obtained through full diallel mating system along with G.Cot.Hy-12 (*G.hirsutum* x *G.hirsutum*) and G.Cot.Hy-102 (*G.hirsutum* x *G.barbadense*) as checks. Source of seeds, pedigree and average values of important characters of the parents are given in Table 1.

A complete set of 38 genotypes was evaluated in a randomized block design replicated thrice. Each plot consisted of single row of 4.5 m length spaced at 1.20 m apart with plant to plant distance of 45 cm. All the recommended agronomical practices and plant protection measures were followed as and when required to raise a good crop of cotton. Observations were recorded for seed cotton yield per plant (g), number of sympodial branches per plant, plant height (cm), number of bolls per plant, boll weight (g), ginning outturn (%), 2.5% span length (mm) and fibre strength (g/tex). Data were recorded on five random competitive plants from each entry from all replications and from all locations and mean of five plants was taken for further analysis. Heterobeltiosis and standard heterosis were estimated as per the procedure suggested by Fonseca and Patterson (1968) and Meredith and Bridge (1972), respectively. Method of analysis for combining ability was based on method-I, model-I as outlined by Griffings (1956).

Results and Discussion

The pooled analysis of variance for experimental design in this investigation revealed that the considerable amount of variability was observed in the experimental materials as evidenced by significant values of mean squares due to genotypes for all the characters studied (Table 2). This validated that the material was appropriate for present study. The mean squares for environments were highly significant indicating variable environmental conditions. Genotypes were found to interact significantly with the environments for all the traits under study as the mean squares due to G x E were significant and thus indicated differential response of genotypes to environments.

Analysis of variance for combining ability over locations revealed that both additive as well as non additive gene effects were important in the inheritance of all the traits under study as evident from the significance of both GCA and SCA mean squares for these characters (Table 3). The ratio of variance due to GCA to that of SCA was greater than one for plant height (1.770), boll weight (2.238), seed cotton yield per plant (1.111) and fibre strength (1.065) indicating preponderance of additive effects in the inheritance of these characters. On the other hand, σ^2GCA**:**σ^2SCA was less than unity for number of sympodia per plant (0.983), number of bolls per plant (0.498), ginning outturn (0.937), 2.5% span length (0.341) and fibre fineness (0.164) indicating importance of dominance gene effects in the inheritance of these characters. These findings are in agreement with those obtained by Elangaimannan *et al.* (2007), Ali *et al.* (2008), Singh *et al.* (2010), Zangi *et al.* (2010), Khan *et al.* (2011) and Simon *et al.* (2013) for various traits under consideration. Preponderance of additive type of gene effects in the present investigations for plant height, boll weight, seed cotton yield per plant and fibre strength suggested directional selection for isolating better homozygous lines from the segregating population for these traits while for the traits like number of sympodia, number of bolls, ginning outturn and 2.5% span length exploitation of heterosis seems to be the most appropriate breeding method.

Mean squares due to reciprocal effects were significant for all the characters studied except fibre strength in pooled analysis. Significant values for mean squares due to reciprocal effects were also noted by Islam *et al.* (2001) for seed cotton yield, number of bolls and boll weight; Ahmad *et al.*, (2005) for number of bolls and seed cotton yield per plant; Abro *et al.* (2009) for plant height, number of sympodia, number of bolls and seed cotton yield per plant; Singh *et al.* (2010) for ginning outturn and 2.5% span length; Khan *et al.* (2011) for ginning outturn and Simon *et al.* (2013) for plant height, number of bolls and seed yield. These results suggest that the selection of a desirable female parent would be important in hybridization programs. Khan *et al.* (2011) opined that in combining ability, the maternal effect which comes through cytoplasm can not be ignored and the F_1 hybrids having desirable reciprocal effects should also be kept under consideration for future breeding. Singh *et al.* (2010) suggested the selection of female parents based on reciprocal analysis and reported that such combinations may give desirable transgressive segregants and these could be utilized for the development of improved genotypes, if additive gene effects are present.

The GCA effects of the parents along with their mean performance for various characters are given in Table 4. Amongst parent, G.Cot.20 and G.Cot.16 emerged as good general combiners for number of sympodia, plant height, number of bolls, boll weight, seed cotton yield per plant and ginning outturn. On the other hand, all the three parents belonging to *G.barbadense* species were found to be good general combiners for fibre quality traits viz., 2.5% span length and fibre strength. Good general combining ability of *G.hirsutum* parents for yield and yield attributing traits while that of *G.barbadense* parents for fibre quality parameters were also reported by Zangi *et al.* (2009) and Zangi *et al.* (2010). In the present study, the GCA effects of parents were positively and significantly associated with their mean values for all the characters. Gururajan and Basu (1992) reported high order relationship between *per se* performance of parents with their GCA effects and their importance in the choice of parents for crossing programme.

A summarized account of the best parent *per se*, best general combiner, best F_1 *per se*, most heterotic crosses and best specific combination for various characters studied in the present investigation are presented in Table 5. The data revealed that the best general combiner may not always produce best specific combinations for all the characters. Bhandari (1978) and Sarasar *et al.* (1986) expressed similar view. However, in some cases, high SCA effects of F_1 hybrids coincided with high GCA effects of their parents. Pathak and Kumar (1975) reported close relationship between GCA effects of parents and SCA effects of their resultant crosses. In addition to these, it was also inferred that the ranking on the basis of SCA effects was not always reflected by the ranking based on *per se* performance and crosses showing high mean performance had not always shown high SCA effects. There was no consistent association between *per se* performance of the crosses and their SCA effects. Although, high SCA effects denote high heterotic response which might be due to poor performance of the parents in comparison with their hybrids. Even with the same amount of heterotic effects, the SCA effects may be lower where the mean performance of the parent is higher. This suggests that estimates of SCA effects may not always lead to a correct choice of hybrid combination (Verma *et al.*, 1991). Hence, the choice of best cross combination on the basis of *per se* performance could be more realistic and useful. Almost identical results have been reported by Patel *et al.* (1997), Khorgade *et al.* (2000), Saini *et al.* (2005) and Patel *et al.* (2012).

The data of top ten crosses selected on the basis of their *per se* performance for seed cotton yield along with heterobeltiosis and standard heterosis as well as SCA effects and GCA effects of the parents involved are tabulated in Table 6. Significant heterobeltiosis and standard heterotic effects as well as significant positive SCA effects appeared in two cross combinations *viz.*, BC-68-2 x G.Cot.20 and G.Cot.20 x GSB-39 for seed cotton yield. The cross BC-68-2 x G.Cot.20 had both good combining parents for seed cotton yield. The heterosis in this cross might have resulted from interaction of dominant gene contributed by both good combining parents. Pathak and Kumar (1975) reported close relationship between GCA effects of parents and SCA effects of their resultant crosses. The cross G.Cot.20 x GSB-39 had good x poor combining parents. Positive SCA effects in crosses between good and poor combiners could be ascribed to better complementation between favourable alleles of the parents involved. Patel and Mehta, (1985), Gururajan and Basu (1992), Rao and Reddy (2002) and Saini *et al.* (2005) also stressed the importance of good x poor crosses in obtaining superior combinations. The highest yielding cross G.Cot.20 x G.Cot.16 (138.98 g/plant), though registered significant and positive heterotic values for better parent heterosis (35.49 %) and standard heterosis (27.99 %), recording significant and negative SCA value for seed cotton yield (-12.757). Both the parents involved in this cross were having good general combining ability. Marked negative effects in crosses between good x good general combiners could be attributed to the lack of co-adaptation between favourable alleles of the parents involved. Gururaj Rao *et al.* (1977) reported that this was probably due to mutual cancellation of components of heterosis. The data presented in Table 6 also reflected the reciprocal effects depicted by various crosses in terms of mean performance, heterosis and SCA effects and thus revealed the importance of full diallel analysis to estimate the influence of maternal effects on the yield performance.

In the light of present investigation, the parent G.Cot.20 was found to be promising due to its high yield potential as well as significant and positive general combining ability effects for yield and its attributes. GSB-39 registered good general combining ability for 2.5% span length and fibre strength and appeared promising for these important fibre quality traits. Therefore, these two parents could be effectively used for hybrid breeding programme as well as introgression breeding. The cross combinations having high mean yield, high heterosis and desirable SCA effects is of immense importance for hybrid cotton breeding programme. For seed cotton yield and major yield attributes as well as important fibre quality parameters, BC-68-2 x G.Cot.20 and G.Cot.20 x GSB-39 showed positive and significant standard heterosis and SCA effects. Consequently, these two hybrids appeared promising for commercial release after thorough testing. The preponderance of additive gene effects for plant height, boll weight, seed cotton yield per plant and fibre strength suggested that significant advancement for these characters can be made in segregating population using mass or pedigree method of breeding, which would increase the frequency of desirable genes.

References:

Abro, S., Kandhro, M. M., Laghari, S., Arain, M. A. and Deho, Z. A. 2009. Combining ability and heterosis for yield contributing traits in upland cotton (*Gossypium hirsutum L.). Pak. J. Bot*., **41**: 1769-1774.

Ahmad, R. D., Malik, A. J., Gul, H. and Subhan, M. 2005. Estimation of combining ability for seed cotton yield and its components in inter-varietal crosses of cotton (*Gossypium hirsutum* L.). *Gomal Univ. J. Res*., **21**: 1-6.

Ali, M. A., Khan, I.A., Awan, S.I., Ali, S. and Niaz, S. 2008. Genetics of fibre quality traits in cotton (*Gossypium hirsutum* L.). *Australian J. Crop Sci.*, **2**: 10-17.

Bhandari, D. R. 1978. Line x tester analysis of combining ability and its interaction with environment in American cotton *G. hirsutum* L. *Madras Agric. J*., **65**: 218-225.

Elangaimannan, R., Anbuselvam, Y., Venkatesan, M. and Karthikeyan, P. 2007. Diallel analysis in cotton (*Gossypium hirsutum* L.). *Intl. J. Plant Sci.,* **2:** 53-56.

Fonseca, S. and Patterson, F. L. 1968. Hybrid vigour in seven parent diallel cross in common wheat (*Triticum aestivum* L.). *Crop Sci.,* **8:** 85-88.

Griffings, B. 1956. Concept of general and specific combining ability in relation to diallel crossing system. *Australian J. Biol. Sci.,* **9:** 463-493.

Gururajan, K. N. and Basu, A. K. 1992. Heterosis and combining ability in medium staple cotton. *J. Indian Soc. Cott. Improv*., **17**(1): 17-22.

Gururaj Rao, M. R., Hiremath, K. G. and Virupakshappa, K. 1977. Genetic analysis of ginning and fibre properties in upland cotton *G. hirsutum* L. II. Combining ability studies in respect of six quantitative characters. *Mysore J. Agric. Sci.*, **2**(4): 453-457.

Islam, Z., Sadaqat, H. A. and Khan, F. A. 2001. Evaluation of some cotton strains for their combining ability in important genetic traits. *Intl. J. Agri. Biol.,* **3:** 409-410.

Khan, S. A., Khan, N. U., Mohammad, F., Ahmad, M., Khan, I. A., Zarina Bibi And Khan, I. U. 2011. Combining ability analysis in intraspecific F_1 diallel cross of upland cotton. *Pak. J. Bot*., **43**: 1719-1723.

Khorgade, P. W., Satange, I. V. and Meshram, L. D. 2000. Diallel analysis in American cotton (*G. hirsutum* L.). *Indian J. Agric. Res.*, **34**(3): 172-175.

Meredith, W. R. and Bridge, R. R. 1972. Heterosis and gene action in cotton (*G. hirsutum* L.). *Crop Sci.,* **12:** 304-310.

Patel, N. A., Patel, B. N., Bhatt, J. P. and Patel, J. A. 2012. Heterosis and combining ability for seed cotton yield and component traits in interspecific cotton hybrids (*Gossypium hirsutum* L. x *Gossypium barbadense* L.) *Madras Agric. J.,* **99:** 649-656.

Patel, U. G. and Mehta, N. P. 1985. Studies on heterosis, combining ability and stability of performance in cotton (*G. herbaceum* L.). Unpublihsed Ph D thesis submitted to G.A.U., Sardarkrushinagar.

Patel, U. G., Patel, J. C., Patel, P. G., Vadodaria, K. V. and Sutaria, C. M. 1997. Combining ability analysis for seed cotton yield and mean fibre length in upland cotton *G. hirsutum* L. *Indian J.Genet*., **57** (3): 315-318.

Pathak, R. S. and Kumar, P. 1975. Combining ability studies in upland cotton *G. hirsutum* L. *Zeitschrift fur Pflanzenchtung,* **75**(4): 297-310.

Rao, N. G. and Reddy S. M. 2002. Combining ability studies of yield and yield contributing traits using diversified plant types in cotton. *J. Cottton Res. Dev.*, **16**(1): 19-23.

Saini, D. P., Ranwah, B. R. and Rokadia, P. 2005. Combining ability and heterosis for yield and its components under different environments in upland cotton (*G. hirsutum* L.). *J. Cotton Res. Dev.,* **19** (2): 134-139.

Sarasar, S. M., Patil, R. A. and Bhatade, S. S. 1986. Heterosis and combining ability in upland cotton. *Indian J. Agric. Sci.*, **56:** 567-573.

Simon, S. Y., Kadams, A. M. and Aliyu, B. 2013. Combining ability analysis in F_1 hybrids of cotton (*Gossypium Species*) by diallel method in Northeastern Nigeria. *Greener Journal of Agricultural Sciences,* **3:** 90-96.

Simpson, D. M. 1954. U. S. Department of Agriculture. *Tech. Bull*., 1094.

Singh, S.A., Singh, V.V. and Choudhary, A.D. 2010. Combining ability estimation for oil content, yield components and fibre quality traits in cotton *Gossypium hirsutum* L. using 8x8 diallel matting design. *Tropical and Subtropical Agroecosystems*, **12:** 161-166.

Sprague, G. F. and Tatum, L. M. 1942. General versus specific combining ability in single crosses of corn. *Agron. J.,* **34:** 923-932.

Verma, S. S., Lather, B. P. S. and Verma, U. 1991. Line x tester analysis for yield and its components in upland cotton. *J. Cotton Res. Dev.,* **5(2):** 90-95.

Zangi, M. R., Jelodar, N. B., Kazemitabar S. K. and Vafaei-tabar, M. 2009. Cytoplasmic and combining ability on fibre quality traits in intra and interspesific crosses of tetraploid cotton (*G. hirsutum* x G. *barbadense*). *Am-Euras. J. Agric. & Environ. Sci.,* **5:** 519-525.

Zangi, M. R., Jelodar, N. B., Kazemitabar S. K. and Vafaei-tabar, M. 2010. Cytoplasmic and combining ability effects on agro-morphological characters in intra and inter crosses of Pima and Upland cottons (*G. hirsutum* and *G. barbadense*). *Intl. J. Biol.,* **2:** 94-102.

Table 1. Source of seed, pedigree and average values of economical characters of the parents

Name of parent	Pedigree	Boll weight (g)	Seed cotton yield (kg/ha)	Ginning outturn (%)	2.5% span length (mm)	Fibre strength (g/tex)
G.Cot.16	Pedigree selection from the cross Reba-TK x G.Cot.10	3.1	1543	33.7	26.6	21.8
G. Cot.20	Pedigree selection from the cross JLH-59 x GCBJ-20	3.5	1684	39.9	25.6	22.1
BC-68-2	Selection from the segregating generation of the cross (DS 2-6-5 x G.6) x DS 2-6-5	3.4	1449	33.3	28.1	22.4
Suvin	Pedigree selection from the cross Sujata x SIV-135	2.6	1104	31.1	33.7	27.6
GSB-39	Selection from PTN-10350	2.8	1157	32.4	34.4	27.2
GSB-41	Selection from PTN-10350	2.7	1065	32.3	32.9	25.6

Table 2. Analysis of variance showing pooled mean squares for different characters in cotton.

Sources of variation	d.f.	Number of sympodia	Plant height	Number of bolls per plant	Boll weight	Seed cotton yield/plant	Ginning outturn	2.5% span length	Fibre strength
Environments	2	155.928**	7325.761**	667.946**	0.784**	13510.164**	125.387*	121.521*	222.828**
Genotypes	35	32.674**	2096.170**	55.519**	2.195**	3422.343**	69.136**	98.149**	43.663**
G x E	70	10.860**	35.186**	9.133**	0.026**	47.146*	7.146**	15.435**	5.230**
Error	210	2.078	21.154	3.641	0.009	30.893	1.967	4.820	1.521

* Significant at 5% level and ** Significant at 1% level

Table 3. Mean squares due to combining ability analysis over environments for different characters in cotton.

Sources of variation	d.f.	Number of sympodia	Plant height	Number of bolls per plant	Boll weight	Seed cotton yield/plant	Ginning outturn	2.5% span length	Fibre strength
GCA	5	52.467**	3993.993**	67.473**	4.4464**	6212.125**	117.905**	124.049**	55.905**
SCA	15	4.780**	203.357**	13.596**	0.1640**	480.267**	12.785**	31.655**	13.082**
Reciprocal	15	3.145**	95.706**	7.093**	0.0554**	110.885**	1.683**	3.329*	2.246
Location (L)	2	51.982**	2442.174**	222.636**	0.2626**	4503.728**	41.768**	40.479**	74.298**
GCA x L	10	0.721	17.624**	6.584**	0.0013	37.404**	4.999**	2.449	1.792
SCA x L	30	0.330	9.937	2.649**	0.0010	7.485	2.495**	1.850	2.055
Reciprocal x L	30	0.275	11.539*	2.260**	0.0006	16.694*	1.398**	1.562	0.777
Error	210	0.692	7.051	1.214	0.0009	10.298	0.656	1.607	1.739
σ^2GCA:σ^2SCA		0.983	1.770	0.498	2.238	1.111	0.937	0.341	1.065

* Significant at 5% level and ** Significant at 1% level

Table 4. Mean performance and General Combining Ability (GCA) of parents for different characters in cotton.

Parents	G.Cot.16			G.Cot.20			BC-68-2			GSB-39			GSB-41			Suvin		
Characters	Mean	GCA		Mean	GCA		Mean	GCA		Mean	GCA		Mean	GCA		Mean	GCA	
Sympodia per plant	9.60	0.407	**	12.18	2.128	**	9.18	-0.178		10.40	-0.147		8.07	-1.325	**	9.18	-0.885	**
Plant height (cm)	114.33	5.926	**	121.80	16.139	**	106.49	3.010	**	94.64	-5.410	**	78.00	-13.089	**	89.18	-6.577	**
Bolls per plant	32.31	0.876	**	34.38	2.231	**	30.72	-0.176		29.93	-0.292		30.45	-1.627	**	28.58	-1.012	**
Boll weight (g)	3.45	0.300	**	3.51	0.410	**	3.33	0.233		2.56	-0.231		2.23	-0.391		2.41	-0.321	
Seed cotton yield per plant (g)	95.00	9.882	**	102.58	18.030	**	89.00	5.279	**	67.00	-6.337	**	58.69	-15.820	**	60.49	-11.034	**
Ginning outturn (%)	35.05	0.610	*	41.63	3.373	**	35.04	-0.566	*	30.67	-1.259	**	33.66	-0.536	*	31.17	-1.622	**
2.5% span length (mm)	26.31	-2.065	**	25.92	-2.090	**	28.35	-0.667	**	36.41	1.894	**	33.91	1.065	**	34.81	1.862	**
Fibre strength (g/tex)	20.85	-1.396	**	19.29	-2.078	**	22.49	-0.679	**	28.18	1.433	**	27.38	1.326	**	28.07	1.394	**

* Significant at 5% level and ** Significant at 1% level

Table 5. Best general combing parents and best specific combining crosses along with their *per se* performance as well as best heterotic crosses for different characters in pooled analysis in cotton.

Characters	Best parents *per se*		Best general combining parent		Best cross *per se*		Heterobeltiosis		Standard heterosis		Best specific combining crosses	
Sympodia per plant	G.Cot.20	12.18	G.Cot.20	2.128**	G.Cot.20 x G.Cot.16	15.73	G.Cot.20 x G.Cot.16	29.21**	G.Cot.20 x G.Cot.16	23.98**	G.Cot.16 x G.Cot.20	1.713**
Plant height (cm)	G.Cot.20	121.80	G.Cot.20	16.139**	G.Cot.20 x G.Cot.16	138.80	G.Cot.20 x G.Cot.16	13.96**	G.Cot.20 x G.Cot.16	15.14**	GSB-41 x BC-68-2	7.867**
Bolls per plant	G.Cot.20	34.38	G.Cot.20	2.231**	GSB-39 x G.Cot.20	36.31	GSB-39 x Suvin	14.11**	GSB-39 x G.Cot.20	13.79**	GSB-41 x GSB-39	2.789*
Boll weight (g)	G.Cot.20	3.51	G.Cot.20	0.410**	G.Cot.20 x G.Cot.16	4.42	G.Cot.20 x G.Cot.16	25.71**	G.Cot.20 x G.Cot.16	11.16**	BC-68-2 x G.Cot.20	0.305**
Seed cotton yield per plant (g)	G.Cot.20	102.58	G.Cot.20	18.030**	G.Cot.20 x G.Cot.16	138.98	G.Cot.20 x G.Cot.16	35.49**	G.Cot.20 x G.Cot.16	27.99**	BC-68-2 x G.Cot.20	8.926**
Ginning outturn (%)	G.Cot.20	41.63	G.Cot.20	3.373**	G.Cot.20 x G.Cot.16	38.89	Suvin x GSB-39	4.03	G.Cot.20 x G.Cot.16	14.34**	G.Cot.16 x BC-68-2	1.420**
2.5% span length (mm)	GSB-39	36.41	GSB-39	1.894**	BC-68-2 x GSB-39	37.96	Suvin x G.Cot.20	5.00	BC-68-2 x GSB-39	6.72*	G.Cot.16 x GSB-41	2.956**
Fibre strength (g/tex)	GSB-39	28.18	GSB-39	1.433**	GSB-39 x Suvin	29.28	G.Cot.16 x G.Cot.20	5.58	GSB-39 x Suvin	8.53*	G.Cot.16 x GSB-41	1.902**

* Significant at 5% level and ** Significant at 1% level

Table 6. Top ten crosses on the basis of their *per se* performance with GCA effects of parents involved and SCA effects of these crosses along with better parent heterosis and standard heterosis for seed cotton yield in cotton.

Sr. No.	Cross	Seed cotton yield per plant (g)	Better parent heterosis (%)		Standard heterosis (%)		SCA effects		GCA effects			
									P1		P2	
1	G.Cot.20 x G.Cot.16 (102.58) (95.00)	138.98	35.49	**	27.99	**	-12.757	**	18.030 G	**	9.882 G	**
2	G.Cot.20 x BC-68-2 (102.58) (89.00)	128.87	25.63	**	18.68	**	-1.933		18.030 G	**	5.279 G	**
3	BC-68-2 x G.Cot.20 (89.00) (102.58)	125.00	21.86	**	15.12	**	8.926	**	5.279 G	**	18.030 G	**
4	BC-68-2 x G.Cot.16 (89.00) (95.00)	115.87	21.96	**	6.71	*	-3.688	*	5.279 G	**	9.882 G	**
5	G.Cot.20 x GSB-39 (102.58) (67.00)	115.78	12.87	**	6.63	*	5.863	**	18.030 G	**	-6.337 P	**
6	G.Cot.16 x G.Cot.20 (95.00) (102.58)	113.46	10.61	**	4.50		3.609	*	9.882 G	**	18.030 G	**
7	G.Cot.20 x Suvin (102.58) (60.49)	109.20	6.46	**	0.57		5.327	**	18.030 G	**	-11.034 P	**
8	GSB-39 x G.Cot.20 (67.00) (102.58)	108.73	6.00		0.14		3.522	*	-6.337 P	**	18.030 G	**
9	G.Cot.16 x BC-68-2 (95.00) (89.00)	108.49	14.20	**	-0.08		2.319		9.882 G	**	5.279 G	**
10	Suvin x G.Cot.20 (60.49) (102.58)	104.84	2.21		-3.44		2.178		-11.034 P	**	18.030 G	**

Value in parenthesis is mean seed cotton yield (g/plant) of respective parents *Significant at 5% level and **Significant at 1% level