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Determining the Combining ability of F_4 lines of RSG population developed through exploitation of heterotic groups in cotton

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ABSTRACT

Elite lines were crossed in this manner (DSMR-10 x DSG-3-5) X (DRGR-32-100 x DRGR-24-178) to generate two highly diverse base population. Then the F1s of within group crosses (DSMR- 10 x DSG-3-5) and (DRGR-32-100 and DRGR-24-178) were advanced to F4 generation to develop population I RSG F4 lines & population II RGR F4 lines respectively. In the present investigation ten random lines of only one population, population I RSG F4 lines were used and crossed with four testers DRGR-32-100 (T_1), DRGR-24-178(T_2), DH - 7225(T_3) & DRGR-4(T_4). All the forty derived hybrids along with ten lines andfour testers was planted on a medium black soil at Agricultural Research Station, Dharwad Farm during kharif2014-15 in a Randomized Block Design with two replications.Line x tester analysis of Population I RSG F_4 Lines showed the existence of significant differences among the parents for all the characters except Boll weight, Seed index and Lint index.Among lines significant differences for most characters except Number of Mono podia per plant, Inter boll distance, Inter branch distance, Ginning outturn, Seed index and Lint index were observed. The mean sum of squares with respect to hybrids were found to be significant for all the characters except Plant height, Inter branch distance, Ginning outturn and Lint index.The ratio of GCA to SCA variance was less than half in most of the traits except seed cotton yield and lint yield. RSG F_4 7 &RSG F_4 9 lines was having significant gca for Seed cotton yieldand among testers DH-7225 (T_3) was the best combiner followed by DRGR-4 (T_4). Hybrid (RSG F_4 9 X DH-7225) has positively significant sca effect for Reproductive points on sympodia, seed cotton yield, lint yield and number of bolls per plant.(RSG F_4 8 X DRGR-32-100) was having significantly positive sca effect for number of sympodia per plant, Reproductive points on sympodia and lint yield.

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INTRODUCTION

Cotton is one of the most important commercial crops of the world and is primarily cultivated for its fibre. Concept of heterosis was given by Shull in 1908 though it was earlier reported in 1894 by Mell (cited indirectly from Randhawa and Singh, 1994). For enhancing the fibre quality of cotton and improving yield scientists have used heterosis from long time. In cotton the reason of heterosis for yield is because of additive and dominance effects (White and Kohel, 1964; White, 1966; Marani, 1968). Combining ability has a prime importance in plant breeding since it provides information for the selection of parents and also provides information regarding nature of gene action. The information of combining ability is very essential for exploitation of potentiality of inbred line hence evaluating the combining ability becomes important part of cotton breeding. Line X Tester (given by Kempthorne) is an important design suiting for evaluating the combining ability of several lines at same time. Higher magnitude of SCA than GCA suggesting the preponderance of dominant genes controlling yield and yield contributing traits like number of bolls, ginning outturn%, seed index, lint index and seed cotton yield (Desphande and Baig). Rokaya *et al*. 2005 found significance of GCA and SCA suggesting the importance of additive as well as dominant genes, nevertheless the ratio of GCA/SCA was greater than the unity further indicating the preponderance of additive genes in the inheritance of seed cotton yield, seed index and lint%.Kumaresan etal. (1999) indicated that both additive and non-additive gene effects were important for controlling number of bolls andseed cotton yield.

MATERIAL AND METHODS

Material generation

For exploiting heterotic groups, opposite groups were identified and heterotic box involving elite lines of these groups were crossed. It was found that lines of stay green and robustgroups give good heterosis with the RGR group hence, elite combiners DSMR-10 line (of stay green group), DSG-3-5 line (of robust group) and two DRGR- 32-100 and DRGR-24-178 lines (of RGR group) were chosen to develop a heterotic box.Elite lines were crossed in this manner (DSMR-10 x DSG-3-5) X (DRGR-32-100 and DRGR-24-178) to generate two highly diverse base population (Patil, 2009).Then the F1s of within group crosses (DSMR-10 x DSG-3-5) and (DRGR-32-100 and DRGR-24-178) were advanced to F4 generation to develop population I RSG F4 lines & population II RGR F4 lines respectively. Population I RSG F4 lines which was derived from (DSMR- 10 x DSG-3-5) were used in current study. These selected lines were crossed with the parents of the opposite group population *i.e.* lines of (DSMR-10 x DSG-3-5) cross were crossed with DRGR-32-100(T_1) and DRGR-24-178(T_2) (opposite testers). The lines were also crossed with one additional tester DH - 7225(T_3) which was common for both populations and one diverse tester DRGR-4(T_4). Selected lines of population I RSG F4 lines were crossed with four testers *viz.,* (DRGR-32-100), (DRGR-24-178), (DH – 7225) and (DRGR-4) to generate the forty derived hybrids.

Season & Field layout

All the forty F4 derived hybrids along with their parental selfed generations i. e. F5 lines, **mallika** and **jadoo** used as commercial check are sown at the Agricultural Research Station Dharwad Farm on the black soil in *kharif* 2014-15. The sowing was done at spacing of (90 X 60) cm for hybrids and (90 X 30) cm for lines under the rainfed situation using randomized block design with two replications. Recommended cultural practices were carried out at regular interval.

Observations

Observations were recorded on four randomly selected plants of each entry in case of all the entries [derived hybrids (F1s), checks, parental lines and testers] on the following traits seed cotton yield (kg/ha), boll weight (gm), number of bolls per plant, plant height (cm), number of monopodia per plant, number of sympodia per plant, sympodial length (cm), reproductive points on sympodia, interboll distance (cm), interbranch distance (cm), lint yield (kg/ha), ginning outturn, seed index (gm) and lint index.

Statistical analysis

Mean data obtained was analysed for Analysis of variance, estimation of Standard Error and Critical Difference by the method suggested by Panse and Sukhatme (1967). Line x Tester analysis of combining ability was performed as suggested by Kempthorne (1957) and the variation among the hybrids was divided into genetic components attributable to general combining ability (*gca*) and specific combining ability (*sca*).

RESULTS

Analysis of variance

Analysis of variance for fourteen characters studied for Population I RSG F_4 Lines is presented in Table 1. Line x tester analysis of Population I RSG F_4 Lines revealed the existence of significant differences among the parents for all the characters except Boll weight, Seed index and Lint index. The lines showed significant differences for most of the characters except Number of Mono podia per plant, Inter boll distance, Inter branch distance, Ginning outturn, Seed index and Lint index. Among the testers significant differences were observed for some of the characters except Plant height, Number of Mono podia per plant, Number of bolls per plant, Boll weight, Sympodial length at 50% height, Inter boll distance Seed cotton yield, Lint yield and Lint index. The interaction between lines and testers was significant for some of the characters except for Number of bolls per plant, Boll weight, Reproductive points on sympodia, Seed cotton yield, Lint yield, Seed index and Lint index.The mean sum of squares with respect to hybrids were found to be significant for all the characters except Plant height, Inter branch distance, Ginning outturn and Lint index. Variance arising from interaction between hybrids and parents was significant for most of the characters except Number of Monopodia per plant and Inter boll distance.

Analysis of variance Combining ability

In case of population I RSG F_4 lines, mean sum of squares due to lines were significant for plant height (cm), seed cotton yield (kg/ha) and lint yield (kg/ha). The tester effect were significant for number of bolls per plant, seed cotton yield (kg/ha) and lint yield (kg/ha). The line x tester interactions showed significant differences for all of the characters except plant height (cm), Ginning outturn, Seed index (g) and Lint index (g). The magnitude of variance due to SCA was greater than those due to GCA variance for all the characters studied except plant height, seed cotton yield and lint yield. The ratio of GCA to SCA variance was less than half in most of the traits except seed cotton yield and lint yield. Analysis of

variance for Combining ability onfourteen characters studied for Population I RSG F_4 Lines is presented in Table 2.

Combining ability effects

Estimates of gca effects of lines (presented in Table 3) found to be positively significant in three lines and negatively significant in three lines for Seed cotton yield (range from (-351.09) (RSG F_4 1) to (333.05) (RSG F_4 7). Two lines with maximum gca for Seed cotton yield are (RSG F_4 7) (333.05) & (RSG F_4 9) (294.18) and lines (RSG F_4 1), (RSG F_4 6) & (RSG F_8 8) considered as poor combiners. Among the testers DH-7225 (T_3) (309.99) was the best combiner followed by DRGR-4 (T_4) (67.58) which were showed positively significant gca effect for Seed cotton yield. For the Seed cotton yield hybrids (RSG F_4 9 X DRGR-32-100) (-378.37) and (RSG F_4 2 X DRGR-24-178) (216.98) shown the significantly lowest and highest sca effect respectively (presented in Table 4). The top three hybrids for highest sca effect are (RSG F_4 2 X DRGR-24-178) (216.98), (RSG F_4 5 X DH-7225) (197.18) and (RSG F_4 9 X DH-7225) (194.49). The gca effects for Number of bolls per plant were found to be positively significant for two lines RSG F_4 7 (1.64) & RSG F_4 9 (1.92) and tester DH-7225 (T_3) (2.42). The sca effect of top four hybrids for Number of bolls per plant are (RSG F_4 1 X DRGR-32-100) (5.74), (RSG F_4 9 X DH-7225) (4.11), (RSG F_4 3 X DRGR-24-178) (3.11) and (RSG F_4 7 X DRGR-4) (3.04). Among the hybrids, three has depicted positively significant sca effect ranging from (-0.96) to 1.55 for Boll weight and cross (RSG F_4 8 X DRGR-24-178) shown highly significant sca effect. For Lint yield, three lines (RSG F_4 7) (139.73), (RSG F_4 9) (108.79) & (RSG F_4 10) (89.81) were found to be positively significant and three lines (RSG F_4 1), (RSG F_4 6) & (RSG F_8 8) were found to be negatively significant. Among the testers DH-7225 (T_3) (113.27) showed significantly positive gca effect and DRGR-32-100 (T_2) (-146.25) showed significantly negative gca effect for Lint yield. The hybrids (RSG F_4 9 X DH-7225) (105.32) and (RSG F_4 8 X DRGR-32-100) (82.57) has showed significantly positive sca effect for Lint yield.

***Per se* performance of parents and hybrids**

Per se performance of parents *i. e.* lines (F_5 lines) and testers were presented in table 5 and derived hybrids were presented in table 6. The mean value for the Number of bolls per plant among the F_5 lines ranged from 12.88 (RSG F_5 8) to 21.38 (RSG F_5 7) and among the testers ranged from 14.63 DRGR-32-100 (T_2) to 18.50 DRGR-24-178 (T_1). For Boll weight mean ranged from 3.15 g (RSG F_5 4 and RSG F_5 6) to 5.08 g (RSG F_5 10) and for testers ranged from 3.40 DRGR-32-100 (T_2) to 4.45 g DRGR-4 (T_4). The variation for Seed Cotton Yield among F_5 lines was from 957.97 kg/ha (RSG F_5 6) to 1984.95 kg/ha (RSG F_5 3) and testers was from 1400.94 kg/ha DRGR-32-100 (T_2) to 1738.08 kg/ha DRGR-4 (T_4. The top two lines that exhibited highest mean seed cotton yield are 1984.95 kg/ha (RSG F_5 3) and 1891.55 (RSG F_5 4). Mean value for lint Yield ranged from 336.28 kg/ha (RSG F_5 6) to 745.16 kg/ha (RSG F_5 3) and for testers ranged from 547.94 DH-7225 (T_3) to 681.47 kg/ha DRGR-4 (T_4).

Among the F_4 derived hybrids mean value for Number of bolls per plantranged from 14 (RSG F_4 9 X DRGR-32-100) to 28.75 (RSG F_4 9 X DH-7225) with a mean value of 20.30. RSG F_4 8 X DRGR-24-178 (6.55 g) hybrid has shown maximum mean Boll Weight followed by RSG F_4 3 X DRGR-32-100 (6.4 g). Mean Seed cotton yield of F_4 derived hybrids varied from 1432.86 kg/ha (RSG F_4 1 X DRGR-32-100) to 2866.71 kg/ha (RSG F_4 9 X DH-7225) with the overall mean of 2068.04 kg/ha. The top five hybrids in F_4 derived hybrids of population I RSG F_4 lines are (RSG F_4 9 X DH-7225) (2866.71 kg/ha), (RSG F_4 7 X DH-7225) (2785.88 kg/ha), (RSG F_4 5 X DH-7225) (2578.70 kg/ha), (RSG F_4 10 X DH-7225) (2570.36 kg/ha) and (RSG F_4 7 X DRGR-4) (2551.44 kg/ha).

DISCUSSION

In the present investigation GCA variances wasfound to be less than the SCA variances for all the characters except seed cotton yield and lint yield which suggests predominance of dominant or epistasis (non-additive gene action) in the inheritanceof these traits (Sprague and Tatum 1942). This suggest that addetive gene action is predominant along with dominant gene action for seed cotton yield and lint yield.Murthy and Rao (1999), Valarmathi and Jahangir (1998) Kajjidoni *et al.* (1999), Karande *et al.* (2004), Patel *et al. (*2004),Patel *et al.* (2005), Karunakar Raju (2005), Cetin K *et.al.* (2007), Shimna B and Ravikesavan (2008), Naqib *et al.*(2009), Patel *et al.* (2009) and Mohammad *et al.* (2010) reported additive gene action for the seed cotton yield. Studies of Sadykhova and Makhmudov (1986), Tomar and Singh (1992), Xuxian *et al.* (1995) and Echekwu and Alabi (1995), Karunakar Raju (2005) and Kalpande *et al.*(2008) revealed additive gene action for the lint yield. Patelet al. (2005), Kumboh et al. (2008), Wankhade et al. (2008), NaqibUllah et al. (2009), Cetin Karademir et al. (2009), Basal et al. (2009), Deosarkar et al. (2009) andMohammad Reza et al. (2010) reported higher dominance variance thanthe additive variance for all the traits.

Lines (RSG F_4 7) and (RSG F_4 9) were having significant gca for seed cotton yield, lint yield and number of bolls per plant. Among testers DH-7225 (T_3) was having significant gca for seed cotton yield, lint yield,

number of bolls per plant and number of Monopodia per plant. Hybrid (RSG F_4 9 X DH-7225) were having significantly positive sca effect for Reproductive points on sympodia, seed cotton yield, lint yield and number of bolls per plant.(RSG F_4 8 X DRGR-32-100) has shown significantly positive sca effect for number of sympodia per plant, Reproductive points on sympodia and lint yield.

Table 1: Analysis of variance for different quantitative characters for evaluation of combining ability in segregating generations from heterotic box (Population I RSG F_4 lines)

Source of variation	df	Plant height (cm)	No. of Monopodia per plant	No. of Sympodia per plant	No. of bolls per plant	Boll weight (g)	Sympodial length at 50% height (cm)	Reproductive points on sympodia	Inter boll distance (cm)	Inter branch distance (cm)	Seed cotton yield (kg ha^{-1})	Lint yield (kg ha^{-1})	Ginning outturn (%)	Seed index (g)	Lint index(g)
Replications	1	37.1	0.75	0.28	7.92	0.7	13.37	2.58**	5.83	0.03	152525.24*	38197.46**	5.74	0.009	0.42
Treatments	53	433.46*	0.56**	11.43**	25.97**	1.14**	88.22**	0.97**	3.35**	9.74**	350748.63**	55789.22**	3.84**	2.76**	1.52**
Parents	13	725.72**	0.63*	19.83**	10.62**	0.55	173.21**	0.78**	4.09*	16.36**	196505.62**	27971.10**	4.62**	2.53	1.28
Lines	9	694.10*	0.52	19.41**	13.34**	0.63*	134.76**	0.57**	3.06	6.42	267931.02**	37516.84**	3.21	1.91	1.29
Testers	3	129.43	0.24	17.02**	5.46	0.47	40.36	1.65**	0.33	15.77*	44087.79	8572.52	5.74*	4.70*	0.8
(L vs T)	1	2799.12**	2.74**	32.09**	1.61	0.003	917.67**	0.007	24.66**	107.63**	10930.5	255.1	14.04**	1.51	2.66
Parent vs Crosses	1	5221.94**	0.06	35.79**	314.17**	20.14**	204.75**	2.89**	0.44	55.52**	5325023.95**	993596.600**	49.24**	17.61**	20.02**
Crosses	39	213.26	0.56**	8.00**	23.70**	0.84**	56.91**	0.98**	3.17*	6.36	274617.45**	41015.59**	2.418	2.46*	1.121
Error	53	262.18	0.27	3.66	3.692	0.30	25.69	0.15	1.72	4.99	21447.69	3513.224	1.585	1.39	0.701

Table 2: ANOVA for combining ability involving population I RSG F_4 lines (F_4 lines of DSMR-10 x DSG-3-5) and its derived hybrids

Source of variation	df	Plant height (cm)	No. of Monopodia per plant	No. of Sympodia Per plant	Number of bolls per plant	Boll Weight	Sympodial length at 50% height (cm)	Reproductive points on sympodia	Inter boll distance (cm)	Inter branch distance (cm)	Seed Cotton Yield (kg ha^{-1})	Lint yield (kg ha^{-1})	Ginning outturn (%)	Seed index (g)	Lint index (g)
Replicates	1	333.33	0.54	0.53	1.37	1.06	39.91	3.16**	17.29**	11.47*	54645.71	19381.85*	5.995	0.21	0.098
Line Effect	9	390.02*	0.27	10.36	21.25	0.81	78.29	1.01	5.62	9.39	468681.30**	71554**	1.89	2.08	0.659
Tester Effect	3	150.9	1.01	4.04	68.28*	0.08	10.11	0.006	0.56	3.93	1678018**	231778.40**	4.558	0.78	1.991
Line* Tester Eff.	27	161.27	0.61**	7.65**	19.56**	0.94**	54.98*	1.08**	2.65**	5.62*	53996.06**	9640.24**	2.356	2.77	1.179
Error	39	169.75	0.19	2.22	4.495	0.39	24.42	0.15	0.65	2.77	18106.55	3168.64	1.81	1.73	0.87
s^2gca		0.59**	0.03	0.25	1.8	-0.035	1.32	0.02	0.09*	0.12*	72810.98**	10144.71**	0.06	0.002	0.01
s^2sca		-50.45	0.17*	1.99*	7.53**	0.27**	14.64*	0.46**	0.46	0.31	17944.75**	3235.80**	0.27	0.68*	0.15
s^2gca/s^2sca		-0.01	0.16	0.13	0.24	-0.13	0.09	0.05	0.21	0.38	4.06	3.14	0.22	0.003	0.07

Table 3: Estimates of general combining ability effects of parents and testers of population I RSG F_4 lines (F_4 lines of DSMR-10 x DSG-3-5) in evaluation of combining ability in segregating generations from heterotic box

Sl. No.	F_4 Line	Plant height (cm)	No. of Monopodia per plant	No. of Sympodia per plant	No. of bolls per plant	Boll weight (g)	Sympodial length at 50% height (cm)	Reproductive points on sympodia	Inter boll distance (cm)	Inter branch distance (cm)	Seed cotton yield (kg ha^{-1})	Lint yield (kg ha^{-1})	Ginning outturn (%)	Seed index (g)	Lint index (g)
1	RSG F_4 1	8.72	-0.07	0.26	-2.01*	0.045	1.73	-0.11	0.53	1.32	-351.09**	-138.25**	-0.19	-0.43	-0.35
2	RSG F_4 2	9.34	-0.06	2.09**	1.08	0.433	5.05*	0.62**	0.22	0.62	-36.45	-8.14	0.3	-0.73	-0.35
3	RSG F_4 3	0.77	0.18	-1.08	-2.23**	0.383	-0.42	-0.11	-0.29	0.45	-40.62	7.26	1.04*	0.23	0.16
4	RSG F_4 4	-8.77	0.31	-1.74*	0.42	-0.443	-2.64	0.05	-0.84	1.58	38.83	6.91	-0.42	0.53	0.21
5	RSG F_4 5	-4.05	0.13	0.57	-0.38	0.158	-5.09*	0.03	-1.05*	0.25	3.48	-7.22	-0.37	0.53	0.19
6	RSG F_4 6	-7.1	-0.18	0.59	-2.29**	-0.23	-3.08	0.37*	-1.28**	0.36	-330.72**	-130.68**	-0.08	0.85*	0.5
7	RSG F_4 7	-5.16	-0.2	-1.02	1.64*	0.17	2.83	0.21	0.51	-1.18	333.05**	139.73**	0.55	-0.35	-0.05
8	RSG F_4 8	9.77	-0.23	0.87	0.98	0.095	2.84	-0.51**	1.31**	-0.79	-165.89**	-68.22**	-0.17	-0.26	-0.22
9	RSG F_4 9	-0.6	0.16	0.17	1.92*	-0.50*	-0.78	-0.15	0.26	-1.14	294.18**	108.79**	-0.28	0.26	0.1
10	RSG F_4 10	-2.91	-0.03	-0.71	0.86	-0.11	-0.44	-0.51**	0.65	-1.49	255.22**	89.81**	-0.39	-0.16	-0.2
	SE (gi)	**5.72**	**0.18**	**0.68**	**0.75**	**0.22**	**1.79**	**0.14**	**0.46**	**0.79**	**47.57**	**19.90**	**0.48**	**0.42**	**0.33**
	CD (gi) 5%	**11.58**	**0.37**	**1.37**	**1.52**	**0.45**	**3.63**	**0.28**	**0.94**	**1.60**	**96.23**	**40.26**	**0.96**	**0.85**	**0.67**
	CD (gi) 1%	**15.50**	**0.50**	**1.83**	**2.03**	**0.60**	**4.85**	**0.38**	**1.25**	**2.14**	**128.83**	**53.89**	**1.29**	**1.13**	**0.89**
	SEd (gi-gj)	**8.09**	**0.26**	**0.95**	**1.06**	**0.31**	**2.53**	**0.20**	**0.66**	**1.12**	**67.28**	**28.15**	**0.67**	**0.59**	**0.47**
1	T_1	-0.84	-0.14	0.46	-0.54	0.03	1.06	0.006	0.15	-0.53	10.91	15.81	0.6	0.15	0.32
2	T_2	-3.52	-0.12	-0.53	-2.02**	0.07	-0.28	-0.009	-0.22	0.09	-388.48**	-146.25**	0.15	0.16	0.2
3	T_3	2.17	0.33**	0.27	2.42**	-0.06	-0.39	0.02	0.11	-0.09	309.99**	113.27**	-0.3	-0.07	-0.24
4	T_4	2.19	-0.07	-0.21	0.14	-0.04	-0.38	-0.02	-0.03	0.54	67.58*	17.17	-0.4	-0.25	-0.29
	SE (gi)	3.62	0.12	0.43	0.4741	0.1394	1.133	0.09	0.29	0.5	30.0887	12.587	0.3008	0.26	0.2085
	CD (gi) 5%	7.32	0.24	0.87	0.9589	0.2819	2.29	0.18	0.59	1.01	60.8599	25.4595	0.6084	0.53	0.4218
	CD (gi) 1%	9.81	0.32	1.16	1.2838	0.3774	3.07	0.24	0.79	1.35	81.4775	34.0845	0.8146	0.72	0.5646
	SEd (gi-gj)	5.12	0.17	0.61	0.6705	0.19	1.61	0.13	0.42	0.71	42.5518	17.8007	0.4254	0.37	0.2949

Table 4: Estimates of specific combining ability effects of derived hybrids of population I RSG F_4 lines for evaluation of combining ability in segregating generations from heterotic box

Sl. No.	(Derived F_1) (F_4 line x tester)	Plant height (cm)	No. of Monopodia per plant	No. of Sympodia per plant	No. of bolls per plant	Boll weight (g)	Sympodial length at 50% height (cm)	Reproductive points on sympodia	Inter boll distance (cm)	Inter branch distance (cm)	Seed cotton yield (kg ha^{-1})	Lint yield (kg ha^{-1})	Ginning outturn (%)	Seed index (g)	Lint index (g)
1	RSG F_4 1 X T_1	-2.67	0.06	1.22	-0.11	-0.10	-3.43	-0.56*	0.73	-1.68	7.09	20.16	1.11	0.77	-0.62
2	RSG F_4 1 X T_2	3.16	-0.05	-3.73**	5.74**	0.37	-2.67	-0.55	-1.90*	-1.65	104.40	29.85	-0.74	-1.43	0.18
3	RSG F_4 1 X T_3	10.82	-0.66	3.26*	-3.70*	0.06	6.57	0.92**	1.51	0.73	-156.81	-81.23*	-1.08	1.79*	0.89
4	RSG F_4 1 X T_4	-11.31	0.65	-0.75	-1.93	-0.32	-0.47	0.21	-0.34	2.60	45.32	31.22	0.72	-1.12	-0.45
5	RSG F_4 2 X T_1	8.06	-0.55	0.48	2.67	-0.04	-1.35	-0.21	-0.06	-1.87	216.98*	51.29	-1.62	-1.58	0.18
6	RSG F_4 2 X T_2	-2.10	-0.07	-0.17	0.39	-0.62	2.64	0.31	0.21	0.29	34.66	23.81	0.68	1.16	-0.37
7	RSG F_4 2 X T_3	3.35	1.47**	-0.56	1.08	0.92*	1.70	0.33	-0.27	-0.31	20.91	9.61	0.00	-0.55	-0.76
8	RSG F_4 2 X T_4	-9.32	-0.86*	0.25	-4.14**	-0.26	-3.00	-0.43	0.13	1.90	-272.55**	-84.71*	0.94	0.97	0.95
9	RSG F_4 3 X T_1	3.77	-0.93*	0.91	3.11*	-0.44	4.12	0.33	0.65	-1.30	64.45	18.13	-0.33	-0.33	0.15
10	RSG F_4 3 X T_2	6.71	-0.21	2.30	2.46	1.08*	2.47	0.34	0.42	3.32*	-114.86	-71.40	-1.18	0.46	-0.14
11	RSG F_4 3 X T_3	1.26	0.64	-2.79*	-6.11**	0.17	1.08	-0.43	0.88	-1.64	-97.60	-10.00	1.28	0.64	0.42
12	RSG F_4 3 X T_4	-11.75	0.50	-0.42	0.54	-0.81	-7.67*	-0.24	-1.96*	-0.37	148.01	63.26	0.23	-0.77	-0.43
13	RSG F_4 4 X T_1	6.57	0.08	-0.43	-0.55	-0.51	-1.65	0.76**	-2.09*	4.15*	36.81	17.04	0.08	0.05	0.20
14	RSG F_4 4 X T_2	-3.74	0.06	0.56	-0.08	0.55	-3.20	-0.22	0.32	-0.82	65.63	27.34	0.08	0.30	0.01
15	RSG F_4 4 X T_3	-2.03	-0.05	0.86	-0.39	-0.51	3.45	-0.24	0.99	-1.03	9.06	-0.19	-0.05	-1.07	0.37
16	RSG F_4 4 X T_4	-0.81	-0.08	-1.01	1.01	0.47	1.39	-0.31	0.78	-2.31	-111.50	-44.20	-0.11	0.71	-0.58
17	RSG F_4 5 X T_1	-5.99	0.02	1.01	-1.36	-0.11	2.54	0.29	0.46	-0.80	-186.60	-42.81	1.48	-1.26	-0.37
18	RSG F_4 5 X T_2	1.63	0.49	-1.49	1.74	0.30	6.49	0.66*	0.78	0.27	85.47	28.96	-0.32	0.20	-0.02
19	RSG F_4 5 X T_3	0.69	-0.36	-0.19	2.43	0.19	-11.39**	-0.42	-2.5*	2.15	197.18*	71.47	-0.05	-0.42	-0.21
20	RSG F_4 5 X T_4	3.67	-0.15	0.68	-2.80	-0.38	2.34	-0.53	1.25	-1.62	-96.05	-57.62	-1.11	1.51	0.60
21	RSG F_4 6 X T_1	1.30	0.43	0.09	-2.83	0.18	-5.71	-1.05**	-0.51	0.28	-127.87	-31.89	1.04	0.89	0.05

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Sl. No.	(Derived F_1) (F_4 line x tester)	Plant height (cm)	No. of Monopodia per plant	No. of Sympodia per plant	No. of bolls per plant	Boll weight (g)	Sympodial length at 50% height (cm)	Reproductive points on sympodia	Inter boll distance (cm)	Inter branch distance (cm)	Seed cotton yield (kg ha^{-1})	Lint yield (kg ha^{-1})	Ginning outturn (%)	Seed index (g)	Lint index (g)
22	RSG F_4 6 X T_2	3.84	-0.19	-0.02	0.89	-0.96*	-5.76	-0.19	-0.39	0.71	109.49	37.76	-0.26	-0.36	0.41
23	RSG F_4 6 X T_3	-18.51	0.11	-0.81	0.33	0.18	1.74	-0.72*	1.87	-0.11	-80.88	-67.11	-1.84	0.36	-1.13
24	RSG F_4 6 X T_4	13.37	-0.34	0.75	1.61	0.61	9.73*	1.96**	-0.97	-0.88	99.26	61.24	1.05	-0.90	0.67
25	RSG F_4 7 X T_1	-0.28	0.44	-1.15	-3.52*	-0.43	2.87	0.35	0.43	0.42	-210.21*	-108.71**	-1.34	-0.85	-1.02
26	RSG F_4 7 X T_2	-11.20	0.22	-0.56	-1.79	-0.46	-2.27	-0.37	0.07	-0.90	52.66	46.85	1.31	-0.76	1.38*
27	RSG F_4 7 X T_3	2.80	-0.53	0.79	2.27	0.78	3.47	0.24	-0.16	0.03	74.79	9.06	-0.73	-0.38	-0.46
28	RSG F_4 7 X T_4	8.68	-0.13	0.92	3.04*	0.11	-4.07	-0.22	-0.36	0.45	82.76	52.80	0.77	1.99*	0.10
29	RSG F_4 8 X T_1	-18.72	-0.03	-2.18	0.76	1.55**	2.46	0.18	-0.25	-0.26	-120.43	-57.82	-0.72	0.95	0.34
30	RSG F_4 8 X T_2	11.31	0.09	5.70**	-0.76	-0.89	4.81	0.79**	-0.33	-0.49	162.72	82.57*	1.18	0.05	0.30
31	RSG F_4 8 X T_3	-0.23	0.14	-1.74	0.55	-0.25	-7.58*	-0.83**	-0.46	-0.50	-98.25	-34.18	0.20	-1.56	-0.80
32	RSG F_4 8 X T_4	7.64	-0.20	-1.76	-0.55	-0.42	0.31	-0.14	1.04	1.26	55.96	9.43	-0.66	0.56	0.16
33	RSG F_4 9 X T_1	8.00	0.47	0.51	-0.18	-0.20	-1.86	-0.18	0.25	-0.02	176.63	79.53	0.39	1.08	0.77
34	RSG F_4 9 X T_2	-4.01	-0.39	-1.35	-6.20**	0.42	-3.41	-0.86**	0.52	-0.19	-378.37**	-156.49**	-0.56	-0.32	-0.48
35	RSG F_4 9 X T_3	0.39	-0.09	-0.39	4.11**	-0.70	5.44	1.45**	-1.06	0.94	194.49*	105.32*	1.31	0.71	0.93
36	RSG F_4 9 X T_4	-4.37	0.01	1.23	2.26	0.48	-0.16	-0.41	0.28	-0.73	7.25	-28.35	-1.15	-1.46	-1.22
37	RSG F_4 10 X T_1	-0.04	0.01	-0.46	2.01	0.10	1.99	0.08	0.36	1.08	143.14	55.07	-0.09	0.31	0.33
38	RSG F_4 10 X T_2	-5.60	0.04	-1.22	-2.39	0.22	0.89	0.09	0.28	-0.54	-121.82	-49.25	-0.19	0.70	-1.27
39	RSG F_4 10 X T_3	1.45	-0.66	1.58	-0.58	-0.85	-4.49	-0.28	-0.80	-0.25	-62.89	-2.74	0.97	0.48	0.74
40	RSG F_4 10 X T_4	4.18	0.60	0.11	0.95	0.53	1.59	0.11	0.15	-0.28	41.57	-3.08	-0.68	-1.48	0.20
SE (ij)		11.44	0.36	1.35	1.50	0.44	3.58	0.28	0.92	1.58	95.15	39.80	0.95	0.84	0.66
CD SCA, @ 5%		23.15	0.74	2.74	3.03	0.89	7.25	0.57	1.88	3.19	192.46	80.51	1.92	1.69	1.33
CD SCA, @ 1%		31.01	1.00	3.66	4.06	1.19	9.71	0.75	2.51	4.28	257.65	107.78	2.58	2.26	1.79
SEd (Sij-Skl)		16.19	0.52	1.91	2.12	0.62	5.07	0.39	1.31	2.24	134.56	56.29	1.35	1.18	0.93

Table 5: *Per se* performance of F_5 lines of (Population I RSG F_4 lines) for yield in evaluation of combining ability in segregating generations from heterotic box

Sl. No.	F_5 lines	Plant height (cm)	No. of Monopodia per plant	No. of Sympodia per plant	Number of bolls per plant	Boll weight (g)	Sympodial length at 50% height (cm)	Reproductive points on sympodia	Inter boll distance (cm)	Inter branch distance (cm)	Seed Cotton Yield (kg ha^{-1})	Lint yield (kg ha^{-1})	Ginning outturn (%)	Seed index(g)	Lint index(g)
1	RSG F_5 1	90.88	0.63	13.25	13.75	3.90	28.63	4.63	6.21	9.94	1620.47	586.16	36.09	9.34	5.28
2	RSG F_5 2	102.00	1.38	16.50	17.00	4.25	29.00	5.00	5.80	13.69	1804.54	663.35	36.75	10.53	6.12
3	RSG F_5 3	126.50	1.50	18.50	17.25	4.05	37.50	5.63	6.69	11.38	1984.95	745.16	37.50	9.79	5.87
4	RSG F_5 4	86.13	1.38	18.13	18.00	3.15	25.63	4.15	6.28	10.94	1891.55	699.28	36.99	9.70	5.70
5	RSG F_5 5	111.50	2.13	14.88	17.13	3.55	40.13	4.63	8.89	12.63	1445.01	523.59	36.15	10.75	6.07
6	RSG F_5 6	84.75	0.50	9.38	13.50	3.15	34.25	4.25	7.47	7.56	957.97	336.28	35.10	9.11	4.92
7	RSG F_5 7	120.88	1.25	19.75	21.38	3.95	52.50	5.35	9.12	10.31	1394.35	523.32	37.46	12.15	7.30
8	RSG F_5 8	122.13	1.50	16.88	12.88	3.75	43.13	5.50	7.30	10.63	998.85	377.85	37.84	10.93	6.65
9	RSG F_5 9	95.50	1.50	18.25	17.00	3.90	33.63	4.63	7.24	12.69	1814.59	689.44	38.01	10.84	6.64
10	RSG F_5 10	71.00	2.00	14.00	14.63	5.08	29.00	5.50	5.33	9.50	1826.13	622.52	34.09	9.17	4.75
	Mean	**101.13**	**1.38**	**15.95**	**16.25**	**3.87**	**35.34**	**4.93**	**7.03**	**10.93**	**1573.84**	**576.70**	**36.60**	**10.23**	**5.93**
	Minimum	**71.00**	**0.50**	**9.38**	**12.88**	**3.15**	**25.63**	**4.15**	**5.33**	**7.56**	**957.97**	**336.28**	**34.09**	**9.11**	**4.75**
	Maximum	**126.50**	**2.13**	**19.75**	**21.38**	**5.08**	**52.50**	**5.63**	**9.12**	**13.69**	**1984.95**	**745.16**	**38.01**	**12.15**	**7.30**
11	T_1	83.75	2.13	9.38	18.50	3.60	22.67	4.88	4.64	13.38	1530.01	549.05	35.90	12.95	7.25
12	T_2	80.88	1.63	14.00	14.63	3.40	20.75	4.00	5.15	14.69	1400.94	555.05	39.63	10.04	6.59
13	T_3	67.13	2.00	16.00	16.50	4.15	28.88	6.18	5.44	19.38	1451.40	547.94	37.85	9.43	5.75
14	T_4	84.25	2.50	14.88	17.50	4.45	18.38	4.75	4.60	13.56	1738.08	681.47	39.22	10.56	6.81
	Mean	**79.00**	**2.06**	**13.56**	**16.78**	**3.90**	**22.67**	**4.95**	**4.96**	**15.25**	**1530.10**	**583.38**	**38.15**	**10.74**	**6.60**
	Minimum	**67.13**	**1.63**	**9.38**	**14.63**	**3.40**	**18.38**	**4.00**	**4.60**	**13.38**	**1400.94**	**547.94**	**35.90**	**9.43**	**5.75**
	Maximum	**84.25**	**2.50**	**16.00**	**18.50**	**4.45**	**28.88**	**6.18**	**5.44**	**19.38**	**1738.08**	**681.47**	**39.63**	**12.95**	**7.25**

Table 6: *Per se* performance of derived hybrids of population I RSG $F_4$for yield in evaluation of combining ability in segregating generations from heterotic box

Sr. No.	(Derived F_1) (F_4 line x tester)	Plant height (cm)	No. of Monopodia per plant	No. of Sympodia per plant	Number of bolls per plant	Boll weight (g)	Sympodial length at 50%	Reproductive points on sympodia	Inter boll distance (cm)	Inter branch distance (cm)	Seed cotton yield (kg ha^{-1})	Lint yield (kg ha^{-1})	Ginning out turn (%)	Seed index (g)	Lint index (g)
1	RSG F_4 1 X T_1	115.9	1.5	18.55	17.63	4.85	34.25	4.65	8	9.65	1734.95	695.19	40.1	11.8	6.45
2	RSG F_4 1 X T_2	119.05	1.4	12.6	22	5.35	33.65	4.65	5	10.3	1432.86	542.82	37.8	9.6	7.15
3	RSG F_4 1 X T_3	132.4	1.25	20.4	17	4.9	42.8	6.15	8.75	12.5	1870.14	691.26	36.95	12.6	7.4
4	RSG F_4 1 X T_4	110.3	2.15	15.9	16.5	4.55	35.75	5.4	6.75	15	1829.86	707.61	38.7	9.5	6.00
5	RSG F_4 2 X T_1	127.25	0.9	19.65	23.5	5.3	39.65	5.75	6.9	8.75	2259.48	856.44	37.9	9.15	7.25
6	RSG F_4 2 X T_2	114.4	1.4	18	19.75	4.75	42.3	6.25	6.8	11.55	1677.77	666.89	39.75	11.9	6.60
7	RSG F_4 2 X T_3	125.55	3.4	18.4	24.88	6.15	41.25	6.3	6.65	10.75	2362.49	912.22	38.55	9.95	5.75
8	RSG F_4 2 X T_4	112.9	0.65	18.75	17.38	5	36.55	5.5	6.9	13.6	1826.61	721.8	39.45	11.3	7.4
9	RSG F_4 3 X T_1	114.4	0.75	16.9	20.63	4.85	39.65	5.65	7.1	9.15	2102.78	838.7	39.9	10.9	7.75
10	RSG F_4 3 X T_2	114.65	1.5	17.3	18.5	6.4	36.65	5.65	6.5	14.4	1524.07	587.09	38.6	11.7	7.35
11	RSG F_4 3 X T_3	114.9	2.8	13	14.38	5.35	35.15	4.9	7.3	9.25	2239.81	908.02	40.55	11.65	7.45
12	RSG F_4 3 X T_4	101.9	2.25	14.9	18.75	4.4	26.4	5.05	4.3	11.15	2243.01	885.18	39.45	10.05	6.55
13	RSG F_4 4 X T_1	107.65	1.9	14.9	19.63	3.95	31.65	6.15	3.8	15.75	2154.59	837.25	38.85	12.05	7.85
14	RSG F_4 4 X T_2	94.65	1.9	14.9	18.63	5.05	28.75	5.15	5.85	11.4	1784.02	685.48	38.4	12.3	7.55
15	RSG F_4 4 X T_3	102.05	2.25	16	22.75	3.85	35.3	5.15	6.85	11	2425.92	917.48	37.75	10.7	7.45
16	RSG F_4 4 X T_4	103.3	1.8	13.65	21.88	4.85	33.25	5.05	6.5	10.35	2062.96	777.37	37.65	12.3	6.45
17	RSG F_4 5 X T_1	99.8	1.65	18.65	18	4.95	33.4	5.65	6.15	9.45	1895.83	763.26	40.3	10.7	7.25
18	RSG F_4 5 X T_2	104.75	2.15	15.15	19.63	5.4	36	6	6.1	11.15	1768.51	672.96	38.05	12.2	7.5
19	RSG F_4 5 X T_3	109.5	1.75	17.25	24.75	5.15	18	4.95	3.15	12.85	2578.7	974.99	37.8	11.35	6.85
20	RSG F_4 5 X T_4	112.5	1.55	17.65	17.25	4.6	31.75	4.8	6.75	9.7	2043.05	749.8	36.7	13.1	7.6

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Sr. No.	(Derived F_1) (F_4 line x tester)	Plant height (cm)	No. of Monopodia per plant	No. of Sympodia per plant	Number of bolls per plant	Boll weight (g)	Sympodial length at 50%	Reproductive points on sympodia	Inter boll distance (cm)	Inter branch distance (cm)	Seed cotton yield (kg ha^{-1})	Lint yield (kg ha^{-1})	Ginning out turn (%)	Seed index (g)	Lint index (g)
21	RSG F_4 6 X T_1	104.05	1.75	17.75	14.63	4.85	27.15	4.65	4.95	10.65	1620.36	650.71	40.15	13.2	8.00
22	RSG F_4 6 X T_2	103.9	1.15	16.65	16.88	3.75	25.75	5.5	4.7	11.7	1458.33	558.3	38.4	11.95	8.25
23	RSG F_4 6 X T_3	87.25	1.9	16.65	20.75	4.75	33.15	5	7.3	10.7	1966.43	712.95	36.3	12.45	6.25
24	RSG F_4 6 X T_4	119.15	1.05	17.75	19.75	5.2	41.15	7.65	4.3	10.55	1904.16	745.21	39.15	11	8.00
25	RSG F_4 7 X T_1	104.4	1.75	14.9	17.88	4.65	41.65	5.9	7.7	9.25	2201.8	844.32	38.4	10.25	6.35
26	RSG F_4 7 X T_2	90.8	1.55	14.5	18.13	4.65	35.15	5.15	6.95	8.55	2065.27	837.8	40.6	10.35	8.65
27	RSG F_4 7 X T_3	110.5	1.25	16.65	26.63	5.75	40.8	5.8	7.05	9.3	2785.88	1059.55	38.05	10.5	6.35
28	RSG F_4 7 X T_4	116.4	1.25	16.3	25.13	5.1	33.25	5.3	6.7	10.35	2551.44	1007.19	39.5	12.7	6.85
29	RSG F_4 8 X T_1	100.9	1.25	15.75	21.5	6.55	41.25	5	7.0	8.95	1792.63	687.24	38.3	12.15	7.55
30	RSG F_4 8 X T_2	128.25	1.4	22.65	18.5	4.15	42.25	5.6	7.35	9.35	1676.38	665.57	39.75	11.25	7.40
31	RSG F_4 8 X T_3	122.4	1.9	16	24.25	4.65	29.75	4	7.55	9.15	2113.89	808.34	38.25	9.4	5.85
32	RSG F_4 8 X T_4	130.3	1.15	15.5	20.88	4.5	37.65	4.65	8.9	11.55	2025.69	755.85	37.35	11.35	6.75
33	RSG F_4 9 X T_1	117.25	2.15	17.75	21.5	4.2	33.3	5	7.25	8.85	2549.77	1001.62	39.3	12.8	8.30
34	RSG F_4 9 X T_2	102.55	1.3	14.9	14	4.85	30.4	4.3	7.15	9.3	1595.36	603.52	37.9	11.4	6.95
35	RSG F_4 9 X T_3	112.65	2.05	16.65	28.75	3.6	39.15	6.65	5.9	10.25	2866.71	1124.86	39.25	12.2	7.90
36	RSG F_4 9 X T_4	107.9	1.75	17.8	24.63	4.8	33.55	4.75	7.1	9.2	2437.05	895.1	36.75	9.85	5.7
37	RSG F_4 10 X T_1	106.9	1.5	15.9	22.63	4.9	37.5	4.9	7.75	9.6	2477.31	958.18	38.7	11.6	7.55
38	RSG F_4 10 X T_2	98.65	1.55	14.15	16.75	5.05	35.05	4.9	7.3	8.6	1812.96	691.79	38.15	12	5.85
39	RSG F_4 10 X T_3	111.4	1.3	17.75	23	3.85	29.55	4.55	6.55	8.7	2570.36	997.83	38.8	11.55	7.40
40	RSG F_4 10 X T_4	114.15	2.15	15.8	22.25	5.25	35.65	4.9	7.35	9.3	2432.41	901.38	37.1	9.4	6.80
Mean		**110.69**	**1.65**	**16.61**	**20.30**	**4.87**	**34.88**	**5.32**	**6.59**	**10.54**	**2068.04**	**797.48**	**38.58**	**11.30**	**7.11**
Min		**87.25**	**0.65**	**12.60**	**14**	**3.6**	**18.00**	**4.00**	**3.15**	**8.55**	**1432.86**	**542.82**	**36.30**	**9.15**	**5.70**
Max		**132.40**	**3.40**	**22.65**	**28.75**	**6.55**	**42.80**	**7.65**	**8.90**	**15.75**	**2866.71**	**1124.86**	**40.60**	**13.20**	**8.65**

REFERENCES

1. Basal, H., Unay, A., Canavar, O. and Yavas, I., 2009, Combining ability for fibre quality parameters and within-boll yield components in intraspecific and interspecific cotton populations. *Spanish J. Agric. Res.,* 7(2): 364-374.
2. Cetin, K., Oktay, G. and Emine, K., 2007, Heterosis and combining ability for yield and fibre properties in cotton (*Gossypium hirsutum* L.*)* under drought stress conditions. *Asian J. Plant Sci.,* 6(4): 667-672.
3. Deosarkar, D. B., Jadhav, D. S. and Patil, S. G., 2009. Heterosis study in cotton (*Gossypium hirsutum* L.) under rainfed conditions. *J. Cotton Res. Dev.,* 23(1): 36-40.
4. Deshpande L.A., and Baig K.S., 2003, Combining ability analysis for yield, economic and morphological traits in American cotton (*Gossypium hirsutum* L.). *J. Res. ANGRAU.,* 31: 28-34
5. Echekwu, C. A. and Alabi, S. G., 1995, Genetic effects of yield and its components in interspecific crosses of cotton. *Disc. Innov.*, 7: 395-399.
6. Kajjidoni, S. T., Patil, S. J., Khadi, B. M. and Salimath, P. M., 1999, A comparative study of heterosis in GMS based and conventional intra *arboreum* cotton hybrids. *Indian J. Genet.,*59(4): 493-504.
7. Kalpande, H. V., Mukewar, A. M. and Kalpande, V. V., 2008, Combining ability analysis in upland cotton (*Gossypium hirsutum* L.). *J. Cotton Res. Dev.,* 22(1): 10-13.
8. Karande, S. S., Wandhare, M. R., Ladole, M. Y., Waode, M. M. and Meshram, L. D., 2004, Heterosis and combining ability studies in interspecific diploid cotton hybrids for fibre quality parameters. *Int. Symp. on Strategies Sustainable Cotton Production – A Global Vision 1. Crop Improv.,* 23-25 November, 2004, Univ. Agric. Sci., Dharwad (India), Karnataka, India.
9. Karunakar Raju, G. B., 2005, Character association and genetic divergence in upland cotton (*Gossypium hirsutum* L.). *M. Sc.* (*Agri.) Thesis*, Acharya N. G. Ranga Agril. Univ., Rajendranagar, Hyderabad.
10. Kempthorne, O., 1957, *An Introduction to Genetic Statistics*, John Wiley and Sons, New York.
11. Kumboh, N., Baloch, M. J., Kumbhar, M. B., Khanzada, S. and Jatoi, W. A., 2008, Diallel analysis for estimating combining ability in upland cotton (*Gossypium hirsutum* L.). *Pakistan J. Agril. Engin. Veter. Sci.,* 24(1): 27-33.

12. Marani A., 1968, Heterosis and F2 performance in intraspecific cross of Gossypium hirsutiom L. and G. barbadense L., *Crop Sci.,* 8: 111-113
13. Mohammad, R. Z., Nadali, B. J., 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 (*Gossypium hirsutum* and *Gossypiumbarbadense*). *Internat. J. Biol*., 2(1): 94-102.
14. Murthy, J. S. V. S. and Rao, B. R., 1999, Components of genetic variation in bollworm tolerant lines of upland cotton (*Gossypium hirsutum* L.). *J. Cotton Res. Dev.,*13(1): 17-21.
15. Naqib, U. K., Gul, H., Khan, B. M., Farhatullah, S. B., Makhdoom, K., Imtiaz, K., Khan, I. A. and Waqas, A., 2009, Genetic variability and heritability in upland cotton. *Pakistan. J. Bot.,* 41(4): 1695-1705.
16. Naqib, U. K., Khan, B. M., Gul, H., Farhatullah, M. B., Aisha, P., Umm-E-Aiman, Muhammad, Z. K. and Zahoor A. S., 2009, Diallel analysis of some quantitative traits in *Gossypium hirsutum* L.*Pakistan J. Bot.,* 41(6): 3009-3022.
17. Panse, V. G. and Sukhatme, P. V., 1967, Statistical Methods for Agricultural Workers (II Edn.), ICAR, New Delhi.
18. Patel, A. D., Patel, U. G. and Kumar, V., 2009, Diallel analysis for combining ability for seed cotton yield and its component traits in upland cotton. *J. Cotton Res. Dev.,* 23(2): 222-225.
19. Patel, K. G., Patel, U. G., Maisuria, A. T. and Chhimpi, B. G., 2004, Heterosis and combining ability in crosses involving multispecies derivatives. *Intl. Symp. on Strategies for Sustainable Cotton Production – A Global Vision. Crop Improvement,* 23rd-25th November, 2004, Univ. Agric. Sci., Dharwad, Karnataka (India).
20. Patel, K. G., Patel, U. G., Patel, J. C., Patel, D. H. and Patel, R. D., 2005, Line x tester analysis for combining ability of introgressed Asiatic cotton. *J. Indian Soc. Cotton Improv.,*30: 105-109.
21. Patil, S. S., 2009, Bt. Cotton: opportunities and prospects. *Proceedings of National symposium*, CICR, Nagpur, November 17-19.
22. Randhawa L.S., and T.H. Singh, 1994, Heterosis breeding for crossing parent yield barriers in cotton, In: G. A. Constable, and N. W. Forester (eds), Proc. World Cotton Res. Conf. 1, Challenging the Future, CSIRO, Brisbane, Australia
23. Rokaya M.H., El-Marakby A.M., El-Agroudy M.H., and Seif G.M., 2005, Heterosis and combining ability for fiber-to-seed attachment force, earliness, yieldand yield components in a half diallel cross of cotton, *Arab Univ. J. Agric. Sci.,* 13: 741-753
24. Sadykhova, L. D. and Makhmudov, T. K., 1986, Combining ability of cotton variety. *Referatinyi Zhurnal No. 5*, pp. 11-17.
25. Shimna, B. and Ravikesavan, R., 2008, Combining ability analysis of yield related traits and fibre quality traits in cotton (*Gossypium hirsutum* L.). *J. Cotton Res. Dev.,* 22(1): 23-27.
26. Sprague, G. F. and Tatum, L. A., 1942, General and specific combining ability in single crosses in corn. *J. American Soc. Agron*., 34: 923-932.
27. Tomar, S. K. and Singh, S. P., 1992, Combining ability analysis over environments in Asiatic cotton (*Gossypium arboreum* L.). *Indian J. Gen. Pl. Breed*., 52:264-269.
28. Valarmathi, M. and Jehangir, K. S., 1998, Studies on genetic parameters for yield and fibre quality traits in intra-varietal crosses of cotton (*Gossypium hirsutum* L.). *J. Indian Soc. Cotton Improv.,* 23(1): 64-67.
29. Wankhade, S. N., Patil, S. P., Kayande, N. V. and Burghate, S. K., 2008, Diallel analysis for estimating combining ability of quantitatively inherited traits in upland cotton. *J. Cotton Res. Dev.,* 22(2): 147-149.
30. White T.G., 1966, Diall analysis of quantitatively inherited characters in Gossypium hirsutiom L., *Crop Sci.,* 6: 253-255
31. White T.G., and R.J. Kohel, 1964, A diall analysis of agronomic characters in selected lines of cotton *Gossypium hirsutiom* L., *Crop Sci.,* 4: 254-257
32. Xuxian, W., Xiaoshuan, Y. Z. and Xie, L., 1995, Analysis of combining ability and heterosis for parental varieties in upland cotton. *J. HebeiAgric. Univ.,* 18: 34-40.

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