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Study of combing ability analysis and gene action for seed cotton yield and its agronomic traits in upland cotton

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ABSTRACT : Combining ability was studied with 13 parents in line x tester analysis for 12 quantitative characters in order to identify suitable parents/crosses, which could be utilized in upland cotton *(Gossypium hirsutum* L.) for further improvement programme. The analysis of variance revealed that both *gca* and *sca* variances were significant for all the characters indicated the importance of both additive and non additive genetic components in controlling the expression of these traits. Average degree of dominance reflected the predominance of over dominance in these characters expression. Combining ability analysis suggested the preponderance of non additive type of gene action for all the traits. The parents, LRA 5166 and G.Cot 16 for seed cotton yield; LRA 5166 and G.Cot 10 for oil content were judged as good general combiners. The cross combinations, LRA 5166 x G Cot 100, G Cot 16 x GTHV 01/9, LRA 5166 x GJHV 515, G Cot 16 x G Cot 100 and G Cot 16 x GTHV 08/70 were identified as potential ones based on their *sca* and heterotic effects, which had involved either G x P or P x P general combiners and confirms the validity of average degree of dominance values.

Key words: Additive, combining ability, heterosis, non additive, upland cotton

Cotton is a major crop of global importance and has high commercial value. It is a principle fibre crop, as well as an important source of edible oil throughout the world. For the success of cotton breeding programme, the basic need is selecting proper parents for hybridization. The study of heterosis shows the percentage as increase or decrease of the F_1 over the economic parents or better parents but it fails to identify the possible causes for the superiority of hybrid. The knowledge of combining ability provides a useful clue for selection of desirable parents for the development of better hybrids, which are superior in yield, quality and resistance to diseases and pests over the present cultivated hybrids. Thus, information regarding heterosis and combining ability are the basic requirements for a thorough understanding of genetic architecture of yield and its components. Keeping these views in mind, the present study was undertaken to obtain the information pertaining to the extent of heterosis and combining ability for 12 characters utilizing a line x tester mating design. The results obtained in the present investigation on the above aspects are discussed as following.

MATERIALS AND METHODS

The experimental material consists of 4 lines *viz.,* G. Cot 10, G. Cot 16, LRA 5166, BC 68-2 and 9 testers *viz.*, G. Cot 100, GTHV 01/9, GTHV 08/69, GTHV 08/70, GJHV 398 (P), GJHV 445, GJHV 482 (P), GJHV 515 and GBHV 166 of *Gossypium hirsutum* L. These parents were crossed in line x tester fashion during *kharif,* 2010-2011. The resulting 36 hybrids along with their parents and standard check hybrid G.Cot.hy.12 were sown during *kharif,* 2011-2012 in randomized block design with 3 replications at Anand Agricultural University, Agricultural Research Station, Sansoli. The parents and F_1s were sown in single row of 4.5 m length with 10 dibbles spacing of 120 x 45 cm. All recommended agronomic practices were adopted. The observations were recorded on 5 randomly selected plants from each lines for 12 characters *viz.,* plant height (cm), monopodia and sympodia/

Table 1. General combining ability effects

Particulars	Days to 50 per cent flowering	Plant height	Monopodia/ plant	Sympodia/ plant	Bolls/ plant	Boll weight (g)	Seed cotton yield/ plant	Lint yield/ plant	Ginning percentage	Seed Index	Lint index	Oil content
Lines												
G. Cot 10	-1.11**	-6.43**	0.02	1.18**	-2.14*	-0.12**	-18.38**	-7.11**	-0.37	-0.29**	-0.23**	0.13**
G. Cot 16	1.44**	2.09	0.17	-0.74**	4.19**	0.24**	32.11**	9.39**	-0.21	0.03	-0.02	-0.29**
LRA 5166	1.96**	10.94**	-0.04	0.60*	0.70	0.09**	13.44**	6.34**	0.49*	0.09	0.17*	0.11*
BC 68-2	-2.30**	-6.60**	-0.15	-1.05**	-2.75**	-0.22**	-27.17**	-8.62**	0.08	0.17	0.08	0.05
S.E. (Lines)	0.21	1.77	0.10	0.26	0.86	0.03	3.91	1.34	0.20	0.11	0.07	0.05
P=0.05	0.41	3.47	0.20	0.51	1.69	0.06	7.66	2.63	0.39	0.22	0.14	0.10
P=0.01	0.54	4.57	0.26	0.67	2.22	0.08	10.09	3.46	0.52	0.28	0.18	0.13
Testers												
G.Cot 100	-3.43**	7.40	0.19	0.18	13.04**	0.12**	65.13**	20.25**	-0.98**	-0.27	-0.29*	-0.95**
GTHV 01/9	0.91**	0.05	-0.15**	0.80	5.91**	-0.19**	13.98*	3.93	-0.02	0.23	0.12	0.27**
GTHV 08/69	0.82*	-0.52	-0.25**	0.41	-4.36**	0.05	-17.47**	0.41	2.40**	-0.11	0.50**	0.11
GTHV 08/70	2.41**	-1.91	0.19**	0.10	3.35*	0.07	12.94*	-0.16	-1.58**	0.26	-0.24*	-0.13
GJHV 398 (P)	-0.51	3.67	-0.07	-1.13**	-3.35*	-0.01	-14.86*	-5.21*	-0.08	-0.06	-0.06	1.17**
GJHV 445	2.41**	-11.10**	0.06	-1.24**	-0.99	0.07	-1.40	1.09	0.50	0.18	0.14	-0.86**
GJHV 482 (P)	-1.34**	2.16	0.31**	-0.50	-7.14**	0.09*	-20.86**	-6.83**	-0.04	-0.49**	-0.24*	0.38**
GJHV 515	-1.09**	0.20	0.16**	0.71	1.79	-0.06	3.30	0.78	0.15	-0.30	-0.11	-0.14
GBHV 166	-0.18	0.04	-0.44**	0.67	-8.25**	-0.13**	-40.76**	-14.25**	-0.34	0.57**	0.18	0.13
S.E. (Testers)	0.34	2.88	0.06	0.42	1.40	0.05	6.39	2.20	0.33	0.19	0.12	0.09
Range (Max)	**-3.43**	**10.94**	**0.31**	**1.18**	**13.04**	**0.24**	**65.13**	**20.25**	**2.40**	**0.57**	**0.50**	**1.17**
(Min)	**2.41**	**-11.10**	**-0.44**	**-1.24**	**-8.25**	**-0.22**	**-40.76**	**-14.25**	**-0.98**	**-0.49**	**-0.29**	**-0.95**
P=0.05	0.67	5.64	0.12	0.82	2.74	0.10	12.52	4.31	0.65	0.37	0.24	0.31
P=0.01	0.88	7.43	0.15	1.08	3.61	0.13	16.49	5.68	0.85	0.49	0.18	0.23

plant, bolls/plant, boll weight (g), seed cotton yield/plant (g), lint yield/plant (g), ginning outturn (%), seed index (g), lint index and oil content (%); while days to 50 per cent flowering was recorded on plot basis. The mean data were subjected to a line x tester analysis and combining ability effects and variances were estimated. Heterobeltiosis was calculated.

RESULTS AND DISCUSSION

The analysis of variance for combining ability revealed that the variance due to lines revealed significant differences among all the characters except monopodia/plant, ginning outturn (%) and seed index, while variance due to testers showed significant differences for all the characters except plant height. The variance due to interaction effect of lines and testers were significant for all the characters reflected the importance of non additive gene action in the inheritance of these traits. The estimates of variance due to both general combining ability and specific combining ability variance were found to be significant for all characters indicated the involvement of additive and non additive gene effects for genetic control of these characters (Ahuja and Dhayal, 2007). However/ratio indicated preponderance of non additive gene action for all the characters.

Estimates of general and specific combining ability : The estimates of *gca* effects (Table 1) were ranged from 2.41 to -3.43 per cent for days to 50 per cent flowering; -11.10 to 10.94 (%) for plant height, -0.44 to 0.31 (%) for monopodia, -1.24 to 1.18 (%) for sympodia, -8.25to 13.04 (%) for bolls/plant, -0.22 to 0.24 (%) for boll weight, -40.76 to 65.13 (%) for seed cotton yield/plant, -14.25 to 20.25 (%) for lint yield/plant, -0.98 to 2.40 (%) for ginning outturn (%), -0.49 to 0.57 (%) for seed index, -0.29 to 0.50 (%) for lint index, and -0.95 to 1.17 (%) for oil content. These results revealed that the lines G. Cot 16 and LRA 5166 and tester G.Cot 100 were found good general combiner for boll weight, seed cotton yield and lint yield/plant. It is observed that good general combiner parents for seed cotton yield were also good general combiners for other yield contributing traits.

For bolls/plant, line G. Cot 16 and testers G. Cot 100, GTHV 01/9 and GTHV 08/70 were found good general combiners. Only 1 line G. Cot. 10 and 3 testers *viz.,* GTHV 08/70, GJHV 515 and GJHV 482 (P) were found good general combiners for sympodia and monopodia/plant, respectively. The parents LRA 5166, GTHV 01/9, GJHV 398 (P) and GJHV 482 (P) were found best combiner for oil content, whereas genotypes GTHV 08/69 and LRA 5166 were best general combiners for both ginning outturn percentage and lint index. The superior parents results into superior hybrids. Hence, these parents *viz.,* G. Cot 16, LRA 5166 and G. Cot 100 may therefore be used in crop breeding programme to improve different traits. The results revealed that the most of the

Table 2. General combining effects of parents in cotton

Characters	Parents	*Per se* performance	*gca* effects
Days to 50 per cent flowering	GBHV 166	61.00	-0.18
	G.Cot 100	62.00	-3.43**
	GTHV 08/69	190.03	-0.52
Plant height	GJHV 398 (P)	185.00	3.67
	LRA 5166	4.27	-0.04
Monopodia/ plant	G.Cot 16	4.23	0.17
	GTHV 08/69	21.37	0.41
Sympodia/ plant	GJHV 482 (P)	21.13	-0.50
	GBHV 166	79.40	-8.25**
Bolls/plant	GJHV 445	77.83	-0.99
	GTHV 08/70	3.77	0.07
Boll weight	GJHV 445	3.72	0.07
	GJHV 445	293.93	-1.40
Seed cotton yield/plant	G.Cot 10	256.58	-18.38**
	GJHV 445	94.18	1.09
Lint yield/ plant	GBHV 166	83.57	-14.25**
	GTHV 08/69	32.55	2.40**
Ginning percentage	GBHV 166	32.48	-0.34
	GTHV 01/9	11.24	0.23
Seed index	GJHV 515	10.72	-0.30
	GTHV 01/9	5.38	0.12
Lint index	GBHV 166	4.99	0.18
	GTHV 01/9	19.54	0.27**
Oil content	GBHV 166	19.40	0.13

parents had high degree of correspondence between *per se* performance and their *gca* effects for most of the characters, which showed additivity of genes (Table 2). Therefore, in selection of parents for varietal development programme due weightage should be given to *per se* performance along with their *gca* effects. This findings are in confirmation with the findings of Rao and Reddy, 2002; Tuteja *et al.,* 2003a; Muthu *et al.,* 2005;Rauf *et al.,* 2005; Patel *et al.,* 2007; Ahuja and Dhayal, 2007; Ashokkumar and Ravikesavan, 2008; Preetha and Raveendran, 2008; Deosarkar *et al.,* 2009; Senthilkumar *et al.,* 2010.

In general, the F_1s which had higher estimates of HB (heterobeltiosis) for seed cotton yield also had positive heterotic effects for bolls/ plant, lint yield/plant, lint index, and ginning percentage (Table 3).

The estimates of specific combining ability effect (Table 3) by and large provide information on role of intra and interallelic interactions in the expression of heterosis and inheritance of a character. Best cross

Table 3. Superior cross combination based on sca effects in cotton

Character	Parents/Cross	*Per se* performance	Heterosis over better parent	*sca* effects	*gca* effects
Days to 50	G.Cot 10 x G.Cot 100	60.33	-2.69	-1.06	G x G
per cent	BC 68-2 x GJHV 445	60.67	-2.67	-5.37**	G x P
flowering	BC 68-2 x GTHV 01/9	60.67	-2.67	-3.87**	G x P
	LRA 5166 x G.Cot 100	198.27	10.23	9.57	G x A
Plant height	LRA 5166 x GTHV 01/9	195.10	8.41	13.75**	G x A
	G.Cot 16 x GTHV 08/70	194.93	14.09*	24.39**	A x A
	G. Cot 16 x GJHV 445	4.70	11.02	0.84**	A x A
Monopodia/plant	BC 68-2 x GTHV 01/9	4.43	15.65	1.10**	A x P
	G.Cot 10 x G.Cot 100	4.30	11.21	0.46**	A x A
	G. Cot 16 x GTHV 08/70	22.83	18.92*	3.93**	P x A
Sympodia/plant	G. Cot 10 x GJHV 515	22.65	18.40*	1.22	G x A
	LRA 5166 x GTHV 01/9	22.33	16.12*	1.39	G x A
	LRA 5166 x G.Cot 100	102.07	39.75**	16.48**	A x G
Bolls/plant	G. Cot 16 x GTHV 01/9	100.33	59.94**	18.38**	G x G
	G.Cot 16 x GTHV 08/70	98.17	53.87**	18.78**	G x G
	G. Cot 16 x GJHV 482 (P)	4.43	22.24**	0.43**	G x G
Boll weight	G. Cot 16 x GBHV 166	4.38	20.86**	0.60**	G x P
	LRA 5166 x G.Cot 100	4.30	28.36**	0.42**	G x G
	LRA 5166 x G.Cot 100	464.12	86.84**	120.31**	G x G
Seed cotton	G. Cot 16 x GTHV 01/9	424.94	78.90**	113.61**	G x G
yield/plant	LRA 5166 x GJHV 515	366.88	63.63**	84.91**	G x A
	LRA 5166 x G.Cot 100	169.23	139.42**	56.84**	G x G
Lint yield/plant	G. Cot 16 x GTHV 01/9	134.79	91.46**	35.67**	G x A
	LRA 5166 x GJHV 515	109.39	66.09**	16.47**	G x A
	LRA 5166 x G.Cot 100	36.40	19.51**	4.50**	G x P
Ginning	G. Cot 16 x GJHV 515	35.75	20.48**	3.42**	A x A
percentage	BC 68-2 x GTHV 08/69	35.67	9.59**	0.80	A x G
	BC 68-2 x GTHV 01/9	11.98	6.65	1.13**	A x A
Seed index	G. Cot 16 x GBHV 166	11.63	12.86*	0.59	A x G
	G. Cot 16 x GTHV 08/69	11.62	13.52*	1.25**	A x A
	LRA 5166 x G.Cot 100	6.23	42.41**	1.35**	G x P
Lint index	G. Cot 16 x GTHV 08/69	6.13	41.86**	0.63**	A x G
	BC 68-2 x GTHV 01/9	6.11	13.69	0.89**	A x A
	BC 68-2 x GJHV 398 (P)	20.59	9.54**	0.28	A x G
Oil content	G. Cot 10 x GJHV 482 (P)	20.50	10.69**	0.89**	G x G
	G. Cot 10 x GJHV 398 (P)	20.47	8.87**	0.07	G x G

combinations revealed the high *sca* effect of F_1s in general corresponded to their high heterotic response, but this may also be accompanied by poor and/or average *gca* effect of the parents. This may be due to the presence of genetic diversity in the form of dispersed genes for these characters. It revealed that good x good type of combinations not necessarily results into high *sca* effects. This is probably due to internal cancellation of gene effects in these parents. Some of the crosses showed significant *sca* effects, which had the combination of good x good and good x average *gca* effects for seed cotton yield, lint yield and bolls/plant may be explained because of the main role of the additive gene action. Good x good general combiners showed additive x additive gene action for many characters and its possibility of fixation, single plant selection could be practiced in further segregating generations to isolate superior pure lines from such combinations.The data indicate that none of the hybrids showed consistent *sca* effects for all the traits under study. The cross L RA 5166 x G .Cot 100 and G. Cot 16 x GTHV 01/9 recorded the more plant height, bolls/plant, lint index, ginning percentage, lint yield/plant and seed cotton yield. This cross also showed significant positive heterobeltiosis, *sca* effects and both the parents involved were good general combiners.

These results are in accordance with the findings of Kaliyaperumal *et al.,* 2010, Muthu *et al.,* 2005; Tuteja *et al.,* 2006b; Verma *et al.,* 2006 and Ashok kumar *et al.,* 2008. On the basis of *per se* performance, heterotic response, combining ability estimates, nature of gene action for seed cotton yield and its component characters, hybrid LRA 5166 x G. Cot 100 was found superior and may be exploited commercially after critical evaluation for its superiority and stability across the locations and over years.

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