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Combining Ability Estimates for Yield Traits in Line x Tester Crosses of Upland Cotton (*Gossypium hirsutum)*

Sukhdeep Singh Sivia*, S. S. Siwach, O. Sangwan, Lingaraja L. and R. D. Vekariya

Department of Genetics and Plant Breeding

CCS Haryana Agricultural University, Hisar - 125 004

*Corresponding Author E-mail: sukhdeepsinghsivia@gmail.com

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ABSTRACT

The aim of this study was to estimate the general combining ability of the parents and specific combining ability of hybrids considered for the development of high yielding cultivars. Nineteen genotypes and 60 F_1 hybrids obtained by crossing 15 lines and 4 testers in line-tester mating system during Kharif 2014 were sown in randomized complete block design in Kharif 2015. Line-Tester analysis revealed significant GCA and SCA effects for all the traits except plant height. Preponderance of non-additive gene action was obtained for seed cotton yield per plant and majority of its component traits. Among the parents: H1156 for days to first flowering, H1471 for plant height, AC726 for monopods per plant, H1464 for boll weight, H476 for seeds per boll and H1470 for seed cotton yield per plant, bolls per plant and sympods per plant were detected with higher general combining ability. The hybrids achieved high seed cotton yield by producing more number of open bolls and boll weight. The significant SCA affects were recorded for seed cotton yield from the cross combination AC726 x H1236, H1476 x H1226, Luxmi PKV X H1226, H1470 X H 1098-I and H1470 X H1236. These cross combinations involved at least one parent with high or average GCA effect for a particular trait. The cross combination involving H1470 and H1236 parents recorded significant positive SCA effect for yield contributing characters. Thus, the parents H1470 and H1236 can be used for hybrid development programme. The study also revealed good scope for commercial hybrid development as well as isolation of pure lines among the progenies.

Key words: *Gossypium hirsutum, GCA, SCA, Line x tester analysis*

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is an important fibre crop and plays a vital role in commerce of many countries such as USA, China, India, Pakistan, Uzbekistan, Turkey, Australia, Greece, Brazil, Egypt *etc.*, where climatic conditions suits its growth, which includes periods of hot and dry weather and adequate moisture. Cotton is harvested as ‘seed cotton’, which is then ‘ginned’ to separate the seed and lint. The long ‘lint’ fibres are further processed by spinning to produce yarn that is knitted or woven into fabrics.

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Cotton is grown across 68 countries in about 33.98 m ha area with a productivity of 622 Kg/ha. India has the largest cotton growing area (118.81 lakh ha) in the world and account for 35.20 million bales of cotton lint production with a productivity of 504 kg/ha. In Haryana, cotton is grown in an area of 5.76 lakh ha with a production of 17 lakh bales and a productivity of 502 kg/ha lint[4].

To make the productivity of Indian cotton comparable to other countries like USA and China, there is a need to give more emphasis on the magnitude of heterosis, *per se* performance and stability of genotypes. The concept of combining ability plays an important role in the identification of parents and development of superior lines or hybrids. Studies have indicated that the genotypes found good in performance might not necessarily produce desirable progenies when used in hybrid development. It is therefore, necessary to identify promising line based on combining abilities combinations using appropriate mating design. There is a need to search for the divergent line in the cotton with superior combining abilities. Exploitation of hybrid vigour has become potential tool for the improvement of this crop. However, lot of information is available on heterosis in cotton but still it holds future promise for further utilization. Hybridization is the most potent technique for breaking undesirable linkages. The choice of suitable parents for the development of desired hybrid depends on the selection of parents based on combining ability.

This necessitates the study of combining ability effects of crosses for the selection of superior parents and hybrids. To study the extent of heterosis and combining ability of a number of parents, Line x Tester analysis is the most appropriate procedure. The Line x Tester analysis[9] is one of the simplest and efficient methods of evaluating large number of inbreds/parents for their combining ability. Based on the information from Line x Tester analysis production of commercially viable hybrid is possible. The purposes of this research were to estimate the GCA and SCA effects for yield components parameters among 15 genotypes taken as female, and 4 taken as male *G. hirsutum* lines and to determine appropriate parents and crosses for the investigated traits.

MATERIALS AND METHODS

Selection of Parental line

The parental lines to be used in the present study were selected based on their genetic diversity. Large number of genetic accessions study and selected fifteen diverse female lines *viz:* H1156, ISR12, HR1, Luxmi PKV, AC726, Deltapine, H1472, H1465, H1463, H1464, H1470, H1471, H1476, H1477 and CSH3075 during the *Kharif* season of 2013. The male lines was selected based on their agronomical superiority and selected four local cultivars, *viz:* H1226, H1098-I, H1117 and H1236.

Hybrid development

All the diverse parental lines (15) were crossed with all the four male parents in Line x Tester fashion during the *Kharif* season of 2014. When the parental lines started to flower, these were crossed in line x tester fashion. Some of the buds of parents were also selfed. Maximum numbers of crosses were made to develop sufficient F_1 seed. The following necessary precautions were taken at the time of emasculation and pollination: (1) Emasculation was done before the anthers are mature and the stigma has become receptive to minimize self-pollination. (2) The flowers selected for emasculation are likely to open the next morning. (3) Care was taken that all the anthers are removed. (4) The gynoecium must not be injured and (5) Bagging of emasculated buds before and after pollination.

Field layout

The 60 hybrids, 19 parents with single check HHH223 were planted in the field during *Kharif* 2015 crop season at cotton research area, CCS Haryana Agricultural University, Hisar (India). Each entry was sown in randomized block design (RBD) with three replications. Each genotype was grown in a 7.2 m length row adopting a spacing of 67.5 cm between rows and 60 cm between the plants in a row, to have 13 plants per row.

Data analysis

Data were recorded on five randomly selected plants per replication for all the eight quantitative characters *viz.,* Days to first flower, plant height (cm), number of monopodia per plant, number of sympodia per plant, number of bolls per plant, boll weight (g), number of seeds per boll and seed cotton yield per plant (g).

Statistical Analysis

The mean values of the characters measured in 80 genotypes in each replication were analyzed for analysis of variance, estimation of standard error and critical difference by adopting the method suggested by Panse and Sukhatme[15]. The Line x Tester analysis of combining ability analysis of the data was done as suggested by Kempthorne[9].

RESULTS AND DISCUSSION

The analysis of variance (Table 1) indicated that the mean squares of genotypes for all the characters investigated were significantly different, indicating the presence of variability among hybrids and their parents. Estimates of variances due to general and specific combining ability for all eight characters under study are presented in Table 2. General combining ability variances for female parents were highly significant for all the characters revealing important role of additive type gene effects. In the assemblage of males general combining ability variances for all the eight characters were highly significant for all traits except plant height which obtained non-significant effects at both (1.00% and 5.00%) level of significance and it revealing that non-additive gene effects as dominant or epistatic. The SCA variances (δ^2 SCA) were higher than gca variance (δ^2 GCA) for almost all the characters (Table 2). The ratio of δ^2 GCA /δ^2 SCA was less than unity for all the eight characters indicating preponderance of non-additive gene action (dominance and epistasis), which is an important in exploitation of heterosis through hybrid breeding. Several authors Ahuja and Dhayal[1], Nidagundi *et al*[14]., and Pushpam *et al*[16]., have reported the predominance of SCA variance in upland cotton for plant morphological, yield and its component characters.

The information on combining ability will help the breeder in developing the future breeding programme to be adopted for exploiting additive and/or non-additive components present in the material. In the present investigation, an attempt was made to obtain information on the magnitude of GCA and SCA variances and GCA and SCA effects for individual parents and crosses in respect of eight traits through combining ability analysis.

Best combining male and female parents along with the poorest combiners for various characters are presented in Table 3 and Table 4. The perusal of table revealed that among the four male parents H1236 was the best combiner for the characters *viz*. seed cotton yield, boll weight, plant height and number of seeds per boll. Male parent H1098-i was best combiner for days to first flower and number of monopods. H1226 was the best combiner for number of sympodia and number of bolls per plant (Table 4).

Among female parents, H1470 was good general combiner for seed cotton yield, number of bolls, number of sympods and the same parent also second best combiner for boll weight. The genotype H1471 was found good combiner for plant height and female parent H1464 was found best combiner for boll weight. Similar results were reported by Deshmukh *et al*[5]., Sanjay *el al*[18]., Kumar *et al*[12]., and Kencharaddi *et al*[10].

Female parent H1156 was observed the best combiner for dwarfness and this parent had second best combiner for number of monopods per plant, AC726 for number of monopods per plant (Table 4). The highest general combiner effect for number of seeds per boll was observed from female parent H1476 and this parent also have second best GCA effect for sympods per plant. Female parent HR1 was recorded second good general combiner for number of bolls per plant. The second best GCA effect was reported from ISR12 for days to first flower, H1476 for sympods per plant. The poor general combiner was obtained for number of bolls per plant from female parent H1477. Female parent Deltapine was found poor combiner for all-important yield-contributing traits. However, considering the economic importance of various characters H1470, H1464, H1471, H1156 among the female, H1236 and H1098-i among male may be used for future breeding.

Out of total sixty crosses, nine cross combinations had significant positive SCA effects in Table 5. Most prominent crosses among the entire cross combination were AC726 x H1236 (27.76) (good x good GCA), H1476 x H1226 (26.19) (good x good GCA), Luxmi PKV x H1226 (24.02) (poor x good GCA) and H1470 x H1098-i (14.64) (good x poor GCA) due to their highest significant positive SCA effect. It is also interesting to note that parallelism existed between SCA values for this best cross AC726 x H1236 (27.76) also observed significant SCA effects in case of number of boll per plant and boll weight which found its suitability for increased seed cotton yield. Similar results were reported by Khan *et al*[11]., Laxman[13], and Alkuddsi *et al*[2].

For number of bolls per plant, five crosses registered positive and significant SCA effects. In table 6, The maximum SCA effect for bolls per plant was observed by cross H1463 x H1226 (8.55) (good x good GCA) followed by Luxmi PKV x H1226 (7.63) (poor x good GCA). Cross combinations, H1476 x H1226 (0.29) and AC726 x H1236 (0.28) observed highest positive significant SCA effects. There are combinations of good x poor and poor x good general combining parents, respectively. The best specific cross combination was revealed for number of sympods by the cross H1463 x H1226 which involved good x good parents as combiners. High negative SCA effects for days to first flower were depicted by hybrid ISR12 x H1226, which was a combination of good x poor combining parent, indicating that both additive and dominance variance were important for these characters. Similar results were reported by Subramanian *et al*[19]., Giri *et al*[6]., and Alkuddsi *et al*[2].

The cross combination ISR12 x H1098-i observed highest SCA effects for tallness and this crosses were combinations of poor x good combining parents; hence, sca effect of these crosses is due to both additive and non-additive gene action. Similar results were reported by Subramanian *et al*[19]., Karademir *et al*[8]., Anandan[3] and Rajamani *et al*[17].

The cross combination H1470 x H1236 (good x good GCA), H1470 x H1098-i (good x average GCA), H1476 x H1226 (poor x average GCA) and AC726 x H1236 (average x poor GCA) were observed high heterosis for seed cotton along with good SCA effects (Table 7). These finding reported that study of SCA effects alone is not appropriate for choosing parents for hybridization programme but study of their heterotic effect are also necessary as reported by Ahuja and Dhayal[1], Karademir *et al*[7]., Laxman[13] and Kencharaddi *et al*[10].

Table 1: Mean Squares for characters under study

Source of variation	D.F	DF	PH	NM/P	NS/P	NB/P	BW	NS/B	SCY/P
Replication	2	18.95	780.91	0.19	12.05	43.13	0.06	18.81	123.02
Treatment	79	35.54*	366.97*	1.01*	8.58*	64.03*	0.29*	3.01*	787.15*
Error	158	2.41	53.95	0.04	0.31	9.44	0.01	0.67	50.24

***Significant at 5% level of significance**

DF- Days to first flower, **PH-** Plant height (cm), **NM/P-** Number of monopod/plant, **NS/P-** Number of sympod/plant, **NB/P-** Number of bolls/plant, **BW-** Boll weight (g), **NS/B-** Number of seeds/boll, **SCY/P-** Seed cotton yield/Plant (g)

Table 2: Combining ability analysis for characters in *Gossypium hirsutum* L.

Source of variation	Df	DF	PH	NM/P	NS/P	NB/P	BW	NS/B	SCY/P
Replication	2	25.27**	405.05**	0.07	9.06**	37.37*	0.05**	25.32**	83.98
Hybrid	59	42.30**	414.67**	.92**	8.69**	71.18**	.31**	3.27**	872.82**
Lines	14	90.36**	1211.96**	2.02**	20.11**	130.88**	0.88**	6.38**	2043.29**
Testers	3	71.267**	65.37	1.282**	2.391**	50.199**	0.48**	5.902**	508.978**
Lines x Testers	42	24.21**	173.86**	0.53**	5.34**	52.77**	0.11**	2.04**	508.66**
Error	118	2.14	50.99	0.04	0.30	9.15	0.01	0.56	49.65
σ^2 **GCA**		1.99	16.31	0.04	0.21	1.33	0.02	0.14	26.93
σ^2 **SCA**		103.95	678.47	2.21	19.06	156.06	0.69	7.17	1888.68
σ^2**GCA**/σ^2**SCA**		0.04	0.05	0.04	0.02	0.02	0.06	0.04	0.03

**Significant at 1% level of significance.

*Significant at 5% level of significance.

DF- Days to first flower, **PH-** Plant height (cm), **NM/P-** Number of monopod/plant, **NS/P-** Number of sympod/plant, **NB/P-** Number of bolls/plant, **BW-** Boll weight (g), **NS/B-** Number of seeds/boll, **SCY/P-** Seed cotton yield/Plant (g).

Table 3: General combining ability effects of parents for different characters in *Gossypium hirsutum* L.

Female Parents	DF	PH	NM/P	NS/P	NB/P	BW	NS/B	SCY/P
H1156	-5.81**	3.08	0.52**	0.83**	0.55	-0.22**	-0.29	-3.58
ISR12	-5.06**	-0.66	0.44**	0.09	-2.93*	-0.08*	0.26	-9.31**
HR1	-2.73**	-8.75**	0.46**	1.16**	3.14*	-0.27**	-0.09	0.22
Luxmi PKV	-0.98	-8.58**	0.52**	-0.82**	-2.11	-0.36**	-0.18	-13.83**
AC726	1.18*	-9.58**	0.56**	-0.01	0.44	-0.01	-0.07	1.71
Delta Pine	-0.06	-19.58**	-0.20*	-1.59**	-2.47*	-0.55**	-2.12**	-20.35**
H1472	1.43*	7.16*	-0.18*	-0.90**	-1.33	0.19**	0.16	0.43
H1465	1.43*	9.33**	-0.17*	-0.01	0.15	0.23**	0.54	5.74*
H1463	2.18**	5.91*	-0.05	0.55*	1.30	0.08*	-0.25	3.31
H1464	1.26*	10.91**	-0.15	-0.86**	0.44	0.42**	0.62*	11.76**
H1470	-1.81**	5.41	-0.15	2.13**	9.30**	0.29**	0.46	34.06**
H1471	3.10**	13.75**	-0.13	1.39**	-0.69	0.18**	0.55	2.29
H1476	1.85**	5.50	-0.62**	1.58**	1.44	0.13**	0.97**	7.14*
H1477	2.76**	-15.33**	-0.12	-1.16**	-5.02**	-0.12**	-0.67*	-16.27**
CSH3075	1.26*	1.41	-0.70**	-2.42**	-2.22	0.10**	0.11	-3.35
SE (d)	0.59	2.91	0.08	0.22	1.23	0.03	0.30	2.87
Male parents								
H1226	0.96**	0.34	0.10*	0.34**	1.28*	-0.09**	-0.11	0.74
H1098-i	-1.47**	-0.63	0.14**	-0.12	-1.08	0.02	0.23	-1.89
H1117	1.12**	-1.23	-0.01	-0.06	-0.60	-0.06**	-0.45**	-3.24*
H1236	-0.61*	1.52	-0.23**	-0.14	0.40	0.13**	0.34*	4.39**
SE (d)	0.30	1.50	0.04	0.11	0.63	0.01	0.15	1.48

**Significant at 1% level of significance

*Significant at 5% level of significance

DF- Days to first flower, **PH-** Plant height (cm), **NM/P-** Number of monopod/plant, **NS/P-** Number of sympod/plant, **NB/P-** Number of bolls/plant, **BW-** Boll weight (g), **NS/B-** Number of seeds/boll, **SCY/P-** Seed cotton yield/Plant (g).

Table 4: Above average and poorest general combining parents for different characters

Characters	Female parent			Male parent
	Above average combiners		Poor combiners	Above average Combiner
	1st	2nd		
Days to first flower	H1156 (-5.82**)	ISR12 (-5.07**)	H1471 (3.10**)	H1098-I (-1.48**)
Plant height	H1471 (13.75**)	H1464 (10.92**)	Deltapine (-19.58**)	H1236 (1.52)
No. of monopods	AC726 (0.56**)	H1156 (0.53**)	CSH3075 (-0.70**)	H1098-I (0.14**)
No. of sympod/plant	H1470 (2.14**)	H1476 (1.59**)	CSH3075 (-2.43**)	H1226 (0.34**)
No. of bolls/plant	H1470 (9.31**)	HR1 (3.14*)	H1477 (-5.03**)	H1226 (1.28*)
Boll weight/boll	H1464 (0.42**)	H1470 (0.30**)	Deltapine (-0.56**)	H1236 (0.13**)
No. of seed/boll	H1476 (0.97**)	H1464 (0.62*)	Deltapine (-2.13**)	H1236 (0.34*)
Seed cotton yield per plant	H1470 (34.07**)	H1464 (11.77**)	Deltapine (-20.35**)	H1236 (4.39**)

GCA value in parenthesis

**Significant at 1% level of significance,

*Significant at 5% level of significance

Table 5: Specific combining ability effects of parents for different characters in *Gossypium hirsutum* L.

Cross	DF	PH	NM/P	NS/P	NB/P	BW	NS/B	SCY/P
H1156 X H1226	1.28	-3.26	-0.55**	-0.75	2.86	-0.06	-1.23*	4.36
H1156 X H 1098-i	-2.93*	-3.28	0.27	0.88*	0.66	0.11	0.41	4.95
H1156 X H1117	0.46	11.31	0.09	0.69	-2.37	-0.08	0.30	-6.80
H1156 X H1236	1.19	-4.77	0.18	-0.82	-1.15	0.03	0.50	-2.51
ISR12 X H1226	-6.46**	-5.51	0.79**	-1.77**	-4.77	0.07	0.61	-9.92
ISR12 X H 1098-i	0.31	16.13**	-0.44**	1.42**	3.05	0.01	0.52	7.93
ISR12 X H1117	7.71**	-8.93	-0.15	-0.03	-1.64	-0.22**	-0.98	-8.65
ISR12 X H1236	-1.55	-1.68	-0.20	0.38	3.36	0.13	-0.15	10.65
HR1 X H1226	-2.80	2.23	-0.41**	0.49	-0.78	0.07	0.50	1.08
HR1 X H 1098-i	-1.02	1.55	0.40*	-1.03*	-2.25	0.06	-0.44	-2.82
HR1 X H1117	1.71	-1.85	-0.23	0.03	3.30	-0.01	0.37	6.20
HR1 X H1236	2.11	-1.93	0.24	0.51	-0.27	-0.13*	-0.42	-4.46
Luxmi PKV X H1226	3.11**	1.73	0.59**	1.38**	7.63**	0.26**	0.32	24.02**
Luxmi PKV X H 1098-i	-2.77*	-6.95	-0.32	-1.04*	-5.67*	-0.22**	-0.12	-17.65**
Luxmi PKV X H1117	-1.70	3.65	0.13	-1.31**	-3.80	-0.01	0.66	-8.41
Luxmi PKV X H1236	1.36	1.56	-0.40**	0.97*	1.84	-0.04	-0.86	2.05
AC726 X H1226	0.61	-4.92	-0.25	-0.47	-2.24	-0.08	-0.79	-10.31
AC726 X H 1098-i	0.72	-7.61	-0.09	-1.27**	-2.55	-0.21**	-0.33	-12.54*
AC726 X H1117	-3.53**	4.65	-0.13	1.86**	-2.15	0.02	-0.11	-4.91
AC726 X H1236	2.19	7.89	0.48**	-0.11	6.96**	0.28**	1.24*	27.76**
Delta Pine X H1226	0.53	-0.26	0.18	1.15**	0.01	0.10	0.83	1.07
Delta Pine X H 1098-i	2.31	2.05	0.53**	-1.14*	-0.97	0.23**	1.08	2.63

Delta Pine X H1117	-0.28	1.65	-0.37*	0.25	4.75	-0.03	-0.26	10.19
Delta Pine X H1236	-2.55*	-3.43	-0.35*	-0.26	-3.79	-0.30**	-1.66**	-13.90*
H1472 X H1226	-1.63	-3.01	0.03	-1.14*	-1.07	-0.30**	-0.29	-8.95
H1472 X H 1098-i	0.81	0.96	0.18	2.29**	0.55	0.08	-0.67	3.46
H1472 X H1117	0.21	1.23	-0.05	-0.46	2.58	0.16*	0.04	9.62
H1472 X H1236	0.61	0.81	-0.16	-0.68	-2.06	0.05	0.91	-4.13
H1465 X H1226	0.36	-4.17	0.08	-0.34	-2.89	0.13	1.29*	-3.73
H1465 X H 1098-i	-1.52	12.13*	-0.22	0.32	3.06	0.11	-0.35	12.47*
H1465 X H1117	-0.78	-15.93**	0.52**	-0.66	-0.74	-0.18**	-0.33	-6.90
H1465 X H1236	1.94	7.97	-0.38*	0.68	0.57	-0.05	-0.60	-1.83
H1463 X H1226	0.28	5.90	-0.10	2.83**	8.55**	-0.38**	-0.94	11.90*
H1463 X H 1098-i	0.72	-8.78	0.32	1.17**	2.24	0.10	0.57	10.46
H1463 X H1117	0.12	-4.51	-0.05	-2.12**	-6.22*	0.04	0.56	-15.88**
H1463 X H1236	-1.13	7.39	-0.16	-1.87**	-4.57	0.24**	-0.20	-6.48
H1464 X H1226	0.20	8.57	0.26	-0.18	-0.32	0.09	-0.28	2.95
H1464 X H 1098-i	0.64	-4.45	-0.71**	-1.81**	-5.72*	0.05	-0.03	-18.64**
H1464 X H1117	1.37	2.48	-0.28	0.39	3.03	-0.10	-0.01	6.39
H1464 X H1236	-2.22	-6.60	0.73**	1.60**	3.01	-0.03	0.32	9.29
H1470 X H1226	3.28**	-7.59	-0.53**	-0.45	-5.78*	-0.08	-0.12	-19.99**
H1470 X H 1098-i	-3.93**	-4.28	-0.04	0.15	6.58**	-0.11	0.12	14.64*
H1470 X H1117	1.46	6.31	0.31	1.25**	-4.55	0.14*	-0.21	-9.10
H1470 X H1236	-0.80	5.56	0.26	-0.96*	3.76	0.06	0.21	14.46*
H1471 X H1226	-1.96	-6.92	-0.21	-0.80	-2.78	-0.11	-0.54	-8.91
H1471 X H 1098-i	-2.18	0.71	-0.32*	1.12*	2.24	0.18**	0.70	7.84
H1471X H1117	2.21	-0.01	0.22	-1.13*	1.77	0.19**	-0.01	11.47*
H1471 X 1236	1.94	6.22	0.31*	0.81	-1.24	-0.26**	-0.14	-10.40
H1476 X H1226	2.61*	11.98*	-0.01	1.20**	5.97*	0.29**	1.16	26.19**
H1476 X H 1098-i	2.72*	7.30	0.75**	-0.32	-0.36	0.04	-0.01	-0.35
H1476 X H1117	-3.53**	-8.43	-0.48**	-1.46**	-1.13	-0.14**	-0.79	-7.25
H1476 X H1236	-1.80	-10.85	-0.26	0.58	-4.48	-0.18**	-0.36	-18.58**
H1477 X H1226	1.03	1.48	0.03	-1.18**	-1.78	-0.03	-0.35	-4.42
H1477X H 1098-i	2.47*	-0.53	-0.07	-1.17**	-1.75	-0.20**	-0.67	-7.96
H1477 X H1117	-0.45	7.73	0.47**	2.09**	4.44	-0.01	-0.71	9.88
H1477 X H1236	-3.05*	-8.68	-0.43**	0.27	-0.90	0.25**	1.74**	2.50
CSH3075 X H1226	-0.46	3.73	0.08	0.05	-2.58	0.04	-0.17	-5.33
CSH3075 X H 1098-i	3.64**	-4.95	-0.22	0.42	0.88	-0.23**	-0.78	-4.42
CSH3075X H1117	-4.95**	0.65	-0.01	0.62	2.74	0.23**	1.49*	14.17*
CSH3075X H1236	1.77	0.56	0.14	-1.09*	-1.04	-0.03	-0.53	-4.41
SE (d)	1.19	5.83	0.15	0.44	2.46	0.06	0.61	5.75

****Significant at 1% level of significance**

***Significant at 5% level of significance**

DF- Days to first flower, **PH**- Plant height (cm), **NM/P**- Number of monopod/plant, **NS/P**- Number of sympod/plant, **NB/P**- Number of bolls/plant, **BW**- Boll weight (g), **NS/B**- Number of seeds/boll, **SCY/P**- Seed cotton yield/Plant (g)

Table 6: Above average specific cross combination for different characters along with *per se* performance

Characters	Above average cross combination			
	1st	*Per se*	2nd	*Per se*
Days to first flower	ISR12 x H1226 (-6.46**)	60.33 (days)	CSH3075 x H1117 (-4.95**)	68.33 (days)
Plant height	ISR12 x H1098-I (16.13**)	134.67 (cm)	H1465 x H1098-i (12.13)	140.67 (cm)
No. of monopods	ISR12 x H1226 (0.79**)	3.13	H1476 x H1098-i (0.75**)	2.07
No. of sympod/plant	H1463 x H1226 (2.83**)	15.87	H1472 x H1098-i (2.29**)	13.40
No. of bolls/plant	H1463 x H1226 (8.55**)	37.33	Luxmi PKV x H1226 (7.63**)	33.00
Boll weight	H1476 x H1226 (0.29**)	3.18 (g)	AC726 x H1236 (0.28**)	3.25 (g)
No. of seed/boll	H1477 x H1226 (1.74**)	27.83	CSH3075 x H1117 (1.49*)	30.13
Seed cotton yield per plant	AC726 x H1236 (27.76**)	103.91 (g)	H1476 x H1226 (26.19**)	104.12 (g)

SCA value in parenthesis

**Significant at 1% level of significance

*Significant at 5% level of significance

Table 7: Performance in terms of *per se,* GCA, SCA and heterosis for the ten better performing crosses based on seed cotton yield

Crosses	*Per se* performance of crosses	GCA of parents		SCA of crosses	Heterosis for seed cotton yield
		P_1	P_2		
H1470 x H1236	122.958	G	G	G	G
H1470 x H1098-i	116.859	G	A	G	G
H1476 x H1226	104.122	P	A	G	G
AC726 x H1236	103.910	A	P	G	G
H1464 x H1236	95.497	G	G	A	G
H1470 x H1117	91.758	G	P	A	G
H1465 x H1098-i	86.372	G	A	A	A
H1463 x H1226	86.001	A	A	A	A
H1464 x H1226	85.501	G	A	A	A
H1464 x H1117	84.958	G	P	A	A

CONCLUSION

The results signify the importance of non-additive genetic effects for attaining maximum improvement in quantitative traits. Parents having high GCA values i.e., H1156 for days to first flowering, H1471 for plant height, AC726 for monopods per plant, H1464 for boll weight, H476 for seeds per boll and H1470 for seed cotton yield per plant, bolls per plant and sympods per plant were detected with higher general combining ability and should be given due consideration in developing superior genotypes. The significant SCA affects were recorded for seed cotton yield from the cross combination AC726 x H1236, H1476 x H1226, Luxmi PKV X H1226, H1470 X H 1098-I and H1470 X H1236. These cross combinations involved at least one parent with high or average GCA effect for a particular trait. The cross combination involving H1470 and H1236 parents recorded significant positive SCA effect for yield contributing characters. Thus, the parents H1470 and H1236 can be used for hybrid development programme.

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