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Heterosis Studies For Economic and Fibre Quality Traits in Line X Tester Crosses of Upland Cotton (*Gossypium hirsutum* L.)

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ABSTRACT

The present study was performed to evaluate the heterosis effects for economic and fibre quality traits of 60 hybrids were obtained from a line x tester analysis of crosses involving fifteen female parents and four male parents along with a check hybrid HHH 223. The heterosis was observed for number of seeds per boll, seed index, lint index, ginning outturn, 2.5 per cent span length, fibre strength, micronaire value, fibre uniformity and seed cotton yield per plant. The results showed that range of economic heterosis varied from -18.18 to 20.45% of number of seeds per boll, 1.58 to 32.91% of seed index, 11.15 to 31.85% of lint index, -11.06 to 3.37% of ginning outturn, -6.32 to 8.80% of 2.5 per cent span length, -2.73 to 18.27 of fibre strength, 17.69 to 21.23 of micronaire value, -2.08 to 1.66 of fibre uniformity and -60.38 to 48.32 of seed cotton yield per plant. The overall study of heterosis revealed that the better performing hybrids, H1316 X H1236 for number of seeds per boll and seed cotton yield, LH2232 x H1236 for seed index, H1300 x H1236 for lint index and ginning outturn, H1300 x H1098-i for 2.5 per cent span length and fibre strength, H1220 x H1226 for micronaire value and H1353 x H1117 for fibre uniformity. So these crosses could be exploited to improve the yield along with one or more fibre quality traits through heterosis breeding.

Key words: *Cotton, Economic heterosis, Line x tester analysis, yield and fibre quality traits.*

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is an important fibre crop and plays a vital role as a cash crop in commerce of many countries such as India, China, USA, Pakistan, Uzbekistan, Australia and Africa. Cotton crop is mainly cultivated for fibre. Development of new variety with high yield and fibre quality is the primary objective of all cotton breeders. The first step in successful breeding program is to select appropriate parents. Cotton plays a key role in the national economy in terms of generation of direct and indirect employment of about 60 million people in the agricultural and industrial sectors of cotton production and processing, textile and related exports which accounts for nearly 33 percent (76,000) of total foreign exchange earnings of our country.

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Cotton though mainly grown for fibre is also ranked as major oilseed crop in the international market. Cotton improvement programmes primarily lay emphasis on development of hybrids, which have contributed in improving productivity of cotton[6].

Cotton fibre is the most important raw material for the textile industry. Both yield and quality of fibre are equally important in cotton. Fibre quality parameters should be given due importance in any cotton improvement programme. High yielding parents may not necessarily transmit their superiority to their progenies in crosses. In any systematic breeding programme, it is a prerequisite to identify the elite parents for hybridization and superior crosses. The Line × Tester mating design is very useful and simple procedure for evaluation of parents for gca and sca variances and effects through hybridization programme.

The phenomenon of heterosis of F_1 hybrids can also reflect SCA and GCA of parental lines. Heterotic studies can also provide the basis for exploitation of valuable hybrid combinations and their commercial utilization in future breeding programs[11].

Heterosis or hybrid vigour is the increment in performance of a hybrid (F_1 generation) in relation to the parental average and can assume positive or negative values[1]. Regarding previous studies on heterosis in cotton, researchers reported different heterosis values for yield components and fiber quality parameters. The amount of exploitable heterosis for seed cotton yield ranged from 15.50%[2] to 35%[26]. The amount of heterosis for fiber properties was usually lower (5- 10%) than that for yield and its components[13,14].

Heterosis is the superiority of the hybrid over the mid-parent or better parent values. It is the allelic or non-allelic interaction of genes under the influence of particular environment. Heterosis has been observed in many crop species and has been the objective of considerable importance as mean of increasing productivity of crop plants. It is now well established fact that heterosis does occur with proper combination of parents. Therefore, present study was carried out to measure heterosis over standard check (HHH 223) for economic and fibre quality traits to obtain information on heterotic potential as to develop hybrids in cotton.

MATERIALS AND METHODS

The present investigation was carried out at Cotton Research Area, Department of Genetics and Plant Breeding, Chaudhary Charan Singh Haryana Agricultural University, Hisar. The Hisar is situated at the latitude 29^o 10$'$ N and longitude 75^{o}46$'$ E and falls in the semi-tropical region of the western zone of India and at an altitude of 215.2 meters above mean sea level. The experimental material was grown during the years 2014-15 and 2015-16, during first year the selected diverse material comprising of 19 parents (15 lines + 4 testers) were presented in Table 1. were grown in the field (crossing block) during *Kharif* 2014. A total of 60 crosses were attempted in a line x tester design by hand emasculation and pollination. Opened crossed bolls of all the F_1 hybrids and selfed seeds of parental lines were picked up and sun dried before ginning. The ginned seed materials were used during 2015-16. During *Kharif* 2015-16, F_1 hybrids (60) and their parents along with the check hybrid HHH223 were grown. Each entry i.e. parents and hybrids were sown in a single row of 7.2 meter length adopting a spacing of 100 cm between rows and 45 cm between the plants in a row in randomized block design with three replication. All the recommended practices were adopted for all the entries from sowing till harvesting. For recording observations, 5 competitive plants were randomly selected and tagged from each treatment in each replication and the average value per plant was computed for economic and fibre quality traits *viz.*, number of seeds per boll, seed index (g), lint index (g), ginning outturn (%), 2.5 per cent span length (mm), fibre strength (g/tex), micronaire value (µg/inch), fibre uniformity (%) and seed cotton yield per plant (g). The mean data of 5 plants over three replications were used for statistical analysis. The data were analyzed to find out the extent of heterosis was carried out according to the model given by Kempthorne[10]. Using the OPSTAT statistical software.

Table 1: Parents used in hybridization programme

S. NO.	LINES	S. NO.		S. NO.	TESTERS
1	H 1300	9	RS 921	1	H 1226
2	H 1316	10	B 59- 1679	2	H 1098-i
3	H1353	11	A 537	3	H 1117
4	H 1442	12	RS 875	4	H 1236
5	H 1442-1	13	Su Flum		
6	R S 810	14	LH 2232		
7	H1220	15	LH2306		
8	H 1455				

RESULTS AND DISCUSSION

The analysis of variance was carried out for all the characters of all the parents and hybrids *viz.,* 15 lines, 4 testers, 60 hybrids (line x tester) and one commercial check hybrid (HHH 223). It is evident from the analysis of variance that mean sum of squares due to parents and hybrids were significant for all characters (Table 2). The extent of heterosis was studied for all the traits against the standard check hybrid HHH 223. The values for the economic heterosis for individual crosses recorded for different characters (Table 3). Heterosis is the superiority of F_1 over the mean of the parents or over the better parent or over the standard check[7] (Hays *et al*., 1956) with respect to agriculturally useful traits. Heterosis may be positive or negative, depending on the magnitude of the hybrid means. For exploitation of hybrid vigour, high degree of heterosis for seed cotton yield, economic and fibre quality is a prerequisite. The negative heterosis is important for characters like micronaire value. In the present study, superiority of the hybrids were observed over standard check HHH 223, a popular hybrid of North India for all the characters viz., number of seeds per boll, seed index (g), lint index (g), ginning outturn (%), 2.5 per cent span length (mm), fibre strength (g/tex), micronaire value (μg/inch) and fibre uniformity (%) and seed cotton yield per plant. The brief description of heterotic response is given here under:

Number of seeds per boll:

The economic heterosis over check for this character ranged from -18.18 % to 20.45%. The cross H1442 x H1117 (20.45%) exhibited highest positive economic heterosis followed by cross H1316 x H1236 (19.31%), H1442 x H1226 (15.90%) and H1442 x H1236 (14.77%) showed better and positive heterotic effects over check variety HHH223 (Table 3). The crosses showing high heterosis for number of seeds per boll were H1442 x H1117, H1316 x H1236, H1442 x H1226 and H1442 x H1236. Heterosis for this trait was reported by the earlier workers Reddy[21], Pathak and Patel[19] and Neelima[15].

Seed index (g):

The range of superiority over check for this trait was 1.58 % to 32.91 %. The cross LH2232 x H1236 (32.91%) exhibited highest positive economic heterosis followed by cross H1442-1 x H1098-i (31.39%), H1316 x H1098-i (30.19%) and H1353 x H1098-i (29.11%) showed better and positive heterotic effects over check variety HHH223 (Table 3). For the seed index, positive heterosis is desirable and maximum heterosis were shown by crosses LH2232 x H1236, H1442-1 x H1098-i, H1316 x H1098-i and H1353 x H1098-i. Heterosis for this trait was reported by the earlier workers Pole *et al*[20]., Hussain *et al*[8]., Balu *et al*[4]., Nirania *et al*[16]., and Tuteja et *al*[27].

Lint index (g):

Heterosis for lint index ranged from -11.15 % to 31.85 %. The cross H1300 x H1236 (31.85%) exhibited highest positive economic heterosis followed by cross H1445 x H1117 (31.39%), B59-1679 x H1226 (27.43%) and LH2232 x H1236 (27.13%) showed positive heterotic effects over check (Table 3). Maximum heterosis for lint index was shown by crosses H1300 x H1236, H1445 x H1117, B59-1679 x H1226, and LH2232 x H1236. Similar result were reported by Sheng *et al*[24]., Basal *et al*[3]., and Balu *et al*[4].

Ginning outturn (%):

The range of heterotic effects for this trait was minimum i.e. -11.063 % to 3.37%. The cross H1300 x H1236 (3.37%) showed highest heterotic effect over check for ginning out turn and was followed by B59-1679 x H1226 (3.02%), RS875 x H1117 (2.24%) and H1445 x H1117 (1.90%) (Table 3). For the ginning outturn, positive heterosis is desirable and maximum heterosis was shown by crosses H1300 x H1236, B59-1679 x H1226, RS875 x H1117, H1445 x H1117. Heterosis for this trait was also reported by the earlier workers Balu *et al*[4]., Nirania *et al*[16]., and Tuteja *et al*[27].

2.5 per cent span length (mm):

Economic heterosis for this character varied from -6.32 % to 8.80 %. Total twelve cross combinations were recorded more than five *percent* positive heterosis of this character. The important crosses which showed high heterotic effect were H1300 x H1098-i (8.80%) followed by LH2232 x H1098-i (8.11%), LH2306 x H1226 (7.65%), A537 x H1098-i (7.65%) and H1442 x H1226 (7.15%) (Table 3). In recent years, more emphasis is laid on quality traits apart from seed cotton yield. The cross H1300 x H1098-i, LH2232 x H1098-i, LH2306 x H1226, A537 x H1098-i and H1442 x H1226 showed maximum desired positive heterosis over standard check for 2.5 percent span length. Out of sixty crosses, twelve crosses showed desirable positive heterosis for 2.5 percent span length. Similar results were obtained by Khan *et al*[12]., Patel *et al*[18]., and Shinde *et al*[25].

Fibre strength (g/tex):

The cross A537 x H1098-i (18.27 %) showed maximum heterosis over check, while range of heterosis for fibre strength was recorded from -2.73 % to 18.27 %. The important crosses showed high heterosis for fibre strength were H1442 x H1236 (15.39 %), H1315 x H1226 (14.53 %) and H1300 x H1098-i (13.81) (Table 3). Maximum heterosis for fibre strength were shown by crosses H1442 x H1236, H1315 x H1226 and H1300 x H1098-i over standard check for fibre strength. Similar results were found Tuteja *et al*[27].

Micronaire value (μg/inch):

Economic heterosis for micronaire value over standard check was ranged from -17.69% to 21.23%. The cross H1220 x H1226 (-17.69%) showed the highest negative heterosis over standard check followed by RS810 x H1117 (-15.92%), H1300 x H1117 (-14.15), B59-1679 x H1098-i (-14.15), H1300 x H1236 (-13.27) and H1442 x H1098-i (-13.27) (Table 3). Twenty crosses showed positive heterosis for micronaire value. Maximum heterosis for this character was recorded in crosses namely, LH2232 x H1236, Su flum x H1117, LH2306 x H1236, H1220 x H1117, RS921 x H1226, A537 x H1098-i, LH2232 x H1226 and A537 x H1098-i. Similar results on heterosis were reported by Neelima[15] and Khan *et al*[12].

Uniformity ratio (%):

The cross H1353 x H117 (1.66 %) showed maximum heterosis over check, while range of heterosis for fibre uniformity was recorded from -2.08% to 1.66%. The highest heterosis was observed in the cross namely, H1316 x H1226 (1.25%), H1316 x H1098-i (1.25%), H1300 x H1226 (1.25%), H1316 x H1117 (0.83 %), H1316 x H1236 (0.83 %), H1442 x H1226 (0.83 %) and H1442 x H1117 (0.83 %) (Table 3). For the fibre uniformity, positive heterosis is desirable. Out of sixty crosses, seventeen crosses showed desirable positive heterosis for fibre uniformity. Maximum heterosis for this character was recorded by the crosses H1316 x H1226, H1316 x H1098-i, H1300 x H1226, H1316 x H1117, H1316 x H1236, H1442 x H1226 and H1442 x H1117. Heterosis for this trait was reported by the earlier workers Baloch *et al*[5]., and Basal *et al*[3].

Seed cotton yield per plant (g):

Among all the traits studied, the range of heterosis for this most important trait i.e. seed cotton yield per plant was -60.38 % (LH2306 x H1117) to 48.32 % (H1316 x H1236). Ten cross combinations showed significant positive heterosis i.e. more than twenty five *per cent* for seed cotton yield per plant was obtained in the crosses H1316 x H1236 (48.32 %) followed by H1442 x H1226 (46.37 %), H1442 x H1098-i (45.98%), H1316 x H1098-i (45.58%), RS875 x H1098-i (33.09%), H1220 x H1236 (30.75%) and H1442 x H1117 (29.19%) (Table 3). For seed cotton yield, which is most important aspect of breeding, ten hybrids exhibited heterotic value of more than 25 per cent. Among these four hybrids, H1316 x H1236, H1442 x H1226, H1442 x H1098-i and H1316 x H1098-i exhibited heterosis of more than 45 percent and these hybrids needs special attention to exploit heterosis for seed cotton yield. Heterosis for seed cotton yield in American cotton has also been reported earlier Nirania *et al*[17]., Jaiwar *et al*[9]., Sawarkar *et al*[22]., and Sharma *et al*[23].

Table 2: Mean squares from the analysis of variance of parents and hybrids

Source of variation	d.f	Number of seeds / boll	Seed index (g)	Lint index (g)	Ginning outturn (%)	2.5% Span length (mm)	Fibre strength (g tex-1)	Micronaire value (µg inch⁻¹)	Fibre uniformity (%)	Seed cotton yield/plant (g)
Replication	2	226.48	11.99	4.99	8.60	9.47	3.97	0.03	20.10	658.18
Treatment	78	11.65*	11.45*	3.77*	8.08*	2.29*	2.38*	0.64*	1.32*	1199.81*
Error	156	6.13	10.65	3.16	13.17	3.85	0.99	0.03	1.81	37.74

Table 3: Estimation of economic heterosis for different characters

Crosses	Number of seeds/ boll	seed index (g)	Lint index (g)	Ginning outturn (%)	2.5% Span length (mm)	Fibre strength (g tex-1)	Micronaire value (µg inch⁻¹)	Fibre uniformity (%)	Seed cotton yield/ plant (g)
H1300 X H1226	-4.54	12.65	-4.02	-9.68	5.22	9.06	-7.96	1.25	-36.18
H1300 X H1098-i	1.13	11.07	-6.33	-10.19	8.80	13.81	-12.38	0.00	15.14
H1300 X H1117	7.95	13.29	16.38	1.64	-2.20	10.07	-14.15	0.41	28.80
H1300 X H1236	10.22	23.79	31.85	3.37	0.96	4.17	-13.27	0.00	6.94
H1316 X H1226	-1.13	15.25	6.13	-5.70	6.87	14.53	-2.65	1.25	-0.66
H1316 X H1098-i	13.63	30.19	8.04	-10.63	4.40	7.91	-6.19	1.25	45.58
H1316 X H1117	-18.18	11.58	-6.13	-10.28	4.67	13.38	-9.73	0.83	-51.87
H1316 X H1236	19.31	12.34	6.53	-3.37	4.12	7.05	-12.38	0.83	48.32
H1353 X H1226	-13.63	19.62	4.72	-8.98	2.20	5.18	-1.77	-1.25	-45.55
H1353 X H1098-i	2.27	29.11	26.73	-1.03	4.12	1.43	-11.50	0.00	-7.76
H1353 X H1117	7.95	21.39	7.43	-8.38	2.20	10.50	-4.42	1.66	1.09
H1353 X H1236	7.95	6.96	2.91	-3.37	0.41	4.31	-10.61	0.00	8.62
H1442 X H1226	15.90	26.20	20.40	-2.42	7.15	13.09	-0.88	0.83	46.37
H1442 X H1098-i	13.63	15.82	11.05	-2.24	7.01	12.37	-13.27	0.41	45.98
H1442 X H1117	20.45	20.12	16.28	-1.72	0.00	5.18	-2.65	0.83	29.19
H1442 X H1236	12.50	27.59	17.28	-5.96	6.87	15.39	8.85	-0.41	-0.46
H1442-1	2.27	16.20	1.50	-7.77	7.15	10.93	-0.88	0.41	-4.76

X H1226									
H1442-1 X H1098-i	6.81	31.39	10.25	-10.37	-1.37	12.95	12.38	0.00	9.68
H1442-1 X H1117	2.27	17.34	2.71	-9.16	-1.37	5.61	3.54	-0.83	-19.59
H1442-1 X H1236	14.77	28.60	22.71	-3.02	5.91	13.09	-7.96	0.00	26.85
RS810 X H1226	2.27	6.83	-7.13	-8.03	2.75	7.05	-2.65	-1.25	18.26
RS810 X H1098-i	2.27	5.69	-8.64	-8.64	3.43	9.35	-12.38	-1.66	10.85
RS810 X H1117	1.13	15.82	15.67	-0.69	-2.06	5.18	-15.92	-1.25	-0.46
RS810 X H1236	5.68	14.87	11.65	-1.46	1.51	8.05	11.50	-0.83	-2.81
H1220 X H1226	4.54	21.01	2.21	-10.19	4.81	12.08	-17.69	-0.41	5.38
H1220 X H1098-i	-1.13	8.22	4.82	-1.90	-2.47	7.62	-10.61	-1.25	-7.10
H1220 X H1117	4.54	10.57	-3.01	-8.90	-1.65	11.36	15.92	0.00	2.65
H1220 X H1236	12.50	15.44	10.85	-2.76	0.68	4.31	-7.08	-0.41	30.75
H1445 X H1226	-4.54	17.35	22.36	0.00	2.33	7.05	-5.31	-0.41	-31.88
H1445 X H1098-i	2.27	21.01	13.26	-5.61	3.30	8.48	-9.73	-2.08	-29.50
H1445 X H1117	3.40	25.50	29.24	1.90	-1.51	4.17	-0.88	-0.41	-23.88
H1445 X H1236	9.09	18.35	6.23	-6.82	0.13	4.17	-4.42	-0.41	-16.08
RS921 X H1226	9.09	17.91	20.00	1.12	-4.95	4.60	15.04	-1.25	11.63
RS921 X H1098-i	-3.40	5.12	-10.15	-9.76	-3.71	9.64	7.08	-0.41	-34.58
RS921 X H1117	6.81	3.98	-3.61	-4.84	4.26	10.79	13.27	-1.25	-10.22
RS921 X H1236	3.40	23.98	20.80	-1.81	0.68	3.45	-5.31	0.41	-2.42
B59-1679 X H1226	9.09	21.83	27.43	3.02	-0.96	3.59	-1.77	0.00	-0.46
B59-1679 X H1098-i	9.09	7.97	5.93	-0.95	1.78	6.04	-14.15	0.00	-11.39
B59-1679 X H1117	10.22	6.64	-0.50	-4.32	-3.43	1.29	-12.38	-1.25	16.90
B59-1679 X H1236	12.50	12.65	12.56	-0.25	4.53	5.32	0.00	-0.83	25.48
A537 X H1226	10.22	8.22	-3.31	-6.65	2.88	10.50	14.15	-1.25	-30.91
A537 X H1098-i	5.68	18.79	13.56	-2.76	7.56	18.27	15.04	0.41	-18.61
A537 X H1117	-1.13	20.57	10.75	-4.92	2.47	8.92	7.08	0.00	-23.88
A537 X H1236	-3.40	7.59	1.40	-3.28	1.65	8.05	-1.77	0.00	-40.98
RS875 X H1226	1.13	16.26	10.05	-3.19	-6.32	-2.73	6.19	0.00	-23.65
RS875 X H1098-i	15.90	20.12	-0.30	-11.06	2.61	11.65	13.27	-1.25	33.09
RS875 X H1117	-2.27	18.35	23.31	2.24	3.43	6.04	-1.77	0.00	-6.32

RS875 X H1236	0.00	6.32	-0.80	-4.06	0.27	3.88	-0.88	-1.25	-46.91
Su Flum X H1226	12.50	10.63	-0.50	-7.08	-1.65	4.74	-4.42	0.00	9.68
Su Flum X H1098-i	7.95	17.15	20.80	1.38	3.57	10.79	-7.96	0.41	-19.98
Su Flum X H1117	2.27	13.10	9.04	-2.16	0.27	9.20	15.92	0.00	-2.61
Su Flum X H1236	3.40	17.72	11.96	-3.19	5.77	8.77	11.50	0.00	-22.91
LH2232 X H1226	4.54	22.78	20.80	-0.95	2.75	11.94	15.04	0.83	19.82
LH2232 X H1098-i	3.40	12.34	10.55	-0.95	8.11	9.49	-1.77	0.83	-26.62
LH2232 X H1117	-2.27	17.08	16.18	-0.34	0.82	9.06	7.08	-0.41	-9.83
LH2232 X H1236	0.00	32.91	27.13	-2.42	0.55	8.48	21.23	-0.83	-13.34
LH2306 X H1226	1.13	16.13	1.60	-8.03	7.56	8.48	7.08	0.83	-35.51
LH2306 X H1098-i	0.00	12.27	3.92	-4.58	3.16	8.48	6.19	-0.41	2.84
LH2306 X H1117	-2.27	1.58	-11.15	-8.21	-3.85	6.61	-4.42	-0.41	-60.38
LH2306 X H1236	4.54	15.19	-0.40	-9.50	2.47	11.51	15.92	0.00	-42.23
Minimum	-18.18	1.58	-11.15	-11.06	-6.32	-2.73	-17.69	-2.08	-60.38
Maximum	20.45	32.91	31.85	3.37	8.80	18.27	21.23	1.66	48.32

CONCLUSION

The present study revealed that the magnitude of heterosis from F_2 to subsequent generations shows inbreeding depression. Based on the economic heterosis, the better performing hybrids were H1316 X H1236 for number of seeds per boll and seed cotton yield, LH2232 x H1236 for seed index, H1300 x H1236 for lint index and ginning outturn, H1300 x H1098-i for 2.5 per cent span length and fibre strength, H1220 x H1226 for micronaire value and H1353 x H1117 for fibre uniformity So these crosses could be exploited to improve the yield along with one or more fibre quality traits can be utilized in future breeding endeavors.

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