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Genetic improvement through standard heterosis for seed cotton yield in upland cotton (*Gossypium hirsutum* L.)

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Abstract : A study was conducted in *Gossypium hirsutum* cotton with line x taster (15 x 4) to estimate the magnitude of heterosis among different cross combinations for yield and its component traits. For this purpose, 60 specific cross combinations were developed by using 19 diverse parents during *kharif*, 2014. These hybrids along with 19 parents and standard check HHH 223 were planted during *kharif*, 2015 at CCS Haryana Agricultural University, Hisar. The analysis of variance indicated the presence of variability among hybrids and their parents. Heterosis studies revealed that the maximum of 45.05 per cent for seed cotton yield was observed in cross combination H1470 x H1236 followed by H1470 x H1098-i (37.84%). Heterosis was obtained for bolls/plant in H1470 x H1098-i (31.55%), for boll weight in H1464 x H1236 (15.11%), for plant height in H 1471 x H1236 (12.77%), for monopodia in ISR12 x H1226 (56.67%), for sympodia in H1463 x H1226 (30.41%), for days to first flower in ISR12 x H1226 (-13.81%) and for seed/boll in H1476 x H1226 (8.27%). The cross combination involving H1470 and H1236 parents recorded significant positive heterosis for most of the characters. Thus, the parents H1470 and H1236 can be used for exploitation of heterosis. The study also revealed good scope for commercial exploitation of heterosis as well as isolation of pure lines among the progenies of other heterotic F_1 hybrids.

Key words : *Gossypium hirsutum*, heterosis, quantitative traits, seed cotton yield

Cotton is one of the most important cash crops of India. Because of its agricultural as well as industrial importance, it is also called as 'White Gold'. In India, cotton is grown on about 11.88 million ha, which represents 27 per cent of the world cotton area. The average cotton production in India is about 35.20 million ha with productivity 503 kg/ha. Millions of people depend on cotton cultivation trade, transportation, ginning and processing for their livelihood. Therefore, there is a need to improve the productivity of cotton crop by developing a high yielding adaptable cotton variety or hybrid. Cotton is highly amenable for heterosis breeding and commercial exploitation of heterosis has achieved a spectacular success in India. Therefore, the present study was undertaken to find out the extent of useful heterosis over the check hybrid HHH 223 for seed cotton yield and its component 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*, 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 *kharif*, 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.

Field layout : The 60 hybrids, 19 parents with single check HHH223 were planted in the field during *kharif,* 2015 at Cotton Research Area, CCS Haryana Agricultural University, Hisar. 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/row.

Data analysis : Data were recorded on five randomly selected plants/replication for all the eight quantitative characters *viz.,* Days to first flower, plant height (cm), monopodia, sympodia and bolls/plant, boll weight (g), seeds/boll, seed cotton yield/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. The line x tester analysis of heterosis was also performed. Heterosis was also calculated in terms of per cent increase (+) or decrease (-) of the F_1 hybrids against its standard check value.

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. Mean expression of the seed cotton yield characters was recorded on the 19 genotypes and their 60 crosses with standard check HHH223. Mean performance of parents, seed cotton yield/plant had a minimum expression of 44.14 kg (H1470) to 82.63 kg (H1472) (Table 2). Previous studies reported that seed cotton yield/plant could vary widely with plant variety and growing conditions. The hybrids Luxmi PKV x H 1098-i and H1470 x H1236 was registered minimum (36.66) and maximum (122.96) seed cotton yield/plant. The mean seed cotton yield/plant of hybrids was 70.04 (Table 3). Sonawane *et al.,* (2015) reported similar results for seed cotton yield/plant.

Table 1. Analysis of variance showing mean square for yield contributing traits in upland cotton

Source of variation	D.F	Days to first flower	Plant height (cm)	Monopods/ plant	Sympods/ plant	Bolls/ plant	Boll weight (g)	Seeds/ boll	Seed cotton yield/ plant (g)
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
C.D.	2.51	11.86	0.32	0.89	4.96	0.15	1.32	11.44	2.51
C.V.	2.18	6.17	10.77	4.58	11.90	3.15	2.83	10.33	2.18

*Significant at 5% level of significance

Bolls/plant and boll weight is very important characteristic of the yield traits of cotton and are extremely useful for increasing the seed cotton yield. In parents, bolls/plant were ranged from 17.33 (H1470) to 29.73(H1236) (Table 2). Maximum and minimum values recorded in hybrids were 17.33 in Luxmi PKV x H 1098-i and 41.00 in H1470 x H1098-i. The average bolls/plant of parents and hybrids was 24.37 and 26.19, respectively (Table 3). Sonawane *et al.,* (2015) observed mean bolls/plant was varied from 9.40 to 15.80, and this is lesser than the value of present results.

The line H1472 recorded the greatest boll weight and seeds/boll of 3.36 g and 31.27, respectively. The lowest boll weight and seeds/boll were of 2.36 g and 27.43 in HR1 (Table 2). Of the 60 hybrids, Deltapine x H1236 recorded the lowest value for boll weight and seeds/boll of 2.13 g and 25.53, respectively. The highest value (3.38 g) was recorded for boll weight by H1464 x H1236 and for seeds/boll (31.00) by H1476 x H1226. The average value of boll weight and seeds/boll in hybrids were 2.86 g and 28.98, correspondingly (Table 3). Sonawane *et al.,* (2015) observed mean boll weight was varied from 1.48 to 2.61 g, and this reported that the present study significantly exploited the hybrids than earlier studies.

The range of monopodia/plant was from 0.67 to 3.47, the genotypes exhibiting the values being Deltapine and H1226 respectively (Table 2). The mean value of monopods/plant for parents was 1.92. Among the hybrids, H1476 x H1117 recorded the lowest value of 0.67 and highest value 3.13 recorded the ISR12 x H1226 (Table 3). The hybrids had mean monopods/plant of 1.79. Sympodia/plant in parents had a range of 9.40 in H1470 to 15.40 in H1472 (Table 2). Among the hybrids, CSH3075x H1236 and H1463 x H1226 were recorded the lowest and highest sympods/plant of 8.47 and 15.87, respectively (Table 3). The mean values of sympods/plant for parents and hybrids were 11.68 and 12.14, correspondingly. Basal *et al.,* (2011) reported similar results for monopods and sympods/plant.

Table 2. Range and mean expression of parents for seed cotton yield and its component traits in upland cotton

S.N.	Character	Minimum value	Maximum value	**Mean**	Parents recording (yield)	
					Lowest	Highest
1	Days to first flower	69.00	76.00	**72.47**	ISR12	H1463
2	Plant height	105.33	130.33	**115.98**	H1156	H1463
3	Monopods/plant	0.67	3.47	**1.92**	Deltapine	H1226
4	Sympods/plant	9.40	15.40	**11.68**	H1470	H1472
5	Bolls/plant	17.33	29.73	**24.37**	H1470	H1236
6	Boll weight/boll	2.36	3.36	**2.80**	HR1	H1472
7	Seed/boll	27.43	31.27	**29.13**	HR1	H1472
8	Seed cotton yield/plant	44.14	82.63	**63.23**	H1470	H1472

In parents, plant height was ranged from 105.33 cm (H1156) to 130.33 cm (H1463) (Table 2). Maximum and minimum values recorded in hybrids were 97.33 cm in H1477 x H1236 and 141.33 cm in H1471 x H1236 (Table 3). The average plant height of parents and hybrids was 115.98 cm and 119.33 cm, respectively. Days to first flower in parents had a range of 69.00 in ISR12 to 76.00 in H1463 (Table 2). The hybrids varied from 60.33 (ISR12 x H1226) to 77.33 (H1471 x H1117) in respect of days to first flower and displayed a mean of 70.90 (Table 3). Sharma *et al.,* (2016) reported similar

Table 3. Range and mean expression of hybrids for seed cotton yield and its component traits in upland cotton

S.N.	Character	Minimum value	Maximum value	**Mean**	Parents recording (yield)	
					Lowest	Highest
1	Days to first flower	60.33	77.33	**70.90**	ISR12 x H1226	H1471 x H1117
2	Plant height	97.33	141.33	**119.83**	H1477 x H1236	H1471 x H1236
3	Monopods/plant	0.67	3.13	**1.79**	H1476 x H1117	ISR12 x H1226
4	Sympods/plant	8.47	15.87	**12.14**	CSH3075 x H1236	H1463 x H1226
5	Bolls/plant	17.33	41.00	**26.19**	Luxmi PKV x H 1098-i	H1470 x H1098-i
6	Boll weight	2.13	3.38	**2.86**	Deltapine x H1236	H1464 x H1236
7	Seed/boll	25.53	31.00	**28.98**	Deltapine x H1236	H1476 x H1226
8	Seed cotton yield/plant	36.66	122.96	**70.04**	Luxmi PKV x H 1098-i	H1470 x H1236

results for seed cotton yield/plant.

Heterosis estimates over best check for different characters of 60 hybrid combinations is presented in Table 4. The results indicated that the phenomenon of heterosis was observed for all the characters, however, its magnitude varied with the characters. It is indicated that among 60 cross combinations, five cross combinations obtained positive and significant heterosis over the check hybrid HHH 223 but the cross combinations H1470 x H1236 (45.04%), H1470 x H1098-i (37.84%) and H1476 x H1226 (22.82%) observed maximum and positive heterosis values for seed cotton yield. Heterosis for seed cotton yield and other related characters in upland cotton has also been reported earlier by Patil *et al.,* (2011), Sawarkar *et al.,* (2015) and Sharma *et al.,* (2016).

For number of bolls/plant, H1470 x H1098-I (31.55%), H1470 x H1236 (27.27%) and DGMS 2 x HD 528 (24.85%) crosses reported highest heterosis value. These hybrids responsible for high heterosis for seed cotton yield with increased number of bolls were mainly responsible for increase in seed cotton yield. Similar results were reported by Sawarkar *et al.,* (2015). Concerning boll weight, ten cross combinations exhibited significant positive heterosis values but the crosses H1464 x H1236 (15.11%), H1464 x H1098-i (14.43%), H1470 x H1236 (14.32%) had maximum and positive heterosis values. Similar finding were reported by Basal *et al.,* (2011) and Sharma *et al.,* (2016). In case of plant height, four cross combinations exhibited positive and significant heterosis values but the maximum being in case of H1471 x H1236 (12.77%), H1465 x H1098-i (12.23%), H1464 x H1236 (11.44%) crosses. fifteen cross combinations exhibited negative and significant heterosis values for plant height. Heterosis for plant height has also been reported by Sharma *et al.,* (2016).

Eight cross combinations observed positive and significant heterosis values for number of monopods. Whereas, twenty cross combinations obtained negative and significant heterotic values for this trait. Maximum heterosis effects were observed for ISR12 x H1226 (56.67%), Luxmi PKV x H1226 (50%), HR1 x H1098 (40%) crosses. For number of sympods, 15 cross combinations exhibited significant positive heterosis values but the crosses H1463 x H 1226 (30.41%) followed by H1470 x H1117 (27.12%), H1476 x H 1226 (25.48%) had maximum and positive heterosis values. Majority of the cross combinations observed negative and significant heterosis effects for sympods/plant. These findings are confirmed by the findings of Kaliyaperumal *et al.,* (2013) and Tuteja (2014).

Table 4. Expression of heterosis in hybrids (%) for seed cotton yield and its component traits in upland cotton

Source of variation	Days to first flower	Plant height (cm)	Monopods/ plant	Sympods/ plant	Bolls/ plant	Boll weight (g)	Seeds/ boll	Seed cotton yield/ plant (g)
H1156 x H1226	-3.81	-4.26	-6.67	3.29	-0.86	-15.68**	-4.54	-15.58**
H1156 x H 1098-i	-13.33**	-5.05	36.67**	12.88*	-15.51*	-5.46	2.45	-18.00**
H1156 x H1117	-4.76	6.12	20.00**	11.78*	-23.74**	-15.11**	-0.35	-33.47**
H1156 x H1236	-6.19*	-4.52	13.33	-1.37	-16.58*	-4.43	3.14	-19.40**
ISR12 x H1226	-13.81**	-9.04	56.67**	-11.23*	-36.58**	-6.02	3.84	-39.21**
ISR12 x H 1098-i	-7.62*	7.45	-3.33	11.23*	-19.04*	-3.86	4.77	-21.24**
ISR12 x H1117	6.67*	-13.03*	3.33	-0.27	-32.62**	-15.34**	-2.91	-42.41**
ISR12 x H1236	-9.05*	-5.05	-10.00	2.47	-13.26	3.64	2.79	-10.63*
HR1 x H1226	-5.24*	-9.31	-3.33	16.16**	-4.28	-12.61*	2.21	-14.96*
HR1 x H 1098-i	-6.19*	-10.64*	40.00**	-0.27	-16.58*	-8.98	0.12	-22.68**
HR1 x H1117	1.43	-13.83*	0.00	9.04	2.78	-14.32*	0.58	-13.62*
HR1 x H1236	-0.48	-11.70*	13.33	12.33*	-5.46	-12.16*	0.58	-17.20**
Luxmi PKV x H1226	5.71*	-9.57	50.00**	7.12	5.88	-9.32	1.28	-4.49
Luxmi PKV x H 1098-i	-6.19*	-17.29**	6.67	-16.71**	-44.39**	-21.82**	0.93	-56.76**
Luxmi PKV x H1117	-0.95	-9.31	21.67**	-18.36**	-36.90**	-17.50**	1.28	-47.46**
Luxmi PKV x H1236	0.95	-8.78	-16.67*	-0.27	-15.51*	-12.16*	-1.28	-26.09**
AC726 x H1226	5.24*	-15.69**	10.00	-1.37	-17.65*	-9.43	-2.21	-26.66**
AC726 x H 1098-i	1.91	-18.62**	20.00**	-11.78*	-26.20**	-9.55	0.58	-32.39**
AC726 x H1117	-0.48	-9.31	10.00	14.52*	-23.42**	-4.66	-1.05	-24.99**
AC726 x H1236	5.24*	-4.52	30.00**	-2.47	9.09	10.91*	6.52*	22.57**
Delta Pine x H1226	3.33	-19.95**	-6.67	-1.10	-19.79*	-21.36**	-3.73	-39.25**
Delta Pine x H 1098-i	2.38	-18.88**	13.33	-23.84**	-30.48**	-12.73*	-1.63	-40.52**
Delta Pine x H1117	2.38	-19.68**	-40.00**	-11.78*	-10.59	-25.11**	-8.73*	-33.19**
Delta Pine x H1236	-3.33	-21.54**	-50.00**	-16.71**	-34.76**	-27.50**	-10.83**	-52.62**
H1472 x H1226	2.38	-0.80	-13.33	-14.25*	-19.57*	-9.55	0.35	-26.56**
H1472 x H 1098-i	2.38	1.60	-3.33	10.14*	-21.93**	7.73	0.23	-15.02**
H1472 x H1117	5.24*	1.33	-23.33**	-12.06*	-13.90	7.27	0.35	-9.36
H1472 x H1236	3.33	3.19	-40.00**	-14.52*	-25.56**	10.46*	6.17*	-16.58**
H1465 x H1226	5.24*	0.00	-10.00	-0.27	-20.64**	6.59	7.22*	-14.14*
H1465 x H 1098-i	-0.95	12.23*	-23.33**	1.37	-9.09	10.34*	2.68	1.88
H1465 x H1117	3.81	-10.64*	6.67	-6.30	-19.79*	-3.18	0.35	-22.58**
H1465 x H1236	5.24*	10.64*	-50.00**	4.11	-12.30	8.07	2.21	-7.59
H1463 x H1226	6.19*	5.32	-13.33	30.41**	19.79*	-16.25**	-3.38	1.45
H1463 x H 1098-i	3.33	-7.18	10.00	12.88*	-8.02	4.66	3.14	-3.36
H1463 x H1117	6.19*	-4.26	-16.67*	-13.70*	-33.69**	-0.46	0.70	-36.05**
H1463 x H1236	1.91	7.45	-33.33**	-12.33*	-25.13**	12.96*	0.82	-15.95**
H1464 x H1226	4.76	11.44*	0.00	-6.03	-11.44	11.59*	1.98	0.86
H1464 x H 1098-i	1.91	0.27	-46.67**	-23.29**	-36.36**	14.43*	4.08	-27.73**
H1464 x H1117	6.67*	5.32	-33.33**	-4.66	-6.74	5.91	1.75	0.21
H1464 x H1236	-0.95	0.27	6.67	4.66	-3.53	15.11**	5.70*	12.65*
H1470 x H1226	4.76	-5.85	-40.00**	16.44**	-0.54	1.25	1.98	0.09
H1470 x H 1098-i	-9.05*	-3.99	-13.33	17.53**	31.55**	4.43	4.08	37.84**
H1470 x H1117	2.38	3.99	-3.33	27.12**	-2.67	10.11*	0.47	8.24
H1470 x H1236	-3.33	5.59	-16.67*	8.22	27.27**	14.32*	4.77	45.04**

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Table 4 contd...

H1471 x H1226	4.29	1.33	-23.33**	7.40	-23.00**	-3.64	0.82	-24.32**
H1471 x H 1098-i	0.48	6.65	-26.67**	19.45**	-14.44	11.02*	6.40*	-7.65
H1471 x H1117	10.48**	5.59	-6.67	1.37	-14.44	8.30	1.51	-4.97
H1471 x H1236	7.62*	12.77*	-13.33	16.71**	-20.86**	-0.80	3.84	-21.77**
H1476 x H1226	9.05*	9.84	-36.67**	25.48**	11.98	8.41	8.27*	22.82**
H1476 x H 1098-i	5.71*	5.32	3.33	9.04	-15.94*	4.21	5.36	-11.60*
H1476 x H1117	0.48	-7.71	-66.67**	0.27	-16.90*	-5.34	0.23	-21.34**
H1476 x H1236	0.48	-7.45	-66.67**	16.44**	-24.39**	0.00	4.54	-25.70**
H1477 x H1226	8.10*	-15.16**	-10.00	-16.71**	-33.69**	-11.59*	-2.79	-40.92**
H1477 x H 1098-i	6.67*	-17.55**	-13.33	-20.55**	-41.18**	-12.84*	-2.68	-48.20**
H1477 x H1117	6.19*	-11.44*	6.67	6.85	-19.79**	-9.66	-5.24*	-28.75**
H1477 x H1236	0.00	-22.34**	-50.00**	-8.77	-33.69**	6.14	6.17*	-28.44**
CSH3075 x H1226	3.81	0.00	-36.67**	-16.99**	-27.27**	-0.80	0.58	-26.77**
CSH3075 x H 1098-i	6.19*	-7.71	-50.00**	-17.81**	-23.74**	-6.02	-0.35	-28.79**
CSH3075 x H1117	-2.38	-3.72	-46.67**	-15.62**	-16.26*	6.82	5.24*	-8.45
CSH3075 x H1236	4.76	-1.60	-50.00**	-30.41**	-25.13**	4.32	0.93	-21.37**
Minimum	-13.81	-22.34	-66.67	-30.41	-44.39	-27.50	-10.83	-56.76
Maximum	10.48	12.77	56.67	30.41	31.55	15.11	8.27	45.04

For seeds/boll, seven cross combinations exhibited significant positive heterosis values but the crosses H1476 x H1226 (8.26%), H1465 x H1226 (7.22%) and AC727 x H1236 (6.52%) had maximum and positive heterosis values. Two cross combinations Deltapine x H1236 (-10.83) and Deltapine x H1117 (-8.73) recorded negative and significant heterosis values for seeds/boll. Similar results reported by Patil *et al.,* (2011) and Tuteja (2014). In case of days to first flower, nine cross combinations exhibited negative and significant heterosis values and the cross combinations ISR12 x H1226 (-13.81%), H1156 x H1098-i (-13.33%) and H1470 x H1098-i (-9.09%) pin pointing the vigour for earliness. Similar result was found by Sonawane *et al.,* (2015).

CONCLUSION

The scope of heterosis breeding is for exploitation of heterosis. The cross combinations H1470 x H1236, H1470 x H1098-i and H1476 x H1226 obtained the standard heterosis values for seed cotton yield and the cross combination involving H 1470 and H1236 parent recorded significant positive heterosis for most of the characters. Thus, these crosses and the parents H1470 and H1236 can be used for development of hybrids. The study also reveals good scope for commercial exploitation of heterosis.

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