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Heterobeltiosis for Yield and Salinity Tolerance in Desi Cotton (*G. herbaceum* L.) Hybrids

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Abstract

The present investigation was carried out to study the performance and heterobeltiosis of desi cotton (G. herbaceum L.) hybrids in saline soils of Gujarat. Analysis of variances revealed significant differences among crosses for all the 22 characters which indicated the presence of substantial amount of genetic variability among the hybrids. Seven hybrids registered significant and positive heterobeltiosis, and high heterobeltiosis in these hybrids was generally associated with their good per se performance. Top three crosses with significant positive heterobeltiosis were G. Cot. 23 x GShv 433/08 (49.12 %), Digvijay x GBhv 293 (41.35 %) and Digvijay x GShv 280/11 (30.09 %). Hybrids exhibiting high heterobeltiosis for seed cotton yield per plant also had high heterobeltiosis for yield contributing characters and physiological parameters.

Keywords- cotton; heterobeltiosis; hybrids; salinity;

I. INTRODUCTION

Cotton plays an important role in Indian economy and it is most important natural fibre for India's textile industry. Sufficient cotton production is required to meet the ever increasing fibre demand of growing World's population. In India, cotton is cultivated on about 115.53 lakh hectare with a production of 375 lakh bales. It occupies second position amongst all cotton producing countries in the world *i.e*. next to China. Average productivity of India is 552 Kg/ha which is much below compared to world average of 754 kg/ha [1]. Cotton contributes 30 % of the GDP of Indian agriculture and 3% of total GDP. Gujarat ranks first in cotton production and productivity in India, and it is contributing nearly 35 % production from 24% area in the country. Gujarat is the second largest cotton growing state with acreage of about 25 lakh hectares; and largest cotton producing state of India with production of nearly 100 lakh bales. The average productivity of cotton in the state (688.51 kg/ha) is higher than the national average [2].

Soil salinity is one of the major environmental constraints in agricultural crop production in our country. Salt affected soils occur to a tune of 6.73 M ha in India of which Gujarat accounts for 2.22 million hectares [3] *i.e*., 32 per cent of the country's total salt affected area and thus needs a holistic approach for generating economically viable agro-management strategies. In South Gujarat alone around 6.3 lakh hectares area is salt affected which covers coastal parts of Bharuch, Surat, Navsari and Valsad districts. Only 45% of cotton growing area in Gujarat is irrigated and while 55% is rainfed. Under the rainfed cotton area, rainfall ranges from 400 to 900 mm coupled with aberrant precipitation patterns over the years leading to large scale fluctuations in cotton production of the country.

Asiatic (*desi*) cottons are still cultivated on limited scale in India because of their good agronomic base, strong resistance to disease and pest, abiotic stress tolerance (salinity and drought) and suitability under rainfed conditions. After the introduction of *Bt* cotton hybrids, area under cultivation of *desi* cotton decreased significantly because of their smaller boll size and low potentiality of yield but, now there is a big demand of short staple cotton for denim and surgical cotton, and hence price of short staple cotton is increased due to shortage of *desi* cotton [4].

As *desi* cotton, especially *G. herbaceum* is grown commercially in Gujarat which is also having maximum salt affected area in the country; it is very much imperative to carry out research for development of salt tolerant hybrids and varieties of *desi* cotton. Studies related to heterosis and heterobeltiosis are regarded useful to select more desirable hybrids/segregates. Several studies have been reported on yield and yield contributing characters but little work has been reported on heterosis for physiological and biochemical traits conferring salinity tolerance *vis-à-vis* yield in cotton. Considering the rapid spread of salinity menace in the country and importance of *desi* cotton as a cash and export value crop especially for Gujarat, the present investigation was undertaken with a view to study the performance and heterobeltiosis of desi cotton hybrids in line x tester design.

II. MATERIALS AND METHODS

The present investigation was part of the study undertaken during Ph.D. programme. A crossing programme was undertaken at the ICAR-CSSRI (Central Soil Salinity Research Institute) Farm, Bharuch during *Kharif* 2014-15, by crossing five females (lines) with nine males (testers) of *G. herbaceum* L. in a line x tester mating system (Table 1). Forty-five hybrids and fourteen parents were evaluated in a randomized block design, replicated thrice at Hansot during *kharif* 2015-16. Soil of Hansot is typical black cotton saline soil (Vertisols) with salinity level upto 7.2 dSm^{-1} coupled with saline groundwater. Each plot was consisting of single row of 4.5 m length. Row to row and plant to plant spacing was 120 cm and 45 cm respectively. One guard row was planted on both sides of the experiments. Recommended agronomical practices and plant protection measures were followed as and when required to raise a good crop of cotton. The data were recorded on twenty two yield related attributes, ionic and physiological characters and subjected to statistical analysis. Heterobeltiosis was calculated based on mean value which is percent increase or decrease of hybrid performance over better parents [5].

$$\text{Heterobeltiosis (\%)} = \frac{\overline{F_1} - \overline{BP}}{\overline{BP}} \times 100$$

Where,

$\overline{F_1}$ = Mean performance of F_1 hybrid

$\overline{BP}$ = Mean performance of better parent

III. RESULTS AND DISCUSSION

Through Line × tester analysis [6], large number of parents and crosses could be evaluated and analysis is also free from any assumptions. This analysis also provided very reliable information about the genetic architecture of inheritance pattern from its combining ability estimates. Screening of test genotypes in native saline environment is best way to find out salt tolerant accessions. Performance of cotton hybrids and estimates of heterobeltiosis have been discussed below.

3.1. Analysis of variance and mean performance of crosses

Analysis of variances revealed significant differences among crosses for all the 22 characters studied in the present investigation which indicated the presence of substantial amount of genetic variability crosses. Significant variation was noticed in parents *vs.* hybrids comparison for almost all the characters except for ginning percentage, fibre strength and proline content in leaf tissue. This suggested that parents significantly differed from the hybrids which indicated the presence of heterosis for the characters under investigation.

The mean performance of parental lines for seed cotton yield per plant varied between 38.23 g (GShv 464/08) to 108.08 g (GBhv 287). Among females, GBhv 287 (108.08 g) had highest yield whereas male parent GShv 280/11 (57.67) performed superior among nine testers for seed cotton yield per plant. The magnitude of variation among hybrids for seed cotton yield per plant (Table 2)

ranged between 69.83 g (G. Cot. 23 x GShv 464/08) to 129.67 g (Digvijay x GBhv 293). Hybrid Digvijay x GBhv 293 was highest yielder followed by GBhv 287 x GShv 233/09 (126.80 g) and G. Cot. 23 x GShv 433/08 (125.47 g).

3.2. Estimates of Heterobeltiosis

Amount of heterosis in F_1 is indication of genetic diversity among the parents involved in crosses [7]. Commercial exploitation of heterosis in crop plants was a major breakthrough in the field of plant breeding. Heterosis breeding has led to considerable yield improvements in a variety of cross as well as self pollinated crops. Heterosis studies guide the breeder in identifying crosses that are likely to throw transgressive segregants [8]. The scope of exploitation of hybrid vigour depends on directions and magnitude of heterosis and type of gene action involved. The measures of heterosis over better parent (heterobeltiosis) and over standard check (standard heterosis) are better rational parameters for assessing its practical utility.

In the present investigation, heterosis over better parent (heterobeltiosis) was studied. Negative heterosis has been considered as desirable for days to 50% flowering, days to 50 % bursting, plant height, number of monopodia per plant, fibre fineness and chloride ion content in leaf, while for other characters significant positive heterosis was considered as desirable. The degree of heterobeltiosis varied from cross to cross for all the characters. None of the hybrid had high heterobeltiosis for all the traits. Sizeable amount of heterobeltiosis in certain crosses and low in other crosses revealed that nature of gene action varied with the genetic architecture of parents.

For seed cotton yield per plant , seven hybrids registered significant positive heterosis over better parent, which varied from -28.97 per cent (GBhv 287 x GShv 464/08) to 49.12 per cent (G. Cot. 23 x GShv 433/08). Similarly, six hybrids registered significant negative heterobeltiosis for seed cotton yield per plant (Table 2). Top three crosses with significant positive heterosis over better parents were G. Cot. 23 x GShv 433/08 (49.12 %), Digvijay x GBhv 293 (41.35 %) and Digvijay x GShv 280/11 (30.09 %). Interestingly, among top three per se performing hybrids, two were superior for heterobeltiosis which revealed that heterobeltiosis was generally associated with good per se performance of the hybrids in desi cotton. In general, the crosses exhibiting high heterobeltiosis for seed cotton yield per plant also had high heterobeltiosis for yield contributing characters and physiological parameters.

The high heterobeltiosis in these crosses is mainly attributed to lower yielding ability of the better parent. Many crosses registered significant heterobeltiosis in desired direction for various component traits *viz.,* days to 50% flowering (6), days to 50 % bursting (6), plant height (22), number of monopodia per plant (16), number of sympodia per plant (21), average boll weight (6), lint yield per plant (5), biomass per plant (10), ginning percentage (5), 2.5 % span length (6), fibre strength (15), fibre fineness (45), K^+/ Na^+ ratio (7), chloride content (27), chlorophyll content (22), proline content (8) and total sugar content (7). Many of the crosses showed low expression of heterosis over better parent for yield and its component characters, which are attributed to disharmony between the gene combinations of the parents involved [9]. Low to high range of heterobeltiosis for seed cotton yield per plant and related attributes in *desi* cotton have been reported by several workers [10], [11].

IV. CONCLUSION

The identification of cross combinations having high mean performance as well as high heterosis/heterobeltiosis is of immense value in breeding programme. In the present investigation, the top ranking hybrids had high *per se* performance and desirable heterobeltiosis for seed cotton yield per plant and some of its component traits. These hybrids have potential for their commercial exploitation under salinity conditions after multi-location /multi-season trial provided seed production is not an issue.

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Table 1: List of parental lines used for experiment.

Sr. No.	Name	Origin
Female Parents		
1.	GBhv 287	RCRS, NAU, Bharuch
2.	GBhv 297	RCRS, NAU, Bharuch
3.	GBhv 305	RCRS, NAU, Bharuch
4.	Digvijay	GAU, Gujarat
5.	G. Cot. 23	GAU, Gujarat
Male Parents		
1.	GBhv 280	RCRS, NAU, Bharuch
2.	GBhv 293	RCRS, NAU, Bharuch
3.	GBhv 291	RCRS, NAU, Bharuch
4.	GBhv 306	RCRS, NAU, Bharuch
5.	GShv 233/09	MCRS, NAU, Surat
6.	GShv 433/08	MCRS, NAU, Surat
7.	GShv 464/08	MCRS, NAU, Surat
8.	GShv 538/08	MCRS, NAU, Surat
9.	GShv 280/11	MCRS, NAU, Surat

*RCRS= Regional Cotton Research Station, Navsari Agricultural University, Bharuch, Gujarat
MCRS = Main Cotton Research Station, Navsari Agricultural University, Surat, Gujarat
GAU= Gujarat Agricultural University, Gujarat (Before 2004).

Table 2. Seed cotton yield per plant-YLD (g) and estimates of % heterosis over better parent (BP) of forty five desi cotton hybrids at Hansot

S. No.	Hybrid	YLD	BP	S. No.	Hybrid	YLD	BP
1	GBhv 287 x GBhv 280	88.49	-18.13 *	24.	GBhv 305 x GShv 433/08	118.40	26.18 **
2	GBhv 287 x GBhv 293	96.08	-11.1	25.	GBhv 305 x GShv 464/08	77.94	-16.94
3	GBhv 287 x GBhv 291	100.25	-7.24	26.	GBhv 305 x GShv 538/08	87.33	-6.93
4	GBhv 287 x GBhv 306	78.22	-27.63 **	27.	GBhv 305 x GShv 280/11	112.45	19.84 *
5	**GBhv 287 x GShv 233/09**	**126.80**	17.32 *	28.	Digvijay x GBhv 280	84.33	-8.07
6	GBhv 287 x GShv 433/08	81.53	-24.56 **	29.	**Digvijay x GBhv 293**	**129.67**	**41.35 ** **
7	GBhv 287 x GShv 464/08	76.77	**-28.97 ** **	30.	Digvijay x GBhv 291	103.22	12.52
8	GBhv 287 x GShv 538/08	86.00	-20.43 *	31.	Digvijay x GBhv 306	89.34	-2.61
9	GBhv 287 x GShv 280/11	113.33	4.86	32.	Digvijay x GShv 233/09	98.40	7.27
1	GBhv 297 x GBhv 280	104.71	7.58	33.	Digvijay x GShv 433/08	94.89	3.44
1	GBhv 297 x GBhv 293	94.34	-3.08	34.	Digvijay x GShv 464/08	82.88	-9.65
1	GBhv 297 x GBhv 291	124.67	28.08 **	35.	Digvijay x GShv 538/08	92.67	1.02
1	GBhv 297 x GBhv 306	98.67	1.37	36.	**Digvijay x GShv 280/11**	119.33	**30.09 ** **
1	GBhv 297 x GShv 233/09	93.72	-3.71	37.	G. Cot. 23 x GBhv 280	85.15	1.2
1	GBhv 297 x GShv 433/08	109.77	12.77	38.	G. Cot. 23 x GBhv 293	87.81	4.36
1	GBhv 297 x GShv 464/08	78.27	-19.59 *	39.	G. Cot. 23 x GBhv 291	99.23	17.94
1	GBhv 297 x GShv 538/08	103.33	6.16	40.	G. Cot. 23 x GBhv 306	87.33	3.8
1	GBhv 297 x GShv 280/11	98.00	0.68	41.	G. Cot. 23 x GShv 233/09	81.93	-2.62
1	GBhv 305 x GBhv 280	98.37	4.83	42.	**G. Cot. 23 x GShv 433/08**	**125.47**	**49.12 ** **
2	GBhv 305 x GBhv 293	93.42	-0.44	43.	G. Cot. 23 x GShv 464/08	69.83	-17.0
2	GBhv 305 x GBhv 291	106.02	12.98	44.	G. Cot. 23 x GShv 538/08	79.33	-5.71
2	GBhv 305 x GBhv 306	97.33	3.73	45.	G. Cot. 23 x GShv 280/11	89.33	6.17
2	GBhv 305 x GShv 233/09	89.30	-4.83	**C.D. at 1 %**		**23.17**	

***, ** Significant at 5 and 1 per cent probability levels, respectively.**

