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Combining Ability Studies in Desi Cotton (*G. herbaceum* L.) in Vertisols of Gujarat

Combining Ability of Desi Cotton

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Abstract

The present investigation was carried out to study combing ability of parental lines and hybrids of desi cotton (G. herbaceum L.) in saline Vertisols of Bharuch, Gujarat. Analysis of variance for combining ability revealed that mean squares due to parents and crosses were highly significant for almost all the characters indicating that considerable gca and sca was present for parents and hybrids, respectively. Combining ability analysis revealed importance of both additive and non-additive components in the expression of seed cotton yield and other traits. Three hybrids viz. G. Cot. 23 x GShv 433/08 (24.90), GBhv 287 x GShv 233/09 (22.76) and GBhv 305 x GShv 280/11 (20.73) were best combiners with high sca effect for seed cotton yield per plant. In general, the crosses exhibiting high sca effects for seed cotton yield per plant also had high sca effects for yield contributing characters and physiological parameters. Per se performance of parents and hybrids agreed well with general combining ability effects of parents and heterotic response of hybrids, respectively.

Keywords-combining ability; cotton; hybrids; salinity; Vertisols

I. INTRODUCTION

Cotton is one of the most important commercial crops, popularly known as the "White Gold". Cotton belongs to the genus *Gossypium* under tribe *Gossypieae* of family *Malvaceae*. Cotton is the most precious gift of nature to the mankind, contributed by the genus "*Gossypium*" to provide clothing to the people all over the world. Cotton contributes not only fibre but also edible oil which plays an important role in meeting the ever increasing demand of edible oil in the country. India has a pride place in the global cotton scenario due to several distinct features such as the largest cotton growing area, cultivation of all the four cultivated species, large area under tetraploid cotton, one of the largest producers of long and extra-long staple cotton, native home of old world cultivated cotton and wide diversity in agro-climatic conditions under which cotton is grown.

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].

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 in the country. 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 M ha [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 ha area is salt affected which covers coastal parts of Bharuch, Surat, Navsari and Valsad districts.

Rapid expansion of saline areas of cotton zones imposes serious threat to the national economy. Hence sustainable measures need to be taken to enhance and stabilize national cotton yield and production. Moreover, in saline Vertisols, there is loss of production and productivity due to accumulation of salt in the root zone. 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.

Combining ability studies are regarded useful to select good combining parents, which on crossing would produce more desirable hybrids/segregates. Such studies also elucidate the nature and magnitude of gene action in the inheritance of yield and its components, which will decide the future breeding programme. 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 general combining ability of parents and specific combining ability of hybrids in line x tester design.

II. MATERIALS AND METHODS

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. The complete sets of sixty one genotypes which included forty-five hybrids and fourteen parents were evaluated against *desi* hybrids, G. Cot. DH 7 and G. Cot. DH 9 as checks in a randomized block design, replicated thrice at Bharuch during *kharif* 2015-16. 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.

III. RESULTS AND DISCUSSION

Line × tester analysis [4] was employed in the present investigation as 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. The knowledge of combining ability provides a useful clue for selection of desirable parents for the development of better hybrids, which should be superior in yield, quality and resistance to biotic and abiotic stresses over the present cultivars.

3.1. Analysis of variance for combining ability

Analysis of variance for combining ability (Table 1) revealed that mean squares due to females and males were significant for days to 50 % flowering, days to 50 % boll bursting, plant height, number of bolls per plant, average boll weight, lint yield per plant, biomass per plant, ginning percentage, 2.5 per cent span length and fibre uniformity ratio (%) in females, while days to 50 % flowering, number of monopodia per plant, number of bolls per plant, seed cotton yield per plant, lint yield per plant, biomass per plant, ginning percentage, fibre uniformity ratio (%), fibre fineness, K^+/Na^+ ratio and total sugar content in males. This suggested that both females and males had considerable general combining ability (gca) and contributed towards additive genetic variance for above mentioned traits. Highly significant mean squares due to females x males were manifested by all the characters (except fibre uniformity ratio), reflecting its significant contribution in favour of specific combining ability (sca) and non-additive variances.

The general combining ability is attributed to additive genetic effects and it is theoretically fixable. Selection is more effective and progress is much faster in evolving the economic characters when genetic variance is primarily due to additive gene action. In such situation, not only the means of generation remain unchanged but the genetic variance is readily translatable from one generation to another. On the other hand, specific combining ability is attributable to non-additive gene action, which may be due to dominance or epistasis or both and is non-fixable in nature. The presence of non-additive genetic variance is the primary justification for initiating the hybrid breeding programme [5].

3.2. Combining ability effects

On the basis of estimates of gca effects (Table 2) it was observed that among parents, one female *i.e.* GBhv 297 (3.52) along with three males *viz.* GBhv 291 (9.47), GBhv 306 (4.51) and GShv 433/08 (10.92) exhibited significant positive gca effects for seed cotton yield/plant. It was also revealed that nine crosses recorded significant positive sca effects and magnitude of sca effects ranged from -26.74 (GBhv 297 x GShv 433/08) to 24.90 (G. Cot. 23 x GShv 433/08). The hybrids G. Cot. 23 x GShv 433/08 (24.90), GBhv 287 x GShv 233/09 (22.76) and GBhv 305 x GShv 280/11 (20.73) were best combiners with high sca effect for seed cotton yield per plant.

In general, the crosses exhibiting high sca effects for seed cotton yield per plant also had high sca effects for yield contributing characters and physiological parameters. The crosses having high heterotic effects for various traits, in general involved either good x good or at least one good or average general combining parents. The crosses exhibiting high sca effects generally involved parents possessing high gca effects, thus suggesting the importance of additive gene action. Best performing parents were mostly good general combiners for majority of characters. Top hybrids having high heterosis and sca effects also manifested good *per se* performance, which clearly highlighted the importance of selection of parents and hybrids based on their *per se* performance.

The variance estimates, σ^2 gca and σ^2 sca were highly significant for most of the characters emphasizing the importance of both additive and non-additive gene actions in inheritance of these characters. However, scrutiny of σ^2 gca/ σ^2 sca ratio (<1) revealed prevalence of non-additive gene action for all the characters. Significance of both the variances has been reported by several workers in cotton [6], [7] and [8]. In those conditions, when parental lines had been subjected to extensive testing and selection in past, variances for sca were of relatively greater importance than the variances for gca [9]. The parental lines used in the present study were promising selections for yield and contributing characters for stress environments (rainfed condition). Therefore, we might expect that the sca portion of the genotypic variances should be expressed to a pronounced extent in the populations evaluated, which has been observed in present investigation also.

As preponderance of non-additive gene action and high heterosis is apparent for seed cotton yield per plant and majority of yield contributing characters along with physiological attributes related to salinity, it is recommended that heterosis breeding could be used for exploitation of hybrid vigour on commercial scale provided seed production is not cumbersome. It was suggested that breeder can exploit non-additive variance through heterosis breeding [10] or other breeding methodologies like bi-parental mating, recurrent selection and diallel selective mating.

IV. CONCLUSION

The identification of cross combinations having high mean performance, high heterosis, and desirable sca effects with stability over environments is of immense value in breeding programme. In the present investigation, the top ranking three hybrids had high *per se* performance and desirable sca effects for seed cotton yield per plant or 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. Analysis of variance for combining ability for various traits in desi cotton under saline soils

Source of Variation (SOV)	df	Analysis of Variance (Mean Square values)									
		FLW	BUR	PHT	MON	SYM	BOL	BWT	YLD	LIN	BIO
Females	58	439.75 **	665.24 *	1977.73 **	0.19	85.88	61.28 **	2.60 **	205.79	201.30 *	11295.26 **
Males	13	97.00 **	279.75	470.71	4.25 *	52.19	31.43 *	1.18	1272.78 *	228.29 **	2838.67 **
Hybrids	44	28.13 **	246.88 **	257.78 **	1.48 **	51.38 **	12.74 **	0.63 **	448.99 **	62.47 **	832.61 **

SOV	df	GIN	SPN	STN	UNI	FIN	KNA	CLO	CHL	PRO	SUG
Females	13	87.10 **	2.98 *	2.28	29.90 *	0.16	2.47	7.44	0.01	85.32	0.05
Males	44	42.25 *	1.07	1.04	36.89 **	0.42 *	15.42 *	16.21	0.02	20.67	0.29 *
Hybrids	58	15.93 **	0.80 **	1.17 **	9.73	0.15 **	5.44 **	15.36 **	0.02 **	33.52 **	0.10 **

FLW	=	Days to 50 % flowering	BOL	=	Number of bolls per plant	GIN	=	Ginning percentage (%)	KNA	=	K^+/Na^+ ratio
BUR	=	Days to 50 % bursting	BWT	=	Average boll weight (g)	SPN	=	2.5 % span length (mm)	CLO	=	Chloride content in leaf (µmole/g)
PHT	=	Plant height (cm)	YLD	=	Seed cotton yield per plant (g)	STN	=	Fibre strength (g/tex)	CHL	=	Chlorophyll content in leaf (mg/g)
MON	=	Number of monopodia per plant	LIN	=	Lint yield per plant (g)	UNI	=	Fibre uniformity ratio (%)	PRO	=	Proline content in leaf (µg/g)
SYM	=	Number of sympodia per plant	BIO	=	Biomass per plant (g)	FIN	=	Fibre fineness (mv)	SUG	=	Total sugar content in leaf (mg/g)

Table 2. Estimates of general combining ability (gca) of parents and specific combining ability (sca) of hybrids for seed cotton yield per plant

Females		**gca**		**Hybrids**	**sca**
1	GBhv 287	-0.14	15	GBhv 297 x GShv 433/08	**-26.74** **
2	GBhv 297	**3.52** *	16	GBhv 297 x GShv 464/08	-3.11
3	GBhv 305	0.26	17	GBhv 297 x GShv 538/08	20.34 **
4	Digvijay	-4.20 *	18	GBhv 297 x GShv 280/11	-7.52
5	G. Cot. 23	0.56	19	GBhv 305 x GBhv 280	0.46
S.E.(g_i)		1.67	20	GBhv 305 x GBhv 293	-2.75
	Males	**gca**	21	GBhv 305 x GBhv 291	-3.17

1	GBhv 280	-4.46 *	22	GBhv 305 x GBhv 306	-4.59
2	GBhv 293	-4.25	23	GBhv 305 x GShv 233/09	-13.43 **
3	GBhv 291	**9.47 ****	24	GBhv 305 x GShv 433/08	11.86 *
4	GBhv 306	**4.51 ***	25	GBhv 305 x GShv 464/08	-0.07
5	GShv 233/09	0.60	26	GBhv 305 x GShv 538/08	-9.06
6	GShv 433/08	**10.92 ****	27	GBhv 305 x GShv 280/11	**20.73 ****
7	GShv 464/08	-19.79 **	28	Digvijay x GBhv 280	-0.39
8	GShv 538/08	-1.27	29	Digvijay x GBhv 293	13.86 **
9	GShv 280/11	4.26	30	Digvijay x GBhv 291	1.30
S.E.(g_j)		2.24	31	Digvijay x GBhv 306	-6.51
Hybrids		**sca**	32	Digvijay x GShv 233/09	-8.70
1	GBhv 287 x GBhv 280	-6.61	33	Digvijay x GShv 433/08	-4.57
2	GBhv 287 x GBhv 293	2.98	34	Digvijay x GShv 464/08	5.07
3	GBhv 287 x GBhv 291	-6.77	35	Digvijay x GShv 538/08	-3.93
4	GBhv 287 x GBhv 306	-14.22 **	36	Digvijay x GShv 280/11	3.87
5	GBhv 287 x GShv 233/09	**22.76 ****	37	G. Cot. 23 x GBhv 280	-6.10
6	GBhv 287 x GShv 433/08	-5.45	38	G. Cot. 23 x GBhv 293	-7.96
7	GBhv 287 x GShv 464/08	-3.85	39	G. Cot. 23 x GBhv 291	-7.77
8	GBhv 287 x GShv 538/08	0.01	40	G. Cot. 23 x GBhv 306	3.09
9	GBhv 287 x GShv 280/11	11.14 *	41	G. Cot. 23 x GShv 233/09	2.15
10	GBhv 297 x GBhv 280	12.64 *	42	G. Cot. 23 x GShv 433/08	**24.90 ****
11	GBhv 297 x GBhv 293	-6.15	43	G. Cot. 23 x GShv 464/08	1.95
12	GBhv 297 x GBhv 291	16.42 **	44	G. Cot. 23 x GShv 538/08	-7.36
13	GBhv 297 x GBhv 306	-3.10	45	G. Cot. 23 x GShv 280/11	-2.90
14	GBhv 297 x GShv 233/09	-2.78		**S.E. (S_{ij})**	0.18

* and ** Significant at 5 % and 1 % level of probability, respectively.

