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Research Article

Heterosis and combining ability estimates through line × tester analysis in inter-specific hybrids of cotton (*G. hirsutum* L. × *G. barbadense* L.)

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Abstract
The present investigation comprised of seventy two inter-specific hybrids obtained by mating twelve diverse lines of *G. hirsutum* and five testers of *G. barbadense* in line × tester fashion and were evaluated to study standard heterosis and combining ability for seed cotton yield and its component traits. Combining ability analysis indicated the preponderance of non-additive gene action for all the traits. The lines, L 762, MR 786, BS 37, NDLH 1938 and H 1442 and the testers, DB 16, DB 11 and GSB 41were found to be good general combiners for seed cotton yield plant^{-1} and its component characters. The hybrid, L 1058 × TCB 37 exhibited high and significant positive *sca* effect for seed cotton yield plant^{-1} and its contributing traits *viz*., number of bolls plant^{-1}, boll weight and seed index. The cross combinations, L 762 × TCB 37, H 1442 × DB 16 and H 1442 × GSB 41 registered high and significant positive heterosis over both the standard checks for seed cotton yield plant^{-1}. The cross combinations which are showing high standard heterosis and *sca* effects may be recommended for commercial cultivation after testing their stable performance for seed cotton yield.

Key words
Cotton, inter-specific hybrids, line × tester analysis, heterosis, combining ability

Introduction

Cotton (*Gossypium* spp.) popularly called “White Gold” is the most important renewable natural fibre crop of global importance. It is grown in tropical and subtropical regions of more than 60 countries of the world and enjoys a premier position amongst all commercial crops contributing nearly 65 per cent of the total raw material needs of the textile industry in our country and is the mainstay of India’s economy with fascinating history from cultural, economical and scientific perspective. Exploitation of heterosis as hybrids and systematic varietal improvement through hybridization are the main tools to increase cotton production in India. It is an often cross pollinated crop and amenable for both heterosis breeding as well as hybridization followed by selection in subsequent generations. The phenomenon of heterosis has proved to be the most important genetic tool in boosting the yield of self as well as cross pollinated crops and is considered as the most important breakthrough in the field of crop improvement. The exploitation of hybrid vigour in cotton on commercial scale has become feasible and economical due to easy hand emasculation and pollination. The identification of specific parental combinations capable of producing the desired level of F_1 heterotic effect is important in improving the yield potential of this crop (Patel *et al*., 2012). Line × Tester analysis provides a systematic approach for detection of appropriate parents and crosses in terms of investigated traits. This method was applied to improve self and cross-pollinated plants (Kempthorne, 1957). Hence, the present study was under taken with an aim to identify high heterotic inter-specific cross combinations for seed cotton yield and its attributing traits.

Material and Methods

Seventy two inter-specific cross combinations were obtained by crossing twelve *hirsutum* lines *i.e*., NDLH 1938, H 1442, ADB 542, ADB 532, WGCV 48, MR 786, TSH 0250, BS 37, SCS 793, MCU 5, L 1058, L 762 with six *barbadese* testers *viz.*, GSB 40, DB 16, DB 11, GSB 41, TCB 37 and SUVIN in line × tester crossing design during off season. The resultant 72 hybrids and 18 parents along with two standard checks *i.e*., DCH-32 and Mahalakshmi (ZCHB-550) were sown in a randomized block design with three replications during *kharif*, 2014-15 at Agricultural Research Station, Jangamaheswarapuram, Acharya N.G Ranga Agricultural University, Andhra Pradesh. A single row of 6 meter length was assigned to each genotype with 10 plants having 60 cm intra row spacing and 120 cm inter row spacing. Five plants were randomly selected from each replication for each genotype and the average value was computed for recording observations on plant height (cm), number of monopodia plant^{-1}, number of sympodia plant^{-1}, number of bolls plant^{-1}, boll weight (g), lint index (g), seed index (g), ginning out-turn (%) and seed cotton yield plant^{-1}. Data for days to 50% flowering was recorded on plot basis. The differences between the genotypes for all the characters under study were tested by adopting analysis of variance as per Panse and Sukhatme (1978). Heterosis was estimated in terms of standard heterosis (Meredith and Bridge, 1972). Combining ability analysis was carried out as per procedure suggested by Kempthorne (1957).

Results and Discussion

Combining ability analysis of variance (Table 1) revealed that the mean squares due to genotypes were significant for all the characters under study. The parents and crosses differed significantly for all the characters. This revealed the existence of considerable genetic variability among the parents and hybrids for all the characters under study. The mean square due to parents vs crosses was significant for all the characters which revealed the presence of considerable amount of heterosis in crosses for all the traits under investigation.

The estimates of *gca* and *sca* effects have been given in tables 2 and 3. Among the 18 parents studied, three lines and none of the testers exhibited significant *gca* effects in desired direction for days to 50% flowering. Five lines and two testers registered significant positive *gca* effects for plant height. Whereas, seven lines and two testers recorded significant positive *gca* effects for number of monopodia plant^{-1}. Out of 18 parents evaluated, three lines and one tester showed *gca* effects in desirable direction for number of symopodia plant^{-1}. Six females and three males showed positive *gca* effects for number of bolls plant^{-1}. For boll weight, five lines and three testers exhibited significant positive *gca* effects. Four females and two males registered significant and positive *gca* effects in desirable direction for lint index. Significant and positive *gca* effects for seed index were shown by five lines and three testers. Five females and two males showed positive *sca* effects for ginning out-turn. However, the perusal of general combining ability effects indicated that among the parents, five females and three males depicted significant and positive *gca* effects for seed cotton yield plant^{-1}. These parents may be used in future seed cotton yield improvement breeding programmes.

Among the 72 hybrids studied, the cross combinations, H 1442 × GSB 41 recorded the highest *sca* effects for days to 50% flowering; WGCV 48 × DB 16, for plant height; ADB 532 × GSB 41, for number of monopodia plant^{-1}; WGCV 48 × DB 16, for number of sympodia plant^{-1}; WGCV 48 × DB 11, for number of bolls plant^{-1}; TSH 0250 × GSB 40, for boll weight; L 1058 × DB 16, for lint index; L 1058 × TCB 37, for seed index; ADB 542 × DB 16, for ginning out-turn. Whereas, the crosses L 1058 × TCB 37, TSH0250 × GSB 40 and WGCV 48 × DB 11 exhibited significant and positive *sca* effects for seed cotton yield plant^{-1}, respectively (Table 3). The estimates of *gca* and *sca* variances for various traits revealed that *sca* variance was higher than *gca* variance for all the traits and indicated the role of non-additive gene action in controlling these characters and it was further confirmed by σ^2gca/σ^2sca ratio (Table 1). Biparental mating or diallel selective mating or heterosis breeding may be employed for the improvement of these traits. These results are in agreement with results of Deosarkar *et al*. (2014), Patel *et al*. (2012), Patel *et al*. (2014), Patel and Jadon (2014) and Rajamani *et al*. (2014).

The estimates of standard heterosis varied from -5.08% to 16.95% for days to 50 % flowering; -12.46% to 17.47% for plant height; -33.50% to 122.17% for number of monopodia plant^{-1}; -14.16% to 25.31% for number of sympodia plant^{-1}; -33.34% to 31.71% for number of bolls plant^{-1}; -19.19% to 33.33% for boll weight; -13.30% to 40.95% for lint index; 4.02% to 55.24% for seed index; -28.07% to 11.27% for ginning out-turn; -36.63% to 53.35% for seed cotton yield plant^{-1} over the checks DCH 32 and Mahalakshmi. The crosses, L 1058 × DB 16, MCU 5 × GSB 40 and SCS 793 × TCB 37 for days to 50% flowering; NDLH 1938 × GSB 40, NDLH 1938 × GSB 41 and TSH0250 × GSB 40 for plant height; ADB 532 × GSB 41, L 1058 × TCB 37 and WGCV 48 × GSB 41 for number of monopodia plant^{-1}; WGCV 48 × DB 16, ADB 542 × GSB 41, MR 786 × GSB 41 and SCS 793 × SUVIN for number of sympodia plant^{-1}; SCS 793 × DB 11, H 1442 × DB 16 and TSH0250 × DB 11 for number of bolls plant^{-1}; MR 786 × GSB 40, TSH0250 × GSB40 and L 762 × TCB 37 for boll weight; L 1058 × DB 16, L 1058 × GSB 41 and L 1058 × TCB 37 for lint index; MR 786 × TCB 37, MCU 5 × DB 16 and MCU 5 × SUVIN for seed index; TSH 0250 × GSB40, MR 786 × GSB 41 and ADB 542 × DB 16 for ginning out-turn; L 762 × TCB 37, H 1442 × DB 16 and H 1442 × GSB 41 for seed cotton yield plant^{-1} were considered as promising heterotic cross combinations for respective traits (Table 4). Similar results were also reported by Amalabalu *et al*. (2012), Kumar *et al*. (2013), Patel *et al*. (2012), Tuteja *et al*. (2013) and Tuteja (2014). The superior heterotic cross combinations may be exploited for commercial cultivation after through testing over large number of locations and seasons for their stable performance. The cross combinations, L 762 × TCB 37, H 1442 × DB 16 and H 1442 × GSB 41 registered considerable *sca* effects and high and significant positive heterosis over both the standard checks for seed cotton yield plant^{-1} and other yield contributing characters so that these cross combinations can be directly used as hybrids for cultivation after thorough checking over locations, seasons and years for stability. The hybrids can be also advanced to further segregating generations for isolating superior genotypes with high yielding and good fibre quality traits.

References

Amalabalu, P., Kavithamani, P.D., Ravikesavan, R. and Rajarathinam, S. 2012. Heterosis for seed cotton yield and its quantitative characters of *Gossypium barbadense* L. *Journal of Cotton Res. and Dev.*, **26**(1): 37-40.

DOI: 10.5958/0975-928X.2017.00068.0

Deosarkar, D.B., Deshmukh, J.D. and Deshmukh, V.D. 2014. Combining ability analysis for yield and fibre quality traits in upland cotton (*Gossypium hirsutum* L.). *Journal of Cotton Res. and Dev.*, **28**(1): 18-23.

Kempthorne, O. 1957. *An Introduction to Genetic Statistics*. John Wiley and Sons Inc., New York. 458-471.

Kumar, S.K., Ashok Kumar, K. and Ravikesavan, R. 2013. Genetic effects of combining ability studies for yield and fibre quality traits in diallel crosses of upland cotton (*Gossypium hirsutum* L.). *African J. of Bio*., **13**(1): 119-126.

Meredith, W.R. and Bridge, R.R. 1972. Heterosis and geneaction in cotton (*G. hirsutum* L.). *Crop Sci.*, **12**: 304- 310.

Panse, V.G. and Sukhatme, P.V. 1978. Statistical Methodsfor Agricultural Workers. Indian Council of Agricultural Research, New Delhi.

Patel, B.N., Patel, N.A., Soni, N.V. and Dave, V.D. 2014. Genetic studies of quantitative traits in inter-specific hybrids of tetraploid cotton (*Gossypium hirsutum* L. × *G. barbadense* L.). *Electron. J. Plant Breed*. **5**(4): 708-715.

Patel, N.A., Patel, B.N., Bhatt, J.P. and Patel, J.A. 2012. Heterosis and combining ability for seed cotton yield and component traits in inter-specific cotton hybrids (*Gossypium hirsutum* L. × *G. barbadense* L.). *Madras Agri. J*., **99**(10-12): 649-656.

Patel, T.T. and Jadon, B.S. 2014. Combining ability studies in *Gossypium herbaceum. Cotton Res. J*., **6**: 28-31.

Rajamani, S., Gopinath, M. and Reddy, K.H.P. 2014. Combining ability for seed cotton yield and fibre charcters in upland cotton (*Gossypium hirsutum* L.). *Journal of Cotton Res. and Dev*., **28**(2): 207-210.

Tuteja, O.P. 2014. Studies on heterosis for yield and fibre quality traits in GMS hybrids of upland cotton (*Gossypium hirsutum* L.). *Journal of Cotton Res. and Dev*., **28**(1): 1-6.

Tuteja, O.P., Manju, B and Hamid, H. 2013. Heterosis for seed cotton yield component and fibre properties of American cotton (*Gossypium hirsutum* L.). *Journal of Cotton Res. and Dev*., **27**(2): 184-187.

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Table 1. ANOVA of combining ability for different characters in inter-specific hybrids of cotton (*G. hirsutum* × *G. barbadense*) during *kharif*, 2014-15

Source of variations	DF	Days to 50% flowering	Plant height (cm)	No. of monopodia plant^{-1}	No. of sympodia plant^{-1}	No. of bolls plant^{-1}	Boll weight (g)	Lint index (g)	Seed index (g)	Ginning out- turn (%)	Seed cotton yield plant^{-1} (g)
Replicates	2	1.144	90.460	0.000	2.286	15.798	0.010	0.025	0.175	1.414	277.320
Genotypes	89	46.570**	1337.378**	2.260**	53.519**	567.345**	0.571**	1.183**	13.128**	27.836**	6642.65**
Parents	17	183.704**	441.854**	0.816**	14.793**	170.190**	1.176**	1.227**	8.718**	26.505**	1878.24**
Crosses	71	9.959**	416.798**	1.616**	15.167**	283.397**	0.432**	0.914**	6.156**	21.786**	4121.554**
Line Effect	11	18.833*	1205.681**	2.834*	17.730	488.520*	1.186**	2.661**	10.484*	59.883**	8063.089**
Tester Effect	5	1.327	890.181 **	1.264	11.057	750.677**	0.911**	2.774**	12.534*	69.870**	11596.610**
Line × Tester Eff.	55	8.969**	215.987**	1.404**	15.027**	199.89**	0.238**	0.395**	4.710**	9.795**	2653.697**
Parents vs Crosses	1	314.712**	81922.427**	72.608**	3434.878**	27479.308**	0.140*	19.618**	583.149**	480.120**	266634.212**
Error	178	3.132	115.005	0.043	2.128	9.671	0.020	0.040	0.274	0.895	213.030
Total	269	17.492	519.387	0.776	19.128	194.185	0.203	0.418	4.527	9.812	2339.333
$\sigma^2 gca$		0.041*	30.813**	0.024**	-0.023*	15.545**	0.030**	0.086**	0.252**	2.040**	265.783**
$\sigma^2 sca$		1.945**	33.660**	0.454**	4.300**	63.407**	0.072**	0.118**	1.478**	2.967**	813.556**
$\sigma^2 gca/\sigma^2 sca$		0.021	0.915	0.053	-0.005	0.245	0.417	0.729	0.170	0.687	0.327

*, **Significant at 5 and 1 per cent level, respectively

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Table 2. General combining ability effects of parents for different characters in cotton during *kharif*, 2014-15

Parents	Days to 50% flowering	Plant height (cm)	No. of monopodia plant^{-1}	No. of sympodia plant^{-1}	No. of bolls plant^{-1}	Boll weight (g)	Lint index (g)	Seed index (g)	Ginning out- turn (%)	Seed cotton yield plant^{-1} (g)
LINES										
NDLH 1938	-1.95**	5.10*	-0.70**	-0.00	1.45*	0.19**	-0.05	-0.82**	0.90**	15.41**
H 1442	-1.45**	-12.37**	-0.50**	-1.13**	2.04**	0.13**	0.19**	-0.79**	1.94**	13.58**
ADB 542	-0.01	-1.79	-0.09	0.35	-2.85**	0.20**	-0.08	-0.44**	0.44	2.41
ADB 532	-0.23	-3.95	0.18**	-1.19**	-3.83**	0.25**	0.07	1.27**	-1.46**	1.28
WGCV 48	0.77	-14.89**	0.46**	-0.47	-8.17**	-0.03	-0.10*	0.26*	-0.75**	-24.77**
MR 786	-0.39	6.98**	-0.48**	1.18**	0.31	0.35**	0.18**	0.01	0.70**	18.22**
TSH 0250	0.33	8.02**	0.19**	-1.28**	1.59*	-0.24**	-0.13**	-0.36**	0.05	-7.48*
BS 37	1.27**	-5.74*	0.24**	0.05	3.73**	0.10**	-0.34**	0.43**	-1.89**	15.66**
SCS 793	0.83*	6.63**	0.22**	1.74**	6.56**	-0.34**	-0.76**	0.37**	-3.41**	-1.50
MCU 5	1.11**	-3.18	0.22**	-0.65	-8.67**	-0.48**	-0.09	0.74**	-1.32**	-48.62**
L 1058	0.61	6.61**	0.50**	1.11**	-0.42	-0.19**	0.88**	0.66**	2.07**	-11.58**
L 762	-0.89*	8.58**	-0.24**	0.29	8.24**	0.06	0.22**	-1.33**	2.72**	27.39**
SE (gi)	0.59	3.57	0.07	0.49	1.04	0.05	0.07	0.17	0.31	4.87
TESTERS										
GSB 40	-0.12	4.56*	0.06	0.24	-5.01**	0.17**	0.28**	0.70**	0.10	-5.99*
DB 16	0.11	3.62*	-0.29**	0.64**	5.09**	0.09**	0.37**	-0.24**	1.70**	19.83**
DB 11	-0.25	3.47	-0.04	0.18	2.88**	0.06*	-0.13**	-0.04	-0.47**	11.71**
GSB 41	0.02	0.63	0.27**	0.27	3.81**	-0.00	0.03	-1.01**	1.56**	10.24**
TCB 37	0.30	-5.17**	-0.09**	-0.44	-1.44**	-0.03	-0.23**	0.35**	-1.36**	-5.67*
SUVIN	-0.06	-7.11**	0.09**	-0.88**	-5.32**	-0.29**	-0.31**	0.23**	-1.51**	-30.12**
SE (gj)	0.42	2.53	0.05	0.34	0.73	0.03	0.05	0.12	0.22	3.44

*, **Significant at 5 and 1 per cent level, respectively

Table 3. The cross combinations having highest positive and significant *sca* effects for different characters in inter specific hybrids of cotton (*G. hirsutum* × *G. barbadense*) during *kharif*, 2014-15

Trait	Cross combination/s	*sca* effects
Days to 50% flowering	H 1442 × GSB 41	-4.190**
Plant height (cm)	WGCV 48 × DB 16	17.136**
Number of monopodia plant^{-1}	ADB 532 × GSB 41	1.305**
Number of sympodia plant^{-1}	WGCV 48 × DB 16	4.751**
Number of bolls plant^{-1}	WGCV 48 × DB 11	15.465**
Boll weight (g)	TSH 0250 × GSB 40	0.805**
Lint index (g)	L1058 × DB 16	6.671**
Seed index (g)	L1058 × TCB 37	10.542
Ginning out-turn (%)	ADB 542 × DB 16	3.601**
	L 1058 × TCB37	69.576**
Seed cotton yield plant^{-1}	TSH 0250 × GSB 40	67.773**
	WGCV 48 × DB 11	50.631**

*, **Significant at 5 and 1 per cent level, respectively

Table 4. Top three superior heterotic cross combinations for different characters in inter specific hybrids of cotton (*G. hirsutum* × *G. barbadense*) during *kharif*, 2014-15

Traits	Cross combination/s	Standard heterosis	
		DCH 32	Mahalakshmi
	L 1058 × DB 16	16.95**	13.11**
Days to 50% flowering	MCU 5 × GSB 40	9.60*	6.01*
	SCS 793 × TCB 37	9.04**	5.46*
	NDLH 1938 × GSB 40	17.47**	3.70
Plant height (cm)	NDLH 1938 × GSB 41, TSH0250 × DB 16	16.86**	3.16
	TSH0250 × GSB 40	15.71**	2.15
	ADB 532 × GSB 41	122.17**	59.83**
Number of monopodia plant^{-1}	L 1058 × TCB 37	105.67**	47.96**
	WGCV 48 × GSB 41	94.50**	39.93**
	WGCV 48 × DB 16	25.31**	14.51**
Number of sympodia plant^{-1}	ADB 542 × GSB 41, MR 786 × GSB 41	24.02**	13.33**
	SCS 793 × SUVIN	23.60**	12.94**
	SCS 793 × DB 11	31.71**	10.59**
Number of bolls plant^{-1}	H 1442 × DB 16	30.09**	9.23**
	TSH0250 × DB 11	25.58**	5.45
	MR 786 × GSB 40,	33.33**	18.17**
Boll weight (g)	TSH0250 × GSB40	28.08**	13.52**
	L 762 × TCB 37	25.66**	11.37**
	L 1058 × DB 16	40.95**	12.82**
Lint index (g)	L 1058 × GSB 41	40.04**	12.10**
	L 1058 × TCB 37	35.79**	8.70**
	MR 786 × TCB 37	55.24**	6.97*
Seed index (g)	MCU 5 × DB 16	54.45**	6.42*
	MCU 5 × SUVIN	54.20**	6.25*
	TSH 0250 × GSB40	11.27**	23.83**
Ginning out-turn (%)	MR 786 × GSB 41	9.11**	21.43**
	ADB 542 × DB 16	8.75**	21.03**
	L 762 × TCB 37	53.35**	32.88**
Seed cotton yield plant^{-1}	H 1442 × DB 16	51.81**	31.55**
	H 1442 × GSB	46.43**	26.89**

*, **Significant at 5 and 1 per cent level, respectively