Electronic Journal of Plant Breeding, 8(1): 10-19 (March 2017)
ISSN 0975-928X
DOI: 10.5958/0975-928X.2017.00002.3

Research Article

Genetic effects of combining ability studies for quantitative traits in intra- and interspecific crosses of diploid cotton (*G. arboreum* and *G. herbaceum*)

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(Received: 20 Jan 2016; Revised: 09 March 2017; Accepted: 12 March 2017)

Abstract
Forty-five intra- and interspecific diploid or *desi* cotton hybrids (*G. arboreum x G. herbaceum*) derived from half diallel mating design, by involving ten diverse parents of *G. herbaceum* and *G. arboreum* were evaluated to study combining ability for seed cotton yield and its component traits. Mean squares due to GCA and SCA variance were highly significant for all the 11 agro-morphological characters studied. The variance due to GCA and SCA for mean squares was highly significant, which suggested that additive and non-additive gene action is involved for controlling all the characters. Combining ability analysis suggested the preponderance of non-additive type of gene action for all the traits except days to 50 % flowering and no. of monopodia per plant. Based on *per se* performance, parent GAM- 165 and cross GBhv- 282 x G-27 was superior for seed cotton yield and lint yield per plant. The parent G-27 and GBhv- 287 was found to be the best general combiner for majority of the traits. Based on *sca* effects, GBhv- 282 x G 27 exhibited significant *sca* effects for seed cotton yield per plant, lint yield per plant, number of bolls per plant, boll weight and no. of sympodia per plant. Heterosis breeding will be useful for diploid cotton improvement due to presence of non-additive type of gene action.

Key words
Diploid, d*esi*, half diallel, and combining ability

Introduction

Cotton is major agricultural commodity which provides fibre, food and fuel to millions of people in the world and also useful to the animals. Cotton seed is an important source of edible oil too. India is one of the largest producers as well as exporters of cotton yarn and the Indian textile industry contributes about 11 per cent to industrial production, 14 per cent to the manufacturing sector, 4 per cent to the GDP and 12 per cent to the country's total export earnings. Cotton cultivation is steadily increased from 117.27 lakh hectares (2013-14) to 126.55 lakh hectares (2014-15). India is also the second largest producer of cotton worldwide with the production of 400 lakh bales (a bale is 170 kg) with productivity of 537 kg/ ha. (Anonymous, 2014-15). Worldwide, India is the only country that cultivates all four cultivated species of cotton. When India got Independence, 97 per cent of the total cultivation was of native diploid *"Desi"* cottons (varieties of *Gossypium arboreum* L. and *G. herbaceum* L). Gradually, *desi* varieties disappeared from the fields of Indian farmers with hybrids and Bt cotton replacing them in a very short time. This year, the cultivation of *desi* cotton has reached an abysmal low of three per cent. Indian *desi* cotton is famous for its medicinal use due its absorbent ability and apart from surgical quality it is used in textile, jeans, tea-coffee filters, fishing nets etc., whose demand is growing and the market price is very high. *Desi* varieties have resistance to pest and disease and can be grown with little rain and are suitable for dry land and mixed farming.

Cotton breeders are trying to develop cotton varieties; those well adapt to poor environmental conditions and produce higher yield and better fibre quality along with increased tolerance to biotic and abiotic stresses. It is well known phenomenon to cotton breeders that, certain crosses make better combinations than the others in transmitting favourable parental traits/genes to their offspring. For breeding programmes, parents should be genetically superior, physiologically efficient, possessing better general and specific combining ability so that they could be utilized for varietal development. Combining ability analysis is most powerful technique in breeding programme for identification and choice of superior genotypes as parents with desirable characters imposing promising increase in production per unit area. Information on gene action and combining ability is essential prerequisite for selection of desirable parents for exploitation of hybrid vigour to develop potential hybrids with a reasonable level of stability. Diallel mating design supports the breeder to identify the potential genotypes and the promising recombinants produced by combining the parental individuals. The present study was designed to generate the information on combining ability that provides idea of selection of superior parents that can be used in breeding program of diploid cotton.

Materials and methods

The present research was conducted at Main Cotton Research Station, (Navsari Agricultural University, Navsari), Surat (Gujarat) India. Breeding material consisted of ten well adapted diverse diploid cotton genotypes from G. *arboreum* and *G. herbaceum*, their 45 inter- and intraspecific F_1 hybrids. The pedigree details of the parental genotypes lines are presented in Table 1. The Parental genotypes were crossed in a half diallel (excluding reciprocals) fashion during *kharif* 2011-12 to generate 45 inter- and intraspecific F_1 hybrids. Dock and Moll (1934) method of hand emasculation and pollination is used to make F_1 hybrids. Ten Parents and forty-five F_1 hybrids were evaluated for combining ability using randomized block design (RBD) with three replications during *kharif* 2012-2013. Each genotype was grown in a row of 4 m length adopting a spacing of 120 cm between rows and 40 cm between the plants, so as to have minimum 10 plants per row.

The data were recorded on five randomly selected plants per replication for seed cotton yield and it's contributing quantitative traits *viz.* days to 50 % flowering, plant height, number of monopodia per plant, number of sympodia per plant, number of bolls per plant, boll weight, seed cotton yield per plant, lint yield per plant, ginning percentage, seed index and lint index. Diallel analysis was carried out as per procedure given by Griffing (1956) method- II and model –I (Fixed effect) as described by Singh and Chaudhary (1979). Statistical analysis for *GCA* and *SCA* was carried out by using the mean values over five sample plants through standard statistical software (INDOSTAT package).

Results and discussion

The analysis of variance of RBD revealed that mean sum of squares due to differences among the genotypes was significant for all the characters studied, which indicates existence of sufficient variability in the breeding materials (Table 2). The variance due to parents and hybrids was highly significant for all the characters. Significance of variance in parents *versus* hybrids interaction provided adequacy for comparing the heterotic expression for all the characters. Ashokkumar and Ravikesavan (2013) observed that all the characters were significantly different with parents and hybrids in upland cotton, confirming the results in present investigation. *GCA* and *SCA* variances were highly significant for all the characters studied (Table 3).

The 10 parents and their 45 F_1 hybrids varied significantly for yield and its contributing traits. For selection of suitable parents in developing superior hybrids, *per se* performance and nature of gene action acted as selection index. Therefore, the present study was aimed to evaluate their *per se* performance and *gca* effects. The *per se* performance of parents for yield and its component characters are presented in Table 4. Based on *per se*, parent GBhv-286 recorded high *per se* for boll weight (2.62 g), ginning percentage (39.07 %), seed index (6.68 g) and lint index (4.28 g). Next to it, the parent GAM-165 recorded higher mean for seed cotton yield per plant (97.70 g/plant), lint yield per plant (33.35 g/boll) and number of sympodial branches per plant (24.53). The *arboreum* type parent 824 recorded high *per se* for plant height (161.18 cm) and no. of monopodia per plant (2.53). G 27 registered higher mean for no. of bolls per plant (42.82) and days to 50 % flowering (63.20 days). High mean values act as a selection index in the choice of parents. Hence, these parents can be used in hybridization for improving these characters through pedigree breeding.

Selection of hybrids can be done based on *per se* performance, although it is not the only criteria for selection of hybrids. Hence, *sca* effects and hybrid vigour for crosses should also be considered when non-additive gene action is predominating. Mean performance for hybrids are presented in table 5 with their *sca* effects. In present study, hybrid GBhv- 282 x G- 27 recorded higher *per se* performance for number of bolls per plant (97.40), seed cotton yield per plant (223.15 g) and lint yield per plant (77.03 g). Cross GBhv- 286 x 824 registered higher mean for seed index (7.42 g) and lint index (3.93 g). Crosses, 824 x GAM- 173, GBhv- 282 x GAM- 141, GBhv- 287 x G- 27 and GShv- 273/07 x G- 27 observed better *per se* performance for days to 50 % flowering (63.47 days), plant height (182.64 cm), number of monopodia per plant (2.00) and number of sympodia per plant (30.07), respectively. GBhv-283 x GAM-165 recorded highest mean for boll weight (2.94 g) while, highest ginning percentage (GP) (38.50 %) was observed in cross GBhv- 282 x GAM -141.

If the *GCA* variance is greater than *SCA* variance for the particular trait, it indicates the preponderance of additive gene action. Additive gene action provides fixable effects, and the non-additive gene action results are non-fixable. In present study mean squares of *GCA* and *SCA* variances were highly significant that indicated presence of both additive and non-additive gene actions. Paulo *et al.* (2007); Wankhade *et al.* (2008); Saadabadi and Tahmasebi, (2008), Laxman, (2010) and Memon *et al.* (2014) also reported presence of non-additive and additive gene action for controlling these traits. In current study, σ^2 *gca*/ σ^2 *sca* ratio was less than unity for all the traits except days to 50 % flowering and number of monopodia per plant, which revealed the preponderance of non-additive gene action for inheritance of these traits and could be exploited by heterosis breeding. Similar findings were also reported by Duhoon *et al.* (1983), Chaudhari *et al*. (1993) and Sakhare *et al*. (2005) in diploid cotton. Preponderance of additive gene action for days to 50 % flowering and number of monopodia per plant, suggested directional selection for isolating better homozygous lines from segregating population for these traits. These observations are in conformity with findings obtained by Khan *et al.* (2005) and Aguiar *et al.* (2007) in upland cotton.

Estimation of general combining ability effects for all the ten parents and specific combining ability effects for 45 half diallel crosses for eleven characters with their corresponding standard error are presented in table 4 and 5, respectively.

The estimate of *gca* effects shown that none of the parental line excelled as good general combiner for all the characters, so it was difficult to pick good combiners for all the characters together because the combining ability effects were not consistent for all the yield components, possibly because of negative association among some of the characters. This shows that genes for different desirable characters would have to be combined from different genotypes. The parent, GBhv-287 recorded highest significant *gca* effects for seed cotton yield per plant and lint yield per plant. For the *gca* effects, parent G-27 exhibited highest and significant *gca* effects in desirable direction for plant height, number of monopodia per plant and no. of bolls per plant. For number of sympodia per plant and seed index, GShv- 273/07 was good general combiner while GBhv- 286 was good general combiner for lint index and ginning percentage. *G. arboreum* parent GAM-141 proved itself as better parent for shortening the crop duration. In conclusion, GBhv- 287 and G-27 were proved as good general combiner for seven and six traits, respectively. High *gca* effect in desirable direction for a particular character indicates the presence of additive genes for that character in the parents. It can be expected that when the parents possessing high *gca* effects are combined; larger proportion of progenies would have high *per se* value for the character concerned facilitating easy selection for the character (Manickam and Gururajan, 2004). No line was good general combiner for all traits hence, it would be desirable to have multiple crosses and subject them to selection in segregating generations to detect superior genotypes with high yield and quality traits.

In present study, the cross GBhv- 286 x GAM- 141 and GBhv- 282 x GAM- 141 recorded highest significant *sca* effects for days to 50 % flowering and plant height, respectively. Cross GBhv- 282 x G 27 revealed highest *sca* effects for seed cotton yield per plant and lint yield per plant. GBhv- 286 x 824 observed better for seed index whereas, GBhv- 282 x GAM- 141 was superior for lint index. For yield characters, GBhv- 282 x G 27 observed better and it showed high *sca* effects for no. of bolls per plant, seed cotton yield per plant and lint yield per plant. In cross combination, GBhv- 282 X G 27, both the parents are good general combiners with positive significant *gca* effects and involve additive gene action that would be easily fixable. GBhv- 283 x GAM- 165 exhibited highest *sca* effects for boll weight while, cross GBhv- 282 x GAM- 141 exhibited highest *sca* effects for ginning percentage.

The hybrid, GBhv- 282 x GAM- 173 was better in case of *sca* effects and it recorded significant *sca* effects for maximum characters such as sympodia per plant, number of bolls per plant, lint yield per plant, seed index and lint index. Hybrids, GBhv- 282 x GAM- 173, GBhv- 283 x 824 and GBhv- 286 x G 27 were combinations of one good general combiner parent and one poor general combiner parent for seed cotton yield per plant. In the present study, there was no relationship between *per se* performance of hybrids and *gca* effects of parents which indicated the presence of epistatic interaction also. Further studies through generation mean analysis or triple test cross analysis, may bring out more useful information on the nature of gene interaction in material (Preetha and Raveendran, 2008).These hybrids exhibited high seed cotton yield per plant due to non-additive gene interactions in these crosses. Poor x good and good x poor combinations produce high performing hybrid due to dominance effects. In such situations recombination breeding is useful and could be exploited to generate stable performing transgressive segregants carrying fixable genes. Similar findings were reported by Muthu*et al.* (2005), Ahuja and Dhayal (2007) and Usharani*et al*. (2014).

Conclusion

The analysis of combining ability revealed that the variances for the *SCA* were larger than *GCA* for all the traits except days to 50 % flowering and number of monopodia per plant branches which could be exploited for the improvement of these traits by heterosis breeding. In the present investigation, parent GAM- 165 and cross GBhv- 282 x G 27 had higher *per se* performance for seed cotton and lint yield per plant. For the *gca* effects, the parent G-27 and GBhv- 287 was considered as best general combiner for most of characters under study. GBhv- 282 x G 27 recorded significant *sca* effects for number of bolls per plant, seed cotton yield per plant and lint yield per plant. Results of present investigation revealed that seed yield per plant is highly influenced by no. of bolls per plant. Hence, it would be desirable to have multiple crosses and subject them to selection in segregating generations to detect superior genotypes with high yield and quality traits.

References

Aguiar, P.A.D., Penna, J.C.V., Freire, E.C., Melo, L.C., 2007. Diallel analysis of upland cotton cultivars. *Crop Breed. Appl. Biotechol.*, **7**: 353–359.

Ahuja, S.L. and Dhayal, L.S. 2007. Combining ability estimates for yield and fibre quality traits in 4 × 13 line × tester crosses of *G. hirsutum*. *Euphytica*, **153**: 87-98.

Anonymous (2014-15). All India Coordinated Cotton Improvement Project. Annual Report, CICR Regional Station, Coimbatore.

Ashokkumar K., Ravikesavan R., 2013. Genetic variation and heterotic effects for seed oil, seed protein and yield attributing traits in upland cotton (*Gossypium hirsutum* L.*). Afr. J. Biotechnol.*, **12**(33): 5183-5191.

Chaudhari, P.N., Borole. D.N., Patil, S.S. and Deshmukh, M.P. 1993. Combining ability studies on quantitative component in *desi* cotton. *J .Maharashtra Agric. Univ*., **18**(3): 418-420.

Dock, J.W. and Moll, R.H. 1934. A new technique in cotton hybridization suggested changes in existing method of emasculating and bagging cotton flower. *Heredity*, **25**: 201-204.

Duhoon, S.S., Basu, A.K. and Sahni, V.M. 1983. Heterosis and combining ability studies in cotton (*G. hirsutum* L.). *ISCI J.*, **8**(1): 19-27.

Griffing, B. 1956. A generalized treatment of for diallel cross in quantitative inheritance. *Heredity,* **10**: 31-50.

Khan, N.U., Hassan, G., Kumbhar, M.B., Ghaloo, S.H. 2005.Combining ability analysis for morphological and yield traits in intra- *G. hirsutum* crosses. *SAARC J. Agric.*, **3**: 211–232.

Laxman, S. 2010. Diallel analysis for combining ability for seed cotton yield and its components in *desi* cotton (*G. arboreum L.*).*J. Cotton Res. Dev.*, **24**(1): 26-28.

Manickam, S. and Gururajan K.N. 2004. Combining ability analysis for fibre quality in upland cotton (*Gossypium hirsutum*L.). *J. Indian Soc. Cotton Improv.*, **29**(2): 91.

Memon, S., Shar, P.A., Shar, A.G., Memon, S., Memon, S., Memon, M. A. and Shar, A. H. 2014. Biometrical analysis of some quantitative traits of Cotton (*Gossypium hirsutum* L.). *International Journal of Science, Environment and Technology*, **3**(6): 2069 – 2075.

Muthu, R., Kandasamy, G., Raveendran, T.S., Ravikesavan, R. and Jayaramachandran, M. 2005. Combining ability and heterosis for yield traits in cotton (*G. hirsutum*). *Madras Agric. J.*, **92**: 17-22.

Preetha, S. and Raveendran, T.S. 2008. Combining ability and heterosis for yield and fibre quality traits in line x tester crosses of Upland cotton (*G. hirsutum*. L). *International Journal of Plant Breeding and Genetics*, **2**(2): 64-74.

Saadabadi, M.F. and Tahmasebi, S. 2008. Estimation of genetic parameters for traits effective on earliness in cotton using diallel crosses. *Seed and Plant*, **24**(3): 501-513.

Sakhare, B.A., Wandhare, M.R., Ladole, M.Y. and Wakode, M.M. 2005.Combining ability studies in diploid cotton. *J. Cotton Res. Dev.*, **19**(1): 52-54.

Singh, R.K. and Chaudhary, B.D., *eds.*, 1979, Biometrical methods in quantitative genetic analysis, Kalyani Publisher, New Delhi, pp.191-200.

Usharani, K.S., Vindhiyavarman, P. and Balu, P. A. 2014. Combining ability analysis in intraspecific F_1 diallel crosses of upland cotton (*Gossypium hirsutum* L.). *Elect. J. Plant Breed.*, **5**(3): 467-474.

Wankhade, S.N., Patil, S.P., Kayande, N.V. and Burghate, S.K. 2008. Diallel analysis for estimating combining ability of quantitatively inherited traits in upland cotton. *Journal of Cotton Research and Development,* **22**(2): 147-149.

Electronic Journal of Plant Breeding, 8(1): 10-19 (March 2017)
ISSN 0975-928X
DOI: 10.5958/0975-928X.2017.00002.3

Table 1. Particulars of *desi* cotton parental material used in study with pedigree and source

Sr. No.	Genotypes	Pedigree	Source
G. herbaceum			
1	GShv- 273/07	G. Cot 23 x G. Cot 11	Main Cotton Research Station, NAU, Surat
2	GBhv- 282	G. Cot 23 x GBhv- 215	Main Cotton Research Station, NAU, Bharuch
3	GBhv- 283	Jaydhar x GBhv- 215	Main Cotton Research Station, NAU, Bharuch
4	GBhv- 286	Digvijay x GBhv- 215	Main Cotton Research Station, NAU, Bharuch
5	GBhv- 287	Jaydhar x GBhv- 198	Main Cotton Research Station, NAU, Bharuch
G. arboreum			
1	824	G1 X Cernnum	Main Cotton Research Station, NAU, Surat
2	G 27	Selection from Sanguineum	Main Cotton Research Station, NAU, Surat
3	GAM- 141	GAM- 20 x GAM- 21	Main Cotton Research Station, NAU, Surat
4	GAM- 165	G. Cot 19 x IET 364	Main Cotton Research Station, NAU, Surat
5	GAM- 173	GAM- 93 x IET 355	Main Cotton Research Station, NAU, Surat
Check			
1	G. Cot DH- 7	Sujay x G 27	Main Cotton Research Station, NAU, Surat

Table 2. Analysis of variance for biometrical traits from half diallel analysis of intra- and interspecific diploid cotton

Source of variations	d.f.	Days to 50 % flowering	Plant height (cm)	Monopods per plant	Sympods per plant	Bolls per plant	Boll weight (g)	Seed cotton yield per plant (g)	Lint yield per plant (g)	Ginning percent - age (%)	Seed index (g)	Lint index (g)
Replications	2	52.12	263.47	0.11	3.56	10.68	0.02	1.059	2.60	2.40	0.08	0.09
Genotypes	54	709.29**	214.31**	4.65**	29.96**	1027.40**	0.25**	4703.52**	602.55**	6.96**	0.82**	0.38**
Parents	9	1332.81**	58.25	5.80**	19.19**	196.50**	0.16**	744.60**	74.79**	11.82**	0.83**	0.70**
Hybrids	44	595.38**	216.09**	4.37**	28.75**	1096.95**	0.26**	5193.64**	665.90**	5.96**	0.76**	0.28**
Parents *vs.* Hybrids	1	110.01*	1540.21**	6.60**	179.92**	5445.44**	0.42**	18768.42**	2564.79**	7.11*	3.27**	1.58**
Error	108	27.39	110.08	0.14	4.46	27.60	0.02	149.02	19.88	1.28	0.07	0.05
SE±		3.02	6.06	0.22	1.22	3.03	0.08	7.05	2.57	0.65	0.15	0.13

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

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ISSN 0975-928X
DOI: 10.5958/0975-928X.2017.00002.3

Table 3. Genetic components of variance and genetic contribution of parents and hybrids in a 10 x 10 half diallel intra- and interspecific crosses of diploid cotton

Source of variations	d.f.	Days to 50 % flowering	Plant height (cm)	Monopods per plant	Sympods per plant	Bolls per plant	Boll weight (g)	Seed cotton yield per plant (g)	Lint yield per plant (g)	Ginning percentage (%)	Seed index (g)	Lint index (g)
gca	9	1328.08**	75.35*	6.81**	6.13**	405.40**	0.15**	1610.88**	210.68**	4.17**	0.70**	0.22**
sca	45	18.10**	70.65**	0.50**	10.76**	329.88**	0.07**	1559.23**	198.88**	1.95**	0.19**	0.11**
Error	108	9.13	36.69	0.04	1.49	9.2	0.01	49.67	6.63	0.43	0.02	0.02
σ^2 gca		109.91	3.22	0.56	0.39	33.01	0.01	130.10	17.00	0.312	0.06	0.02
σ^2 sca		8.97	33.96	0.45	9.27	320.68	0.06	1509.56	192.26	1.52	0.17	0.10
σ^2 gca / σ^2 sca		12.25	0.10	1.25	0.04	0.10	0.19	0.09	0.09	0.21	0.34	0.19

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

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Table 4. ***Per se*** **performance and general combining ability effects of parents for yield and its yield attributing characters in a 10 x 10 half diallel intra- and interspecific crosses of diploid cotton**

Parents	Days to 50 % flowering		Plant height (cm)		Monopods per plant		Sympodia Per plant		Bolls per plant		Boll weight (g)	
	Mean	*GCA*	Mean	*GCA*	Mean	*GCA*	Mean	*GCA*	Mean	*GCA*	Mean	*GCA*
GShv- 273/07	106.40	11.12**	150.17	2.10	6.00	0.88**	23.40	0.87*	39.90	-1.62	2.19	0.10**
GBhv- 282	105.53	11.29**	149.35	2.19	5.53	0.72**	22.00	0.80*	42.22	3.11**	1.85	0.07**
GBhv- 283	108.20	9.92**	149.27	-1.50	5.60	0.91**	20.40	-1.42**	26.22	-7.83**	2.24	0.15**
GBhv- 286	101.87	8.57**	153.59	-0.77	5.47	0.65**	15.93	-0.29	19.98	-4.59**	2.62	0.03
GBhv- 287	103.53	8.81**	157.61	-3.53*	4.60	0.28**	21.60	0.25	33.88	7.52**	2.33	0.05**
824	65.33	-8.88**	161.18	2.62	2.53	-0.81**	22.07	0.46	38.59	4.64**	2.14	-0.11**
G 27	63.20	-10.18**	158.26	3.94*	3.00	-0.87**	23.93	0.29	42.82	8.95**	2.08	-0.18**
GAM- 141	65.60	-10.46**	149.11	-0.82	3.00	-0.49**	21.00	0.13	33.48	-0.06	2.44	-0.03
GAM- 165	66.40	-9.83**	153.04	-2.14	3.53	-0.58**	24.53	-0.29	38.22	-5.25**	2.56	0.07**
GAM- 173	65.80	-10.36**	156.93	-2.08	2.60	-0.71**	19.07	-0.79*	23.37	-4.86**	2.29	-0.15**
S.E.(gi) ±		0.83		1.66		0.06		0.33		0.83		0.02
S. E. (gi – gj) ±		1.23		2.47		0.09		0.50		1.24		0.03

Parents	Seed cotton yield / plant (g)		Lint yield per plant (g)		Ginning Percentage (%)		Seed Index (g)		Lint index (g)	
	Mean	*GCA*	Mean	*GCA*	Mean	*GCA*	Mean	*GCA*	Mean	*GCA*
GShv- 273/07	87.27	0.01	28.29	-0.61	32.37	-0.50**	6.31	0.42**	3.02	0.15**
GBhv- 282	78.16	11.19**	26.18	3.83**	33.52	-0.28	5.54	-0.20**	2.79	-0.14**
GBhv- 283	58.14	-12.87**	19.20	-5.0**	32.70	-0.76**	5.20	-0.10*	2.53	-0.16**
GBhv- 286	52.07	-9.97**	20.45	-2.90**	39.07	0.99**	6.68	0.20**	4.28	0.26**
GBhv- 287	78.73	17.50**	27.20	6.66**	34.46	0.58**	5.80	0.03	3.05	0.09**
824	82.49	6.88**	26.59	1.58*	32.20	-0.78**	6.26	0.32**	2.97	0.05
G 27	88.80	12.35**	31.27	4.95**	35.11	0.49**	5.19	-0.18**	2.81	-0.03
GAM- 141	81.33	-0.98	27.22	-0.02	33.33	0.21	5.45	-0.34**	2.72	-0.15**
GAM- 165	97.70	-8.89**	33.35	-3.14**	34.09	0.11	6.40	-0.08	3.31	-0.03
GAM- 173	53.68	-15.23**	18.43	-5.33**	34.44	-0.06	5.78	-0.07	3.04	-0.05
S.E.(gi) ±		1.93		0.70		0.18		0.04		0.03
S. E. (gi – gj) ±		2.88		1.05		0.27		0.06		0.05

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

Table 5. *Per se* performance and specific combining ability effects of intra and interspecific hybrids of diploid cotton for yield and yield contributing traits

S. No.	Crosses	Days to 50 % flowering		Plant height (cm)		Number of monopodia /plant		Number of sympodia / plant	
		Mean	*SCA*	Mean	*SCA*	Mean	*SCA*	Mean	*SCA*
1	GShv- 273/07 x GBhv- 282	109.80	3.93	163.56	-1.06	5.33	-0.031	24.80	-0.48
2	GShv- 273/07 x GBhv- 283	104.47	-0.03	149.74	-11.19*	4.07	-1.49**	21.47	-1.59
3	GShv- 273/07 x GBhv- 286	105.33	2.19	159.42	-2.24	5.00	-0.29	22.53	-1.65
4	GShv- 273/07 x GBhv- 287	106.67	3.28	164.93	6.03	5.33	0.41*	20.00	-4.73**
5	GShv- 273/07 x 824	86.33	0.63	177.72	12.67*	4.07	0.23	28.13	3.20**
6	GShv- 273/07 x G 27	80.67	-3.73	179.66	13.28*	3.00	-0.78**	30.07	5.30**
7	GShv- 273/07 x GAM- 141	82.87	-1.26	170.21	8.60	5.07	0.92**	28.00	3.40**
8	GShv- 273/07 x GAM- 165	80.00	-4.74	163.42	3.13	4.07	0.002	23.40	-0.79
9	GShv- 273/07 x GAM- 173	82.53	-1.69	159.87	-0.48	4.00	0.07	24.93	1.25
10	GBhv- 282 x GBhv- 283	106.13	1.47	155.55	-5.47	6.00	0.60**	22.20	-0.79
11	GBhv- 282 x GBhv- 286	108.53	5.22	157.31	-4.44	5.40	0.26	21.47	-2.65*
12	GBhv- 282 x GBhv- 287	108.07	4.52	153.42	-5.57	6.07	1.30**	22.13	-2.53*
13	GBhv- 282 x 824	84.80	-1.07	168.21	3.07	3.20	-0.48*	23.67	-1.20
14	GBhv- 282 x G 27	82.53	-2.03	179.22	12.76*	2.47	-1.15	28.27	3.56**
15	GBhv- 282 x GAM- 141	79.67	-4.6	182.64	20.94**	3.53	-0.46*	29.53	5.00**
16	GBhv- 282 x GAM- 165	83.07	-1.84	163.42	3.04	3.00	-0.91	23.27	-0.85
17	GBhv- 282 x GAM- 173	79.80	-4.59	167.89	7.45	4.00	0.22	30.00	6.38**
18	GBhv- 283 x GBhv- 286	107.67	5.73*	160.18	2.12	6.00	0.67**	23.60	1.71
19	GBhv- 283 x GBhv- 287	103.67	1.49	154.63	-0.67	5.00	0.04	24.53	2.10
20	GBhv- 283 x 824	82.40	-2.09	165.23	3.78	3.40	-0.47*	26.33	3.69**
21	GBhv- 283 x G 27	80.47	-2.73	181.41	18.63**	3.60	-0.21	22.07	-0.41
22	GBhv- 283 x GAM- 141	79.00	-3.92	159.18	1.17	4.60	0.42*	20.00	-2.31*
23	GBhv- 283 x GAM- 165	79.67	-3.87	164.54	7.85	4.00	-0.10	17.53	-4.36**
24	GBhv- 283 x GAM- 173	77.13	-5.88*	156.66	-0.10	4.47	0.51*	24.07	2.67*
25	GBhv- 286 x GBhv- 287	107.53	6.71*	165.13	9.10	6.00	1.30**	28.00	4.44**
26	GBhv- 286 x 824	83.80	0.66	168.92	6.75	4.00	0.39	29.00	5.22**
27	GBhv- 286 x G 27	78.20	-3.64	169.31	5.81	3.80	0.25	24.40	0.79
28	GBhv- 286 x GAM- 141	74.33	-7.23**	151.61	-7.13	3.00	-0.92**	27.33	3.90**
29	GBhv- 286 x GAM- 165	75.33	-6.86**	160.31	2.89	2.60	-1.24**	23.07	0.04
30	GBhv- 286 x GAM- 173	76.33	-5.33	155.00	-2.45	2.47	-1.24**	24.93	2.41*
31	GBhv- 287 x 824	78.67	-4.72	156.17	-3.25	3.00	-0.24	29.00	4.69**
32	GBhv- 287 x G 27	80.93	-1.15	153.11	-7.63	2.00	-1.18**	22.07	-2.08
33	GBhv- 287 x GAM- 141	78.07	-3.74	150.84	-5.14	2.60	-0.95**	23.33	-0.65
34	GBhv- 287 x GAM- 165	76.33	-6.09*	158.39	3.73	3.00	-0.47*	26.00	2.43*
35	GBhv- 287 x GAM- 173	76.67	-5.24	149.44	-5.28	2.60	-0.74**	24.40	1.36
36	824 x G 27	67.33	2.93	158.16	-8.73	2.00	-0.09	21.33	-3.03**
37	824 x GAM- 141	65.67	1.55	160.46	-1.67	2.47	0.002	20.07	-4.13**
38	824 x GAM- 165	68.33	3.60	153.20	-7.61	2.53	0.152	23.47	-0.31
39	824 x GAM- 173	63.47	-0.76	164.62	3.75	2.00	-0.25	20.07	-3.21**
40	G 27 x GAM- 141	65.33	2.51	160.80	-2.65	2.60	0.20	22.20	-1.83
41	G 27 x GAM- 165	68.67	5.22	153.33	-8.80	3.00	0.68**	24.00	0.390
42	G 27 x GAM- 173	65.33	2.41	159.45	-2.74	2.53	0.35	20.93	-2.18
43	GAM- 141 x GAM- 165	65.67	2.50	161.62	4.25	2.60	-0.09	26.20	2.76*
44	GAM- 141 x GAM- 173	70.73	8.10**	158.22	0.79	3.00	0.44*	22.53	-0.41
45	GAM- 165 x GAM- 173	70.13	6.87*	153.65	-2.46	2.60	0.12	20.20	-2.33*
	S.E.(sij) ±		2.78		5.58		0.20		1.12
	S.E.(sij - sik) ±		4.09		8.20		0.29		1.65
	S.E.(sij - skl) ±		3.90		7.82		0.28		1.57

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

Electronic Journal of Plant Breeding, 8(1): 10-19 (March 2017)
ISSN 0975-928X
DOI: 10.5958/0975-928X.2017.00002.3

Table 5. Contd.,

S. No.	Crosses	Number of bolls per plant		Boll weight (g)		Seed cotton yield per plant (g)		Lint yield per plant (g)	
		Mean	*SCA*	Mean	*SCA*	Mean	*SCA*	Mean	*SCA*
1	GShv- 273/07 x GBhv- 282	39.11	-8.44**	2.31	-0.023	90.62	-19.04**	29.18	-8.23**
2	GShv- 273/07 x GBhv- 283	29.69	-6.91*	2.29	-0.13	66.83	-18.78**	23.25	-5.33*
3	GShv- 273/07 x GBhv- 286	30.82	-9.02**	2.26	-0.04	69.81	-18.70**	24.31	-6.37**
4	GShv- 273/07 x GBhv- 287	26.73	-25.23**	2.81	0.50**	74.88	-41.09**	27.11	-13.12**
5	GShv- 273/07 x 824	68.60	19.53**	2.20	0.05	151.28	45.93**	49.80	14.65**
6	GShv- 273/07 x G 27	71.70	18.32**	1.91	-0.18	136.76	25.94**	48.75	10.23**
7	GShv- 273/07 x GAM- 141	56.85	12.48**	2.17	-0.06	123.67	26.17**	42.06	8.50**
8	GShv- 273/07 x GAM- 165	39.78	0.60	2.42	0.09	96.00	6.41	33.40	2.97
9	GShv- 273/07 x GAM- 173	44.05	4.47	2.25	0.14*	98.84	15.60*	34.29	6.05*
10	GBhv- 282 x GBhv- 283	22.66	-18.68**	2.65	0.26**	59.46	-37.33**	19.81	-13.19**
11	GBhv- 282 x GBhv- 286	34.60	-9.97**	2.23	-0.04	76.78	-22.91**	26.62	-8.49**
12	GBhv- 282 x GBhv- 287	38.97	-17.71**	2.20	-0.09	85.87	-41.28**	29.92	-14.74**
13	GBhv- 282 x 824	36.15	-17.66**	2.09	-0.04	75.66	-40.87**	24.55	-15.04**
14	GBhv- 282 x G 27	97.40	39.29**	2.29	0.23**	223.15	101.15**	77.03	34.08**
15	GBhv- 282 x GAM- 141	62.00	12.90**	2.47	0.27**	152.33	43.66**	58.96	20.97**
16	GBhv- 282 x GAM- 165	44.73	0.82	2.62	0.31**	117.18	16.42*	40.90	6.04*
17	GBhv- 282 x GAM- 173	83.86	39.55**	2.14	0.05	180.00	85.58**	62.57	29.89**
18	GBhv- 283 x GBhv- 286	39.08	5.45	2.42	-0.07	95.00	19.37**	30.93	4.65*
19	GBhv- 283 x GBhv- 287	42.68	-3.07	2.17	-0.20**	92.33	-10.76	32.88	-2.96
20	GBhv- 283 x 824	76.56	33.70**	2.07	-0.14*	158.33	65.86**	54.99	24.23**
21	GBhv- 283 x G 27	54.56	7.39**	1.94	-0.20**	105.57	7.63	36.62	2.49
22	GBhv- 283 x GAM- 141	34.29	-3.87	2.76	0.48**	95.01	10.39	31.80	2.63
23	GBhv- 283 x GAM- 165	22.41	-10.56**	2.94	0.55**	65.86	-10.85	23.06	-2.98
24	GBhv- 283 x GAM- 173	38.27	4.90	1.95	-0.22**	73.99	3.63	24.25	0.40
25	GBhv- 286 x GBhv- 287	50.94	1.95	2.18	-0.07	111.00	5.01	36.98	-0.96
26	GBhv- 286 x 824	61.70	15.60**	1.98	-0.11	122.22	26.85**	42.27	9.41**
27	GBhv- 286 x G 27	79.59	29.19**	2.02	0.004	160.67	59.83**	59.32	23.10**
28	GBhv- 286 x GAM- 141	48.35	6.95*	1.86	-0.30**	89.60	2.08	33.19	1.925
29	GBhv- 286 x GAM- 165	29.09	-7.11*	1.89	-0.38**	54.93	-24.68**	20.55	-7.58**
30	GBhv- 286 x GAM- 173	37.36	0.76	2.13	0.08	79.33	6.07	26.10	0.16
31	GBhv- 287 x 824	93.09	34.88**	2.30	0.19**	210.86	88.02**	72.70	30.29**
32	GBhv- 287 x G 27	72.29	9.77**	2.02	-0.02	146.73	18.42**	54.72	8.94**
33	GBhv- 287 x GAM- 141	72.73	19.22**	2.07	-0.11	150.57	35.58**	53.07	12.25**
34	GBhv- 287 x GAM- 165	62.83	14.51**	2.05	-0.23**	128.74	21.69**	44.99	7.29**
35	GBhv- 287 x GAM- 173	68.84	20.12**	1.96	-0.11	134.63	33.91**	49.10	13.59**
36	824 x G 27	35.85	-23.79**	2.10	0.22**	73.16	-44.53**	25.99	-14.72**
37	824 x GAM- 141	38.23	-12.40**	1.90	-0.12	73.00	-31.37**	25.26	-10.49**
38	824 x GAM- 165	42.37	-3.07	1.93	-0.19**	81.64	-14.81*	27.43	-5.19*
39	824 x GAM- 173	32.53	-13.31**	1.68	-0.23**	54.50	-35.61**	18.76	-11.67**
40	G 27 x GAM- 141	39.52	-15.42**	1.77	-0.19**	70.10	-39.73**	22.74	-16.38**
41	G 27 x GAM- 165	45.90	-3.84	1.88	0.18*	86.33	-15.59*	29.51	-6.47**
42	G 27 x GAM- 173	31.50	-18.64**	1.62	-0.22**	51.16	-44.42**	18.13	-15.67**
43	GAM- 141 x GAM- 165	50.87	-10.13**	1.81	-0.39**	92.14	3.54	32.04	1.02
44	GAM- 141 x GAM- 173	36.06	-5.08	1.73	-0.25**	62.28	-19.97**	22.28	-6.56**
45	GAM- 165 x GAM- 173	29.11	-6.83*	1.99	-0.10	58.20	0.12		-2.33*
	S.E.(sij) ±		2.79		0.07		6.49		2.37
	S.E.(sij - sik) ±		4.11		0.10		9.54		3.49
	S.E.(sij - skl) ±		3.92		0.10		9.10		3.32

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

Electronic Journal of Plant Breeding, 8(1): 10-19 (March 2017)
ISSN 0975-928X
DOI: 10.5958/0975-928X.2017.00002.3

Table 5. Contd.,

S. No.	Crosses	Ginning percentage (%)		Seed index (g)		Lint index (g)	
		Mean	***SCA***	**Mean**	***SCA***	**Mean**	***SCA***
1	GShv- 273/07 x GBhv- 282	32.30	-1.49*	6.16	-0.22	2.94	-0.33**
2	GShv- 273/07 x GBhv- 283	34.20	0.89	6.75	0.27	3.51	0.26*
3	GShv- 273/07 x GBhv- 286	34.90	-0.16	6.80	0.02	3.65	-0.02
4	GShv- 273/07 x GBhv- 287	36.10	1.46*	6.47	-0.14	3.66	0.16
5	GShv- 273/07 x 824	33.00	-0.28	7.36	0.46**	3.63	0.17
6	GShv- 273/07 x G 27	35.60	1.05	6.98	0.58**	3.86	0.48**
7	GShv- 273/07 x GAM- 141	34.10	-0.18	6.36	0.12	3.29	0.04
8	GShv- 273/07 x GAM- 165	34.70	0.52	6.88	0.38**	3.66	0.28*
9	GShv- 273/07 x GAM- 173	34.60	0.60	6.42	-0.09	3.40	0.04
10	GBhv- 282 x GBhv- 283	33.00	-0.54	5.51	-0.36*	2.71	-0.25*
11	GBhv- 282 x GBhv- 286	34.50	-0.79	6.18	0.02	3.26	-0.13
12	GBhv- 282 x GBhv- 287	34.90	0.03	5.79	-0.20	3.10	-0.11
13	GBhv- 282 x 824	32.50	-1.01	5.90	-0.38**	2.84	-0.33**
14	GBhv- 282 x G 27	34.50	-0.28	5.79	0.004	3.05	-0.05
15	GBhv- 282 x GAM- 141	38.50	4.00**	5.98	0.36*	3.74	0.77**
16	GBhv- 282 x GAM- 165	34.90	0.49	6.50	0.61**	3.48	0.39**
17	GBhv- 282 x GAM- 173	34.80	0.57	6.52	0.63**	3.48	0.41**
18	GBhv- 283 x GBhv- 286	32.70	-2.11**	6.07	-0.19	2.95	-0.41**
19	GBhv- 283 x GBhv- 287	35.50	1.11	6.26	0.17	3.45	0.25*
20	GBhv- 283 x 824	34.70	1.67**	6.53	0.15	3.47	0.32**
21	GBhv- 283 x G 27	34.60	0.30	6.53	0.65**	3.45	0.38**
22	GBhv- 283 x GAM- 141	33.60	-0.42	6.33	0.61**	3.20	0.25*
23	GBhv- 283 x GAM- 165	35.00	1.07	5.68	-0.30*	3.06	-0.02
24	GBhv- 283 x GAM- 173	32.50	-1.25*	6.52	0.53**	3.14	0.08
25	GBhv- 286 x GBhv- 287	33.30	-2.84**	6.66	0.28*	3.33	-0.29*
26	GBhv- 286 x 824	34.60	-0.18	7.42	0.75**	3.93	0.36**
27	GBhv- 286 x G 27	36.96	0.91	5.87	-0.31*	3.44	-0.05
28	GBhv- 286 x GAM- 141	36.91	1.14	5.98	-0.03	3.50	0.13
29	GBhv- 286 x GAM- 165	37.38	1.70**	5.50	-0.78**	3.28	-0.20
30	GBhv- 286 x GAM- 173	32.80	-2.70**	6.28	-0.01	3.07	-0.40**
31	GBhv- 287 x 824	34.48	0.12	7.02	0.52**	3.69	0.29*
32	GBhv- 287 x G 27	37.45	1.82**	5.78	-0.23	3.46	0.13
33	GBhv- 287 x GAM- 141	35.21	-0.15	5.92	0.08	3.22	0.01
34	GBhv- 287 x GAM- 165	34.93	-0.33	6.35	0.24	3.41	0.09
35	GBhv- 287 x GAM- 173	36.39	1.31*	6.24	0.12	3.57	0.27*
36	824 x G 27	34.52	0.25	6.98	0.68**	3.68	-0.40**
37	824 x GAM- 141	34.78	0.78	5.77	-0.36*	3.08	-0.08
38	824 x GAM- 165	33.55	-0.35	6.18	-0.22	3.12	-0.16
39	824 x GAM- 173	34.33	0.61	5.87	-0.54**	3.07	-0.19
40	G 27 x GAM- 141	32.51	-2.76**	5.36	-0.28*	2.58	-0.50**
41	G 27 x GAM- 165	34.20	-0.97	5.83	-0.07	3.03	-0.17
42	G 27 x GAM- 173	35.53	0.54	6.12	0.21	3.37	0.19
43	GAM- 141 x GAM- 165	34.80	-0.09	5.38	-0.36*	2.87	-0.212
44	GAM- 141 x GAM- 173	35.71	0.99	5.67	-0.08	3.15	0.09
45	GAM- 165 x GAM- 173	33.98	-0.64	5.73	-0.28*	2.95	-0.23
	S.E.(sij) ±		0.60		0.14		0.12
	S.E.(sij - sik) ±		0.89		0.20		0.17
	S.E.(sij - skl) ±		0.84		0.19		0.16

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