



Electronic Journal of Plant Breeding

Research Article

Line x tester mating design analysis with GMS based system for seed cotton yield, its component traits and fibre quality parameters in Asiatic cotton (*Gossypium arboreum* L.)

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Abstract

Sixteen parents and 28 F_1 (14×2) genetic male sterility based cross combinations were evaluated in a line x tester mating design in Asiatic cotton (*Gossypium arboreum*). The statistical analysis was performed using the method developed by Kempthorne (1957) with the help of an OPSTAT computer program (developed by CCS Haryana Agricultural University, Hisar). Sufficient variability among hybrids and their parents was found as the mean squares of genotypes for all the traits including fibre quality investigated were significant. The total genetic variability was partitioned to general combining ability (GCA) and specific combining ability (SCA). The variance due to GCA was higher than SCA for fibre strength (g/tex) only. For other traits viz., seed cotton yield, plant height (cm), bolls per plant, boll weight (g), 2.5 % span length and micronaire value, the SCA was higher which reflects the role of both additive and non-additive types of gene action (dominant or epistatic). In the present study, additive variances were significant for a 2.5% span length, fineness and fibre strength and non-additive as well as additive gene effects for seed cotton yield, plant height, boll number, boll weight and ginning percentage. GCA was significant for male parents, G-27, DLSA-17, DLSA-8, PA-496, LD-713, LD-853 and LD-733 for seed cotton yield; G-27, DLSA-17, DLSA-8, PA-255, PA-304, PA-405, PA-496 and LD-713 for plant height; G-27, DLSA-202, PAIG-8/1, PA-464 and PA-496 for bolls per plant; G-27, DLSA-202, PAIG-8/1, PA-464 and PA-496 for boll weight; DLSA-202, DLSA-17, PAIG-8/1, PA-405, PA-464, LD-733 for ginning out turn (GOT%); DLSA-202, DLSA-17, DLSA-8, PA-255, PA-464, PA-496, LD-713 and LD-733 for 2.5% span length (mm); DLSA-17, DLSA-8, PA-255, PA-464, PA-496 and LD-713 for lower micronaire value having fineness and DLSA-17, PAIG-8/1, DLSA-8, PA-255, PA-304, PA-496 and LD-713 for fibre strength (g/tex) which were considered as good general combiners. Similarly among 28 cross combinations, SCA was positively significant for 9 crosses for seed cotton yield, 11 crosses for plant height, 7 crosses for boll number, 10 crosses for boll wt, 9 crosses for GOT(%), 15 crosses for 2.5% span length, 8 crosses for micronaire and 8 crosses for fibre strength.

Key words

Asiatic Cotton, Combining ability, Seed cotton yield and its components, Genetic male sterility, Fibre quality traits.

INTRODUCTION

Cotton, an important commercial cash crop, occupies a prominent and significant position in the world economy. It has manifold merits where it is used as fibre as lint for making clothes, food and feed, cotton seed oil, linters used in the manufacturing of high grade paper and rayon,

and for making X-ray films. It influences the economies of many countries such as the USA, China, India, Pakistan, Uzbekistan, Australia, Africa and others. In the world, India is the only country where all the four cultivated species of cotton (tetraploid and diploid) viz., *G. hirsutum*,

G. barbadense, *G. arboreum* and *G. herbaceum* are grown from north to the deep south. *G. hirsutum* covers more than 90% of acreage while the diploids the least. However, the diploids are relatively tolerant to biotic as well as abiotic stresses including fewer inputs as compared to *G. hirsutum* (Verma *et al.*, 2020). The cotton leaf curl disease is prevalent in *G. hirsutum* in north India and presently no genotype is immune to this disease and diploid cotton *G. arboreum* is observed to be immune to this dreaded disease. As an alternative, the diploid cotton may be taken for large scale cultivation if they are giving remunerative price equal to or higher than *G. hirsutum* crop.

The primary objective for any breeder is to enhance the yield per unit area, the fibre yield and improvement in its quality- length, strength and fineness, particularly in cotton. Parents which are diverse genetically and geographically should be used for gain, enhancement and improvement of yield and fibre quality in cotton. The first step in a successful breeding program is to select the most desired and appropriate parents. Findings of early researchers revealed that variation in seed cotton yield and its components is controlled by genes having additive and non-additive action. Line x Tester mating design analysis provides a systematic approach for the detection of appropriate parents and crosses in terms of estimation of general and specific combining abilities in both self and cross pollinated plants (Kempthorne, 1957). This method has been used by many workers for analysis and identification of potential combiners in an early generation (Ashokkumar *et al.*, 2010; Verma *et al.*, 2004 & 2005; Tuteja and Verma, 2011; Tuteja *et al.*, 2013 and Verma *et al.*, 2017). Therefore, in view of the importance of combining the ability of parents from diverse geographical regions for various characters in cotton, a line x tester mating design of 28 crosses involving two

genetic male sterile lines and 14 male parents of Asiatic cotton (*G. arboreum*) was studied for gene action and combining ability estimates.

MATERIALS AND METHODS

The experimental material utilized for the present study, consisted of 14 male parents, 4 from North India (G-27, LD-713, LD-853 and LD-733), 5 from Central India (PA-255, PA-304, PA-405, PA-464 and PA-496), 5 from South India (DLSA-16, DLSA-202, DLSA-17, PAIG-8/1, DLSA-8) having a different ecological and geographical background and 2 female GMS lines *viz.* DS-5 and CISA-2 and crossed in a line x tester (2×14) mating design at the Central Institute for Cotton Research, Regional Station, Sirsa in 2013-14. The GMS line DS-5 was identified at CCHAU, Hisar while the CISA-2 GMS line was identified at ICAR-CICR, Regional Station, Sirsa from a spontaneous mutation and was different from DS-5 having two genes responsible for male sterility (Tuteja *et al.*, 2005). Sixteen parents and 28 crosses were grown in a Randomized Block Design (RBD) with three replications and crop geometry of 67.5 x 45cm during the 2014-15 crop season. Five random plants were selected to record the data on plant height (cm), the number of bolls/plant and boll weight (g). The data on seed cotton yield was recorded on per plot of 10.8 m² basis and converted to kg/ha. All the seed cotton samples were cleaned and ginned carefully in the laboratory for estimation of GOT % (ginning outturn percentage) and analyzed for fibre quality parameters, *viz.* 2.5% span length, micronaire value and fibre strength (g/tex) on High Volume Instrument (HVI) as per the standard methods. The data were used for statistical analysis using the method developed by Kempthorne (1957) with the help of an OPSTAT computer program which was developed by Chaudhary Charan Singh Haryana Agricultural University, Hisar (Sheoran *et al.*, 1998).

Table 1. Analysis of variance for Line x Tester (parents excluded) for fixed effect model

Source of Variation	DF	Seed Cotton Yield	Plant height	Bolls/Plant	Boll weight	Ginning outturn percentage	2.5% Span length	Micronaire	Fibre strength
Replication	2	3,300.54	78.53	4.852	0.055	0.843	0.062	0.004	1.047
Genotypes	27	218,012.07**	2,081.27**	186.86**	0.124**	7.781**	3.819**	0.674**	2.940**
Due to Males	13	297,841.57**	2,327.02**	165.86**	0.120**	6.019**	6.012**	0.993**	3.524**
Due to Female	1	27,907.60	1,903.63	808.48	0.001	27.630	8.234	1.686	18.012
Male x Female	13	152,800.75**	1,849.28**	160.03**	0.138**	8.017**	1.287**	0.278**	1.196**
Error	54	3,667.37	236.20	13.93	0.028	0.597	0.116	0.029	0.139
σ^2_{gca}		419.74	11.085	13.631	-0.003	0.367	0.243	0.044	0.399
σ^2_{sca}		49,711.13	537.695	48.701	0.037	2.473	0.390	0.083	0.352
$\sigma^2_{gca}/\sigma^2_{sca}$		0.008	0.021	0.28	0.08	0.15	0.62	0.53	1.13
σ^2_A		839.49	22.170	27.262	-0.006	0.734	0.486	0.088	0.798
σ^2_D		49,711.13	537.695	48.701	0.037	2.473	0.390	0.083	0.352
$(\sigma^2_D/\sigma^2_A)^{1/2}$		59.22	24.25	1.79	6.17	3.36	0.80	0.94	0.44

Significance **P=0.01

RESULTS AND DISCUSSION

The analysis of variance (**Table 1**) indicated that the mean squares of genotypes for all the traits including fibre quality investigated were significantly different, indicating the presence of sufficient variability among hybrids. The parent contribution of L x T to total hybrid variation was 33.75 per cent. Hence, further analysis for combining ability was possible. The total genetic variability was partitioned to general combining ability (GCA) and specific combining ability (SCA). The variance due to GCA was lower than SCA for all traits except fibre strength which reflects the preponderance of non-additive types of gene action (dominant or epistatic) controlling these traits, which is in accordance with previous results of Ahuja and Dhayal, (2007), Karademir *et al.* (2009), Tuteja and Verma (2011), Tuteja *et al.* (2013) and Verma *et al.* (2017) and Giri *et al.* (2020). The results are similar to the findings of Rauf *et al.* 2006, Karademir *et al.* (2009), Verma *et al.* (2017) who studied the conventional cross combinations in *G. arboreum*. Dominance genetic variance was larger than the additive genetic variance for all the traits. These results are supported by a ratio of the variance of general to specific combining ability ($\sigma^2_{gca}/\sigma^2_{sca}$) which was smaller than unity and by the degree of dominance $\sigma^2_D/\sigma^2_A)^{1/2}$ which takes values greater than unity (**Table 1**). Therefore, it appeared that the inheritance of all the studied characters was controlled by a preponderance of non-additive gene effects.

The GCA effects of parents and hybrids are presented in **Table 2**. Estimates for seed cotton yield, the male parents G-27, DLSA-17, DLSA-8, PA-496, LD-713, LD-853, LD-733 and none of the female parents showed significant positive GCA effects, whereas other parents DLSA-202, PA-255, PA-304, PA-405, PA-464 showed significant negative GCA effects. For seed cotton yield, the male parents G-27, DLSA-17, DLSA-8, PA-496, LD-713, LD-853, LD-733 and female parent CISA 2 appeared to be a good general combiner. For plant height, male parents G-27, DLSA-17, DLSA-8, PA-255, PA-304, PA-405, PA-496, LD-713 and no female parent had significant positive GCA effects, whereas DLSA-16, DLSA-202, PAIG-8/1, PA-464, LD-853 and LD-733 exhibited significant negative GCA effect. For plant height also G-27, DLSA-17, DLSA-8, PA-255, PA-304, PA-405, PA-496, LD-713 and female parent CISA 2 appeared to be a good general combiner. For the number of bolls/plant, the male parents G-27, DLSA-202, PAIG-8/1, PA-464 and PA-496 and no female parent showed female parents significant positive GCA effects whereas DLSA-16, DLSA-17, DLSA-8, PA-255, PA-304, LD-713, LD-853 and LD-733 recorded significant negative GCA effect. For the number of bolls/plant, G-27, DLSA-202, PAIG-8/1, PA-464, PA-496 and CISA 2 were general good combiner. For GOT, male parents G-27, DLSA-202, DLSA-8, PA-255, PA-304, PA-405, PA-464, LD-713 and no female parent showed significant positive GCA effects whereas DLSA-16, DLSA-17, PAIG-8/1, PA-496, LD-853 and LD-733 recorded significant negative GCA effect. Parents G-27,

DLSA-202, DLSA-8, PA-255, PA-304, PA-405, PA-464, LD-713 and CISA-2 were appeared to be a general good combiner for GOT (%). For boll weight male parent DLSA-202, DLSA-17, PAIG-8/1, PA-405, PA-464, LD-733 and no female parent showed significant positive GCA effects appeared to be good general combines along with female parent CISA-2 whereas the parents DLSA-16, DLSA-8, PA-255, PA-304, PA-496, LD-713 and LD-853 exhibited significant negative GCA effects. For 2.5% span length the male parents DLSA-202, DLSA-17, DLSA-8, PA-255, PA-464, PA-496, LD-713, LD-733 and no female parents recorded significant positive GCA effects and observed to good general combiner for this trait, this may be due to as the male parents are having the blood of genotypes from Central and South zone whereas other male parents G-27, PAIG-8/1, PA-304, PA-405, LD-853 and no female parent were having significant negative GCA effects which may not be advisable to use these parents for improving this trait. For micronaire value the male parents DLSA-17, DLSA-8, PA-255, PA-464, PA-496, LD-713 and no female parent showed significant negative GCA effects however, female parent CISA-2 showed negative GCA effect but not significant indicating that CISA-2 and above mentioned male parents are appeared to be general good combiner as lower micronaire value increases the fineness of cotton fibre whereas other male parents G-27, DLSA-16, DLSA-202, PAIG-8/1, PA-304, PA-405, LD-853, LD-853 exhibited significant positive GCA effects. For fibre strength, the male parents DLSA-17, PAIG-8/1, DLSA-8, PA-255, PA-304, PA-496, LD-713 and no female parents recorded significant positive GCA effects and appeared to be good general combiner whereas male parents G-27, DLSA-16, DLSA-202, PA-405, PA-464 and LD-853 showed significant negative GCA effects.

The SCA effects of hybrids are presented in **Table 3**. The positive significant specific combining ability effects for seed cotton yield (kg/ha) were predicted from DS-5 x G-27, DS-5 x DLSA-202, DS-5 x PAIG-8/1, DS-5 x PA-405, DS-5 x PA-464, CISA-2 x DLSA-17, CISA-2 x DLSA-8, CISA-2 x LD-853 and CISA-2 x LD-733 cross combinations while negative significant SCA effects were predicted from DS-5 x DLSA-17, DS-5 x DLSA-8, DS-5 x LD-853, DS-5 x LD-733, CISA-2 x G-27, CISA-2 x DLSA-202, CISA-2 x PAIG-8/1, CISA-2 x PA-405, CISA-2 x PA-464 cross combinations. For plant height positive significant specific combining ability effects were expressed by crosses DS-5 x G-27, DS-5 x DLSA-202, DS-5 x PAIG-8/1, DS-5 x PA-464, DS-5 x PA-496, CISA-2 x DLSA-16, CISA-2 x DLSA-17, CISA-2 x PA-304, CISA-2 x LD-713 and CISA-2 x LD-853 while negative significant SCA effects were predicted from DS-5 x DLSA-16, DS-5 x DLSA-17, DS-5 x PA-304, DS-5 x LD-713, DS-5 x LD-853, CISA-2 x G-27, CISA-2 x DLSA-202, CISA-2 x PAIG-8/1, CISA-2 x PA-464 and CISA-2 x PA-496. For boll number, DS-5 x G-27, DS-5 x LD-853, DS-5 x LD-733, CISA-2 x PA-464 and CISA-2 x PA-496, the crosses had positive and significant estimates for SCA effects while negative significant SCA effects were predicted from

Table 2. Mean performance and general combining ability (GCA) effects for seed cotton yield, its components traits and fibre quality parameters in *Gossypium arboreum* in 16 lines and 28 hybrids

Entry	Seed cotton yield (kg/ha)		Plant height (cm)		Bolls/ Plant		Boll weight (g)		GOT (%)		2.5% Span length (cm)		MIC		Fibre strength (g/tex)	
Lines	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA
DS 5	1,711.53	-18.23	174.3	-4.76	36.2	-3.10	2.3	-0.004	36.2	0.574	24.1	-0.313	6.5	0.142	19.4	-0.463
CISA 2	1,915.17	18.23	186.9	4.76	43.2	3.10	2.3	0.004	35.7	-0.574	24.3	0.313	5.8	-0.142	20.2	0.463
SE±	23.824		6.046		1.468		0.066		0.304		0.134		0.067		0.147	
Testers																
G-27	1755.97	365.50**	180.8	13.3**	37.7	12.02**	2.3	0.01	36.2	0.73**	23.3	-1.92**	6.7	0.70**	18.8	-1.30**
DLSA-16	1413.68	-9.72	163.6	-29.43**	37.1	-6.18**	2.4	-0.16**	37.0	-0.22**	23.8	0.01	7.2	0.21**	17.6	-0.95**
DLSA-202	1207.27	-38.09**	164.2	-5.33**	21.3	2.47**	1.9	0.04**	31.3	0.81**	24.5	0.53**	5.8	0.25**	18.8	-0.03
DLSA-17	1327.62	185.98**	195.0	15.48**	37.0	-4.43**	2.1	0.11**	33.7	-0.70**	25.0	1.45**	6.1	-0.29**	19.7	1.25**
PAIG-8/1	1262.07	-2.92	166.8	-10.37**	34.0	4.21**	2.6	0.21**	36.5	-0.19**	24.4	-0.04	6.6	0.05**	17.1	0.45**
DLSA-8	1276.05	143.06**	179.9	13.25**	35.6	0.34	2.0	-0.19**	32.9	0.75**	25.6	0.2**	5.6	-0.57**	20.5	0.17**
PA-255	1342.42	-279.54**	176.5	17.53**	32.3	-1.28**	2.5	-0.09**	33.7	0.50**	25.5	0.40**	6.2	-0.89**	19.7	0.30**
PA-304	1373.72	-310.57**	185.2	23.88**	31.4	-4.80**	2.4	-0.08**	37.4	0.31**	23.9	-0.97**	6.5	0.13**	19.3	0.17**
PA-405	1419.20	-268.22**	204.0	8.15**	40.4	0.12	2.2	0.16**	35.1	1.23**	25.2	-1.62**	6.1	0.28**	20.6	-0.43**
PA-464	1238.61	-265.89**	160.2	-19.9**	41.1	2.82**	2.4	0.09**	35.1	0.45**	20.0	0.56**	8.2	-0.17**	17.1	-0.13**
PA-496	1278.35	363.78**	161.7	16.27**	40.5	6.87**	2.2	-0.06**	34.5	-0.37**	23.9	0.16**	6.7	-0.24**	18.3	0.85**
LD-713	1737.40	64.81**	180.3	10.9**	36.7	-4.80**	1.9	-0.18**	39.1	0.50**	22.6	1.08**	6.8	-0.04*	16.5	0.85**
LD-853	1749.50	28.81**	176.3	-38.7**	37.7	-2.43**	2.0	-0.09**	39.2	-2.62**	22.6	-0.84**	6.7	0.2**	16.5	-1.22**
LD-753	1623.92	23.01**	194.5	-15.03**	40.9	-4.95**	2.5	0.23**	44.3	-1.19**	25.5	0.10**	5.7	0.38*	19.1	0.018
SE±	6.608		1.677		0.407		0.018		0.084		0.037		0.019		0.041	
Lines x Testers																
DS 5 x G- 27	1889.93		202.0		54.2		2.3		38.4		20.3		7.1		16.2	
DS 5 x DLSA-16	1402.80		125.7		19.6		2.0		36.3		22.2		6.8		15.9	
DS 5 x DLSA-202	1648.87		176.4		38.5		2.1		38.1		23.2		6.7		17.6	
DS 5 x DLSA-17	1554.87		216.1		24.6		2.4		37.4		24.0		6.3		18.5	
DS 5x PAIG-8/1	1670.13		180.1		43.3		2.5		37.5		22.9		6.5		19.0	
DS 5 x DLSA-8	1502.17		217.5		33.0		1.9		37.9		22.5		6.5		18.0	
DS 5 x PA-255	1172.07		219.7		32.7		2.1		39.8		23.4		6.2		17.5	
DS 5 x PA-304	1136.97		237.6		23.6		2.1		39.5		22.5		6.7		18.1	
DS 5 x PA-405	1288.77		204.1		30.4		2.3		37.1		20.6		6.8		17.0	
DS 5 x PA-464	1233.43		185.3		40.7		1.9		38.7		23.7		6.3		17.9	
DS 5 x PA-496	1761.40		211.8		42.8		1.9		39.4		22.0		6.3		18.0	
DS 5 x LD-713	1487.97		209.5		24.4		2.0		39.4		23.1		6.5		18.1	
DS 5 x LD-853	1254.00		123.0		22.1		2.3		36.0		21.2		7.0		16.4	
DS 5 x LD-733	1101.23		152.2		28.2		2.5		38.1		23.4		6.9		17.7	
CISA 2 x G-27	1749.63		214.3		41.5		2.0		38.1		21.5		7.2		17.2	
CISA 2 x DLSA-16	1486.30		205.1		39.7		2.0		38.4		23.5		6.5		18.3	
CISA 2 x DLSA-202	1183.50		202.6		38.1		2.3		38.6		23.5		6.7		18.3	
CISA 2 x DLSA-17	1725.63		204.5		38.2		2.2		36.2		24.6		6.1		20.1	
CISA 2 x PAIG-8/1	1232.57		188.9		36.8		2.3		37.2		22.7		6.5		18.0	
CISA 2 x DLSA-8	1692.50		198.7		39.3		2.0		38.7		23.5		5.3		18.4	
CISA 2 x PA-255	1177.40		205.0		36.4		2.0		36.3		23.0		5.0		19.2	
CISA 2 x PA-304	1150.43		199.8		38.4		2.1		36.2		21.2		6.5		18.3	
CISA 2 x PA-405	1083.33		201.9		41.5		2.3		40.4		21.8		6.7		18.2	
CISA 2 x PA-464	1143.33		164.6		36.6		2.6		37.2		23.1		6.3		17.8	
CISA 2 x PA-496	1874.68		210.4		42.6		2.3		34.9		23.9		6.2		19.8	
CISA 2 x LD-713	1550.20		202.0		37.7		2.0		36.7		24.7		6.4		19.7	
CISA 2 x LD-853	1712.18		189.3		44.7		1.9		33.8		22.7		6.4		17.2	
CISA 2 x LD-733	1853.33		207.4		33.6		2.2		34.6		24.2		6.8		18.3	
Overall Mean	1462.55		188.8		36.0		2.2		37.0		23.3		6.5		18.3	
CD (5%)	96.91		24.59		5.97		0.27		1.24		0.55		0.27		0.60	

*P=0.05, **P=0.01 respectively

DS-5 x PA-464, DS-5 x PA-496, CISA-2 x G-27, CISA-2 x LD-853 and CISA-2 x LD-733. The positive significant specific combining ability effects for boll wt (g) were predicted from DS-5 x PA-255, DS-5 x PA-304, DS-5 x PA-496, DS-5 x LD-713, DS-5 x LD-733, CISA-2 x DLSA-16, CISA-2 x DLSA-202, CISA-2 x DLSA-8 and CISA-2 x PA-405 cross combinations while negative significant SCA effects were predicted from DS-5 x DLSA-16, DS-5 x DLSA-202, DS-5 x DLSA-8, DS-5 x PA-405, CISA-2 x PA-255, CISA-2 x PA-304, CISA-2 x PA-496, CISA-2 x LD-713 and CISA-2 x LD-733 cross combinations. In case of GOT cross combinations DS-5 x PAIG-8/1, DS-5 x PA-255, DS-5 x PA-304, DS-5 x PA-464, CISA-2 x G-27, CISA-2 x DLSA-16, CISA-2 x PA-496, CISA-2 x LD-713 and CISA-2 x LD-853 recorded significant positive SCA effects while negative and significant SCA effects were showed by DS-5 x G-27, DS-5 x DLSA-16, DS-5 x PA-

496, DS-5 x LD-713, DS-5 x LD-853, CISA-2 x PAIG-8/1, CISA-2 x PA-255, CISA-2 x PA-304 and CISA-2 x PA-464 cross combinations. The cross combinations DS-5 x DLSA-8, DS-5 x PA-255, DS-5 x LD-853, CISA-2 x G-27 and CISA-2 x PA-464 showed positive and significant SCA effects for 2.5% span length, while DS-5 x G-27, DS-5 x PA-464, CISA-2 x DLSA-8, CISA-2 x PA-255, CISA-2 x LD-853 showed negative and significant SCA effects. For cotton fibre fineness (micronaire value), negative SCA effects are desirable as lower the micronaire value fine will be the cotton fibre, negative and significant SCA effects were obtained from DS-5 x G-27, DS-5 x DLSA-202, DS-5 x PAIG-8/1, DS-5 x PA-464, DS-5 x PA-496, DS-5 x LD-733, CISA-2 x DLSA-8, CISA-2 x PA-255 and CISA-2 x LD-853 cross combinations while undesirable that is positive and significant estimates for SCA effects were predicted from DS-5 x DLSA-8, DS-5 x PA-255,

Table 3. Specific combining ability effects for seed cotton yield, its components traits and fibre quality parameters in *Gossypium arboreum* hybrids.

Crosses	Seed Cotton Yield	Plant height	Bolls/ Plant	Boll weightt	GOT (%)	2.5% Span length	MIC	Fibre strength
DS 5 x G-27	88.36**	9.49**	0.17**	-0.44	-0.29**	-0.20**	-0.05	-0.05
DS 5 x DLSA-16	-23.52	-6.95**	-0.03	-1.62**	-0.32**	0.01	-0.73**	-0.74**
DS 5 x DLSA-202	250.91**	3.34**	-0.06	-0.86**	0.19	-0.12*	0.11	0.11
DS 5 x DLSA-17	-67.15**	-3.66**	0.10*	0.03	0.01	-0.05	-0.33**	-0.34**
DS 5x PAIG-8/1	237.01**	6.34**	0.10*	-0.42	0.43**	-0.12*	0.96**	0.96**
DS 5 x DLSA-8	-76.94**	-0.06	-0.06	-0.99**	-0.20	0.49**	0.28*	0.28*
DS 5 x PA-255	15.56	1.29	0.03	1.16**	0.49**	0.44**	-0.38**	-0.38**
DS 5 x PA-304	11.50	-4.29**	-0.01	1.07**	0.93**	-0.07	0.38**	0.38**
DS 5 x PA-405	120.95**	-2.48*	-0.01	-2.24**	-0.25*	-0.05	-0.15	-0.15
DS 5 x PA-464	63.28**	5.18**	-0.34**	0.17	0.59**	-0.14**	0.51**	0.51**
DS 5 x PA-496	-38.42	3.20**	-0.23**	1.69**	-0.63**	-0.11*	-0.43**	-0.43**
DS 5 x LD-713	-12.89	-3.53**	-0.01	0.76**	-0.45**	-0.07	-0.34**	-0.33**
DS 5 x LD-853	-210.85**	-8.23**	0.20**	0.51*	-0.44**	0.15**	0.03	0.03
DS 5 x LD-733	-357.82**	0.39	0.15**	1.17**	-0.07	-0.12*	0.16	0.16
CISA 2 x G-27	-88.36**	-9.49**	-0.17**	0.44	0.29**	0.21**	0.05	0.05
CISA 2 x DLSA-16	23.52	6.94**	0.03	1.62**	0.32**	-0.01	0.73**	0.74**
CISA 2 x DLSA-202	-250.91**	-3.33**	0.06	0.85**	-0.20	0.12*	-0.11	-0.11
CISA 2 x DLSA-17	67.15**	3.66**	-0.10	-0.02	-0.01	0.06	0.33**	0.34**
CISA 2 x PAIG-8/1	-237.01**	-6.33**	-0.10*	0.42	-0.43**	0.12*	-0.96**	-0.96**
CISA 2 x DLSA-8	76.94**	0.06	0.06*	0.99**	0.20	-0.49**	-0.28*	-0.28*
CISA 2 x PA-255	-15.56	-1.28	-0.03	-1.16**	-0.49**	-0.44**	0.39**	0.39**
CISA 2 x PA-304	-11.50	4.29**	0.01	-1.07**	-0.93**	0.07	-0.38**	-0.38**
CISA 2 x PA-405	-120.95**	2.48*	0.01	2.24**	0.25*	0.06	0.15	0.15
CISA 2 x PA-464	-63.28**	-5.19**	0.34**	-0.17	-0.59**	0.14**	-0.51**	-0.51**
CISA 2 x PA-496	38.42	-3.20**	0.23**	-1.69**	0.63**	0.11*	0.43**	0.44**
CISA 2 x LD-713	12.89	3.53**	0.01	-0.76**	0.45**	0.07	0.33**	0.34**
CISA 2 x LD-853	210.85**	8.23**	-0.20**	-0.51*	0.43**	-0.16**	-0.03	-0.03
CISA 2 x LD-733	357.82**	-0.38	-0.15**	-1.18**	0.07	0.12*	-0.16	-0.16
SE±	23.824	1.47	0.07	0.30	0.13	0.07	0.15	0.15

*P=0.05, **P=0.01 respectively

DS-5 x LD-853, CISA-2 x G-27 and CISA-2 x PA-464 cross combinations. The crosses DS-5 x PAIG-8/1, DS-5 x PA-304, DS-5 x PA-464, CISA-2 x DLSA-16, CISA-2 x DLSA-17, CISA-2 x PA-255, CISA-2 x PA-496 and CISA-2 x LD-713 had positive and significant SCA effects for fibre strength while DS-5 x DLSA-16, DS-5 x DLSA-17, DS-5 x PA-255, DS-5 x PA-496, DS-5 x LD-713, CISA-2 x PAIG-8/1, CISA-2 x PA-304 and CISA-2 x PA-464 showed negative GCA effect.

Testers (T) contributed more to the total sum squares for all the traits studied. The contribution of lines (L) was

lower to the testers and line x testers (LxT) interaction for all the traits under study. The contribution due to lines was the least except fibre strength. The contribution of line x tester was greater than lines for all the traits and for boll wt and GOT (%) in case of testers (Table 4). These results showed that testers and the interaction line x testers brought many variation in the expression of the studied traits. The concomitant significance of mean squares due to lines, testers and lines x testers for all the traits suggested that both additive and non-additive types of gene actions were involved in the genetic control of the characters.

Table 4. Proportional (%) contribution of lines, testers and lines x testers to total hybrids variation in *Gossypium arboreum*.

	Seed cotton yield	Plant height	Bolls/ Plant	Boll weight	GOT (%)	2.5% Span length	MIC	Fibre strength
Lines (L)	0.474	3.387	16.02	0.03	13.15	7.98	9.26	22.69
Testers (T)	65.78	53.83	42.74	46.43	37.24	75.79	70.90	57.71
L x T	33.75	42.78	41.24	53.54	49.61	16.22	19.84	19.59

The present study based on line x tester mating design analysis utilizing the GMS (Genetic Male Sterility) system in cotton revealed that additive variances were significant for 2.5% span length, fineness and fibre strength and non-additive as well as additive gene effects for seed cotton yield, plant height, boll number, boll weight and ginning percentage. GCA was significant for male parents G-27, DLSA-17, DLSA-8, PA-496, LD-713, LD-853 and LD-733 for seed cotton yield; G-27, DLSA-17, DLSA-8, PA-255, PA-304, PA-405, PA-496 and LD-713 for plant height; G-27, DLSA-202, PAIG-8/1, PA-464 and PA-496 for bolls per plant; DLSA-202, DLSA-17, PAIG-8/1, PA-405 and PA-464 and LD-733 for boll weight; G-27, DLSA-202, DLSA-8, PA-255, PA-304, PA-405, PA-464 and LD-713 for ginning outturn (GOT%); DLSA-202, DLSA-17, DLSA-8, PA-255, PA-464, PA-496, LD-713 and LD-733 for 2.5% span length; DLSA-17, DLSA-8, PA-255, PA-464, PA-496 and LD-713 for lower micronaire value having fineness and DLSA-17, PAIG-8/1, DLSA-8, PA-255, PA-304, PA-496 and LD-713 for fibre strength. These all considered to be a good general combiner for seed cotton yield, boll no, boll wt, 2.5% span length and fibre strength. Similarly among 28 cross combinations, SCA was positively significant for 9 crosses for seed cotton yield, 11 crosses for boll number, 8 crosses for boll weight, 10 crosses for 2.5% span length, 9 crosses for micronaire value and 9 crosses for fibre strength.

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