



Combining ability estimates for yield and quality characters of parents and crosses based on genetic male sterility in cotton (*Gossypium hirsutum*)

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Cotton (*Gossypium hirsutum* L) is an important industrial crop of India, providing raw material for the textile industry of the country. All the four cultivated species, *Gossypium hirsutum*, *G. barbadense*, *G. arboreum*, *G. herbaceum*, are grown in India. But for the establishment of a gene bank with global accessions of the four cultivated species has facilitated genetic improvement of cotton in India. Genetic control of the economic traits has been studied by biometrical approaches, particularly the line \times tester analysis (Tuteja and Verma 2011). Plant breeders also rely on genetic variation between parents to create unique gene combinations necessary for new superior cultivars. Genetically distant parents should be used in the cotton improvement program for higher yield and best fiber quality. The line \times tester analysis method can be used to estimate general and specific combining abilities in both self and cross-pollinated plants (Kempthorne 1957). Line \times tester analysis provides for the detection of appropriate parents and crosses superior in terms of the characters. So application of the analysis has been widely used by plant breeders to selection in early generations (Ahuja and Dhayal 2007, Tuteja and Banga 2011). Besides elucidating the nature and magnitude of gene action involved in the inheritance of these characters, combining ability analysis also provides useful information for selecting high order parents for effective breeding strategy. Therefore, keeping in view the importance of combining ability of parents for various plant characters in cotton, a line \times tester set of 15 parents involving five genetic male sterile lines and ten male parents of upland cotton was studied for gene action and combining ability estimates.

The experimental material utilized for the present study, consisted of 10 male parents RS 810, RS 2013, CNH 911, 0238DA, 001NAH, 002-NAH, 005-NAH, F 1861, LH 2076, Biyani 161 and 5 female GMS lines, viz GMS 4, GMS 16,

GMS 20, GMS 26, GMS 27 and crossed in a line \times tester design at the Central Institute for Cotton Research, Regional Station, Sirsa in 2008-09. 15 parents and 50 crosses were grown in a Randomized Block Design (RBD) with 2 replications and crop geometry of 100 cm \times 60 cm. Five random plants were selected to record the data on number of monopods, number of sympods, number of bolls/plant and boll weight. The data on seed cotton yield was recorded on per plot of 10.8m² basis and converted to kg/ha basis. All the seed cotton samples were cleaned and ginned carefully in laboratory for estimation of ginning percentage and analyzed for fiber quality parameters, viz. 2.5% span length, Micronaire value, tenacity and fiber maturity 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 OPSTAT computer program which was developed by Chaudhary Charan Singh Haryana Agriculture university, Hisar.

The analysis of variance (Table 1) indicated that the mean squares of genotypes for all the characters investigated were significantly different, indicating the presence of variability among hybrids and their parents. Hence, later 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 seed cotton yield, ginning percentage, boll weight, number of monopods, number of sympods, 2.5% span length, fibre maturity and fibre strength except fibre fineness which reflects the role of non-additive type of gene action (dominant or epistatic), which is in accordance with the previous results of Ahuja and Dhayal (2007) and Cetin Karademir *et al.* (2009). However, General combining ability variance (σ^2 GCA) was higher than SCA variance (σ^2 SCA) for fibre fineness which reflects the role of additive type of gene action (Table 1). The results are similar with the findings of Rauf *et al.* (2006) and Cetin Karademir *et al.* (2009) who studied the conventional cross

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Table 1 Analysis of variance for line x tester and combining ability for yield and quality characters in cotton

Source	D F	Seed cotton yield (kg/ha)	No. of monopodia	No. of sympodia	No. of bolls/plant	Boll weight (g)	Ginning out turn (%)	2.5% span length (mm)	Maturity coefficient	Micronaire value	Fibre strength (g/tex)
Replication	1	17,008.99*	0.10*	10.69**	1.80*	0.03*	0.22*	1.18**	0.13**	0.48**	0.49**
Genotypes	64	285828.21**	3.07**	7.30**	86.08**	0.48**	4.67**	0.56**	0.88**	0.02*	0.20**
Parents	14	131615.30**	3.59**	15.94**	141.30**	0.28**	4.97**	0.41**	0.97**	0.03*	0.15**
Parents vs Hybrids	1	192825.87	2.52	10.16	18.63	1.06	10.79	1.93	1.76	0.00	0.54
Hybrids	49	331787.05**	2.93**	4.77**	71.68**	0.52**	4.45**	0.58**	0.84**	0.02*	0.21**
GCA (Lines)	4	1,611588.23**	5.97**	1.96**	156.64*	2.81**	10.63**	0.71**	0.83**	0.01*	0.28*
GCA (Tester)	9	264123.67**	3.08**	6.41**	48.22**	0.46**	6.72**	1.47**	0.94**	0.05*	0.49**
SCA (Line x Tester)	36	206502.76**	2.55**	4.66**	68.10**	0.29**	3.20**	0.34**	0.81**	0.02*	0.14**
Error	64	16309.80**	0.06	1.43*	5.26**	0.03	0.40	0.09	0.05	0.03	0.04
σ^2 GCA		48756.88	0.13	-0.03	2.28	0.09	0.36	0.05	0.00	0.001	0.01
σ^2 SCA		94852.04	1.24	1.64	31.35	0.12	1.39	0.12	0.38	-0.01	0.04
σ^2 GCA/ σ^2 SCA		0.51	0.10	-0.01	0.07	0.71	0.26	0.40	0.01	-0.0	0.32

* $P=0.05$, ** $P=0.01$ respectively

combinations.

The GCA effects of parents are presented in Table 2. Estimates for GCA effects for seed cotton yield, the male parents RS 2013, CNH 911, 0238 DA and F 1861 and female parents GMS 4, GMS 26 showed significant positive GCA effects, whereas other parents 001NAH, 002NAH, 005NAH, GMS 16 and GMS 20 showed negative GCA effects. For seed cotton yield improvement, the male parents RS 2013, CNH 911, 0238-DA, F 1861 and female parents GMS 4 and GMS 26 appeared to be a good general combiner. For number of monopodia, the male parents CNH 911, 005NAH and female parents GMS 4 showed the positive and significant GCA effects while RS 810, RS 2013, 0238 DA, GMS 16, GMS 26 showed the negative and significant GCA effects and for sympodial branches only one male parent 001 NAH had the positive and significant GCA effects while other parents 0238 DA, Biyani 161, GMS 16 showed negative and significant value for GCA effect. For number of bolls/plant the male parents RS 810, 005-NAH and the female parent GMS 27 exhibit positive and significant GCA effect and parents 0238 DA, LH 2076, Biyani 161, GMS 16 showed negative and significant value for GCA effect. Similarly, for boll weight, among the 15 only 3 parents CNH 911, 0238 DA, GMS 4 had the significant and positive GCA effects while RS 810, RS 2013, GMS 16, GMS 20 parents showed negative and significant GCA effect. The male parents 0238-DA, 001-NAH, Biyani 161 and the GMS lines GMS 26, GMS 27 had the significant and positive GCA effects for ginning percentage while the negative and significant GCA for ginning percentage were observed from RS 810, RS 2013, 005-NAH, F 1861, GMS 16. For ginning percentage male parents 0238 DA, 001-NAH, Biyani 161 and female parents GMS 26, GMS 27 appeared to be a good general combiner.

The parents CNH 911, 0238 DA, 002 NAH, 005 NAH, GMS 20 showed positive and significant GCA effects for 2.5% span length and were considered to be good general combiner while the negative and significant GCA for 2.5% span length were observed from RS 810, RS 2013, F 1861, Biyani 161, GMS 27. Likewise, parental lines RS 810, RS 2013, CNH 911, F 1861 and GMS 4 seems to be good combiners for fibre maturity and 002 NAH, 005NAH, GMS 16 for fibre strength (g/tex). None of the male and female parents showed significant estimates of GCA for fiber fineness. But the male parents RS 810, RS 2013, 0238-DA, 002-NAH, 005-NAH, Biyani 161 and female parents GMS 4, GMS 20, GMS 26 showed negative GCA effect which is desirable for improvement of Micronaire value.

The positive significant specific combining ability effects for seed cotton yield were predicted from GMS 4 \times 002 NAH, GMS 4 \times F 1861, GMS 4 \times LH 2076, GMS 16 \times 0238 DA, GMS 16 \times 001 NAH, GMS 16 \times 005 NAH, GMS 16 \times Biyani 161, GMS 20 \times RS 2013, GMS 20 \times 001 NAH, GMS 20 \times 005 NAH, GMS 26 \times CNH 911, GMS 26 \times 002 NAH,

Table 2 General combining ability effects of parents for yield and quality characters in cotton

Parents	Seed cotton yield (kg/ha)	No. of monopodia	No. of sympodia	No. of boll/plant	Boll weight (g)	Ginning out turn (%)	2.5% span length (mm)	Maturity coefficient	Micronaire value	Fibre strength (g/tex)
RS 810	44.290	-0.404**	-0.023	1.656*	-0.241**	-1.016**	-0.460**	0.290**	-0.018	-0.280**
RS 2013	171.990**	-0.564**	0.217	-1.144	-0.317**	-0.516*	-0.340**	0.290**	-0.062	0.010
CNH 911	103.190*	1.026**	-0.153	1.346	0.422**	-0.216	0.266*	0.190*	0.106	-0.001
0238 DA	147.290**	-0.564**	-1.473**	-2.404**	0.244**	0.534*	0.476**	-0.410**	0.024	-0.220**
001 NAH	-303.810**	-0.174	1.147*	1.316	-0.107	0.834**	-0.080	-0.010	0.096	0.080
002 NAH	-192.810**	0.116	0.317	1.256	-0.058	0.344	0.246*	-0.210*	-0.024	0.230**
005 NAH	-98.010*	0.906**	0.657	3.236**	0.013	-0.716**	0.610**	-0.510**	-0.114	0.439**
F 1861	176.590**	-0.004	0.427	0.426	0.062	-1.016**	-0.470**	0.390**	0.046	-0.240**
LH 2076	10.090	-0.164	0.107	-1.944*	0.001	0.384	-0.040	-0.110	0.066	0.043
Biyani 161	-58.810	-0.174	-1.223**	-3.744**	-0.019	1.384**	-0.210*	0.090	-0.074	-0.060
SE	38.883	0.083	0.354	0.697	0.059	0.191	0.092	0.071	0.063	0.063
GMS 4	367.940**	0.861**	0.032	0.041	0.602**	0.134	0.065	0.240**	-0.036	0.019
GMS 16	-377.310**	-0.174*	-0.498*	-4.699**	-0.426**	-1.261**	0.078	-0.060	0.001	0.156*
GMS 20	-152.760**	0.001	-0.013	1.146	-0.125*	0.134	0.218*	0.040	-0.004	0.060
GMS 26	144.690**	-0.649**	0.362	0.816	0.003	0.434*	-0.082	-0.310**	-0.003	-0.095
GMS 27	17.440	-0.039	0.117	2.696**	-0.053	0.559*	-0.280*	0.090	0.042	-0.140*
SE	25.922	0.055	0.236	0.465	0.039	0.127	0.061	0.048	0.042	0.042

* P=0.05, ** P=0.01 respectively

GMS 26 × LH 2076, GMS 27 × RS 810, GMS 27 × RS 2013, GMS 27 × 0238 DA cross combinations, while negative SCA effect were predicted from GMS 4 × RS 810, GMS 4 × RS 2013, GMS 4 × 005 NAH, GMS 4 × Biyani 161, GMS 16 × RS 810, GMS 16 × RS 2013, GMS 16 × CNH 911, GMS 16 × F 1861, GMS 16 × LH 2076, GMS 20 × 002 NAH, GMS 20 × LH 2076, GMS 20 × Biyani 161, GMS 26 × 0238 DA, GMS 26 × 001 NAH, GMS 27 × 001 NAH, GMS 27 × 002 NAH, GMS 27 × 005 NAH cross combinations.

For number of monopodial branches, 18 crosses had positive and significant estimates for SCA effects, the maximum being in case of GMS 4 × 001 NAH, GMS 16 × CNH 911, GMS 16 × 002 NAH, GMS 27 × 0238 DA, GMS 27 × LH 2076. Similarly, 6 cross combinations exhibited positive and significant estimates for SCA effects for number of sympodial branches GMS 16 × CNH 911, GMS 16 × F 1861, GMS 16 × LH 2076, GMS 20 × 005 NAH, GMS 26 × 0238 DA, GMS 27 × Biyani 161 while negative and significant SCA effect were showed by GMS 4 × CNH 911, GMS 16 × 0238 DA, GMS 16 × 005 NAH, GMS 16 × Biyani 161, GMS 20 × RS 2013, GMS 20 × Biyani 161, GMS 27 × F 1861, GMS 27 × LH 2076 cross combinations.

For boll/plant positive and significant SCA effects were predicted from GMS 4 × 0238 DA, GMS 4 × 005 NAH, GMS 4 × F 1861, GMS 4 × Biyani 161, GMS 16 × CNH 911, GMS 16 × 002 NAH, GMS 20 × RS 810, GMS 20 × RS 2013, GMS 20 × LH 2076, GMS 26 × CNH 911, GMS 26 × 001 NAH, GMS 26 × Biyani 161, GMS 27 × 0238 DA while negative and significant SCA effects were predicted from GMS 4 × RS 810, GMS 4 × CNH 911, GMS 4 × 001 NAH, GMS 4 × LH 2076, GMS 16 × 0238 DA, GMS 16 × 001 NAH, GMS 16 × Biyani 161, GMS 20 × CNH 911, GMS 20 × 0238 DA, GMS 20 × 002 NAH, GMS 26 × RS 2013, GMS 26 × 002 NAH, GMS 26 × LH 2076, GMS 27 × 002 NAH, GMS 27 × F 1861, GMS 27 × LH 2076. The cross combinations GMS 4 × 0238 DA, GMS 4 × F 1861, GMS 4 × Biyani 161, GMS 16 × RS 810, GMS 16 × CNH 911, GMS 16 × LH 2076, GMS 20 × RS 810, GMS 20 × F 1861, GMS 26 × RS 2013, GMS 26 × 0238 DA, GMS 27 × CNH 911, GMS 27 × 002 NAH, GMS 27 × 005 NAH showed positive and significant SCA effect for boll weight, while GMS 4 × RS 810, GMS 4 × RS 2013, GMS 4 × CNH 911, GMS 16 × 0238 DA, GMS 16 × 002 NAH, GMS 16 × F 1861, GMS 20 × 002 NAH, GMS 20 × LH 2076, GMS 26 × 001 NAH, GMS 26 × Biyani 161, GMS 27 × RS 810, GMS 27 × 0238 DA, GMS 27 × F 1861 showed negative and significant SCA effect.

For ginning percentage, positive and significant SCA effect were predicted from GMS 4 × 005 NAH, GMS 4 × LH 2076, GMS 4 × Biyani 161, GMS 16 × CNH 911, GMS 16 × 0238 DA, GMS 16 × 002 NAH, GMS 20 × 001 NAH, GMS -20 × LH 2076, GMS 20 × Biyani 161, GMS 26 × RS 810, GMS 26 × 002 NAH, GMS 27 × RS 2013, GMS 27 × 0238

Table 3 Crosses with high SCA for seed cotton yield and its component traits in cotton

Hybrids/cross	Seed cotton yield (kg/ha)	No. of monopodia	No. of sympodia	No. of bolls/plant	Boll weight (g)	GOT (%)	2.5% span length (mm)	Maturity coefficient	Micronaire value	Bundle strength (g/tex)
GMS 4 × 002 NAH	389.36**	0.06	-1.23	-0.92	0.18	0.55	-0.27	0.36*	0.00	-0.45**
GMS 4 × F 1861	362.96**	-0.31*	0.15	3.10*	0.23*	0.41	0.24	-0.24	-0.01	0.06
GMS 4 × LH 2076	553.96**	-1.10**	-0.52	-2.72*	0.19	0.76*	0.41*	-0.74**	0.11	-0.01
GMS 16 × 0238 DA	230.01**	-0.86*	-3.06**	-9.52**	-0.25*	0.76*	0.33	-0.64**	-0.18	0.004
GMS 16 × 001 NAH	411.61**	-1.10**	-0.53	-5.24**	0.10	0.46	0.09	0.46**	-0.00	0.004
GMS 16 × 005 NAH	156.81*	-0.68**	-2.04**	-2.31	-0.19	-1.23**	-0.14	-0.54**	-0.09	-0.34**
GMS 16 × Biyani 161	362.61**	-0.25	-2.31**	-5.33**	0.08	-0.33	0.97**	0.36*	-0.08	0.49**
GMS 20 × RS 810	108.46	0.64**	0.15	6.27**	0.24*	-0.58	0.18	0.06	0.06	0.26*
GMS 20 × RS 2013	422.76**	0.80**	-1.58*	4.72**	-0.005	-0.33	0.06	0.06	-0.13	-0.38**
GMS 20 × CNH 911	147.56	-0.48**	-0.36	-8.26**	-0.07	0.36	0.00	0.16	-0.00	-0.32**
GMS 20 × 001 NAH	187.06*	0.71*	-0.51	0.91	0.18	0.81*	-0.49**	0.36*	-0.09	-0.05
GMS 20 × 005 NAH	201.76**	-0.66**	1.82**	-2.15	0.10	0.36	0.51**	-1.14**	0.06	-0.15
GMS 26 × CNH 911	267.61**	-0.13	0.70	3.21*	-0.12	-1.18**	-0.09	0.51**	0.09	0.08
GMS 26 × 002 NAH	219.61**	0.57**	-0.91	-4.34**	-0.14	2.75**	0.17	-2.09**	-0.12	-0.09
GMS 26 × 005 NAH	100.31	0.98**	-0.70	-0.82	-0.21	0.56	-0.28	0.21	0.01	0.49**
GMS 26 × LH 2076	262.21**	-1.44**	0.29	-4.64**	0.20	-0.28	-0.08	0.31*	0.03	-0.15
GMS 27 × RS 810	478.26**	-1.81**	0.17	-1.97	-0.23*	-0.25	-0.07	0.01	-0.04	0.16
GMS 27 × RS 2013	399.56**	-0.50**	0.28	1.67	0.01	1.49**	-0.04	0.01	-0.00	0.12
GMS 27 × 0238 DA	326.26**	1.49**	-0.528	8.63**	-0.66**	0.94*	-0.20	-0.79**	0.02	-0.15
GMS 27 × Biyani 161	114.86	0.60**	2.72**	-2.57	0.02	0.34	-0.57**	0.21	0.12	-0.36**
SE	77.76	0.16	0.70	1.39	0.11	0.38	0.18	0.14	0.12	0.12

$P=0.05$, ** $P=0.01$ respectively

DA, GMS 27 × 001NAH cross combinations while negative and significant SCA effect were obtained from GMS 4 × 0238 DA, GMS 4 × 001 NAH, GMS 16 × 005 NAH, GMS 16 × LH 2076, GMS 20 × 002 NAH, GMS 26 × RS 2013, GMS 26 × CNH 911, GMS 26 × Biyani 161, GMS 27 × 002 NAH, GMS 27 × 005 NAH cross combinations.

The crosses GMS 4 × LH 2076, GMS 16 × RS 2013, GMS 16 × Biyani 161, GMS 20 × 002 NAH, GMS 20 × 005 NAH, GMS 26 × 0238 DA, GMS 27 × CNH 911, GMS 27 × 002 NAH had positive and significant SCA effects for 2.5% span length while GMS 4 × Biyani 161, GMS 16 × RS 810, GMS 16 × 002 NAH, GMS 20 × 0238 DA, GMS 20 × 001 NAH, GMS 20 × LH 2076, GMS 26 × RS 2013, GMS 27 × Biyani 161 showed negative GCA effect. Seventeen cross combinations showed positive and significant SCA effects in terms of fibre maturity, the maximum SCA effects were observed from GMS 4 × 0238 DA, GMS 4 × 005 NAH, GMS 16 × 002 NAH, GMS 20 × 0238 DA GMS 20 × 002 NAH, GMS 26 × Biyani 161, GMS 27 × 005 NAH. For fiber strength, GMS 4 × RS 2013, GMS 16 × Biyani 161, GMS 20 × RS 810, GMS 20 × 002 NAH, GMS 26 × 005 NAH cross combinations showed positive and significant SCA effects while GMS 4 × 001 NAH, GMS 4 × 002 NAH, GMS 16 × 005, GMS 20 × RS 2013, GMS 20 × CNH 911, GMS 26 ×

RS 810, GMS 27 × Biyani 161 showed negative and significant SCA effect. However, 25 out of 50 cross combinations had negative specific combining ability for fibre fineness these hybrid combinations seems to be desirable for this traits.

SUMMARY

The present study based on genetic male sterility in cotton revealed that additive variances were significant only for fibre fineness and non-additive gene effects for seed cotton yield, ginning percentage, fibre length, maturity and strength. GCA was significant for male parents RS 2013, F 1861, 0238DA, CNH 911 and female parents GMS 4, GMS 26 for seed cotton yield, Parents 0238DA, 001NAH, Biyani 161, GMS 26, GMS 27 for ginning percentage and 0238DA, CNH 911, 002 NAH, 005 NAH, GMS 20 for 2.5% span length. Similarly, among 50 cross combinations, SCA was significant for 15 crosses, the maximum being in case of GMS 4 × LH 2076, GMS 16 × 001 NAH, GMS 20 × RS 2013, GMS 27 × RS 2013, GMS 27 × 0238 DA. These all were seem to be good general combiner for seed cotton yield, ginning percentage and fibre length.

REFERENCES

Ahuja S L and Dhayal L S. 2007. Combining ability estimates for

- yield and fibre quality traits in 4×13 line \times tester crosses of *Gossypium hirsutum*. *Euphytica* **153**: 87–8.
- Cetin Karademir, Emine Karadmir, Remzi Ekinici and Oktay Gencer. 2009. Combining ability estimates and heterosis for yield and fiber quality of cotton in line \times tester design. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca* **37**: 228–33.
- Kempthorne O. 1957. *An Introduction to Genetic Statistics*, pp 73–8. John Wiley and Sons Inc., New York.
- Rauf S, Hassan M, Shahzad M A B and Ergashev A. 2006. Combining ability analysis in upland cotton (*Gossypium hirsutum*) L. *International Journal of Agriculture and Biology* **8**: 341–3.
- Tuteja O P and Verma S K. 2011. Effect of alien cytoplasm and nuclear genes on seed cotton yield and fibre quality traits in cotton (*Gossypium hirsutum*). *Indian Journal of Agricultural Sciences* **81**: 314–20.
- Tuteja O P and Banga Manju. 2011. Effect of cytoplasm on heterosis for agronomic traits in upland cotton (*Gossypium hirsutum*). *Indian Journal of Agricultural Sciences* **81**: 1 001–07.