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Combining ability estimates and genetic variance for yield and quality traits of parents and crosses in upland cotton (*Gossypium hirsutum*)

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Cotton (*Gossypium hirsutum* L.) is an important fibre crop and plays a vital role as a cash crop in commerce of many countries such as USA, China, India, Pakistan, and Africa. Cotton crop is mainly cultivated for fibre. High seed cotton yield is the ultimate objective of any crop breeding program. Seed cotton yield is the end product of number of yield components such as boll number, boll weight etc. Seed cotton yield and its quality parameters are quantitative traits, which are controlled by several genes thus showing a range of values in segregating generation. Genetic control of economic traits has been studied by biometrical approaches, particularly the line×tester analysis (Tuteja and Verma 2011, Tuteja and Banga 2011 and 2013). As Line × tester analysis is one of the most widely used techniques for identification of genetic variation in characters. Besides elucidating the nature and magnitude of gene action involved in the inheritance of these characters, combining ability analysis provides an ample opportunity to cotton breeders to understand the basis on which certain parental lines could be exploited in the breeding programme. Therefore, keeping in view the importance of combining ability of parents for various plant characters in cotton, a line×tester was studied for gene action and combining ability estimates, for selecting the superior hybrids that can be used in breeding program.

The line × tester design used in the present study comprised 17 parents (4 lines namely GMS-26, GMS-20, GMS-27, GMS-17 and 13 testers SA 1017, SA 1422, SA 1652, MC 88, MC 127, SV 413, 358371, EC 128334, EC 138572, EC 141679, 359051, ND 163, CSH 3129, was undertaken at Central Institute for Cotton Research, Regional Station, Sirsa during the year 2012-13. Seventeen parents and fifty two crosses were grown in a Randomized Block Design (RBD) with three replications and also with a spacing of 100×60 cm between row to row and plant to plant respectively. Data were recorded on five competitive plants for seed cotton yield (kg/plot), number of monopods/plant, number of sympods/plant, number of bolls/plant, boll weight (g), ginning outturn (%), seed index (g), 2.5% span length (mm), Micronaire value (µg/inch), fibre strength (g/tex), The data on seed cotton yield was recorded on per plot basis and converted to kg/ha basis. The data were used for statistical analysis using the method developed by Kempthorne (1957).

The analysis of variance indicated that the mean squares due to genotypes for all the characters were significantly different, which revealed presence of genetic diversity among them. The mean squares due to parents and hybrids were significant for seed cotton yield (kg/ha), number of monopodia, sympodia/plant, number of bolls/plant, boll weight (g), GOT (%), seed index, 2.5% span length and fibre strength (g/tex) except Micronaire value. Similarly the interactions due to parents vs. hybrids were also significant for seed cotton yield, number of monopods, number of sympods/plant, number of bolls/plant, boll weight, ginning out turn, 2.5% span length and bundle strength except Micronaire value.

The variance due to GCA was lower than SCA for seed cotton yield, ginning per-centage, boll weight, number of bolls/plant, number of monopods and sympods, Micronaire value expressed non-additive gene action which is in accordance with the previous results of Ahuja and Dhayal (2007), Ilyas *et al. (*2007), and Cetin Karademir *et al.* (2009). However, General combining ability variance (σ^2 GCA) was higher than specific combining ability variance (σ^2 SCA) for fibre strength, which reflects the role of additive type of gene action. The results are in agreement with the findings of Rauf *et al.* (2006) and Cetin Karademir *et al.* (2009). Lukange *et al.* (2007) revealed additive gene effects for fibre strength and Micronaire value and non-additive gene action for fibre length. These results suggested that heterosis breeding was suitable for all the characters including fibre properties. The non-additive gene actions are also important for varietal adaptability.

The GCA effects of parents are presented in Table 1. Among the parents, the best general combiner was line GMS-20, GMS-26 and testers SA 1017, SA 1422, MC 88, SV 413 which recorded positive significant GCA effects for

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Table 1 General combining ability effects of parents for yield its components and quality characters in upland cotton

Parent	Seed cotton yield (kg/ha)	Number of monopods/ Plant	Number of sympods/ plant	Number of bolls/ plant	Boll weight (g)	GOT (%)	Seed Index	2.5% span length (mm)	Micronaire value	Fibre strength (g/tex)
SA 1017	217.141*	1.359*	0.263	1.122	0.044	0.200	-0.287*	-0.584	-0.208*	-0.178
SA 1422	351.974*	0.609*	-1.404*	-1.795	-0.031	0.092	-0.078	-0.526	0.317*	-0.728
SA 1652	51.391	-0.058	-0.321	-1.962	-0.106*	0.758*	-0.245*	0.166	0.267*	-0.019
EC 128334	-122.192*	-0.641*	-0.237	-4.212*	0.003	0.075	-0.353*	-0.159	-0.083	-0.378
EC 138572	-75.942*	0.192	0.513	-1.545	0.203*	-0.750*	0.055	0.541	-0.283*	1.347*
EC 141679	-187.109*	0.359	0.096	1.622	-0.006	0.633*	-0.337*	-0.676	-0.133*	0.022
MC 88	332.724*	2.276*	-0.404	2.955	-0.172*	-0.075	-0.103	-0.559	0.050	-0.553
MC 127	-14.276	-0.224	-0.571	0.122	-0.231*	0.067	-0.328*	0.366	0.117	-0.528
358371	-114.526*	-1.808*	0.596	-0.295	0.044	0.142	0.013	0.416	-0.008	0.072
359051	-180.192*	1.192*	-0.404	1.955	0.253*	0.167	0.322*	0.416	-0.083	0.347
SV 413	193.891*	-0.308	0.096	0.955	0.303*	0.300*	-0.095	-0.434	0.217*	-0.553
ND 163	-168.526*	-2.891*	1.263*	-3.545*	0.111*	-0.317*	0.863*	1.366*	-0.158*	1.347*
CSH 3129	-284.359*	-0.058	0.513	4.622*	-0.414*	-1.292*	0.572*	-0.334	-0.008	-0.203
SE	31.02	0.219	0.339	1.707	0.056	0.157	0.090	0.716	0.068	0.437
GMS 17	-103.974*	-0.064	0.167	-2.000*	-0.237*	-0.093	-0.104*	-0.704*	0.103*	-0.612*
GMS 20	131.923*	0.064	-0.372*	1.179	0.081*	0.420*	0.099*	0.034	-0.128*	0.267
GMS 26	115.436*	0.705*	-1.038*	0.667	0.094*	-0.360*	-0.014	0.701*	-0.097*	0.311
GMS 27	-143.385*	-0.705*	1.244*	0.154	0.061*	0.033	0.019	-0.030	0.121*	0.034
SE	15.50	0.11	0.17	0.85	0.03	0.08	0.05	0.36	0.03	0.22

* P=0.05

seed cotton yield. Therefore these lines were identified as good source in improving yield characters. Apart from this SA 1017, SA 1422, MC 88, 359051, GMS-26 has recorded high GCA for number of monopods/plant and while only two parents ND 163 GMS 27 has positive and significant GCA effects for number of sympods/plant.

Significant and positive GCA effects were recorded for number of bolls/plant by the male parents CSH 3129. Similarly, for boll weight only 4 male parents EC 138572, 359051 SV 413, ND 163 and 3 female parents GMS 20, GMS 26 and GMS 27 had the significant and positive GCA effects. It was also found that for bolls/plant, none of the female parents showed significant GCA effect. Among the 17 parents, only one line GMS-20 showed significant and positive GCA for ginning percentage while male parents SA 1652, EC 141679 SV 413 effects were significant. For seed index 4 parents 359051, ND 163, CSH 3129 and GMS-20 showed significant and positive GCA effect and these were considered as good combiners for seed index.

For fibre quality characters only one male parent ND 163 and female parent GMS 26 showed significant GCA effects for 2.5 % span length. SA 1422, SA 1652 and SV 413 male parent and GMS 17 and GMS 27 female parent showed significant positive estimates of GCA for Micronaire value. Likewise, only two male parent EC 138572 and ND 163 displayed positive and significant GCA effect for fibre strength (g/tex). For this reason these parents were selected as the most promising parents to improve the fibre property.

The SCA effects of the crosses are presented in Table 2. The specific combining ability value of any cross was helpful in predicting the performance of the better parents. Out of the 52 hybrids, 13 hybrids, viz. GMS 17×SA 1422, GMS 17×MC 127, GMS 17×358371, GMS 17 ×359051, GMS 20×SA 1652, GMS 20×MC 88, GMS 26×EC 128334, GMS 26 ×CSH 3129, GMS 27×SA 1422, GMS 27×EC 138572, GMS 27 ×358371 , GMS 27×SV 413, GMS 27× ND 163, showed significantly positive SCA effects but GMS 26×CSH 3129, GMS 17×MC 127, GMS 17×359051 hybrids had the highest SCA. Therefore, these were selected as the promising hybrids to increase seed cotton yield in the breeding programme.

Among 52 cross combinations, 12 cross combinations had positive and significant estimates for SCA effects for number of monopodial branches but GMS 26×CSH 3129, GMS 26 ×CSH 3129, GMS 26×SA 1422 hybrids had the highest SCA effect. Similarly GMS 26× SA 1017, GMS 20 × EC 138572 hybrids exhibited maximum positive and significant estimates for SCA effects for number of sympodial branches. Eight cross combinations GMS 17×SA 1422, GMS 17×MC 127, GMS 17×SV 413, GMS 20×EC 138572, GMS 20 ×EC 141679, GMS 20×CSH 3129, GMS 26×CSH 3129, GMS 27×359051 exhibited positive and significant SCA effects for boll/plant but the maximum being in case of GMS 20×CSH 3129, GMS 20 × EC 138572.Therefore, these hybrids are important for improvement of bolls/plant.

Among 52 cross combinations, only 13 cross combinations showed positive and significant SCA effect for boll weight and 18 for ginning percentage but the maximum being in case of GMS 17×EC 128334, GMS 20×EC

Table 2 Specific combing ability effects of seed cotton yield its components and quality traits in upland cotton

Crosses	Seed cotton yield (kg/ha)	Number of monopods/ plant	Number of sympods/ plant	Number of bolls/ plant	Boll weight (g)	GOT (%)	Seed Index	2.5% span length (mm)	Micro– naire value	Fibre strength (g/tex)
GMS 17 × SA 1017	–139.192	–0.436	–0.417	2.083	–0.013	–0.449	0.346*	1.704	–0.453*	0.262
GMS 17 × SA 1422	204.308*	1.314*	–0.083	7.000*	0.262*	0.160	–0.229	0.446	0.222	0.312
GMS 17 × SA 1652	–328.109*	–0.019	0.500	0.500	–0.163	1.326*	–0.429*	–2.446*	–0.028	–0.996
GMS 17 × EC 128334	185.141*	–0.103	1.083*	1.083	0.428*	–0.357	0.279	1.379	0.322*	1.162
GMS 17 × EC 138572	–385.776*	–1.269*	–0.333	–10.917*	–0.105	–2.499*	–0.029	–0.921	0.122	–0.563
GMS 17 × EC 141679	–101.942	0.897*	–0.250	–3.750	–0.130	–0.149	0.262	0.229	0.072	0.362
GMS 17 × MC 88	38.224	–0.019	–0.083	3.583	–0.030	2.093*	–0.038	0.179	–0.212	0.037
GMS 17 × MC 127	694.224*	1.814*	–0.250	7.083*	0.262*	0.385	0.121	–0.346	–0.078	0.012
GMS 17 × 358371	300.808*	0.064	–0.750	3.500	–0.080	0.876*	0.546*	0.404	0.047	0.012
GMS 17 × 359051	412.808*	–0.269	–0.417	–1.083	0.012	–0.115	–0.329*	–0.796	0.322*	–0.963
GMS 17 × SV 413	–84.942	2.231*	–0.250	7.583*	–0.105	0.018	–0.246	0.754	0.122	0.237
GMS 17 × ND 163	–370.859*	–0.186	2.917*	1.750	0.320*	1.068*	0.062	1.554	–0.503*	1.537*
GMS 17 × CSH 3129	–424.692*	–4.019*	–1.667*	–18.417*	–0.655*	–2.357*	–0.313*	–2.146	0.047	–1.413
GMS 20 × SA 1017	–112.756	1.103*	–0.878	–6.763*	–0.198*	–0.295	–0.424*	–0.734	0.578*	–0.117
GMS 20 × SA 1422	–124.256	–2.814*	–1.212*	–3.179	0.177	0.513*	0.201	–0.159	–0.147	–0.267
GMS 20 × SA 1652	407.994*	0.186	0.038	–0.346	0.119	–0.353	0.601*	–0.084	0.103	0.358
GMS 20 × EC 128334	–220.756*	–0.231	–0.045	–3.429	–0.123	0.530*	–0.324*	–1.059	–0.547*	–0.217
GMS 20 × EC 138572	–97.340	0.269	2.872*	8.904*	–0.023	1.122*	–0.265	–0.559	–0.347*	–0.942
GMS 20 × EC 141679	–16.840	1.769*	–0.045	8.071*	0.452*	–0.828*	–0.007	1.058	–0.097	0.583
GMS 20 × MC 88	388.994*	0.853*	0.455	–2.929	0.152	0.013	–0.274	–0.259	0.319*	–0.242
GMS 20 × MC 127	–267.006*	–0.314	0.288	–0.763	–0.590*	1.105*	–0.582*	0.516	0.253*	0.033
GMS 20 × 358371	–105.090	0.603	–0.545	1.321	–0.131	–0.437	–0.824*	–0.434	–0.122	–0.467
GMS 20 ×359051	114.910	–0.731	0.122*	–3.596	–0.106	–0.895*	0.535*	0.766	–0.247*	0.358
GMS 20 × SV 413	33.827	–2.231*	0.955	–4.929	0.244*	–0.395	0.151	0.116	0.053	–0.442
GMS 20 × ND 163	134.244	–0.314	–1.212*	–1.096	–0.198*	–0.912*	0.560*	0.016	0.228	–0.342
GMS 20 × CSH 3129	–135.923	1.853*	–0.795	8.737*	0.227*	0.830*	0.651*	0.816	–0.022	1.708*
GMS 26 × SA 1017	120.064	–0.872*	2.788*	0.417	–0.078	0.485	0.056	–0.101	–0.353*	–0.561
GMS 26 ×SA 1422	–262.102*	2.545*	0.788	–2.333	–0.336*	0.126	–0.019	0.341	0.022	0.389
GMS 26 × SA 1652	–223.186*	–0.455	0.038	–4.167	–0.128	–0.707*	0.214	1.949	0.072	0.481
GMS 26 × EC 128334	258.731*	0.128	0.622	5.417	–0.103	–1.024*	0.189	–0.526	0.122	–0.461
GMS 26 × EC 138572	150.814	–1.372*	–0.128	–0.250	0.331*	0.635*	0.181	–0.426	0.222	–0.286
GMS 26 × EC 141679	91.981	–1.872*	–1.378*	0.583	0.039	0.851*	–0.494*	–1.309	–0.228	–0.961
GMS 26 × MC 88	143.148	–0.788*	0.122	0.917	–0.294*	–1.707*	0.606*	1.074	–0.312*	1.314
GMS 26 × MC 127	11.814	–0.288	–1.378*	–3.250	0.231*	0.418	–0.003	0.249	–0.078	0.389
GMS 26 × 358371	–566.603*	–1.372*	0.122	–3.167	0.289*	–1.124*	0.289	–0.001	–0.053	0.289
GMS 26 × 359051	–177.269*	0.295	0.122	–3.083	–0.253*	1.251*	–0.353*	–1.901	0.022	–1.186
GMS 26 × SV 413	–335.353*	1.128*	–1.045*	2.583	0.097	–0.349	–0.336*	–0.851	0.022	–0.086
GMS 26 × ND 163	73.731	0.045	–1.878*	–1.583	–0.044	0.335	–0.294	0.749	0.197	0.614
GMS 26 × CSH 3129	714.231*	2.878*	1.205*	7.917*	0.247*	0.810*	–0.036	0.749	0.347*	0.064
GMS 27 × SA 1017	131.885	0.205	–1.494*	4.263	0.289*	0.259	0.022	–0.870	0.229*	0.416
GMS 27 × SA 1422	182.052*	–1.045*	0.506	–1.487	–0.103	–0.799*	0.047	–0.628	–0.096	–0.434
GMS 27 × SA 1652	143.301	0.288	–0.577	4.013	0.172	–0.266	–0.386*	0.580	–0.146	0.158
GMS 27 × EC 128334	–223.115*	0.205	–1.660*	–3.071	–0.203*	0.851*	–0.144	0.205	0.104	–0.484
GMS 27 × EC 138572	332.301*	2.372*	–2.410*	2.263	–0.203*	0.742*	0.114	1.905	0.004	1.791*
GMS 27 × EC 141679	26.801	–0.795*	1.673*	–4.904	–0.361*	0.126	0.239	0.022	0.254*	0.016
GMS 27 × MC 88	–570.365*	–0.045	–0.494	–1.571	0.172	–0.399	–0.294	–0.995	0.204	–1.109
GMS 27 × MC 127	–439.032*	–1.212*	1.340*	–3.071	0.097	–1.908*	0.464*	–0.420	–0.096	–0.434
GMS 27 ×358371	370.885*	0.705	1.173*	–1.654	–0.078	0.684*	–0.011	0.030	0.129	0.166
GMS 27 × 359051	–350.449*	0.705	0.173	7.763*	0.347*	–0.241	0.147	1.930	–0.096	1.791*
GMS 27 × SV 413	386.468*	–1.128*	0.340	–5.237	–0.236*	0.726*	0.431*	–0.020	–0.196	0.291
GMS 27 × ND 163	162.885	0.455	0.173	0.929	–0.078	–0.491	–0.328*	–2.320*	0.079	–1.809*
GMS 27 × CSH 3129	–153.615	–0.712	1.256*	1.763	0.181	0.717*	–0.303	0.580	–0.371*	–0.359
SE	85.23	0.38	0.59	2.96	0.097	0.27	0.16	1.24	0.12	0.76

*P=0.05

141679 and GMS 17×MC 88, GMS 17×SA 1652, respectively. For seed index 9 cross combinations showed positive and significant SCA effect but GMS 20xCSH 3129, GMS 26×MC 88and GMS 20×SA 1652 hybrids showed highest SCA effect. Therefore, these hybrids are important for improvement of seed index.

For 2.5% span length only 2 cross combinations GMS 17×SA 1652, GMS 27×ND 163 shown negative and significant SCA effect. Four crosses, viz. GMS 17×ND 163, GMS 20×CSH 3129, GMS 27×EC 138572, GMS 27×359051displayed positive and cross GMS 27 × ND 163 negative significant SCA effect for fibre strength. To improve the fibre fineness lower Micronaire value is desirable. Out of 52 crosses, 8 cross combinations exhibited significant negative SCA effect for Micronaire value. Therefore, these crosses can be selected to improve the fibre fineness.

Improvement of yield and fibre quality is one of the important targets of all cotton breeders. The present study aimed to facilitate the se-lection and development of cotton with high yielding and better fibre quality in cotton breeding program. In this study, non-additive gene effects were predominant for seed cotton yield, ginning percentage, boll weight, number of bolls/plant, number of monopods and sympods, Micronaire value, fibre length and strength. Similarly, GCA was significant for male parents SA 1017, SA 1422, MC 88, SV 413 and female parents GMS-20, GMS-26 for seed cotton yield, parents SA 165, EC 141679 SV 413, GMS-20 for ginning percentage and ND 163, GMS 26 for 2.5% span length and parents EC 138572, ND 163 for fibre strength (g/tex). Among 52 cross combinations, SCA was significant for 13 crosses in terms of seed cotton yield, maximum being in case of GMS 26×CSH 3129, GMS 17× MC 127, GMS 17× 359051 hybrids had the highest SCA. These all were seem to be good general combiner for seed cotton yield and its component traits.

SUMMARY

Combining ability was studied in a line×tester design involving 4 GMS lines as female parent and 13 germplasm lines as male parent for yield and quality traits. Analysis of variance for combining ability indicated predominance of non-additive variance for all the characters. GCA of parents revealed that the male parents SA 1017, SA 1422, MC 88, SV 413 and female parents GMS-20, GMS-26 for seed cotton yield were found to good general combiners. Similarly GMS-20 female parent and SA 1652, EC 141679, SV 413 male parent for ginning percentage and ND 163, GMS 26 for 2.5% span length and EC 138572, ND 163 for fibre strength (g/tex) showed significant positive GCA effects. Among 52 cross combinations, SCA was significant for 13 parents in terms of seed cotton yield and GMS 26×CSH 3129, GMS 17 × MC 127, GMS 17× 359051 hybrids showed the highest SCA. The crosses showing significant positive SCA effects were having one of the parents with good general combining ability.

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Corrigendum

In the folio heading of the *Indian Journal of Agricultural Sciences* November 2015 issue, please read vol. 85 (11) instead of vol. 85 (10)