COMBINING ABILITY ESTIMATES FROM LINE X TESTER MATING DESIGN IN UPLAND COTTON

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Abstract: Combining ability estimates are important genetic attributes to cotton breeders in predicting improvement via hybridization and selection programmes. Line x tester analysis involving five cotton leaf curl virus resistant female lines and three testers, was carried out to study five yield related traits in upland cotton. The significance of GCA and SCA variances was evident from mean squares of all the five traits indicating that additive as well as non-additive genes controlled the traits. However, among the five female lines, CIM-707 showed maximum GCA effects for number of bolls, seed cotton yield and seed index, while female lines FH-1000 and FH-925 were good general combiner for GOT% (1.760) and boll weight (0.340) respectively. The next high GCA scoring parent for seed cotton yield (4.016) nevertheless was CIM-499. Among the testers, parent CRIS-134 was desirable as it manifested higher estimates of GCA effects for all the characters except seed index. The GCA estimates as a whole suggested that if most of the traits are to be improved through hybridization and selection, then priority should be given to parents CRIS-134 from among the testers and CIM-707 and FH-1000 from among the female lines. The hybrid CIM-707 x CRIS-134 exhibited maximum SCA effect for number of bolls per plant; CIM-707 x CRIS-377 for seed cotton yield; FH-1000 x CRIS-342 for boll weight and GOT% and FH-1000 x CRIS-377 for seed.

Keywords: line x tester analysis, combining ability estimates, upland cotton

Introduction

The concept of combining ability is important in designing plant breeding programmes. It is especially useful in testing procedures, where it is desired to study and compare the performance of lines in hybrid combinations. Combining ability or productivity in crosses is defined as the ability of parents or cultivars to combine amongst each other during the process of hybridization so that favourable genes/characters are transmitted to their progenies. Two types of combining ability, general and specific, have been recognized in quantitative genetics. Specific combining ability is defined as the deviation in the performance of hybrids from the expected productivity based upon the average performance of lines involved in the hybrid combination, whereas general combining ability is defined as average performance of a line in a series of crosses. According to Sprague and Tatum [1], general combining ability is due to genes which are largely additive in their effects and specific combining ability is due to the genes with dominance or epistatic effect. Rawlings and Thompson [2] used line x tester analysis to estimate GCA and SCA of inbred parents. Since the development of new cultivars through hybridization is a continuous process, information on combining ability of new cultivars remains important. Desphande and Baig [3] noted that though GCA and SCA variances were important, the magnitude of SCA was higher than GCA indicating the preponderance of dominant genes controlling number of bolls, ginning outturn%, seed index, lint index and seed cotton yield. Contrary to the above findings, Rokaya *et al.* [4] found significance of GCA and SCA suggesting the importance of additive as well as dominant genes, nevertheless the ratio of GCA/SCA was greater than the unity further indicating the preponderance of additive genes in the inheritance of seed cotton yield, seed index and lint%.

Thus, keeping in view the importance of combining ability of the parents for various plant characters in cotton, the line x tester analysis was carried out. The estimates of various genetic parameters would provide guidelines to the cotton breeders to launch effective breeding strategies.

Materials and Methods

The seed of 15 F1 hybrids developed from line x tester mating design by crossing 5 lines/ females viz. CIM-707, CIM-499, CIM-506, FH-1000 and FH-925 and 3 testers/males i.e. CRIS-134, CRIS-342 and CRIS-377 was sown in the experimental area of the Department of Plant Breeding and Genetics, Sindh Agriculture University Tandojam, during 2006 crop season. The experiment was laid-out in a Randomized Complete Block Design (RCBD) with four replications. The distances between row to row and plant to plant were 2.5 feet and 9.0 inches, respectively. Ten plants per genotype per replication were tagged at random for data. All the inputs like irrigation and fertilizer were applied as per recommendations when ever needed. The insect pests were controlled with proper insecticides. The data were recorded on number of bolls per plant, boll weight (g), seed cotton yield per plant (g), ginning outturn% (G.O.T %) and seed index (g). After recording the observations for each character, the analysis of variance was carried out according to Gomez and Gomez [5]. The mean squares from line x tester design and the general combing ability (GCA) and specific combing (SCA) variances and effects were calculated according to the procedures developed by Kempthorne [6] and adopted by Singh and Choudhry [7].

Results and Discussion:

The mean squares due to GCA as well as SCA were significant for bolls per plant, boll weight, seed cotton yield, ginning outturn% and seed index (Table 1). Thus, the significance of GCA (variances due to lines and testers) and SCA (variances due to lines x testers) implied that both additive and non-additive types of variation was available for all the characters, yet additive genes were more important than the dominant genes because variance due to GCA was higher than that of SCA. Similar to present findings, Liu and Han [8], Banumathy and Patel [9], Baloch and Bhutto [10], Laxman and Ganesh [11], Neelima *et al.* [12], Nirania *et al.* [13] and Samreen [14] also noted additive and non-additive variation for bolls per plant, boll weight, seed cotton yield, ginning outturn% and seed index. Results regarding the magnitude of GCA and SCA variances, variable results were reported by different scientists. For instance, Baloch and Bhutto [10] Neelima *et al.* [12] reported higher magnitude of SCA over GCA for number of bolls per plant, boll weight, and seed cotton yield while for lint% and seed index Meena *et al.* [15] and Zia-ul-Islam *et al.* [16] obtained higher SCA variances than the GCA. The general combining ability and specific combining ability effects are depicted in Tables 2 and 3, respectively. Among the F_1 hybrids *per se*, the maximum bolls were formed by the cross CIM-707 x CRIS- 134 followed by the hybrid CIM-707 x CRIS-342. The GCA effects of parents shown in Table 2 suggested that among the female lines, CIM-707 exhibited maximum GCA effect, while among the testes/ male pollinators, CRIS-134 displayed highest GCA effect of 2.891 implying that if both the parents are used in the hybridization programme, the promising progenies could be developed and selected to improve number of bolls per plant. It is generally assumed that hybrids which perform well as *per se* also exhibit better SCA effects. Such assumption held true in our studies because

Table 1
Mean squares from line x tester analysis for various characters in upland Cotton.

Source of variation	D.F.	No. of bolls per plant	Boll weight	Seed cotton yield per plant	GOT%	Seed index
Replications	3	2.760	0.024	10.070	0.400	0.150
Hybrids	14	372.760**	0.234**	286.141**	9.770**	3.270**
Lines (GCA)	4	628.950**	0.525**	2360.020**	16.200**	3.630**
Testers (GCA)	2	140.830**	0.088**	1226.070**	10.810**	4.090**
Lines x tester (SCA)	8	302.650**	0.125**	3520.912**	6.292**	4.140**
Error	42	2.77	0.010	12.420	0.720	1.010

**Significant at 1% probability levels.

Table 2
General combining ability (GCA) effects of lines and testers for various characters in upland cotton.

Parents	No. of bolls per plants	Boll weight	Seed cotton yield per plant	Ginning outturn%	Seed index
Lines (females)					
CIM-707	7.913	0.050	18.908	- 1.31	0.320
CIM-499	-2.745	0.055	4.016	0.260	0.140
CIM-506	2.963	-0.203	-3.934	-0.700	-0.050
FH-1000	2.931	-0.160	0.933	1.760	-0.220
FH-925	-11.053	0.340	-19.917	0.010	-0.170
S.E. (gi.)	**0.480**	**0.028**	**1.017**	**0.244**	**0.290**
Testers (pollinators)					
CRIS-134	2.891	0.080	8.355	0.890	-0.080
CRIS-342	-0.568	-0.045	-1.180	-0.500	0.030
CRIS-377	-2.293	-0.035	-7.170	-0.330	0.040
S.E. (gi.)	**0.372**	**0.022**	**0.788**	**0.189**	**0.224**

hybrid CIM-707 x CRIS-134 with highest SCA effect also produced highest number of bolls *per se*. The top two specific combiners were CIM-707 x CRIS-134 (7.341) and CIM-707 x CRIS-342 (Table 3) suggesting that both the hybrids could prove useful material for hybrid crop development. In respect to boll weight of the F_1 hybrids, FH-925 x CRIS-134 showed the highest value followed by the hybrids FH-925 x CRIS-342 and CIM-499 x CRIS-134 (Table 3). The GCA effects indicated that among the lines and testers, highest GCA effects were expressed by FH-925 (0.340) and CRIS-134 (0.080) implying their good general combining ability. It

Table 3

Specific combining ability (SCA) estimates and mean performance of hybrids *per se* (in parenthesis) from line x tester analysis of various characters in upland cotton.

F_1 Hybrids	No. of bolls per plant	Boll weight	Seed cotton yield per plant	GOT %	Seed index
1 CIM-707 x CRIS-134	7.341 (57.97)	-0.230 (3.45)	21.120 (198.42)	0.770 (37.30)	0.200 (8.05)
2. CIM-707 x CRIS-342	7.298 (54.47)	0.030 (3.55)	25.200 (192.90)	-1.410 (33.77)	-0.060 (7.90)
3. CIM-707 x CRIS-377	-16.321 (30.77)	0.220 (3.75)	44.230 (115.55)	0.620 (35.97)	-0.140 (7.85)
4. CIM-499 x CRIS-134	-2.301 (37.77)	0.200 (3.95)	13.361 (149.50)	0.250 (38.35)	0.130 (7.80)
5. CIM-499 x CRIS-342	4.308 (40.82)	-0.050 (3.57)	26.510 (134.17)	0.220 (36.97)	-0.000 (7.77)
6. CIM-499 x CRIS-377	-3.931 (32.65)	-0.130 (3.50)	13.680 (133.77)	0.49 (36.42)	-0.110 (7.67)
7. CIM-506 x CRIS-134	-5.061 (40.62)	0.060 (3.55)	-10.340 (144.12)	-0.110 (37.20)	-0.040 (7.42)
8. CIM-506 x CRIS-342	2.328 (42.55)	-0.210 (3.15)	-11.850 (133.80)	-1.010 (34.72)	0.170 (7.75)
9. CIM-506 x CRIS-377	3.058 (45.20)	0.180 (3.55)	21.480 (160.42)	1.150 (37.10)	-0.090 (7.05)
10. FH-1000 x CRIS-134	-3.271 (45.17)	0.010 (3.55)	-0.980 (157.95)	-0750 (38.85)	-0.280 (7.02)
11. FH-1000 x CRIS-342	-12.231 (32.75)	0.240 (3.65)	-29.900 (119.50)	2.100 (40.35)	0.040 (7.45)
12. FH-1000 x CRIS-377	5.423 (50.32)	-0.220 (3.20)	32.090 (175.50)	-1.390 (37.70)	0.250 (7.67)
13. FH-925 x CRIS-134	0.388 (32.50)	-0.020 (4.20)	3.990 (142.47)	-0.170 (37.67)	0.020 (7.37)
14. FH-925 x CRIS-342	-2.561 (25.70)	0.040 (3.95)	-10.160 (118.77)	0.120 (36.62)	-0.210 (7.35)
15. FH-925 x CRIS-377	0.448 (28.57)	0.000 (3.92)	6.230 (119.15)	0.050 (36.72)	0.100 (7.57)
S.E. (si.)	**0.83**	**0.050**	**1.762**	**0.424**	**0.502**

suggested that cross between FH-925 and CRIS-134 would likely produce desirable boll weight in the segregating populations.

Regarding boll weight, FH-1000 x CRIS-342 and CIM-707 x CRIS-377 were the best specific combinations (Table 3). Regarding seed cotton yield, CIM-707 x CRIS-134 expressed the highest value (Table 3). The GCA effects of lines and testers (Table-2) suggested that among the lines, CIM-707 expressed maximum GCA effect (18.908) whereas among the testers, CRIS-134 gave highest GCA effect of 8.355. These results suggest that both the parents are good general combiners and may be desirable for hybridization programme to improve seed cotton yield through selection. The SCA results presented in Table-3 indicate that CIM-707 x CRIS-377 (44.23) and FH-1000 x CRIS-377 were the best specific combinations for seed cotton yield. Based on the mean performance of F1 hybrids *per se*, hybrid FH-1000 x CRIS-342 produced the highest lint% of 40.35. The GCA effect of lines and testers shown in Table-2 suggests that parent FH-1000 among the lines and CRIS-134 among the testers were the top general combiners and might be desirable parents for improving ginning outturn. The SCA effects shown in Table 3 indicate that FH-1000 x CRIS-342 (2.100) and CIM-506 x CRIS-377 were the highest ranking hybrids for GOT % and could be exploited for hybrid cotton development. The F1 hybrid CIM-707 x CRIS-134 gave maximum seed index (8.05g). The highest GCA for seed index was exhibited CIM-707 (0.320) among females and by CRIS-377 among male parents (Table 2). These two parents could be useful source for high seed index in hybridization programmes. The SCA effects shown in Table 3 reveal highest values for FH-1000 x CRIS-377 and CIM-707 x CRIS-134. The results regarding significant GCA and SCA effects are in conformity with those of Liu and Han [8] for number of bolls per plant, Tuteja *et al.* [17] for boll weight, Desphande and Baig [3] for seed cotton yield per plant, Zia-ul-Islam *et al.* [16] for ginning outurn% and Rokaya *et al.* [4] for seed index.

Conclusions and recommendations

The significance of GCA and SCA mean squares suggests the importance of both additive and non-additive variances for all the characters studied. The tester CRIS-134 demonstrates the ability to distinguish the merit of the female lines. However, the higher GCA effects of female line CIM-707 and male tester CRIS-134 for majority of the traits indicate that both these parents may be preferred for hybridization and selection programmes. The SCA effects reveal that, for hybrid crop development, cross CIM-707 x CRIS-134 could be the better choice for number of bolls, FH-1000 x CRIS-342 for boll weight and ginning outturn% and CIM-707 x CRIS-377 for seed cotton yield.

References

1. **Sprague, G.F. and Tatum, L.A.** 1942. General versus specific combining ability in single crosses of corn. *J. Amer. Soc. Agron*.34:923.
2. **Rawlings, J.O. and Thompson, D.L**. 1962. Performance level as criterion for the choice of maize testers. *Crop Sci*. 2:217-220.
3. **Deshpande, L.A. and Baig, K.S**. 2003. Combining ability analysis for yield, economic and morphological traits in American cotton (*Gossypium hirsutum* L.). *J. Res. ANGRAU* 31:28-34.
4. **Rokaya, M. H., El-Marakby, A. M., El-Agroudy M. H and Seif, G.M**. 2005. Heterosis and combining ability for fiber-to-seed attachment force, earliness, yieldand yield components in a half diallel cross of cotton. Arab Univ. J. Agric. Sci. 13: 741-753.
5. **Gomez, K. A. and Gomez, A.A.** 1984. *Statistical Producers for Agriculture Research.* John Wiley and Sons Inc., 2nd (ed.) New York, U.S.A.
6. **Kempthorne, O.** 1957. *An Introduction to Genetic Statistics*. John Wiley and Sons, New York, U.S.A. pp. 191-200.
7. **Singh, R.K. and Choudhry, B.D.** 1979. Biometrical methods in quantitative genetic analysis (Revised ed. 1979). Kalyani Publisher, New Delhi. pp. 191-200.

8. **Liu, Y.X and Han, X.M.** 1998. Research on the combining ability and inheritance of 12 economic characters in upland cotton. *China Cottons* 25:9-11.
9. **Banumathy, S. and Patel, S.** 2001. Diallel analysis for seed cotton yield and its components in cotton. *Annal. Pl. Physiol*.14:56-61.
10. **Baloch, M.J. and Bhutto, H.U.** 2003. Design-II analysis for estimating general and specific combining ability effects of cotton leaf curl virus resistant inbred parents. *Zagazig J. Agric. Res*. 30:635-649.
11. **Laxman, S. and Ganesh, M.** 2003. Combining ability for yield components and fibre characters in cotton (*Gossypium hirsutum* L.). J. Res. ANGRAU 31: 19-23.
12. **Neelima, S., Reddy, V.C. and Reddy, A.N.** 2004. Combining ability studies for yield and yield components in American cotton (*Gossypium hirsutum* L.). *Annals Agric. Biol. Res*. 9:1-6.
13. **Nirania, K. S., Chhabra, B. S., Jain, P. P., and Dutt. Y.** 2004. Heterosis for yield and its component traits in genetic male sterility based upland cotton hybrids. *J. Cotton Res. Develop*. 18:145-149.
14. **Samreen, K**. 2007. *Line x tester analysis for estimating heterosis and combining ability in upland cotton (Gossypium hirsutum L.)*. M.Sc. (Agric.) Hons. thesis submitted to Sindh Agriculture University, Tandojam.
15. **Meena, R.A., Mishra, M.N. and Daani, R.G**. 2001. Combining ability analysis for seed quality traits in cotton (*Gossypium hirsutum L.*). *Seed Sci*. 2:77-84.
16. **Zia-ul-Islam, H., Sadaqat, A. and F. A. Khan**. 2001. Combining ability of some hirsute cotton types for economic traits. *Int. J. Agric. Biol*. 3:411-412
17. **Tuteja, O.P., Kumar, S., Verma, S.K. and Ahuja, S.L**. 2004. Estimation of heterosis for seed cotton yield and its component characters in *Gossypium hirsutum* L. *J. Cotton Res. Develop*. 18:38-41.