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Determination of General and Specific Combining Ability of Five Upland Cotton Cultivars

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Abstract

The present investigation was aimed to determine the general combining ability of the parental lines and specific combining ability of the hybrids respectively and also heterotic effect of F_1 hybrids for some agro-economical traits in upland cotton. Five parent genotypes viz. NIAB-78, Chandi-95, Haridost, CRIS-134 and Shahbaz were used to generate ten F_1 hybrids through diallel mating design. The seeds of F_1 hybrids along with their parents were sown in Randomized Complete Block Design (RCBD) in three replications during 2009-10. All the traits showed highly significant variation and GCA and SCA variances were also significant for all the parameters studied. Among the parents, NIAB-78, Haridost and CRIS-134 were best general combiners for plant height, sympodial branches per plant, bolls per plant, boll weight, seed cotton yield per plant, GOT% and seed index. Cross NIAB-78×Chandi-95 was best specific combiner for plant height and bolls per plant and CRIS-134×Haridost for sympodial branches per plant. However, the hybrid Chandi-95×CRIS-134 proved best specific combiner for seed cotton yield per plant and GOT%, while NIAB-78×CRIS-134 gave maximum SCA effects for seed index.

Keywords: diallel analysis, GCA, quantitative traits, SCA, upland cotton

1. Introduction

Cotton cultivation in the Old World began from India, where cotton has been grown for more than 6000 years, since Pre-Harappan period. Cotton from the Harappan civilization was exported to Mesopotamia during the 3rd millennium BC and it was soon known to the Egyptians as well. The famous Greek historian Herodotus also wrote about Indian cotton: "There are trees which grow wild there, the fruit of which is wool, exceeding in beauty and goodness to that of sheep. The Indians make their clothes of this tree wool" (World Trade Organization (WTO), 2006).

Cotton is being grown in Pakistan on an area of 2.82 million hectares with annual production of 11.8 million bales and average yield of 713 kg/ha. Sindh shares 0.56 million hectares with 2.97 million bales and average yield of 902 kg/ha (Agri. Stat. of Pakistan 2008-09). It accounts for 8.2 percent of the value added in agriculture and about 2 percent to GDP in its national economy (Anonymous, 2009). However, the area under cotton during 2008-09 has decreased by 7.6 in Sindh and 7.7% in Pakistan as a whole as compared to 2007-08. The cotton yield of the country is very low due to biotic (diseases and insect pests particularly sucking complex) and abiotic stresses. The output of cotton from Pakistan in 2009-10 was more than 12.5 million bales, compared with 11.8 million bales recorded in the previous year. Pakistan is the world's fourth biggest cotton producer but often has to import supplies to meet the demand of its textile sector, which accounts for about 60 percent of total exports.

The diallel analysis has been used more than any other matting design to designate general combining ability (GCA) and specific combine ability (SCA) of the parental cultivars, thereby, obtaining the information on the types of gene actions controlling different quantitative traits in cotton. Keeping in view the need of higher yield of cotton to face ever increasing human population, the present study was designed to generate the information about the combining ability of parents for various plant characters of cotton, which can further help to design a breeding plan for cotton production.

2. Materials and Methods

An experiment was conducted at the experimental field of Botanical Garden at the Department of Plant Breeding and Genetics, Sindh Agriculture University Tando Jam, during Kharif season 2009. The experimental material consisted of five upland cotton (*Gossypium hirsutum* L.) varieties/cultivars *viz.* NIAB-78, Chandi-95, CRIS-134, Haridost and Shahbaz. The F_1 seeds of ten hybrids developed by half diallel crossing system were obtained from the Department of Plant Breeding and Genetics, Sindh Agriculture University, Tandojam. The F_1 seeds along with each parental line were sown in Randomized Complete Block Design (RCBD) in three replications. The distance between rows was kept 75cm and plant-to-plant distance was 30cm. Three rows of each genotype were grown. Sowing was done by dibbling method. Three seeds per hill were sown to ensure uniform stand and were thinned to only one plant per hill after first irrigation. Five plants were tagged at random from central row excluding border plants and evaluated for selected parameters. The parents and crosses were as under.

2.1 Parents

P1 =NIAB-78

P2 = CHANDI-95

P3 = CRIS-134

P4 = HARIDOST

P5= SHAHBAZ-95

2.2 Direct Crosses

C1 = NIAB-78 × CHANDI-95

C2 = NIAB-78 × CRIS-134

C3 = NIAB-78 × HARIDOST

C4 = NIAB-78 × SHAHBAZ-95

C5 = CHANDI-95 × CRIS-134

C6 = CHANDI-95 × HARIDOST

C7 = CHANDI-95 × SHAHBAZ-95

C8 = CRIS-134 × HARIDOST

C9 = CRIS-134 × SHAHBAZ-95

C10 = HARIDOST × SHAHBAZ-95

The data was collected for plant height (cm), number of sympodial branches per plant, number of bolls per plant, boll weight (g), seed index (g), ginning out percentage (GOT%), seed cotton yield per plant (g), staple length (mm) and Micronaire value (µg/inch) according to known standards.

The analysis of variance was carried out to determine the differences among the genotypes (parents and F_1 hybrids) according to procedures adopted by K. A. Gomez and A. A. Gomez (1984). The mean squares for general combing ability, specific combining ability and their effects were determined according to statistical procedures by Singh and Chaudhry (1979).

3. Results

The mean squares from analysis of variance for genotypes, general and specific combining ability were highly significant $P \geq 0.01$ (Table 1) for plant height, sympodial branches per plants, bolls per plant, boll weight, seed cotton yield per plant, GOT percentage and seed index. The GCA effects are shown in Table 2 and SCA effects in Table 3.

Table 1. Mean square from analysis of variance for genotypes, GCA and SCA for some quantitative traits of cotton

Source of variance	DF	Plant height	No. of sympodial branches	No. of bolls per plant	Boll weight	Seed cotton yield	GOT %	Seed index	Staple length (mm)	Micronaire value (µg/inch)
		CHARACTERS								
Replications	2	0.55	2.11	4.69	0.02	70.35	2.51	1.89	0.01	0.02
Genotypes	14	214.35**	42.41**	120.35**	1.35**	1200.35**	16.35**	4.51**	7.79**	0.09**
GCA	4	290.00**	40.43**	75.34**	0.34*	1000.45**	14.35**	3.35**	0.01	0.02
SCA	9	160.78**	35.39**	55.35*	0.24*	820.10*	12.42*	2.24*	0.08	0.03
Error	28	2.35	1.69	1.43	0.02	60.35	0.41	1.45	0.04	0.001

Note. DF = Degree of freedom; GCA = General combining ability; SCA = Specific combining ability; GOT = Ginning out turn; * Significant at 5% probability level; ** Significant at 1% probability level.

Table 2. GCA effects for selected quantitative traits of cotton

S. No.	Parents	Plant height (cm)	No. of sympodial branches	No. of bolls per plant	Boll weight (g)	Seed cotton yield (g)	GOT %	Seed index (100 grain weight)	Staple length (mm)	Micronaire value (µg/inch)
		CHARACTERS								
1.	NIAB-78	4.208	2.89	-1.86	0.14	-17.00	0.45	1.41	0.45	-0.45
2.	Chandi-95	-4.10	-4.31	-2.35	0.21	-13.45	0.62	1.42	-0.80	-0.80
3.	CRIS-134	-0.56	2.80	3.45	0.02	5.19	-1.67	-0.35	0.35	0.95
4.	Haridost	4.42	2.15	-1.34	-1.50	15.15	0.32	-0.89	1.00	-0.48
5.	Shahbaz	-5.30	-2.85	-1.65	0.60	10.41	-0.34	-1.35	-1.00	0.48
S.E. (g.i)		0.41	0.39	0.43	0.05	4.35	0.12	0.45	0.49	0.250

Note. GCA = General combining ability; GOT = Ginning out turn.

Table 3. SCA effects for selected quantitative traits in cotton

S. No.	Hybrids/Parents	Plant height (cm)	No. of sympodial branches	No. of bolls per plant	Boll weight (g)	Seed cotton yield (g)	GOT %	Seed index (100 weight)	Staple length (mm)	Micronaire value (µg/inch)
		CHARACTERS								
1.	NIAB-78 × Chandi-95	10.91	2.61	6.68	0.15	0.75	2.20	1.89	-1.45	1.89
2.	NIAB-78 × CRIS-134	8.351	3.51	-3.41	0.351	10.15	2.35	2.35	0.49	0.50
3.	NIAB-78 × Haridost	- 4.41	-2.31	-3.15	-0.30	12.35	-3.35	-1.40	0.85	0.82
4.	NIAB-78 × Shahbaz	-4.40	4.35	5.51	-0.14	13.41	-4.35	-1.350	-0.38	-0.38
5.	Chandi-95 × CRIS-134	-3.51	-1.89	3.35	0.89	17.50	1.15	2.24	-0.95	-0.85
6.	Chandi-95 × Haridost	-10.89	-4.30	4.15	0.80	-14.30	-2.13	1.89	0.82	-0.89
7.	Chandi-95 × Shahbaz	4.35	-2.14	-3.20	-0.75	-11.10	2.35	-1.41	-0.92	0.85
8.	CRIS-134 × Haridost	3.44	4.40	-3.41	-0.34	10.75	2.14	-1.35	0.82	1.85
9.	CRIS-134 × Shahbaz	-3.35	2.15	4.15	0.61	2.20	-1.15	1.45	1.52	0.95
10.	Haridost × Shahbaz	-6.60	1.89	3.151	0.31	4.45	2.25	1.80	1.84	-1.30
S.E. (gi)		1.340	0.675	1.890	0.035	8.359	0.381	0.815	0.354	0.254

Note. SCA = Specific combining ability; GOT = Ginning out turn.

3.1 Plant Height (PH)

The maximum GCA effects were produced by the parent Haridost followed by NIAB-78, while other three parents gave negative GCA effects for PH (Table 2). However, four crosses out of ten recorded positive SCA effects while rest showed negative SCA effect for PH. The top ranking three crosses were NIAB-78×Chandi-95, NIAB-78×CRIS-134 and Chandi-95×Shahbaz showed maximum SCA effects for PH respectively (Table 3).

3.2 Sympodial Branches per Plant (SB)

The evaluation of SB provided the three parents NIAB-78, CRIS-134, and Haridost with significant GCA (Table 2), while Chandi-95 and Shahbaz have negative GCA. Four hybrids showed negative SCA effects and rest had significant positive SCA effects for SB (Table 3). However highest SCA effects were given by crosses CRIS-134×Haridost and NIAB-78×Shahbaz. While Haridost×Shahbaz produced lowest SCA effects for this trait.

3.3 Number of Bolls per Plant (NB)

Only one parent CRIS-134 produced positive GCA effects for NB while others were negative in their GCA effects (Table 2). As for as SCA effects are concerned six parents exhibited significant positive effects, the maximum SCA effects were recorded by the cross NIAB-78×Chandi-95 followed by NIAB-78×Shahbaz. The crosses NIAB-78×CRIS-134, NIAB-78×Haridost, Chandi-95×Shahbaz and CRIS-134×Haridost had negative SCA effects (Table 3).

3.3 Boll Weight (BW)

Among the five parents, three *viz*., Shahbaz, Chandi-95, NIAB-78 revealed significant positive GCA effects, whereas CRIS-134 and Haridost had non-significant negative GCA for BW (Table 2). Out of 10 hybrids, six showed significant positive SCA effects (Table 3). The highest SCA effect for BW was exhibited by Chandi-95×CRIS-134.

3.4 Seed Cotton Yield (SCY)

Three parents, Haridost, Shahbaz and CRIS-134 had significant positive GCA for SCY while NIAB-78 and Chandi-95 showed negative GCA for SCY (Table 2). The positive significant SCA effects (Table 3) were recorded in eight crosses. The three top scoring crosses in terms of SCA effects were Chandi-95×CRIS-134, NIAB-78×Shahbaz and NIAB-78×Haridost for SCY.

3.5 Ginning Out Turn Percentage (GOT%)

The results in Table-2 regarding GOT% showed that Chandi-95 gave maximum GCA effect followed by NIAB-78 and Haridost. However, six crosses showed significant SCA effects where cross NIAB-78×CRIS-134 and Chandi-95×Shahbaz produced maximum SCA effects for GOT%, while four combinations showed non-significant SCA effects (Table 3).

3.6 Seed Index (SI)

Among the five parents Chandi-95 and NIAB-78 showed significant positive while CRIS-134, Haridost and Shahbaz recorded negative GCA effects for SI (Table 2). However, six hybrids indicated significant positive SCA effects for SI (Table 3). Among hybrids, the highest SCA effects for SI were produced by NIAB-78×CRIS-134 followed by Chandi-95×CRIS-134 and NIAB-78×Chandi-95.

3.7 Staple Length (SL)

Three parents Haridost, NIAB-78 and CRIS-134 provided positive GCA effects for SL, while Chandi-95 and Shahbaz recorded negative GCA effects (Table 2). Six hybrids revealed significant positive SCA effects for SL (Table 3). The highest SCA effects among hybrids were produced by the Cross Haridost×Shahbaz followed by CRIS-134×Shahbaz for SL.

3.8 Micronaire Value

GCA effects for micronaire value of two parents showed positive GCA effects namely CRIS-134 and Shahbaz, while the other parents exhibited negative GCA effects (Table 2). Five of ten crosses provided positive SCA effect for micronaire value. Among hybrids, the highest SCA effects were produced by the cross NIAB-78×Chandi-95 followed by CRIS-134×Haridost (Table 3).

4. Discussion

For PH, the mean squares from analysis of variance for genotypes, GCA and SCA were highly significant (Table 1). The significant GCA and SCA results proposed that additive and non-additive type of gene action controlled the character PH and it can be improved through selection in segregating populations. Similar results were obtained by Basal and Turgut (2003), Leghari, Baloch, Kumbhar, and Ansari (2004) and Fan, Yu, Zhang, Yuan, and Song (2004). They reported significant positive GCA and SCA effects for PH.

The analysis of variance for SB revealed highly significant difference among genotypes, hybrids crosses and GCA and SCA variances (Table 1). Among the parents, three parents CRIS-134, NIAB-78 and Haridost produced positive GCA effects for SB and these parents could be used for hybridization and selection programme for improving the SB. However, among the hybrids CRIS-134×Haridost gave maximum SCA effects for this trait. Similar results were obtained by Basal and Turgut (2003), who observed positive GCA and SCA effects for SB.

The results for bolls per plant revealed that CRIS-134 produced positive GCA effects while NIAB-78, Shahbaz, Haridost and Chandi-95 gave negative GCA effects. CRIS-134 proved to be promising variety and could be used in breeding programmes for improving the bolls per plant. Whereas, hybrid NIAB-78×Chandi, NIAB-78×Shahbaz, Chandi×Haridost and CRIS-134×Shahbaz produced highest SCA effects among the hybrids for NB (Table 3). Similar results were obtained by Ahmed (2006) and Gong Cao, Ji, and He (2005). They also reported significant GCA and SCA variances for NB.

The highly significant difference for BW was observed among the genotypes. However, GCA and SCA variances were also significant at $P < 0.01$. Higher GCA variance than SCA revealed that maximum numbers of additive genes are involved in the control of boll weight. Our results confirm those of Elangaimannan, Anbuselvam, Venkatesan, and Karthikeyan (2007) and Kiani, Nematzadeh, Kazemitabar, and Alishah (2007). They also determined significant positive GCA and SCA variances for boll weight.

The analysis of variance showed the highly significant difference for SCY among the genotypes, GCA and SCA (Table 1). However, GCA variance was higher than SCA variance indicating that additive type of genes were controlling the character. Three parents Haridost, Shahbaz and CRIS-134 recorded positive GCA effects for SCY. These parents could be used in hybridization and selection for improving the SCY percent. Eight crosses showed positive SCA effects (Table 3) for SCY. Similar results were obtained by Kiani et al. (2007), Pole, Kamble, Madrap, and Sarang (2008), Gong et al. (2005) and Rashid, Khan, Anjam, and Ali (2008). They reported significant GCA and SCA variances for SCY.

Among hybrids and genotypes, the mean squares from analysis of variance showed highly significant difference. However, GCA and SCA variance were also highly significant for ginning outturn percentage showing that additive and non-additive type of gene action was controlling the character GOT%. Other researchers like Zangi, Jelodar, Kazemitabar, and Vafaei-Tabar (2009), Basal and Turgut (2003), Leghari et al. (2004) and Fan et al. (2004) also reported significant positive GCA and SCA effects for ginning outturn percentage.

Two parents Chandi-95 and NIAB-78 gave positive GCA effects for seed index. However, mean squares from analysis of variance were higher for GCA than SCA which proposed that maximum number of additive genes were involved in controlling the seed index. Similar results were obtained by Elangaimannan et al. (2007) and Kiani et al. (2007).

The information obtained in this experiment help us to confirm that the genotypes NIAB-78, Haridost and CRIS-134 can use to develop a successful and profitable synthetic variety while the NIAB-78×CRIS-134 can use to get commercial benefits as a cotton hybrid.

5. Conclusion

All the characters were highly significant at $P \leq 0.01$; GCA and SCA variances were also significant for all the character studied. Among the parents, NIAB-78, Haridost and CRIS-134 were best general combiners for PH, sympodial branches per plant, bolls per plant, boll weight, seed cotton yield per plant, G.O.T%, seed index, staple length and micronaire value. So, they can be use in a breeding program to develop a new variety for commercial practice. NIAB-78×Chandi-95 was best specific combiner for PH and bolls per plant and CRIS-134×Haridost for sympodial branches per plant. However, Chandi-95×CRIS-134 proved best specific combiners for seed cotton yield per plant, and GOT% while NIAB-78×CRIS-134 showed maximum SCA effects for seed index, staple length and micronaire value. The specific combiner of different traits can further use for ideotype breeding and development of hybrid cotton.

References

Ahmed, M. F. (2006). Cotton diallel cross analysis for some agronomic traits under normal and drought conditions and biochemical genetic markers for heterosis and combining ability. *Egyptian Journal Plant Breeding, 11*, 57-73.

Anonymous. (2009). *Achievements of kharif crop 2008-2009 and targets for 2009-10*. Report Federal Commission of Agriculture Islamabad Anex-II.

Basal, H., & Turgut, N. (2003). Heterosis and combining ability for yield components and fiber quality parameters in a half diallel cotton (*G. hirsutum* L.) population. *Turkish Journal of Agricalture and Forestry, 27*, 207-212.

Elangaimannan, R. Y., Anbuselvam, M., Venkatesan, & Karthikeyan, P. (2007). Diallel analysis in cotton (*Gossypium hirsutum* L.). *International Journal of Plant Science (Muzaffarnagar), 2*(2), 53-56.

Fan, S. L., Yu, S. X., Zhang, C. J., Yuan, R. H., & Song, M. Z. (2004). Study on heredity and combining ability of earliness of short season cotton. *Cotton Science, 16*(4), 211-215.

Gomez, K. A., & Gomez, A. A. (1984). *Statistical Procedure for Agriculture Research* (2nd ed.). John Willey and Sons Inc., New York, U.S.A.

Gong, P., Cao, X. C., Ji, L. H., & He, L. R. (2005). Genetic analysis and analysis of combining ability of boll characters of upland cotton. *China Cotton, 32*(1), 11-13.

Kiani, G., Nematzadeh, G. A., Kazemitabar, S. K., & Alishah, O. (2007). Combining ability in cotton cultivars for agronomic traits. *International Journal of Agriculture and Biology, 9*(3), 521-522.

Leghari, A., Baloch, G. M., Kumbhar, M. B., & Ansari, B. A. (2004). Combining ability analysis for yield and yield components in cotton. *Indus Cottons, 1*(2), 54-57.

Pole, S. P., Kamble, S. K., Madrap, I. A., & Sarang, D. H. (2008). Diallel analysis for combining ability for seed cotton yield and its components in upland cotton (*Gossypium hirsutum* L.). *Journal of Cotton Research and Development, 22*(1), 19-22.

Rashid, M., Khan, I. A., Anjam, M. S., & Ali, K. (2008). Genetics of some fiber quality traits among intraspecific crosses of American cotton (*Gossypium hirsutum*). *International Journal of Agriculture and Biology, 10*(2), 196-200.

Singh, R. K., & Chaudhry, B. D. (1979). *Biometrical methods in quantitative genetic analysis*. Kalyani Publ. New Dehli, India.

World Trade Organization. (2006). *United States Subsidies on Upland Cotton*.

Zangi, M. R., Jelodar, N. B., Kazemitabar, S. K., & Vafaei-Tabar, M. (2009). Cytoplasmic and combining ability on fiber quality traits in intera and interspesific crosses of tetraploid cotton (*G. hirsutum* x *G. barbadense*). *American-Eurasian Journal of Agriculture and Environmental Sciences, 5*(4), 519-525.

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