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Diallel Analysis for Estimating Combining Ability of Quantitatively Inherited Traits in Upland Cotton

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Abstract: An 8×8 diallel analysis study on cotton (*Gossypium hirsutum* L.) was launched in the Department of Plant Breeding and Genetics, Faculty of Agriculture, Gomal University, D.I. Khan, Pakistan during, 1996-99 to estimate the combining ability analysis in the inheritance and expression of some significant quantitative characters like, height of main stem, number of bolls plant^{-1}, yield of seed cotton plant^{-1}, boll weight and lint percentage using Griffing's Method- II, Model-1 in F_1 generation. The mean squares for General combining ability (GCA) effects, (SCA) effects and reciprocals effects were observed to be highly significant for all the mentioned characters. The estimates of component of variance clarified that the variance due to SCA was much higher in magnitude and more vital than GCA for traits like height of main stem plant^{-1}, number of bolls plant^{-1}, yield of seed cotton plant^{-1} and boll weight showing thereby the predominance of non additive type of gene action with (dominance or epistatic effects) in the inheritance of these traits. Whilst GCA was much higher in magnitude and more vital than SCA reflecting the role of additive type of gene action in case of lint percentage.

Key words: *Gossypium hirsutum* L., genotypes, general combining ability, specific combining ability and reciprocal effects, agronomic characters, Pakistan

Introduction

Identification and selection of flexible parental lines are required to be used in any hybridization program to produce genetically modified and potentially rewarding germplasm with assembly of fixable gene effects more or less in a homozygous line. Information pertaining to the different types of gene action, relative magnitude of genetic variance and combining ability estimates are important and vital parameters to mold the genetic makeup of cotton crop. This important information could prove an essential strategy to the cotton breeders in the screening of better parental combinations for further enhancement. Exploitation of heterosis primarily dependent on the screening and selection of available germplasm that could produce better combinations of genetically modified important characters. The entire genetic variability observed in the analysis for each trait was partitioned into its components i.e. general and specific combining ability as defined by Sprague and Tatum (1942) and reciprocal effects as sketched by Griffing (1956). They stated that GCA effects were due to additive type of gene action whereas SCA effects were due to genes which are non-additive (dominant or epistatic) in nature. Ghafoor and Khan *et al.* (1987), Sayal *et al.* (1997) and Hassan *et al.* (1999) reported the importance of SCA effects than GCA revealing the importance of non-additive (dominant or epistatic) type of gene action. At the other hand, Bhatade and Bhale (1983), Khan *et al.* (1991), Yaqoob *et al.* (1997), Baloch *et al.* (2000) and Bhutto *et al.* (2001) who stressed upon the appreciable degree of variance due to GCA for these characters.

Many commercial cultivars besides their high agronomic performances accomplish poorly since of genetic hindrances in diverse cross combinations. Thus crossing in a diallel fashion is the only specific and flourishing technique of measurement for identification and selection of superior genetically modified material. The current research work was launched to analyze some important cotton cultivars/genotypes to ascertain the relative performance regarding combining ability effects for yield and its components.

Materials and Methods

The present studies were conducted to trace the combining abilities for various quantitative traits of cotton *Gossypium hirsutum* L. at research area of cotton, Department of Plant Breeding and Genetics, Faculty of Agriculture, Gomal University, Dera Ismail Khan during the years 1996-98. The experimental germplasm comprised of eight genotypes from local varieties of *Gossypium hirsutum* L.. CYTO 9/91, CYTO-11/91, B-622, B-496, SLS-1, Niab-78, NIAB-313/12 and NIAB-92. All of these varieties were grown during the cropping season in 1996, keeping row to row 75 cm and plant to plant 30 cm distance, respectively. All the required agronomic practices and crop protection measures were engaged from sowing till harvesting of the crop. During the flower initiation, in the month of August and September 1996, all possible crosses, including reciprocals were adopted among the eight cultivars. The F_1 hybrid seed from all the crosses along with their selves (parents) were sown in the field during May 1997 in a triplicated randomized complete block design. Each entry was planted in a 3.3 meter long row keeping ten plants experimental while two plants were left as non experimental on either side of the row.

The data concerning, plant height, number of bolls plant^{-1}, boll weight, yield of seed cotton and lint percentage were recorded in F_1 generations during the crop seasons.

The averaged data were subjected to the standard techniques of analysis of variance (Steel and Torrie, 1980) to establish the level of significance. The estimates of general and specific combining ability as defined by Sprague and Tatum (1942) and reciprocal effects as sketched by Griffing method I, model I (1956) were calculated.

Results and Discussion

Combining ability effects: The mean squares for GCA, SCA and reciprocals were observed to be highly significant for parameters, viz: height of main stem, number of bolls plant^{-1}, yield of seed cotton, boll weight and lint percentage (Table 1). The estimates of component of variance clarified that the variance due to SCA was much higher in magnitude and more vital than GCA in case of height of main stem plant^{-1}, number of bolls plant^{-1}, yield of seed cotton plant^{-1} and boll weight showing thereby the predominance of non additive type of gene action for the inheritance of these traits.

This reflected that the major portion of genetic variance (in percentage) for these characters is due to non-additive type of gene action with (dominance or epistatic effects). Kaushik *et al.* (1984), Khajjidoni *et al.* (1984), Ghafoor and Khan *et al.* (1987), Sayal *et al.* (1997) and Hassan *et al.* (1999), who already reported the importance of SCA effects regarding such characters.

Correspondingly the estimates of components of variance clarified that the variance due to GCA was much higher in magnitude and more imperative than SCA for the important character like lint percentage showing in that way the prevalence of additive type of gene action for the inheritance of this trait. These research findings are fairly in accordance with Bhatade and Bhale (1983), Khan *et al.* (1991), Yaqoob *et al.* (1997), Baloch *et al.* (2000) and Bhutto *et al.* (2001) who stressed upon the appreciable degree of variance due to GCA for this characters (Table 2).

General combining ability effects: The variety Niab-313/12 expressed its superiority and proved to be the best general combiner for Number of bolls, Yield of seed cotton and boll weight. Like wise variety Niab-78 was superior in general combining ability for lint percentage. Since Niab-313 /12 and Niab-78 showed their best general combining ability for yield and yield components, therefore, the best yielding parents might be exploited for varietal improvement for different cross combinations. Sufficient literature is available in support of such inferences such as Hassan *et al.* (1999), Kalwar and Babar (1999) and Hassan *et al.* (2000) who also concluded that best yielding parents having high GCA produced the best hybrid combinations (Table 3).

Specific combining ability: Cyto-9 /91 x Niab-92 showed the best performance for number of bolls plant^{-1} whereas Cyto-9 /91 x SLS-1 followed by B-496 x Niab-78 for yield of seed cotton concerning specific combining ability effects. The hybrids, Cyto-9 /91 x SLS-1 followed by B-496 x Niab-313 /12 were superior for boll weight, despite the fact that Cyto-9 /91 x Niab-78 was exposed as the best in case of lint percentage and thus surpassed other crosses. Moreover, Niab-313 /12 x B-622 cross achieved the first rank for height of main stem (Table 4).

Out come of the present study of combining ability is that in case of number of bolls plant^{-1}, yield of seed cotton plant^{-1}, boll weights the parents with best general combining ability on their exploitation in cross combinations as one of the parents did not produce superior hybrid combinations. Nevertheless the parents with highest general combining ability produced good hybrid combinations for height of main stem and lint percentage.

The results are in partial agreement with the findings of Khan and Khan (1985), Ghafoor and Khan (1987) and Baloch *et al.* (1995) who reported that GCA is not the decisive factor for predicting the SCA. At the same time as the results are partially matching with the conclusions of previous workers like, Khan *et al.* (1991), Baloch *et al.* (1997), Hassan *et al.* (1999), Kalwar and Babar (1999) and Hassan *et al.* (2000) who reported that the parents with best general combining ability on their utilization in cross combination as one of the parents produced good hybrid combinations. Contradiction like this may be due to different germplasm materials utilized and the distinct climatic conditions under which these workers launched their experiments.

Table 1: Mean square due to GCA, SCA and Reciprocal effects for various characters of cotton (*Gossypium hirsutum* L.) in an 8 x 8 diallel cross experiment (1996-98)

Source of variation	D.F.	Height of main stem	Bolls per plant	Yield of S.cotton	Boll weight	Lint %age
General combining ability	7	520.01**	42.26**	1790.94**	0.36**	2.99**
Specific combining ability	28	177.05**	13.50**	481.22**	0.11**	0.35**
Reciprocals	28	24.77**	1.34**	35.94**	0.008**	0.03**
Error	126	17.01	1.76	15.12	0.005	0.30

Table 2: Estimates of components of variance due to GCA, SCA and reciprocal effects for various characters of cotton (*Gossypium hirsutum* L.) in an 8 x 8 diallel cross experiment (1996-98)

Variance components	Height of main stem	Bolls per plant	Yield of S.cotton	Boll weight	Lint %age
General combining	21.61	01.81	82.37	00.01	00.16
Ability	16.34	18.19	10.99	19.82	45.78
Specific combining	89.85	06.59	261.67	00.05	0.02
Ability	67.88	66.19	084.59	71.86	7.38
Reciprocals	03.88	-0.21	10.41	0.002	-00.13
	02.93	-2.15	1.96	2.11	-36.05
Error	17.01	01.77	15.12	0.005	00.30
	12.85	17.77	02.46	6.21	82.89
Total	132.35	10.18	379.74	0.08	0.49
	100.00	100.00	100.00	100.00	100.00

* Upper values denote variance estimates

** Lower values denote variance components in percentage

Table 3: Estimates of general combining ability effects for various characters of cotton (*Gossypium hirsutum* L.) in a 8 x 8 diallel cross experiment (1997-98)

Varieties	Height of main stem	Bolls per plant	Yield of S.cotton	Boll weight	Lint %age
CYTO-9/91	5.65	-1.59	-6.95	-0.04	-0.42
B-496	4.86	-0.49	-4.44	-0.07	-0.30
SLS-1	-0.55	0.90	2.19	-0.04	0.15
NIAB-78	-8.75	0.54	7.18	0.16	0.78
NIAB-313/12	-3.29	3.38	22.15	0.26	0.29
B-622	8.11	-0.31	-2.96	-0.05	-0.28
NIAB-92	-3.07	-1.39	-6.16	-0.00	0.21
CYTO-11/91	-2.95	-1.03	-11.01	-0.22	-0.43
CD (gi – gj)	2.85	0.92	2.69	0.04	0.37

Table 4: Estimates of specific combining ability effects for various characters of cotton (*Gossypium hirsutum* L.) in a 8 x 8 diallel cross experiment (1996-98)

Cross combinations	Height of main stem	Bolls per plant	Yield of S.cotton	Boll weight	Lint %age
CYTO-9/91 X B-496	8.37	-0.45	-0.92	0.07	-0.30
CYTO-9/91 X SLS-1	9.42	1.95	18.75	0.37	0.52
CYTO-9/91 X NIAB-78	11.59	0.30	3.96	0.13	0.70
CYTO-9/91 X NIAB-313/12	-3.32	1.48	10.74	0.16	0.34
CYTO-9/91 X B-622	-4.44	-0.49	0.54	0.12	0.01
CYTO-9/91 X NIAB-92	-16.68	3.72	13.73	0.00	0.36
CYTO-9/91 X CYTO-11/91	3.99	-0.72	-2.39	0.03	-0.24
B-496 X SLS-1	5.55	0.33	1.82	0.03	0.24
B-496 X NIAB-78	-2.25	2.71	16.88	0.18	0.34
B-496 X NIAB-313/12	5.41	0.55	9.76	0.24	0.22
B-496 X B-622	-0.42	2.57	14.32	0.15	-0.40
B-496 X NIAB-92	4.76	-0.92	-1.62	0.09	0.40
B-496 X CYTO-11/91	-8.58	-0.07	-4.69	-0.13	-0.16
SLS-1 X NIAB-78	6.23	0.89	0.74	-0.08	0.26
SLS-1 X NIAB-313/12	-2.79	1.16	6.10	0.03	-0.29
SLS-1 X B-622	-4.40	1.26	2.99	-0.03	0.29
SLS-1 X NIAB-92	-0.80	-1.63	-2.31	0.14	-0.39
SLS-1X CYTO-11/91	5.78	1.85	9.72	0.11	-0.27
NIAB-78 X NIAB-313/12	4.20	1.07	3.90	-0.05	-0.52
NIAB-78 X B-622	0.17	1.18	8.05	0.11	-0.28
NIAB-78 X NIAB-92	-2.62	-1.73	-6.83	0.02	0.01
NIAB-78 X CYTO-11/91	3.21	0.22	4.79	0.14	0.13
NIAB-313/12 X B-622	13.79	1.29	6.08	0.01	0.32
NIAB-313/12 X NIAB-92	5.71	1.40	5.23	-0.02	0.02
NIAB-313/12 X CYTO-11/91	-0.22	1.69	4.93	-0.02	0.44
B-622 X NIAB-78	11.10	-1.02	-4.55	-0.01	-0.03
B-622 X CYTO-11/91	6.09	0.22	2.74	0.08	0.32
NIAB-92 X CYTO-11/91	5.21	2.45	12.35	0.10	0.30
CD(Sij – Sik)	7.56	2.44	7.13	0.13	1.00
CD(Sij - Ski)	7.00	2.26	6.60	0.12	0.93

Table 5: Estimates of reciprocal effects for various characters of cotton (*Gossypium hirsutum* L.) in an 8 x 8 diallel cross experiment (1996-98)

Cross combinations	Height of main stem	Bolls per plant	Yield of S.cotton	Boll weight	Lint %age
B-496 X CYTO-9/91	2.49	0.73	4.33	0.05	-0.28
SLS-1 X CYTO-9/91	2.69	1.06	6.18	0.06	0.10
NIAB-78 X CYTO-9/91	3.17	1.07	1.86	-0.09	-0.10
NIAB-313/12 X CYTO-9/91	1.34	-0.96	-5.79	-0.05	0.05
B-622 X CYTO-9/91	3.09	0.42	4.94	0.11	0.05
NIAB-92 X CYTO-9/91	15.56	0.59	-0.50	-0.09	0.10
CYTO-11/91 X CYTO-9/91	1.73	0.66	-0.79	-0.10	0.05
SLS-1 X B-496	2.92	0.47	0.22	-0.04	0.08
NIAB-78 X B-496	1.13	0.55	0.57	-0.05	0.05
NIAB-313/12 X B-496	1.21	-1.12	-7.87	-0.11	-0.05
B-622 X B-496	0.97	0.59	3.04	0.02	-0.05
NIAB-92 X B-496	1.63	1.13	4.76	-0.01	0.05
CYTO-11/91 X B-496	1.43	0.94	6.39	0.10	-0.05
NIAB-78 X SLS-1	1.77	-1.00	-3.55	0.04	0.03
NIAB-313/12 X SLS-1	1.41	-1.11	-5.89	-0.03	0.10
B-622 X SLS-1	-1.47	0.52	1.68	-0.05	0.00
NIAB-92 X SLS-1	0.77	0.68	5.04	0.09	0.05
CYTO-11/91 X SLS-1	1.96	0.59	4.80	0.08	0.10
NIAB-313/12 X NIAB-78	2.64	-0.66	-1.40	0.04	0.10
B-622 X NIAB-78	1.15	1.15	5.50	0.02	-0.54
NIAB-92 X NIAB-78	-0.59	0.76	4.49	0.05	0.05
CYTO-11/91 X NIAB-78	-0.81	0.57	5.98	0.12	0.08
B-622 X NIAB-313/12	-1.83	-1.17	-2.02	0.06	0.03
NIAB-92 X NIAB-313/12	2.03	-0.75	-1.72	0.04	0.03
CYTO-11/91X NIAB-313/12	1.60	0.52	1.34	-0.02	0.05
NIAB-92 X B-622	1.24	1.07	3.89	-0.01	0.05
NIAB-92 X CYTO-11/91	3.25	0.67	4.56	0.07	0.05
CYTO-11/91 X NIAB-92	2.63	0.29	2.73	0.05	0.27
CD(rij - rki)	8.08	2.61	7.62	0.14	1.07

Reciprocal effects: Finally, Table 5 condensed that the cross Niab-92 x Cyto-9/91 was exposed for highest score in case of height of main stem plant^{-1} while B-622 x Niab-78 achieved the top position with reference to number of bolls. The cross Cyto-11/91 x B-496 reflected the highest value for yield of seed cotton plant^{-1} and likewise the highest reciprocal effect value for boll weight was achieved by the hybrid Cyto-11/91 x Niab-78.

Cyto-11/91 x Niab-92 excelled other crosses in reciprocal effects for lint percentage. From the findings, it is suggested, that single cross performance could be composited with their reciprocal effects, if yield and its components, lint percentage and its components are to be kept in view. Bhatade *et al*. (1980) also recommended this type of proposal previously.

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