Pakistan Journal of Applied Sciences 3 (6): 391-399, 2003
ISSN 1607-8926

Comparison of Combining Ability of Yield Components of Plan Land and Ridges Pattern of Plantation in *Gossypium hirsutum* L.

Riazud Din Ahmad, [1]Abdul Jabbar Malik, [1]M. Ali Chang, [2]Gul Hassan,
Muhammad Subhan, M. Umar Khan and [3]Liaqat Ali
Faculty of Agriculture, Gomal University, D.I. Khan, Pakistan
[1]Department of Plant Breeding and Genetics, Sindh Agriculture University,
Tandojam, Sindh, Pakistan
[2]Department of Weed Sciences, NWFP Agriculture University, Peshawar, Pakistan
[3]Pakistan Academy for Rural Development, Peshawar, Pakistan

Abstract: Experiment of 8×8 diallel analysis was conducted on Upland cotton (*Gossypium hirsutum* L.) in the Faculty of Agriculture, Gomal University, D.I.Khan, Pakistan during copping season 1997-99. Sowing was managed both on Flat land and Ridges to differentiate the estimation of combining ability analysis in the inheritance of some important yield components viz., Seed Index, Lint %age, Lint Index and Staple length by Griffing's Method- II, Model-1 in F_1 generation. The mean squares for General Combining Ability (GCA), Specific Combining Ability (SCA) and reciprocals effects of both flat land and ridges plantation were observed to be highly significant for the characters mentioned. The estimates of component of variance clarified that the variance due to SCA was much higher in magnitude and more imperative than GCA for all the traits mentioned above except for lint index in flat land but the SCA was quite higher in style of ridges for all the parameters. This type of variance percentage surly indicated the significant role of non additive type of gene action with (dominance or epistatic effects) in the inheritance of these traits, though additive type of gene action was reflected in case of Lint index because of its higher GCA (Flate Land).

Key words: *Gossypium hirsutum* L., local cultivars, GCA, SCA, reciprocal effects, yield components, flat/ridges plantation, Pakistan

Introduction

Flexible parental lines are desirable to be utilized in any hybridization strategy to engineer genetically modified and potentially better genotypes with collection of varying gene effects relatively in a homozygous line. To estimate different types of gene action, relative magnitude of genetic variance and combining ability estimates are essential and indispensable requirements to mould the genetic base of cotton crop. This noteworthy information could prove a critical approach to the cotton breeders in the selection of better parental combinations for future improvement. Utilization of heterosis mainly reliant on the screening and selection of existing germplasm that could guarantee improved combinations of characters.

The total genetic variability concluded in the analysis for each character was classified into its components i.e. Generaland Specific combining ability as defined by Sprangue and Tatum (1942) and Reciprocal as proposed by Griffing (1956); 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 the characters understudy.

Many marketable cultivars above and beyond their attractive agronomic reflection execute badly because of genetic hindrances in diverse cross combinations. Consequently crossing in a diallel fashion is the only accurate and prosperous method of assessment for gradation and selection of better genetically customized material. The present research program was designed to investigate some important cotton cultivars/genotypes to determine their relative performance concerning combining ability effects for yield and its components.

Materials and Methods

The research study was conducted at Faculty of Agriculture, Gomal University, Dera Ismail Khan during the years 1997-99. The germplasm material was consisting of eight cultivars of cotton (***Gossypium hirsutum*** L.) viz; CIM-443, MNH-93, CIM-448, NIAB-78, SLS-1, CIM-446, FH-634 and CIM-1100 which were crossed in all possible combinations. The axis of this study was to expose the gene action through combining ability for various yield components. All the genotypes along with parents were grown to examine the data of diverse parameters of F_1 in triplicated Randomized Complete Block Design (RCBD) by arranging row to row distance as 75 cms and plant to plant 30 cms equally on flat land and ridges. Agronomic and crop protection measures were also maintained from sowing to harvesting. Every treatment was set in a 3.3 meter long row keeping ten plants experimental while two plants were kept as non experimental on either side of the row.

The data were recorded on Seed Index, Lint %age, Lint Index and Staple length in F_1 generation. The mean data were subjected to the standard techniques of analysis of variance (Steel and Torrie, 1980) to check the level of significance. The general and specific combining ability as defined by Sprague and Tatum (1942) and reciprocal effects as proposed by Griffing method I, model II (1956) were estimated.

Results and Discussion

Combining ability effects

GCA, SCA and reciprocals were observed for mean squares to be highly significant for traits, viz: Seed Index, Lint %age, Lint Index and Staple length (Table 1a, b). The estimates of component of variance uncovered that the variance due to SCA was much higher in magnitude and more vital than GCA in case of Seed Index, Lint %age and Staple length clarifying thus the prevalence of non additive type of gene action for the inheritance of these traits. Although GCA was quite high in case of Lint index exposing additive type of gene action in Flat Land. 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).

Table 1a: F1 Flat land (1997-98)

Source of variation	Seed index	Lint %age	Lint index	Staple length
General Combining Ability	0.3657**	4.1772**	0.7822**	1.9521**
Specific combining Ability	0.1972**	0.9751**	0.2411**	1.5799**
Reciprocals	9.2679**	0.3139**	0.0464**	0.1420**
Error	3.3857	0.3378	5.3836	0.1536

Table 1b: F1 Ridges Plantation (1997-98)

Source of variation	Seed index	Lint %age	Lint index	Staple length
General Combining Ability	1.0577**	4.0693**	0.5060**	5.0448**
Specific combining Ability	0.1977**	1.2279**	0.1675**	1.2551**
Reciprocals	0.1047**	1.1249**	0.1010**	0.2490**
Error	9.7929	0.2608	1.9810	0.3021

Table 2: Estimates of components of variance due to GCA, SCA and reciprocal effects of various characters of cotton (*Gossypium hirsutum* L.) in an 8 x 8 diallel cross experiment (1998-99)

Variance Components	Seed index	Lint %age	Lint index	Staple length
F_1 Flat Land plantation				
General Combining Ability	0.0107	0.2008	3.4028	0.0248
	6.4670	22.7047	38.2866	2.5478
Specific Combining Ability	0.0916	0.3577	0.1051	0.8008
	55.3107	40.4455	1.18253	82.2683
Reciprocals	0.0294	-0.0119	-0.0037	-0.0058
	17.7526	-1.3455	-0.0416	-0.1511
Error	0.0339	0.3378	5.3835	0.1536
	17.7526	38.1954	60.5725	15.7797
Total	0.1656	0.8844	8.8877	0.9734
F_1 Ridges plantation				
General Combining Ability	0.0539	0.1786	0.0213	0.2379
	0.5441	12.6219	1.0020	22.6874
Specific Combining Ability	0.05603	0.5430	0.0829	0.5351
	0.5656	38.3746	3.8997	51.0299
Reciprocals	0.0040	0.4326	0.0406	-0.0265
	0.0433	30.5724	1.9099	-2.5272
Error	9.7929	0.2608	1.9810	0.3021
	98.8500	18.4311	93.1884	28.8098
Total	9.9068	1.4150	2.1258	1.0486
	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	Seed index	Lint %age	Lint index	Staple length
Flat Land Plantation				
CIM-443	-0.07	-0.19	-0.09	-0.04
MNH-93	0.07	-0.00	0.19	-0.02
CIM-448	-0.17	-0.28	-0.30	-0.11

Table 3: Continue

Varieties	Seed index	Lint %age	Lint index	Staple length
NIAB-78	-0.13	0.42	0.05	-0.18
SLS-1	-0.13	-0.59	-0.22	-0.13
CIM-446	0.10	0.41	0.01	-0.49
FH-634	0.06	-0.60	-0.03	0.27
CIM-1100	0.28	0.82	0.40	0.70
CD (gi - gj)	0.13	0.40	0.16	0.27
(Ridges)				
CIM-443	-0.22	-0.13	-0.14	-0.19
MNH-93	0.14	0.36	0.17	-0.20
CIM-448	-0.03	-0.60	-0.15	-0.20
NIAB-78	-0.23	0.48	-0.02	-0.57
SLS-1	-0.26	-0.56	-0.27	-0.32
CIM-446	-0.13	0.06	0.02	-0.26
FH-634	0.39	-0.37	0.15	0.66
CIM-1100	0.34	0.77	0.25	1.08
CD (gi - gj)	0.22	0.35	0.097	0.38

Table 4: Estimates of specific combining ability effects for various characters of cotton (*Gossypium hirsutum* L.) in a 8 × 8 diallel cross experiment Flat Land Plantation (1998-99)

Cross combinations	Seed index	Lint %age	Lint index	Staple length
Flat Land Plantation				
CIM-443 × MNH-93	-0.16	0.62	-0.08	-0.15
CIM-443 × CIM-448	0.31	0.93	-0.11	0.19
CIM-443 × NIAB-78	0.28	-0.04	0.30	-0.03
CIM-443 × SLS-1	-0.24	-0.18	-0.25	0.52
CIM-443 × CIM-446	0.43	0.10	0.37	0.39
CIM-443 × FH-634	-0.15	-0.72	0.43	-0.10
CIM-443 × CIM-1100	0.17	0.58	-0.05	0.03
MNH-93 × CIM-448	0.01	0.12	0.08	0.83
MNH-93 × NIAB-78	0.20	0.74	0.21	0.05
MNH-93 × SLS-1	0.35	0.32	0.18	0.26
MNH-93 × CIM-446	-0.11	-0.53	0.24	-0.41
MNH-93×FH634	0.18	-0.82	-0.16	0.57
MNH-93 × CIM-1100	0.01	-0.08	0.32	0.13
CIM-448 × NIAB-78	-0.05	0.07	-0.12	0.15
CIM-448 × SLS-1	-0.06	-0.13	-0.13	0.22
CIM-448 × CIM-446	0.45	-0.24	0.31	-0.59
CIM-448 × FH-634	0.14	0.39	0.22	0.83
CIM-448 × CIM-1100	0.35	0.66	0.39	1.17
NIAB-78 × SLS-1	0.02	0.12	0.15	-0.93
NIAB-78 × CIM-446	-0.34	-0.03	-0.26	0.23
NIAB-78 × FH-634	0.23	1.21	0.01	1.07
NIAB-78 × CIM-1100	0.13	-0.95	0.42	0.66
SLS-1 × CIM-446	-0.23	0.60	-0.10	0.35
SLS-1 × FH-634	-0.06	-0.30	-0.09	1.14
SLS-1 × CIM-1100	0.42	0.30	0.35	0.18
CIM-446 × FH-634	0.32	0.91	0.61	-0.39

Table 4: Continue

Cross combinations	Seed index	Lint %age	Lint index	Staple length
CIM-446 × CIM-1100	0.05	0.28	-0.05	1.07
FH-634 × CIM-1100	-0.32	0.39	-0.37	-1.55
CD(Sij - Sik)	0.34	1.07	0.43	0.72
CD(Sij - Ski)	0.31	0.99	0.39	0.67
Ridges plantation				
CIM-443 × MNH-93	0.02	0.99	0.23	0.07
CIM-443 × CIM-448	0.34	0.89	0.25	-0.29
CIM-443 × NIAB-78	-0.11	-0.24	-0.11	-0.07
CIM-443 × SLS-1	0.06	-0.02	0.09	-0.13
CIM-443 × CIM-446	0.06	0.36	0.08	0.76
CIM-443 × FH-634	-15.00	-0.66	-0.26	-0.88
CIM-443 × CIM-1100	0.01	0.10	0.15	0.82
MNH-93 × CIM-448	-0.26	-0.13	-0.15	1.46
MNH-93 × NIAB-78	-0.07	-0.25	-0.27	-0.71
MNH-93 × SLS-1	-0.11	0.05	-0.03	0.75
MNH-93 × CIM-446	0.64	0.23	0.38	-0.58
MNH-93 × FH-634	-0.01	-0.24	-0.04	0.94
MNH-93 × CIM-1100	0.36	0.26	0.41	-0.68
CIM-448 × NIAB-78	0.16	0.44	0.20	0.42
CIM-448 × SLS-1	-0.54	-1.39	-0.23	-0.15
CIM-448 × CIM-446	0.25	0.04	0.12	-1.04
CIM-448 × FH-634	0.38	1.29	0.53	0.32
CIM-448 × CIM-1100	-0.22	0.46	-0.17	0.60
NIAB-78 × SLS-1	0.14	1.54	0.26	0.43
NIAB-78 × CIM-446	-0.02	0.15	-0.08	-0.31
NIAB-78 × FH-634	0.40	0.44	0.28	0.19
NIAB-78 × CIM-1100	0.39	-0.72	0.15	1.25
SLS-1 × CIM-446	-0.18	0.59	-0.02	-0.17
SLS-1 × FH-634	0.22	-0.27	0.08	0.50
SLS-1 × CIM-1100	0.12	0.41	0.30	-0.09
CIM-446 × FH-634	-0.03	0.71	0.08	0.66
CIM-446 × CIM-1100	-0.41	-0.74	-0.32	0.74
FH-634 × CIM-1100	-0.13	0.07	-0.03	-1.04
CD(Sij - Sik)	0.57	0.94	0.26	1.01
CD(Sij - Ski)	0.53	0.87	0.23	0.93

Table 5: Estimates of reciprocal effects for various characters of cotton (*Gossypium hirsutum* L.) in an 8 × 8 diallel cross experiment (1997- 98)

Cross combinations	Seed index	Lint %age	Lint index	Staple length
Flat Land				
CIM-443 × MNH-93	0.06	-0.25	-0.22	0.16
CIM-443 × CIM-448	0.18	-0.14	0.07	-0.39
CIM-443 × NIAB-78	0.09	-0.34	0.01	0.07
CIM-443 × SLS-1	-0.48	0.08	-0.34	0.08
CIM-443 × CIM-446	-0.50	-0.12	-0.26	0.19
CIM-443 × FH-634	0.04	0.22	0.06	0.10
CIM-443 × CIM-1100	-0.02	0.09	0.05	-0.06

Table 5: Continue

Cross combinations	Seed index	Lint %age	Lint index	Staple length
MNH-93 × CIM-448	0.07	-1.25	-0.01	-0.31
MNH-93 × NIAB-78	0.41	-0.35	0.25	0.33
MNH-93 × SLS-1	-0.25	-0.45	-0.38	0.14
MNH-93 × CIM-446	-0.10	-0.15	-0.18	-0.65
MNH-93 × FH-634	-0.04	0.92	0.00	-0.11
MNH-93 × CIM-1100	0.07	-0.16	0.01	-0.05
CIM-448 × NIAB-78	0.03	0.16	0.06	0.09
CIM-448 × SLS-1	0.06	-0.07	0.02	0.20
CIM-448 × CIM-446	-0.04	-0.20	-0.13	0.00
CIM-448 × FH-634	-0.05	-0.08	-0.06	0.15
CIM-448 × CIM-1100	-0.04	-0.47	-0.01	-0.52
NIAB-78 × SLS-1	-0.14	-0.25	-0.03	0.04
NIAB-78 × CIM-446	0.23	-0.16	0.14	0.02
NIAB-78 × FH-634	-0.10	-0.35	-0.02	-0.21
NIAB-78 × CIM-1100	-0.20	0.29	-0.19	-0.30
SLS-1 × CIM-446	-0.11	0.10	-0.05	0.32
SLS-1 × FH-634	-0.41	0.15	-0.06	-0.34
SLS-1 × CIM-1100	-0.38	0.69	-0.26	0.29
CIM-446 × FH-634	-0.23	-0.42	-0.05	0.29
CIM-446 × CIM-1100	0.11	-0.29	-0.04	-0.16
FH-634 × CIM-1100	0.06	-0.03	0.07	-0.44
CD(rij - rki)	0.36	1.14	0.45	0.77
Ridges plantation				
CIM-443 × MNH-93	0.21	0.99	0.34	-0.25
CIM-443 × CIM-448	-0.41	-0.82	-0.24	-0.30
CIM-443 × NIAB-78	-0.21	0.32	-0.05	-0.33
CIM-443 × SLS-1	0.08	0.95	0.24	-0.54
CIM-443 × CIM-446	-0.02	-0.39	0.09	-0.35
CIM-443 × FH-634	-0.26	0.98	0.06	-0.09
CIM-443 × CIM-1100	-0.50	-1.50	-0.56	-0.17
MNH-93 × CIM-448	0.03	-0.49	-0.08	-0.37
MNH-93 × NIAB-78	0.00	-0.20	-0.04	-0.06
MNH-93 × SLS-1	-0.25	-0.50	-0.41	0.67
MNH-93 × CIM-446	0.05	0.11	0.01	-0.48
MNH-93 × FH-634	-0.22	0.67	-0.01	0.01
MNH-93 × CIM-1100	-0.05	-0.70	-0.17	-0.06
CIM-448 × NIAB-78	-0.22	-0.40	-0.24	0.34
CIM-448 × SLS-1	0.09	0.77	0.10	-0.30
CIM-448 × CIM-446	-0.39	0.05	-0.25	0.40
CIM-448 × FH-634	-0.33	-0.85	-0.37	-0.29
CIM-448 × CIM-1100	-0.04	-0.11	-0.04	-0.15
NIAB-78 × SLS-1	-0.22	-0.20	-0.12	0.03
NIAB-78 × CIM-446	0.25	0.72	0.30	0.00
NIAB-78 × FH-634	0.02	-0.63	-0.13	-0.46
NIAB-78 × CIM-1100	-0.44	-0.41	-0.34	-0.26
SLS-1 × CIM-446	-0.07	-0.30	-0.12	-0.19
SLS-1 × FH-634	-0.31	-0.26	0.06	-0.27

Table 5: Continue

Cross combinations	Seed index	Lint %age	Lint index	Staple length
SLS-1 × CIM-1100	-0.04	0.15	-0.05	-0.23
CIM-446 × FH-634	0.18	-1.40	-0.20	0.28
CIM-446 × CIM-1100	0.11	-1.88	-0.32	-0.13
FH-634 × CIM-1100	-0.05	0.08	0.09	-0.98
CD(rij - rki	0.61	1.00	0.28	1.08

On the other hand SCA was fairly high in all the parameters showing and confirming non additive type of gene action (Epistasis and Dominance) pointing towards heterosis indirectly (Ridges). This confirmed that the decisive role of genetic variance (in percentage) for these characters is due to non additive type of gene action (with dominance or epistatic effects). Khajidoni ***et al.*** (1984), Ghafoor and Khan ***et al.*** (1987), Sayal ***et al.*** (1997), Hassan ***et al.*** (1999) and Subhan ***et al.*** (2003), who already concluded the crucial role of SCA effects regarding such characters.

General combining ability effects

The variety CIM-1100 expressed its superiority and proved to be the best general combiner for Seed Index, Lint %age, Lint Index and Staple length (Flat Land). Like wise the same variety was superior in general combining ability effect for, Lint %age, Lint Index and Staple length (ridges plantation). While FH-634 surpassed all the others in case of seed index as general combiner (Ridges). Moreover, CIM-1100 also reached at the climax regarding all the rest of the parameters (Ridges). Therefore, the best yielding parents like FH-634 and CIM-1100 might be selected for varietal improvement in different cross combinations. Adequate 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 with high GCA produced the best hybrid combinations (Table 3).

Specific combining ability

Considering Table 4 CIM-448 × CIM-446 showed the most excellent presentation for seed Index whereas NIAB-78 × FH-634 for Lint %age concerning specific combining ability effects. The hybrid, CIM-446 × FH-634 was superior for Lint Index, despite the fact that CIM-448 × CIM-1100 was clarified as the best in case of Staple length thus surpassed other crosses (Flat Land). MNH-93 × CIM-446 was the best one with respect to Seed Index although NIAB-78 × SLS-1 was exposed as the most superior regarding Lint %age among all the hybrids. Furthermore, CIM-448 × FH-634 reached at the climax in case of Lint Index, although for Staple length the hybrid like MNH-93 × CIM-448 was noted as the most superior one (Ridges).

Out come of the present study of combining ability of both Flate Land / Ridges is that in case of Lint percentage and Lint Index, the parents with best general combining ability on their exploitation in cross combinations as one of the parents could not produce superior hybrid combinations. Nevertheless the parents like, FH-634 and CIM-1100 with highest general combining ability produced good hybrid combinations for seed Index and staple length respectively.

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 crucial factor for estimating the SCA. At the same time as the results are partially identical with the conclusions of previous workers like Marani (1964), Waldia ***et al.*** (1984), Khan ***et al.*** (1991a), Baloch ***et al.*** (1997), Hassan ***et al.*** (1999), Kalwar and Babar (1999), Hassan ***et al.*** (2000) and Subhan ***et al.*** (2003) who concluded that the parents with best general combining ability on their utilization in cross combination as one of the parents produced good hybrid combinations. This type of contradiction may be due to diverse germplasm materials utilized and the dissimilar climatic conditions under which these workers conducted their experiments.

Reciprocal effects

Table 5 highlighted that hybrid MNH-93 × NIAB-78 obtained Lint %age highest position regarding seed, lint indices and Staple length while MNH-93 × FH-634 achieved its superiority in case of lint percentage. Further more, NIAB-78 × CIM-446 was exposed for highest score in case of seed index and cross MNH-93 X FH-634 for lint percentage while NIAB-78 X CIM-446 was noted for lint index (Ridges). Moreover MNH-93 × SLS-1 achieved the top position with reference to staple length (Ridges). From the fore going discussion, it is suggested, that single cross performance could be compo sited with their reciprocal effects, if yield and its components are to be kept in view. Bhatade ***et al.*** (1980) also concluded this kind of observation in advance.

References

Baloch, M.J., H.U. Bhutto, R. Rind and G.H. Tunio. 1995. Combining ability estimates in 5 × 5 diallel intra-hirsutum crosses. Pak. J. Bot., 27:121-126.

Baloch, M.J., H.U. Bhutto and A.R. Lakho, 1997. Combining ability estimates of highly adapted tester lines crossed with pollinator inbreds of cotton ***Gossypium hirsutum*** L. Pak. J. Sci. Ind. Res., 40: 95-98.

Baloch, M.J., A.R. Lakho, H.U. Bhutto. A.M. Memon, G.N. Panhwar and A.H. Soomro, 2000. Estimates of combining ability and genetic parameters for yield and fiber traits in Upland cotton. Pak. J. Biol. Sci., 3: 1183-1186.

Bhatade, S.S., M.R. Shobhane and P.K. Unchangaonkar, 1980. Heterosis and Combining ability in (***Gossypium arboreum*** L.). Ind. J. Agric. Sci., 50: 310-316.

Bhutto, H., M.J. Baloch and M. Yousaf, 2001. Diallel analysis for estimating combining ability of quantitatively inherited traits in Upland cotton. Pak. J. Biol. Sci., pp: 89-91.

Griffing, B., 1956. Concept of general and specific combining ability in relation to diallel system. Aust. J. Biol. Sci., 9: 463-493.

Ghafoor, A. and M.A. Khan, 1987. Combining ability effects and genetic interpretation of four quantitative characters in Upland cotton. J. Agri. Res., 25: 7-15.

Hassan, G., G. Mahmood, N.U. Khan and A. Razzaq, 1999. Combining ability and heterobeltiotic estimates in a diallel cross of cotton ***Gossypium hirsutum*** L. Sarhad J. Agri., 15: 563-568.

Hassan, G., G. Mahmood, A. Razzaq and Hayatullah, 2000. Combining ability in inter-varietal ***Gossypium herbaceum*** L. ***Gossypium arboeium*** L. Indian J. Agric. Sci., 54: 9-16.

Khajjidoni, S.T., K.G. Hiremath, S.N. Kadapa and J.V. Coul, 1984. Heterosis and combining ability in ***G. herbaceum*** L. and ***G. arboreum*** L. Ind. J. Agric. Sci., 54:9-16.

Khan, M.A and A.A. Khan. 1985. Estimation of combining ability effects in ***Gossypium hirsutum*** L. crosses. The Pak. Cottons, 29: 33-42.

Khan, M.A., K.L. Cheema, A. Masood and H.A. Sadaqat, 1991. combining ability in cotton (***Gossypium hirsutum*** L.). L. J. Agric. Res. 29: 311-318.

Kalwar, M.S. and S.B. Babar, 1999. Estimates of combining ability in Upland cotton (***Gossypium hirsutum*** L.). The Pak. Cottons, 43: 25-30.

Sayal, O.U., S.A. Jatoi, M.S. Baloch and I. Hussain, 1997. Estimation of combining ability for quantitative traits in ***G. hirsutum*** L. using Griffings technique of diallel. Scientific Khyber, 10: 13-21.

Sprague, G.F. and L.A. Tatum, 1942. General versus specific combining ability in single crosses of corn. J. Amer. Soc. Agron., 34: 923-952.

Subhan, M., M. Qasim, Ruiazud Din Ahmad, M. Umar Khan, M. Amin Khan and M. Amir Amin, 2003. Combining Ability for yield and its components in Upland cotton. Asian J. Plant Sci., 2: 519-522.

Steel, R.G.D. and J.H. Torrie, 1980. Principles and Procedures of Statistics, a Biological Approach. Second Edition, McGraw Hill Inc New York, Toronto, London.

Waldia, R.S., B.R. Mor and J.S. Yadava, 1984. Combining ability for yield and its components in desi cotton (***G. arboreum*** L.). Haryana Agric. Univ. J. Res., 14:151-156.

Yaqoob, M., G. Hassan, G. Mahmood and N.H. Shah, 1997. Combining ability studies for some quality traits in cotton ***Gossypium hirsutum*** L. J. Pure and App. Sci., 16: 47-50.