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Genetics of Some Fiber Quality Traits Among Intraspecific Crosses of American Cotton (*Gossypium hirsutum*)

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ABSTRACT

Five American cotton (*Gossypium hirsutum* L.) varieties namely Coker-4601, MNH-552, S-14, Stoneville and Allepo-41 were crossed in a complete diallel fashion and evaluated in randomized complete block design. Gene action and combining ability effects were estimated for the fiber quality its fineness, staple length, uniformity ratio and strength. Fiber fineness, staple length and fiber strength were found to be controlled by additive type of gene action with partial dominance while fiber uniformity ratio with over dominance type of gene action. For fiber fineness and staple length genotype Coker-4601 was a good general combiner whereas S-14 and Stoneville were good combiner for fiber uniformity ratio and its strength. The cross combinations, Coker-4601 X Stoneville showed better SCA for staple length and fiber strength while Coker-4601 X Allepo-41 and Coker-4601 X S-14 showed good SCA for fiber fineness and fiber uniformity ratio.

Key Words: Gene action; Combining ability; Genetic studies; Fiber quality traits; American cotton

INTRODUCTION

Pakistan is an agricultural country and cotton crop is the backbone for its foreign exchange earnings. It plays an important role in the economy of Pakistan by contributing 10.5% to the value addition in agriculture, about 2.4% to GDP and 60% to the total foreign exchange earnings through exports of raw cotton and cotton products. It is grown on 3.28 million hectares, mainly for fiber purpose (Government of Pakistan, 2005).

The longer and finer staple contributes to its better quality, since it can be used to produce thinner and lighter textiles without knots or uneven surfaces. Although Pakistan is self-sufficient in cotton production but lacks in production of types with better fiber quality traits and per unit area production as compared to advanced cotton growing countries (USA, Australia, Egypt, China) of the world. Improvement in this direction is possible if existing scarce genetic sources are properly utilized. Selection of parental lines is required in any hybridization program to produce genetically modified germplasm to exploit high potential. Information pertaining to different types of gene action is important. Also the knowledge and complete understanding of inheritance pattern for economic traits is a pre-requisite to enhance progress in breeding new varieties of cotton. While aiming to select a desirable genotype, the simple technique of crossing/hybridizing of contrasting parents has facilitated breeders to identify the genetics of simply inherited characters. The diallel analysis technique of Mather and Jinks (1982) is a useful tool to obtain precise information about the type of gene action involved for the expression of fiber quality traits. It provides a systematic approach for the detection of appropriate parents and crosses superior in terms of the investigated traits.

The present research work was carried out to obtain the genetic information for some fiber quality characters by using diallel technique, following Hayman (1954) and Jinks (1954).

MATERIALS AND METHODS

The present studies were conducted at the experimental farms of the department of Plant Breeding and Genetics, University of Agriculture, Faisalabad during the years 2004-05. The experimental material for these studies was developed by crossing five parental genotypes namely; coker-4601, MNH-552, S-14, Stoneville and Allepo-41 in all possible combinations.

Greenhouse cultivation. The seeds of these five parents were sown in earthen pots placed in greenhouse during November 2004. During germination and growth, optimum conditions (light & temperature) were possibly provided and required agronomic practices were followed. At the time of flowering the parental lines were crossed in a complete diallel fashion (5 x 5) to generate 20 F_1 crosses (direct & reciprocals) and 5 selfed parents. All necessary

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precautionary measures were taken to avoid contamination of genetic material at the time of crossing and selfing. At maturity, crossed and selfed bolls were picked and seed cotton of each cross was ginned separately using single roller electric ginner.

Field evaluation. The F1 seed from all crosses along with their selfed parents were sown in the field in a randomized complete block design with three replications during June-2005. In each replication 25 genotypes were planted in a single row having 10 plants with plant to plant and row to row distances of 30 cm and 75 cm, respectively. All the recommended agronomic practices and crop protection measures were applied from sowing till harvest. At maturity, the data were recorded on five randomly selected plants from each entry on individual plant basis.

Fiber evaluation. About 8-10 g of each sample was taken to measure fiber quality traits. A High Volume Instrument (HVI-900 SA) was used to measure the fiber quality in the Department of Fiber Technology, University of Agriculture, Faisalabad.

Statistical analysis. The data collected was subjected to standard techniques of analysis of variance (Steel *et al.*, 1997) to establish the level of genotypic differences for the plant traits under study. The characters showing significant genotypic differences were further analyzed genetically following additive-dominance model of genetic analysis developed by Hayman (1954) and Jinks (1954).

RESULTS AND DISCUSSION

Fiber fineness. Analysis of variance for fiber fineness exhibited highly significant differences among the parental varieties and their F_1 hybrids (Table I). The b value deviated significantly from zero indicating the adequacy of the data for genetic analysis (Table II). Mean values of the genotypes are given in 5 X 5 diallel table (Table III) and variance (Vr) and covariance (Wr) values were calculated to draw Vr/Wr graph. Additive type of gene action with partial dominance was involved in the inheritance of this trait as regression line passed through the Wr-axis above the point of origin (Fig. 1).

As regression line did not deviate from unit slope, therefore the interaction of genes was not involved. The results are compatible with the findings of Pavasia *et al.* (1999), Mukhtar *et al.* (2000), Ahmad and Azhar (2000), Amin and Hussain (2000), Ahmad *et al.* (2003), Iqbal *et al.* (2003) and Azhar *et al.* (2004), while Banumathy and Patil (2000), Islam *et al.* (2001), Khan *et al.* (2001), Cheatham *et al.* (2003), Haq and Azhar (2005) and Murtaza *et al.* (2005) reported non additive type of gene action involved in the phenotypic expression of this trait. From the varietal positions on regression line it was observed that MNH-552 being closest to the origin had maximum dominant genes and Coker-4601 being away from origin possessed most of recessive ones (Fig. 1). In case of fiber fineness genotype showing lower micronair values is finer as regards its fiber quality. The micronair values indicated that variety Coker-4601 with minimum array mean value (4.59) had best general combining ability, while the cross Coker-4601 X Allepo-41 (4.68) indicated the best specific combining ability for fiber fineness (Table III).

Table I. Mean squares for fiber traits in 25 crosses including selfs

S.O.V.	d.f.	Fiber Fineness	Staple Length	Fiber uniformity ratio	Fiber strength
Replication	2	0.069	1.030	6.708	2.980
Genotypes	24	0.284**	2.673**	3.548**	2.819**
Error	48	0.033	0.586	1.321	1.018
Total	74				

** = Highly Significant at 0.01% level.

Table II. Tests for adequacy of additive-dominance model for 5 X 5 diallel of cotton

Characters	Joint regression	Test for b=0	Test for b=1	Test for t^2	Remarks
Fiber fineness	b=0.894±0.144	6.201**	0.731^{NS}	0.226^{NS}	The data were adequate for simple additive-dominance model.
Staple length	b=0.875±0.089	9.734**	1.381^{NS}	1.348^{NS}	The data were fit for additive-dominance model
Fiber uniformity ratio	b=0.963±0.234	4.118*	0.154^{NS}	0.039^{NS}	The data were adequate for additive-dominance model
Fiber Strength	b=0.960±0.080	11.865**	0.486^{NS}	0.126^{NS}	The data were fit for additive-dominance model

* = Significant, ** = Highly Significant, NS= Non Significant

Table III. 5 X 5 Diallel table for fiber fineness

	Allepo-41	Stoneville	S-14	MNH-552	Coker-4601
Allepo-41	5.166	5.033	5.283	5.166	4.683
Stoneville	5.033	4.666	5.300	4.850	4.700
S-14	5.283	5.300	5.133	5.133	4.816
MNH-552	5.166	4.850	5.133	4.866	4.850
Coker-4601	4.683	4.700	4.816	4.850	3.900
Totals	25.333	24.550	25.666	24.866	22.950
Array Means	5.066	4.910	5.133	4.973	4.590

Table IV. 5 X 5 Diallel table for staple length

	Allepo-41	Stoneville	S-14	MNH-552	Coker-4601
Allepo-41	26.400	28.566	27.150	27.933	29.066
Stoneville	28.566	28.466	28.350	27.933	29.600
S-14	27.150	28.350	27.100	27.900	29.166
MNH-552	27.933	27.933	27.900	26.733	28.733
Coker-4601	29.066	29.600	29.166	28.733	29.366
Totals	139.116	142.916	139.666	139.233	145.933
Array Means	27.823	28.583	27.933	27.846	29.186

Table V. 5 X 5 Diallel table for fiber uniformity ratio

	Allepo-41	Stoneville	S-14	MNH-552	Coker-4601
Allepo-41	50.133	50.433	50.100	50.683	50.083
Stoneville	50.433	48.566	50.083	51.633	50.200
S-14	50.100	50.083	52.300	51.183	52.250
MNH-552	50.683	51.633	51.183	49.700	51.700
Coker-4601	50.083	50.200	52.250	51.700	48.600
Totals	251.433	250.916	255.916	254.900	252.833
Array Means	50.286	50.183	51.183	50.980	50.566

Staple length. Analysis of variance revealed highly significant genetic differences among all the genotypes for staple length (Table I). The data were adequate for genetic analysis as indicated by joint regression analysis (Table II). As the regression line passed through Wr-axis above the point of origin, hence it signified that inheritance of this trait was controlled by additive type of gene action with partial dominance. The regression line did not deviate from unit slope, therefore interactions of genes was not involved. These results confirmed the findings of Babar and Khan (1999), Baloch *et al.* (2000), Amin and Hussain (2000), Azhar *et al.* (2004) and Haq and Azhar (2005), while Banumathy and Patil (2000), Khan *et al.* (2001), Cheatham *et al.* (2003), Subhan *et al.* (2003) and Ahmad *et al.* (2006) reported non-additive type of gene action. From the position of array points on the regression line it is clear that the variety Coker-4601 occupied the nearest position from the point of origin so had maximum dominant genes whereas variety Allepo-41 that occupied the farthest position from point of origin possessed maximum recessive genes (Fig. 2). As far as combining ability of the varieties was concerned Coker-4601 proved to be best general combiner for staple length as it secured the maximum array mean (29.18). The cross Coker-4601 X Stoneville exhibited best specific combining ability as it secured maximum value (29.60) within array of crosses (Table IV).

Fiber uniformity ratio. The results of analysis of variance indicated highly significant differences among the parents and their crosses showing that these genotypes differed genetically from each other for this trait (Table I). Results of joint regression analysis suggested that data was fit for additive-dominance model (Table II). A study of Fig. III illustrated over dominance type of gene action controlling the inheritance of this trait as the regression line intercepted the Wr-axis below point of origin. As regression line is of unit slope, it confirmed the absence of epistasis. These results seemed to be in agreement with those of Banumathy and Patil (2000), Baloch *et al.* (2000) and Khan *et al.* (2001) while Mukhtar *et al.* (2000) found additive type of gene action involved in the phenotypic manifestation of this trait. As far as the position of array points on regression line was concerned variety Allepo-41 received maximum dominant genes and variety Coker-4601 secured maximum recessive genes because of their closet and farthest positions from the origin, respectively (Fig. 3). The results obtained revealed that variety S-14 with higher array means (51.18%) was the best general combiner, while within array of crosses its cross with Coker-4601(52.25%) indicated its goods specific combining ability (Table V).

Fiber strength. Highly significant genetic differences were observed among the genotypes evaluated for fiber strength (Table I). Joint regression analysis showed the adequacy of data for genetic analysis as suggested by Hayman (1954) and Jinks (1954). It was observed that inheritance of fiber strength was controlled by additive type of gene action with partial dominance as regression line intercepted the Wr-axis above the point of origin (Fig. 4). As the regression line did not deviate from unit slope so epistasis is not involved in the phenotypic manifestation of this trait. These results confirmed the findings of Hussain *et al*. (1999), Ahmad *et al.* (2003), Cheatham *et al.* (2003) and Azhar *et al.* (2004) while differ from those of Mukhtar *et al.* (2000), Banumathy and Patil (2000), Khan *et al.* (2001) and Haq and Azhar (2005) who reported non-additive type of gene action. The distribution of array points along the regression line indicated that variety Stoneville received most of the dominant genes while variety S-14 secured maximum recessive genes because of their nearest and farthest positions from origin, respectively (Fig. 4). The results obtained suggested that variety Stoneville had good general combining ability as it secured maximum array mean value (25.33) whereas within array of crosses, the cross of this variety with Coker-4601 showed good specific combining ability effects and secured a highest value of 25.98 (Table VI).

Table VI. 5 X 5 Diallel table for fiber strength

	Allepo-41	Stoneville	S-14	MNH-552	Coker-4601
Allepo-41	24.433	25.766	24.300	24.616	25.100
Stoneville	25.766	24.700	25.05	25.366	25.983
S-14	24.300	25.050	21.56667	24.300	24.116
MNH-552	24.616	25.366	24.300	24.466	25.500
Coker-4601	25.100	25.983	24.116	25.500	24.000
Totals	124.216	126.866	119.333	124.250	124.700
Array Means	24.333	25.333	23.867	24.850	24.940

Table VII. List of some outstanding cross combinations

Crosses	Fiber Fineness (Micronair)	Staple Length (mm)	Fiber uniformity ratio (%)	Fiber strength (g/tex)
Coker-4601 X Allepo-41	4.683	29.066	50.083	25.100
Coker-4601 X Stoneville	4.700	29.600	50.200	25.983
Coker-4601 X S14	4.816	29.166	52.25	24.116
Stoneville X MNH-552	4.850	27.933	51.633	25.366
Coker-4601 X MNH-552	4.850	28.733	51.700	25.500
Allepo-41 X Stoneville	5.033	28.566	50.433	25.766

Fig. 1. Vr/Wr graph for fiber fineness

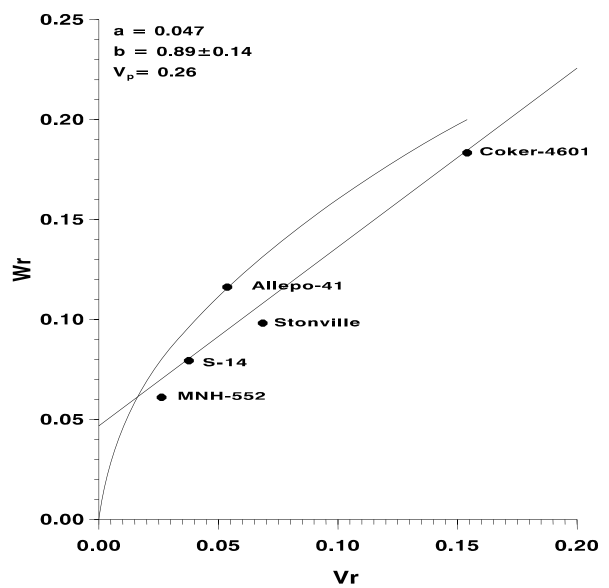


Fig. 2. Vr/Wr graph for staple length

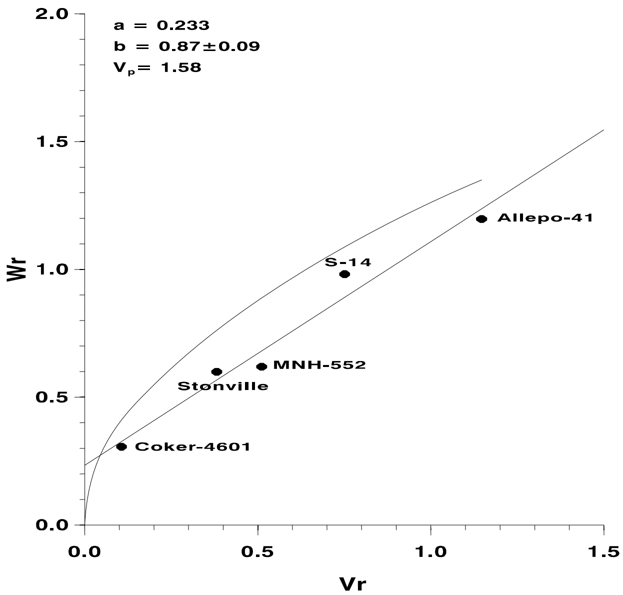


Fig. 4. Vr/Wr graph for fiber strength

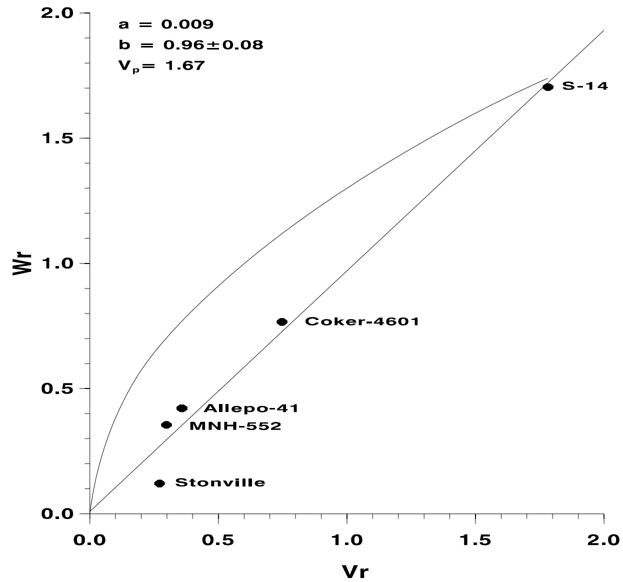
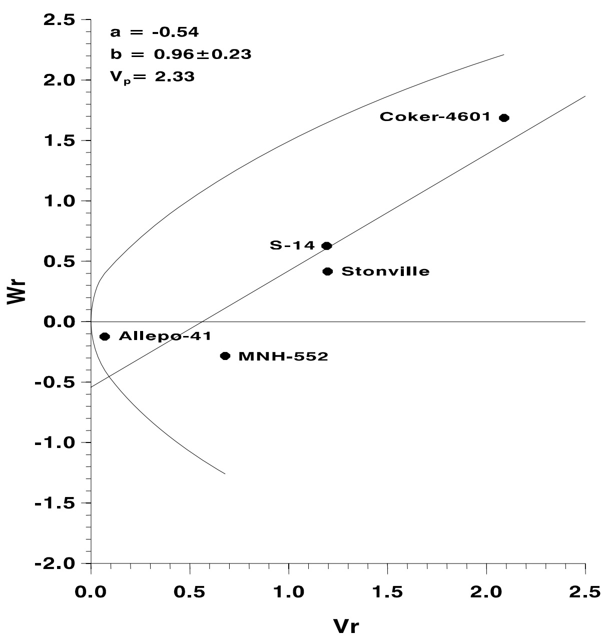


Fig. 3. Vr/Wr graph for fiber uniformity ratio



Some potential cross combinations were also selected on the basis of their outstanding performance (Table VII). Crosses such as Coker-4601 X MNH-552, Coker-4601 X Stoneville, Coker-4601 X S14 and Coker-4601 X Allepo-41 could be exploited in the form of good varieties. Besides, these combinations can be reconstituted for commercial production of hybrid cotton.

CONCLUSION

Generally additive type of gene action with partial dominance was involved in the phenotypic expression of plant traits like, fiber strength, staple length and fiber fineness. The involvement of additive type of gene action suggests that significant advancement is possible through further selection and breeding. Fiber uniformity ratio was controlled by over dominance type of gene action. In other words it can be called as heterosis or hybrid vigor. Over dominance does not offer an ideal condition to breeder for doing selection but heterosis may be exploited in a breeding program where hybrid varieties in cotton are the ultimate aim for some important plant traits. Although results of present studies are compatible with most of previous researchers also are incompatible with many others. These differences in phenotypic expression from other scientists may be due to different types of genetic materials tested under different climatic and soil conditions.

REFERENCES

Ahmad, M. and F.M. Azhar, 2000. Genetic analysis of fibre properties in the exotic and indigenous germplasm of *hirsutum* species. *Int. J. Agric. Biol*., 2: 112–5

Ahmad, S., M.Z. Iqbal, A. Hussain, M.A. Sadiq and A. Jabbar, 2003. Gene Action and Heritability Studies in Cotton (*Gossypium hirsutum* L.). *Onl. J. Biol. Sci*., 3: 443–50

Ahmad, H.M., M.M. Kandhro, S. Laghari and S. Abro, 2006. Heritability and genetic advance as selection indicators for improvement in cotton (*Gossypium hirsutum* L.). *Pakistan J. Biol. Sci*., 6: 96–9

Amin, M.A. and B. Hussain, 2000. Diallel analysis of varietal differences for some ginning and fiber traits in *Gossypium hirsutum* L. *J. Agric. Res*., 38: 183–9

Azhar, M.T., A.A. Khan and N. Mahmood, 2004. Combining ability analysis of fiber characteristics in *Gossypium hirsutum* L. *Int. J. Agric. Biol*., 6: 272–4

Babar, M. and I.A. Khan, 1999. Genetic analysis of some agronomic and fiber characters in upland *cotton (Gossypium hirsutum L.). Pakistan J. Biol. Sci.* 2: 1484–7

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. *Pakistan J. Biol. Sci.,* 3: 1183–6

Banumathy, S. and S. Patil, 2000. Diallel analysis for seed cotton yield and its components in cotton. *Annal. Plant Physiol.*, 14: 56–61

Cheatham, C.L., J.N. Jenkins, J.C. Jr McCarty, C.E. Watson and J.X. Wu, 2003. Genetic variances and combining ability of crosses of American cultivars, Australian cultivars and wild cottons. *J. Cotton Sci.*, 7: 16–22

Government of Pakistan, 2005. *Economic Survey of Pakistan*. Ministry of Finance, Islamabad

Hayman, B.I., 1954. The theory and analysis of diallel crosses. *Genetics*, 39: 789–809

Hussain, B., A.G. Ghaffari, M.A. Amin and M.A. Khan, 1999. Genetic analysis of some agronomic traits in cotton. *J. Agric. Res*., 37: 1–8

Haq, I. and F.M. Azhar, 2005. Genetic analysis of some fiber quality characters in *Gossypium hirsutum* L. *Int. J. Agric. Biol.*, 7: 266–8

Iqbal, M., M.A. Chang, M.Z. Iqbal, Mahmood-ul-Hassan, A. Karim and S. Ahmad, 2003. Breeding Behavior Effects for Yield, its Components and Fiber Quality Traits in Intraspecific Crosses of Cotton (*G. hirsutum* L.). *Pakistan J. Biol. Sci*., 3: 451–9

Islam, Z., H.A. Sadaqat and F.A. Khan, 2001. Evaluation of some cotton strains for their combining ability in important genetic traits. *Int. J. Agric. Biol.*, 3: 409–10

Jinks, J.L., 1954. The analysis of continuous variations in diallel crosses of (*Nicotiana rustica* L.) varieties*. Genetics*, 39: 767–88

Khan, I.A., A. Shakeel and F.M. Azhar, 2001. Genetic analysis of fiber quality traits in upland cotton. *Sci. Int.*, 13: 165–9

Mather, K. and J.L. Jinks, 1982. *Biometrical Genetics,* 3rd edition. Chapman and Hall Ltd. London, U.K

Mukhtar, M.S., T.M. Khan and A.S. Khan, 2000. Gene action study in some fiber traits in cotton (*Gossypium hirsutum* L.). *Pakistan J. Biol. Sci.* 3: 1609–11

Murtaza, N., G.M. Ali and H. Rahman, 2005. Inheritance of fiber quality characters in upland cotton genotypes having non-preference traits for insect pests. *Int. J. Food Agric. Environ.*, 3: 180–4

Pavasia, M.J., P.T. Shukla and U.G. Patel, 1999. Combining ability analysis over environment for fiber characters in upland cotton. *Indian J. Genet*., 59: 77–81

Steel, R.G.D., J.H. Torrie and D.A. Dicky, 1997. *Principles and Procedures of Statistics: A Biological Approach.* McGraw Hill, lnc. New York, Toronto, Landon

Subhan, M., M. Qasim, A. Riaz ud Din, M.U. Khan, M.A. Khan and M.A. Amin, 2003. Combining Ability for Yield and its Components in Up-land Cotton. *Asian J. Plant Sci*., 2: 519–22

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