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Genotypic and Phenotypic Correlation Analysis of Yield and Fiber Quality Determining Traits in Upland Cotton (*Gossypim hirsutum*)

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ABSTRACT

Fifty nine varieties/genotypes of cotton (*Gossypium hirsutum* L.) collected from various cotton research institutes in Pakistan were grown in the field. Five cotton cultivars were selected out of this germplasm contrasting for three fiber quality traits viz; staple length, fiber strength and fiber fineness. Three crosses were made using these five genotypes each between two varieties contrasting for one fiber quality trait, cross CIM-707×4-F for staple length designated as cross-I, cross NIAB-111×RH-1 for fiber strength designated as cross-II and cross MS-40×4-F for fiber fineness designated as cross-III. Four generations P1, P2, F1 and F2 of each cross were developed and evaluated in the field. Measurements were made relating to various seed cotton yield and fiber quality components. Results revealed significant differences for all the traits under study. The correlation among different pairs of plant traits in three crosses indicated that seed cotton yield can be improved by increasing number of bolls per plant and boll weight. Seed cotton yield has positive association with staple length and fiber fineness. Seed cotton yield and fiber strength showed negative association in three crosses, indicating less gain through selection. The simultaneous improvement in fiber strength and seed cotton yield could be achieved through intermating in early generations along with selection of desirable segregants in the following generations and repeating the process till desirable results obtained. The simultaneous improvement in staple length and fiber strength seemed possible as observed from correlations among them in cross II (RH-1×NIAB-111) and cross III (4-F×MS-40).

Key Words: Cotton; Yield components; Fiber traits; Correlations

INTRODUCTION

Pakistan has an agriculture based economy and largely depends upon the successful cotton crop. In Pakistan cotton is currently cultivated on an area of about 3.1 million hectares with production of about 11.7 million bales (Anonymous, 2007). It is the fourth largest cotton producer in the world with production of 2.26 million metric tons and generates significant proportion of foreign exchange. The value of raw cotton and its products exported each year is about Rs. 215 billion (Anonymous, 2007). It accounts for 11.5% of the value added products in agriculture sector. Textile ready-made garments and other cotton-based industries are generating major employment in the country. In addition to the employment involved in its cultivation and cotton picking/harvesting, edible oil industry is also heavily dependent on cotton crop, as 35% of total edible oil comes from cottonseed.

Remarkable progress has been made in cotton breeding after independence of Pakistan. Nonetheless, still Pakistan lags behind the other progressive cotton producing countries of the world as far as yield per unit area is concerned. The increase in yield can be possible if the existing genetic resources and information are properly utilized. Knowledge of correlation between different traits is necessary in plant breeding. If two traits are positively correlated, then one trait can be improved indirectly by improving the other trait. Correlation coefficients are useful if indirect selection of a secondary trait is to be used for improving the primary trait of interest. This depends upon the magnitude of narrow sense heritability for the traits and extent of correlation between them. In cotton, yield and quality are almost equally important; hence knowledge about the nature and magnitude of character association is essential for an efficient breeding program to improve both these parameters. In cotton, several studies have reported negative correlations between lint quality and agronomic traits. Such genetic correlations can be changed from antagonistic to favorable by intermating of several generations in an isolated block (Meredith & Bridge, 1971). Tyagi (1994) found negative correlation of lint length with ginning out turn (GOT) and lint fineness. Lancon *et al.*

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(1993) observed negative association between fiber fineness and fiber strength. Larik *et al.* (1997) observed negative correlation for micronaire and lint length in cotton. Azhar *et al.* (2004) observed negative correlation between staple length and fiber fineness. Ulloa (2006) reported negative correlation between GOT and lint strength.

The present study was undertaken with objective to estimate genotypic and phenotypic correlation coefficients between pairs of plant traits in F2 generation.

MATERIALS AND METHODS

The present research work was carried out in the Department of Plant Breeding and Genetics and Centre of Agricultural Biochemistry and Biotechnology (CABB), University of Agriculture, Faisalabad, Pakistan during 2004-2007. The seed of 59 varieties/genotypes was obtained from the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, Cotton Research Institute, AARI, Faisalabad and Central Cotton Research Institute, Multan. The varieties/genotypes were grown during normal crop season of 2004 in the experimental area of the department of Plant Breeding and Genetics, University of Agriculture, Faisalabad. Five varieties/genotypes (Table I) with contrasting lint traits like staple length, lint fineness and lint strength were selected.

In the coming crop season, selected parent lines were planted during October 2004 in pots placed in the green house. Crossing between two parents having contrasting characters was made at the time of flowering during January and February 2005. Three crosses including CIM-707×4-F for staple length, RH-1×NIAB-111 for fiber strength and MS-40×4-F for fiber fineness were made to produce F1 followed by F2 generation. Four populations viz., parents (P1, P2), hybrids (F1, F2) for each of the crosses were grown in replicated field trail during the year 2006 as separate experiment. The field experiment was laid out in a triplicate randomized complete block design. Row to row distance of 75 cm and plant to plant distance of 30 cm was maintained by thinning out plants at early four–leaf stage in every experimental plot. Row length was kept at 4 m. A single row for parental and F1 generations and 15 rows for each of the F2 generations were planted in each replication. Normal agronomic practices were followed for the experiment. Observations were recorded on individual plant basis for number of bolls, seed cotton yield, boll weight, number of seeds per boll, seed index, lint index, lint %, lint index, fiber length (mm), fiber strength (g/tex) and fiber fineness (µg/inch).

The individual plant data regarding all traits measured at plant maturity were analyzed using standard analysis of variance technique as described by Steel *et al.* (1997). Genotypic and phenotypic correlation coefficients between pairs of plant traits were also determined in F2 data. The genotypic correlation (*rg*) between two characters, X and Y were calculated following the formula of Edhaie *et al.* (1993).

$$r_g = \frac{\text{COV}(X, Y)}{\sqrt{V_g(X).V_g(Y)}}$$

Where, COVg (X, Y), COV are covariance of X and Y associated with genetic effects and Vg (X) and Vg (Y) are genetic variances of X and Y, respectively.

Phenotypic correlation coefficients (*rp*) were also determined following statistical procedure described by Kwon and Torrie (1964).

$$r_p = \frac{\text{COV}_p(X, Y)}{\sqrt{V_p(X).V_P(Y)}}$$

Where, COVp (X, Y) is the mean phenotypic covariance of traits i and j, Vp (x) and Vp (Y) are the phenotypic variances of the same traits, respectively.

RESULTS AND DISCUSSION

The development of an effective plant breeding program and the efficiency of selection largely depends upon the magnitude of genetic variability existed in plant material under study, because it is pre-requisite for finding nature and extent of association among various yield and fiber traits. Therefore analysis of variance was applied in order to test the significance of differences. Mean square values showed significant differences (P ~ 0.01) for all traits under study (not presented here).

In general the magnitude of genotypic correlations *(rg)* was higher than those of phenotypic correlations *(rp).* When value of *rp* was greater than *rg,* it showed that apparent association of two traits was not only due to genes but also due to favorable influence of environment, whereas if value of *r* was zero or insignificant (Table II, III & IV). This implied that these two traits were independent.

Number of bolls per plant showed a positive association with seed cotton yield in cross-I (*rg*=0.99, *rp*=0.90), cross-II (*rg*=0.90, *rp*=0.80) and cross-III (*rg*=0.95, *rp*=0.80). Tyagi (1987) and Tomar *et al.* (1992) observed positive association between number of bolls per plant and seed cotton yield. Number of bolls per plant showed a positive associations with seed index (*rg*=0.42, *rp*=0.25), staple length (*rg*=0.32, *rp*=0.22) in cross-I and fiber uniformity ratio (*rg*=0.92, *rp*=0.51) in cross II. Seed cotton yield showed a positive and significant association with boll weight in cross-I and cross-III but the association was observed negative in cross-II (*rg*=-0.17, *rp*=-0.16). Tyagi

Table I: List of Selected Varieties/Genotypes contrasting for important traits

Sr. #	Genotype	Trait
1	CIM-707	Long staple, High seed index
2	4-F	Short staple, low seed index, low lint fineness
3	RH-1	High lint strength, High lint fineness
4	NIAB-111	Low lint strength
5	MS-40	High lint fineness, long staple length

(1994) and Azhar *et al.* (1998) reported positive association between seed cotton yield and boll weight. Seed cotton yield showed positive but weak associations with number of seeds in cross-II (*rg*=0.19, *rp*=0.14) and observed negative association between these two traits in cross-I (*rg*=-0.1 1, *rp*=-0.07) and cross-III (*rg*=-0.23, *rp*=-0.07) but in none of the crosses it was significant. Positive correlation was observed between seed cotton yield and seed index in all three crosses. Positive association between seed cotton yield and seed index observed in three crosses was also reported by Khan *et al.* (1985) and Tomar *et al.* (1992).

A positive and significant association between seed cotton yield and lint percentage was recorded in cross-I (*rg*=0.42, *rp*=0.22) and cross-III (*rg*=0.20, *rp*=0.08) but the association was negative in cross-II (*rg*=-0.13, *rp*=0.07). Tomar *et al.* (1992) and Tyagi (1994) observed positive association between the two traits in their studies. The positive and significant association between seed cotton yield and lint index observed in cross-II (*rg*=0.37, *rp*=0.24) and cross-III (*rg*=0.27, *rp*=0.20). Positive association between seed cotton yield and lint index were in accordance to those of Tomar *et al.* (1992) and Tyagi (1994), whereas Khan *et al.* (1985) found negative association between the two traits in their studies.

Table II: Estimates of genotypic (top values) and phenotypic (bottom values) correlation coefficients between pairs of traits in F2 generation in cross-I (CIM-707 x 4-F)

Traits		Seed cotton yield	Boll weight	Number of seeds	Seed index	Lint %age	Lint index	Staple length	Fiber fineness	Fiber strength	Fiber uniformity ratio
Number	*rg*	0.99	-0.10	-0.3	0.42	0.06	0.09	0.32	0.21	-0.20	-0.81
of bolls	*rp*	0.90**	-0.02	-0.06	0.25*	-0.04	-0.02	0.22*	-0.15	-0.05	-0.46**
Seed cotton	*rg*		0.44	-0.11	0.55	0.42	0.04	0.52	0.32	-0.30	-0.55
Yield	*rp*		0.36**	-0.07	0.23*	0.22*	0.00	0.28**	0.15	-0.14	-0.37*
Boll	*rg*			0.49	0.87	0.36	-0.14	0.69	0.43	-0.14	0.47
weight	*rp*			0.37**	0.60**	0.27**	0.05	0.37**	0.32**	-0.07	0.24*
Number of	*rg*				-0.15	0.12	0.29	0.44	0.11	0.22	0.56
Seeds	*rp*				-0.03	-0.03	0.07	0.28**	0.02	0.14	0.27*
Seed	*rg*					-0.38	0.75	0.61	0.42	-0.59	-0.60
Index	*rp*					-0.25*	0.58**	0.33**	0.38**	-0.43**	-0.30*
Lint	*rg*						0.79	-0.28	0.57	-0.73	-0.34
%age	*rp*						0.45**	-0.1 8**	0.30**	-0.46**	0.04
Lint	*rg*							-0.24	0.26	-0.13	-0.40
index	*rp*							-0.19	0.22*	-0.11	-0.10
Staple	*rg*								0.22	-0.42	0.25
length	*rp*								0.18	-0.33*	0.18
Fibre	*rg*									-0.23	-0.36
Fineness	*rp*									-0.18	-0.29*
Fibre	*rg*										0.87
Strength	*rp*										0.57**

*, ** = Significant at P~ 0.05 and P~ 0.01 probability levels, respectively

Table III: Estimates of genotypic (top values) and phenotypic (bottom values) correlation coefficients between pairs of traits in F2 generation in cross-II (NIAB- 111 x RH-1)

Traits		Seed cotton yield	Boll weight	Number of seeds	Seed index	Lint %age	Lint index	Staple length	Fiber fineness	Fiber strength	Fiber uniformity ratio
Number	*rg*	0.90	0.04	-0.15	-0.27	0.21	-0.30	-0.34	0.25	-0.11	0.92
of bolls	*rp*	0.80**	-0.02	-0.08	0.00	-0.09	-0.09	-0.25*	0.12	-0.02	0.51**
Seed cotton	*rg*		-0.17	0.19	0.40	-0.13	0.37	-0.44	0.40	-0.19	0.96
Yield	*rp*		-0.16	0.14	0.13	0.07	0.24*	-0.39**	0.22*	-0.02	0.55**
Boll	*rg*			0.58	0.60	-0.44	0.47	0.58	0.43	-0.23	0.68
weight	*rp*			0.25**	0.50**	-0.27**	0.33**	0.33**	0.37**	0.08	0.43**
Number of	*rg*				-0.50	-0.25	-0.23	0.13	-0.35	0.22	0.98
Seeds	*rp*				-0.44**	0.08	-0.18	0.07	-0.18	0.07	0.63**
Seed	*rg*					-0.75	0.40	-0.35	0.53	-0.39	0.29
Index	*rp*					-0.48**	0.30**	-0.22*	0.48**	-0.30*	0.31**
Lint	*rg*						0.69	-0.43	0.55	0.23	-0.90
%age	*rp*						0.54**	-0.22*	0.28**	0.20*	-0.54**
Lint	*rg*							-0.25	0.55	-0.14	-0.18
index	*rp*							-0.22*	0.47**	-0.30*	-0.08
Staple	*rg*								-0.43	0.77	0.01
length	*rp*								-0.42**	0.55**	-0.00
Fibre	*rg*									-0.25	0.31
Fineness	*rp*									0.12	0.22*
Fibre	*rg*										-0.93
Strength	*rp*										-0.55**

*, ** = Significant at P~ 0.05 and P~ 0.01 probability levels, respectively

Table IV: Estimates of genotypic (top values) and phenotypic (bottom values) correlation coefficients between pairs of traits in F2 generation in cross-III (MS-40 x 4-F)

Traits		Seed cotton yield	Boll weight	Number of seeds	Seed index	Lint %age	Lint index	Staple length	Fiber fineness	Fiber strength	Fiber uniformity ratio
Number	*rg*	0.95	-0.05	-0.17	0.08	0.06	-0.18	-0.15	0.12	-0.22	-0.28
of bolls	*rp*	0.80**	-0.04	-0.13	0.02	0.04	0.02	-0.12	0.07	-0.06	-0.08
Seed cotton	*rg*		0.42	-0.23	0.30	0.20	0.27	-0.28	0.23	-0.22	-0.57
Yield	*rp*		0.40**	-0.07	0.41**	0.08	0.20*	-0.07	0.03	-0.06	-0.32**
Boll	*rg*			0.68	0.85	0.22	-0.15	0.19	0.54	0.31	0.07
weight	*rp*			0.50**	0.62**	0.06	0.07	0.03	0.38**	0.09	0.01
Number of	*rg*				-0.40	0.45*	-0.26	-0.29	0.14	-0.12	0.70
Seeds	*rp*				-0.29**	0.20	-0.22*	-0.11	0.07	-0.07	0.54**
Seed	*rg*					-0.58	0.72	-0.30	0.70	-0.35	-0.95
Index	*rp*					-0.39**	0.47**	-0.18	0.44**	-0.23*	-0.55**
Lint	*rg*						0.72	-0.29	0.70	-0.35	-0.79
%age	*rp*						0.47**	-0.18	0.44**	-0.23*	-0.63**
Lint	*rg*							-0.13	0.38	-0.05	-0.99
index	*rp*							-0.05	0.32**	-0.02	-0.88**
Staple	*rg*								-0.13	0.67	-0.79
length	*rp*								-0.06	0.44**	-0.73**
Fiber	*rg*									-0.47	0.01
Fineness	*rp*									-0.32**	0.03
Fiber	*rg*										0.72
Strength	*rp*										0.56**

*, ** = Significant at P~ 0.05 and P~ 0.01 probability levels, respectively

The association between seed cotton yield and staple length was positive and significant in cross-I (*rg*=0.52, *rp*=0.28), while the negative and significant association between these two traits observed in cross-II. Tyagi (1994) also found negative association between these two traits. Seed cotton yield showed positive association with fiber fineness in three crosses but observed significant association between these traits in cross-II (*rg*=0.40, *rp*=0.22) only. No association between seed cotton yield and fiber strength existed in three crosses. Seed cotton yield was negatively associated with fiber uniformity ratio in cross-I and in cross-III, whereas positive association between these traits was noted in cross-II (*rg*=0.96, *rp*=0.55).

Boll weight showed positive and significant association with number of seeds per boll, fiber fineness and seed index in all crosses, lint percentage in cross-I (*rg*=0.36, *rp*=0.27), lint index in cross-II (*rg*=-0.47, *rp*=0.33), staple length in cross-I and cross-II, fiber fineness, fiber uniformity ratio in cross-I and cross-II and exhibited negative and non-significant correlation with fiber strength in cross-I and II. Lint percentage has positive and significant correlation with lint index, fiber fineness in all three crosses and showed negative association with staple length (*rg*=-0.28, *rp*=-0.18), fiber strength in cross-I (*rg*=-0.73, *rp*=-0.46) and cross-III (*rg*=-0.35, *rp*=-0.23) and fiber uniformity ratio in all three crosses. Scholl and Miller (1976) observed positive, while Tyagi (1994) noted a negative association of lint percentage with lint index.

Lint index showed positive association with fiber fineness in all crosses. Positive association between these two traits was also observed by Tyagi (1994) and Coyle and Smith (1997). Lint index showed negative association with staple length in cross-II (*rg*=-0.25, *rp*=-0.22). Coyle and Smith (1997) observed negative correlation between lint index and staple length. Staple length showed negative association with fiber fineness in cross-II (*rg*=-0.43, *rp*=-0.42) and cross-III (*rg*=-0.13, *rp*=-0.06). Tyagi (1994), Larik *et al.* (1997) and Azhar *et al.* (2004) observed negative correlation between staple length and fiber fineness. Correlation between staple length and fiber strength was positive in cross-II (*rg*=0.77, *rp*=0.55) and cross-III (*rg*=0.67, *rp*=0.44) and negative significant in cross-I (*rg*=-0.42, *rp*=-0.33). Staple length showed negative association with fiber uniformity ratio in cross-III (*rg*=-0.79, *rp*=-0.73), positive association in cross-I (*rg*=0.25, *rp*=0.18). Fiber fineness had negative correlation with fiber strength in three crosses. Lancon *et al.* (1993) observed negative association between fiber fineness and fiber strength. It showed negative association with fiber uniformity ratio in cross-I (*rg*=-0.36, *rp*=-0.29) and in cross-II (*rg*=-0.93, *rp*=-0.55). Fiber strength showed highly significant and positive correlation with fiber uniformity ratio in all three crosses.

A strong association between number of bolls with seed cotton yield, staple length and seed index along with moderate to high heritability for these traits (not presented here) suggested that seed cotton yield, staple length and seed index can be improved indirectly by selecting plants with higher number of bolls per plant. Boll weight was also important factor for improving seed cotton yield, lint percentage, seed index and staple length. A strong association between seed cotton yield with lint percentage and staple length along with high heritability showed possibility of simultaneous improvement in these traits. Association between seed cotton yield and fiber fineness was not strong as evident from correlation coefficient values. There could be a possibility of plants with desirable attributes of fiber fineness and seed cotton yield in segregating generations. Fiber strength in three crosses was negatively correlated with seed cotton yield. This will cause a difficulty in simultaneous improvement of two traits. Positive genetic association between staple length and fiber strength indicated that selection for increased value of one trait will result increase in value of other.

CONCLUSION

Number of bolls per plant should be used as a Indirect selection criteria for improving the seed cotton yield and fiber quality in the present germplasm under study as it is positively and significantly correlated with seed cotton yield, GOT% and staple length.

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