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CORRELATION AND PATH ANALYSIS IN YIELD AND QUALITY TRAITS IN F_3 AND F_4 GENERATION OF CARMEN X DEVETÜYÜ-176

Fatma Aykut Tonk*, Deniz İştipliler, Muzaffer Tosun, Emre İlker and Gizem Çivi

Ege University, Faculty of Agriculture, Department of Field Crops, İzmir, TURKEY

*Corresponding author: fatma.aykut@ege.edu.tr

ABSTRACT

Cotton (*Gossypium hirsutum* L.) is one of the most important plants worldwide because of its fiber that is used as raw material for the textile industry. Since the dyes used in dyeing process negatively affect the environment, many people prefer to use natural colored cotton products. The objective of this study was to establish the inter-relationship and direct and indirect effect of various quality traits on seed cotton yield in colored cotton genotypes. The F_3 and F_4 generations of the cross between Carmen (white) and Devetüyü-176 (brown fiber) were used for selection process in terms of seed cotton yield per plant and fiber color. The measured quality traits in the selected genotypes from F_3 and F_4 generations were micronaire, fiber strength, fiber length, uniformity ratio, short fiber index, fiber elongation. Phenotypic correlation and path coefficients were calculated separately for each generation. As results of the correlation analysis, seed cotton yield was not negatively associated with fiber quality properties. It may be concluded that the selection for seed cotton yield and fiber color should be applied in early generations and fiber quality properties of the selected promising colored cotton genotypes can be determined in further generations of Carmen x Devetüyü-176.

Keywords: colored cotton, yield, fiber traits, correlation, path analysis

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is one of the most important plants worldwide because of its fiber that is used as raw materials for the textile industry. As almost all the cotton varieties in use have white fiber, dyeing is required to obtain different color in textile fabrics. The enormous consumption of dyes has negatively affected the environment and human health (Hua *et al.* 2007). Many people prefer to wear clothes made from natural colored cotton which does not contain the dangerous chemicals used by textile units.

Colored cotton is commonly referred as cotton with naturally colored lint. Naturally colored cottons are mutants of plants that normally produce white fiber and have existed for over 5000 years (Hua *et al.* 2007; Khan *et al.* 2010). It is stated that colored cotton is being grown and used since 2500 B.C. (Singh *et al.* 2000).

Commercial cotton has all bright white and creamy yellow lint colors. Colored cotton is a naturally pigmented fiber and has several different lint colors such as brown, black, red, pink, blue and green (Murthy 2001). The brown colour, which is the most common colour, is found in different shades and ranges from light brown to intense mahogany red in all the four cultivated as well as many of the wild species (Singh *et al.* 2000).

Even though the demand for colored cotton is increasing, its cultivation remains behind white fiber cotton. The most important reason of this is that cotton farmers do not like colored cotton because of low lint yield, short, weak and coarse fiber and nonuniform colour (Murthy 2001; Dutt *et al.* 2004). Also, the ability of the fiber from colored cotton to be machine spun is lower and color range is limited. In addition to this, the uncertain market demands and the need for newly invented looms for short-fibered colored cotton have contributed to its reduced cultivation (Khan *et al.* 2010).

Cotton breeders are trying to improve colored cotton with high yield and quality at least similar with white fiber cotton. However, the genes for lint colour are found to be pleotropic that means they control more than one trait (Murthy 2001), and seed cotton yield and fibre quality are controlled by polygenes and highly influenced by the environment (Magadum *et al.* 2012). Therefore, improving colored cotton varieties with high yield and quality is very grueling. It may be an alternative solution to take advantages of advanced lines of white and colored cotton crosses to combine the superior properties of white cotton with different fiber colors. Although there are limited studies using segregating population of white and colored cotton (Carvalho *et al.* 2014), it would be helpful to investigate and identify of the associations between yield components and fiber quality traits in colored cottons genotypes for cotton breeders. For this purpose, correlation coefficient and path analysis are mostly used to determine the characters for selection to improve yield or quality in many cotton researches (Ahuja *et al.* 2006; Magadum *et al.* 2012; Thiyagu *et al.* 2010; Ekinci *et al.* 2010; Wadeyar and Kajjidoni 2014). So, the aims of this research to reveal the relationship between seed cotton yield and quality traits among colored cotton genotypes of F_3 and F_4 generations after crossing white x brown fiber colored cotton varieties.

MATERIALS AND METHODS

The varieties, Carmen (*G. hirsutum* L.) originated from Australia and Devetüyü-176 (*G. hirsutum* L.) were used as parents in the study. Carmen has high yield potential and its vegetation period is in middle late class. The adaptation ability is very high against all kind of land and climate conditions. It is resistant against the shedding of the flowers and the squares caused by drought conditions. Its ginning out-turn is 43%. It has high resistance against to pests. There are approximately 9700 seeds in 1 kg. With the fiber quality on Fibermax standards, it is the prior choice for textile industry. Devetüyü-176 is a natural colored cotton line. It has brown fiber color and is one of the high-class genotypes in the brown color scale.

The crosses between the parents were made in 2007. The generations (F_1, F_2, F_3, F_4) were obtained every following year and cultivated in field conditions. Growing of all generations was designed as single rows in experimental station of Ege University, Field Crops Department, Bornova, İzmir, Turkey. The seeds of all generations were sown by hand then thinned to 20 cm in rows. The rows were three-meter length; consisted of 15 individual plants and the length between the rows were 70 cm. The fertilization was applied to all experiments as 80 kg/ha nitrogen and P_2O_5 before sowing, then 80 kg/ha nitrogen was given in half ratio with first and second irrigation. All generations were irrigated 5 times after flowering stage by furrow irrigation and the plants were hoed two times for weed control.

Seed cotton yield per plant and some yield components were measured for all individual plants in F_3 and F_4 generations. The selection process was performed with the 10% selection intensity depending upon seed cotton yield per plant and fiber color based on individual plants in both F_3 and F_4 generations. In other words, the plants with high yielding and colored fiber were selected for the next generation. For fiber color, the plants were visually selected for two generations at first, later fiber colors of parents and the selected plants in F_3 generation were quantified as L, a, b, ΔL, Δa, Δb, ΔE parameters using Minolta C400 Chromameter (Konica Minolta Holdings, Inc., Tokyo, Japan). The 54 and 42 individuals were selected in F_3 and F_4 generations, respectively, and the fiber quality properties of hand harvested selected individual plants that are micronaire, fiber strength (g/tex), fiber length (mm), uniformity ratio (%), short fiber index (%), fiber elongation (%) were measured by using of USTER HVI 900 A (High Volume Instrument).

The seed cotton yield per plant and quality measurements of selected individual were taken to correlation and path coefficient analyses separately for the F_3 and F_4 generations. Phenotypic correlation and path coefficients were calculated separately for each set according to the procedures from Singh and Chaudhary (1985) and Dewey and Lu (1959), respectively.

RESULTS

The phenotypic variations of seven fiber color parameters of the parents, Carmen (white) and Devetüyü-176 (brown fiber) and the selected individual plants from F_3 generation were summarized in Table 1. The skewness and kurtosis values, which should be near zero for normal distributions ranged from -0.38 to 0.40 and -1.62 to -1.49, respectively in the F_3 generation. Transgressive segregations could be observed for all fiber color parameters in selected F_3 plants (Table 1).

Correlation coefficients at phenotypic level of the selected plants in F_3 and F_4 generations were presented in the Table 2. The correlations with the plant seed cotton yield were found negative and nonsignificant for micronaire, fiber strength and short fiber index while it was found positive and nonsignificant for other quality traits in F_3 generation. However, seed cotton yield had positive nonsignificant correlations for all traits except short fiber index in F_4 generation. Micronaire values of the selected plants in F_3 generation presented negative and positive significant correlation with fiber length and short fiber index, respectively. Fiber strength revealed positive significant correlation for fiber length, uniformity ratio and fiber elongation and negative significant correlation for short fiber index in F_3 generation. This trait only showed positive significant correlation for uniformity ratio in F_4 generation. In both generations, fiber length had negative significant correlations with short fiber index and positive significant correlation with fiber elongation. It presented positive significant correlation with uniformity ratio only in F_3 generation. Significant and negative correlations were observed between uniformity index and short fiber index in both generations. However, uniformity index showed positive and significant correlation with fiber elongation in F_3 generation. Short fiber index had negative and significant correlations with fiber elongation in both generations (Table 2).

The path coefficients showing direct and indirect effects of the quality traits on seed cotton yield per plant in F_3 generation are presented in Table 3. The maximum direct effect on seed cotton yield was contributed mostly by fiber elongation (0.3530), followed by uniformity ratio (0.0543) and micronaire (0.0064). On the other hand, the maximum negative direct effect was exhibited by fiber strength (-0.3972), followed by short fiber index (-0.1400) and fiber length (-0.0923).

The direct effect of micronaire to the seed cotton yield was positive but three indirect effects of this trait were negative. Fiber strength recorded a high negative indirect effects via fiber length, uniformity ratio and fiber elongation on the seed cotton yield. Short fiber index caused high positive indirect effect via fiber length on the seed cotton yield. Fiber elongation revealed positive indirect effects via fiber strength, fiber length and uniformity ratio while high negative indirect effects via short fiber index. The rest of traits showed moderate low positive or negative indirect effects on the seed cotton yield (Table 3).

The path coefficients showing direct and indirect effects of the quality traits on seed cotton yield per plant in F_4 generation are presented in Table 4. The maximum direct effect on seed cotton yield was contributed by fiber strength (0.2118), followed by fiber elongation (0.1415), fiber length (0.1263) and micronaire (0.0545). However, the maximum negative direct effect was exhibited by uniformity ratio (-0.1167), followed by short fiber index (-0.0397).

Fiber strength had positive indirect effects via all quality traits except short fiber index on the seed cotton yield. Fiber length caused high negative indirect effects via short fiber index on the seed cotton yield. The indirect effects of uniformity ratio were negative via all other traits except short fiber index. The rest of traits showed moderate to low positive or negative indirect effects on the seed cotton yield.

Table 1. Phenotypic variation of the fiber color parameters in the parent lines Carmen and Devetüyü-176 and 54 selected F_3 individuals.

Fiber color parameters*	Parent lines		Variation in the selected plants					
	Carmen	Devetüyü	Mean	Min.	Max.	Std. Dev.	Skewness	Kurtosis
L	87.45	64.91	78.16	61.53	88.70	9.23	-0.38	-1.49
a	-0.11	7.59	3.09	-0.36	7.89	2.93	0.40	-1.58
b	6.68	22.12	14.77	5.62	24.59	6.08	0.16	-1.54
ΔL	-5.76	-40.74	-15.04	-31.67	-4.50	9.23	-0.38	-1.49
Δa	-0.38	7.44	2.81	-0.64	7.61	2.93	0.40	-1.58
Δb	8.85	22.95	16.92	7.77	26.74	6.08	0.16	-1.54
ΔE	10.64	38.58	23.12	9.15	40.20	10.78	0.31	-1.62

* Fiber color parameters: L indicates color brightness (L=0 is black and L=100 is white); a indicates red-green (+ is red and - is green); b indicates yellow-blue (+ is yellow and - is blue); ΔL indicates total black-white color change; Δa indicates total red-green color change; Δb indicates total yellow-blue color change; ΔE indicates total color change independent from each other.

Table 2. Correlation coefficients between quality properties and seed cotton yield among selected plants 54 in F_3 and 42 in F_4 generation.

	Generation	Micronaire	Fiber Strength (g/tex)	Fiber Length (mm)	Uniformity Ratio (%)	Short Fiber Index (%)	Fiber Elongation (%)
Yield (g/plant)	F_3	-0.057ns	-0.206ns	0.028ns	0.041ns	-0.098ns	0.235ns
	F_4	0.028ns	0.199ns	0.202ns	0.089ns	-0.183ns	0.194ns
Micronaire	F_3		-0.020ns	-0.546**	0.079ns	0.430**	-0.187ns
	F_4		0.176ns	-0.162ns	0.266ns	0.041ns	-0.077ns
Fiber Strength	F_3			0.301*	0.571**	-0.282*	0.420**
	F_4			0.104ns	0.445**	-0.188ns	0.064ns
FiberLength	F_3				0.324*	-0.901**	0.283*
	F_4				0.293ns	-0.875**	0.439**
Uniformity Ratio	F_3					-0.541**	0.475**
	F_4					-0.587**	0.258ns
Short Fiber Index	F_3						-0.358**
	F_4						-0.452**

*, ** : Significant at the 0.05 and 0.01 probability levels, respectively; ns: nonsignificant.

Table 3. Direct (bold) and indirect effects of the quality properties to seed cotton yield per plant among 54 selected plants in F_3 generation

	Micronaire	Fiber Strength (g/tex)	Fiber Length (mm)	Uniformity Ratio (%)	Short Fiber Index (%)	Fiber Elongation (%)	Correlation With Yield
Micronaire	**0.0064**	0.0078	0.0504	0.0043	-0.0602	-0.0662	-0.057ns
Fiber Strength	-0.0001	**-0.3972**	-0.0278	0.0310	0.0395	0.1482	-0.206ns
Fiber Length	-0.0035	-0.1195	**-0.0923**	0.0176	0.1262	0.1001	0.028ns
Uniformity Ratio	0.0005	-0.2269	-0.0299	**0.0543**	0.0758	0.1677	0.041ns
Short Fiber Index	0.0028	0.1121	0.0832	-0.0294	**-0.1400**	-0.1264	-0.098ns
Fiber Elongation	-0.0012	-0.1668	-0.0262	0.0258	0.0501	**0.3530**	0.235ns

*, ** : Significant at the 0.05 and 0.01 probability levels, respectively; ns: nonsignificant.

Table 4. Direct (bold) and indirect effects of the quality properties to seed cotton yield per plant among 42 selected plants in F_4 generation.

	Micronaire	Fiber Strength (g/tex)	Fiber Length (mm)	Uniformity Ratio (%)	Short Fiber Index (%)	Fiber Elongation (%)	Correlation With Yield
Micronaire	**0.0545**	0.0372	-0.0205	-0.0310	-0.0016	-0.0109	0.028ns
Fiber Strength	0.0096	**0.2118**	0.0131	-0.0519	0.0075	0.0090	0.199ns
Fiber Length	-0.0088	0.0220	**0.1263**	-0.0341	0.0347	0.0621	0.202ns
Uniformity Ratio	0.0145	0.0943	0.0370	**-0.1167**	0.0233	0.0365	0.089ns
Short Fiber Index	0.0023	-0.0398	-0.1105	0.0685	**-0.0397**	-0.0640	-0.183ns
Fiber Elongation	-0.0042	0.0135	0.0555	-0.0301	0.0180	**0.1415**	0.194ns

*, ** : Significant at the 0.05 and 0.01 probability levels, respectively; ns: nonsignificant.

DISCUSSION

Natural colored cotton is a very old cotton variety and was firstly cultivated by American Indians (Waghmare and Koranne 1998; Dutt *et al.* 2004). Nowadays, the white cotton cultivars that have high yield potential and quality properties have been developed. So that, cultivation and usage of natural colored cotton is very limited. At the same time, colored cotton varieties are deficient based on both yield potential and fiber quality properties; hence they are not suitable for textile industry. Thus, it is necessity that improving of yield and quality potentials of natural colored cotton cultivars via crossing them with the white colored cotton genotypes. Since, they do not need any chemicals for painting and bleaching, they are eco-friendly industrial fibers.

There is a lot of research on fiber quality and yield associations in cotton; however this research is one of the important studies conducted with similar aims in segregating populations of white x colored cotton cross. The insignificant correlation coefficients between seed cotton yield and micronaire, fiber strength, and uniformity ratio, fiber elongation in both F_3 and F_4 generations agreed with the results of Dinakaran *et al.* (2012). But, Clement *et al.* (2012) reported significant negative correlations between yield and fiber length and fiber strength while correlation with micronaire was inconsistent between years. In an another study, the positive and significant phenotypic correlation coefficients between fiber yield and fiber length, fiber uniformity, fiber strength were determined while non-significant correlations occurred with elongation and micronaire (Araujo *et al.* 2012). Clement *et al.* (2015) emphasized that the negative association between yield and quality had been effectively broken in one cross cotton population. Notwithstanding, they proposed more research and information on understanding the prime reasons for negative association between yield and quality.

Unlike these studies, the associations between yield and other quality traits were investigated in colored and high yielding individual plants selected from F_3 and F_4 generations in this study. The results of correlation analyses showed that at least the significant negative correlation was absent between yield and the quality characteristics of the selected colored plants. This result indicates that the fiber quality traits did not decrease in the selected colored and high yielding cotton plants. Inability to obtain the significant positive correlation may arise from a single plant selection. Because the single plant selection or analyses on individual plants could not reveal performance of cross population for the association between yield and quality. Indeed, Clement *et al.* (2015) proposed to use the bulk made from F_2 or F_3 population prior to single plant selection to decide utilization of the population in cotton. Besides, Sundarmurthy *et al.* (1994), Singh *et al.* (1996) and Dutt *et al.* (2004) reported that heterosis emerged in F_1 plants via crosses between white and colored cottons can be utilized for developing colored cotton genotypes with high yield and quality potential. When fiber color is considered, in the selected single plants from F_3 generation, the skewness and kurtosis values were less than 1.0 for all fiber color parameters which indicates continuous variation and quantitative genetic basis. Another reason for this variation is that the selected plants had different shades of fiber color. However, as homozygosity increases in advanced generations, the variation will decrease and the fiber color will become more stable.

As a result of path analysis, fiber elongation and fiber strength had the maximum direct effect on seed cotton yield in F_3 and F_4 generations, respectively. However, fiber strength had the maximum negative direct effect on seed cotton yield in F_3 generation. The contrast on fiber strength and some other quality traits varied between two generations could occur because of the generation differences. Since, the percentage of homozygosity of genes responsible for these traits in the population increase as generation progresses.

In summary, seed cotton yield was not negatively significant associated with fiber quality properties as results of the correlation analysis. It may be concluded that the selection applied in those generations in terms of seed cotton yield and fiber color should be applied and fiber quality properties of the selected individual colored cotton genotypes can be determined in further generations. Also, another suggestion depend on insignificant association between yield and quality properties is that the colored cotton genotypes with high yielding can be selected, made bulk and transferred to the next generations.

REFERENCES

Ahuja, S.L., L. S. Dhayal, and R. Prakash (2006). A correlation and path coefficient analysis of components in *G. hirsutum* L. hybrids by usual and fibre quality grouping. Turk. J Agric. For. 30: 317-324.

Araujo, L.F., W.S. Almeida, C.H.C.M. Bertini, F.C.V. Neto, and E. Bleicher (2012). Correlations and path analysis in components of fiber yield in cultivars of upland cotton. Bragantia 71(3): 328-335.

Carvalho, L.P., F.J.C. Farias, M.M.A. Lima, and J.I.S. Rodrigues (2014). Inheritance of different fiber colors in cotton (*Gossypium barbadense* L.). CBAB 14: 256-260.

Clement, J.D., G.A. Constable, W.N. Stiller, and S.M. Liu (2012). Negative associations still exist between yield and fibre quality in cotton breeding programs in Australia and USA. Field Crops Res. 128: 1-7.

Clement, J.D., G.A. Constable, W.N. Stiller, and S.M. Liu (2015). Early generation selection strategies for breeding better combinations of cotton yield and fibre quality. Field Crops Res. 172: 145–152.

Dewey, J.R. and K.H. Lu (1959). A correlation and path co-efficient analysis of components of crested wheat seed production. Agron. J. 51: 515-518.

Dinakaran, E., S. Thirumeni, and K. Paramasivam (2012). Yield and fibre quality components analysis in upland cotton (*Gossypium hirsutum* L.) under salinity. Ann. Biol. Res. 3(8): 3910-3915.

Dutt, Y., X.D. Wang, Z. Ying, and Y.Y. Li (2004). Breeding for high yield and fibre quality in colored cotton. Plant Breed. 123:145-151.

Ekinci, R., S. Basbag, and O. Gencer (2010). Path coefficient analysis between seed cotton yield and some characters in cotton (*Gossypium hirsutum* L.) J. Environ. Biol. 31(5): 861-864.

Hua, S.J., X.D. Wang, S.N. Yuan, M.Y. Shao, X.Q. Zhao, S.J. Zhu, and L.X. Jiang (2007). Characterization of pigmentation and cellulose synthesis in colored cotton fibers. Crop Sci. 47(4): 1540-1546.

Khan, N. U., K. B. Marwat, G. Hassan, S. B. Farhatullah, S. Batool, K. Makhdoom, W. Ahmad, and H.U. Khan (2010). Genetic variation and heritability for cottonseed, fiber and oil traits in *G. hirsutum* L. Pakistan J. Bot. 42(1): 615-625.

Magadum, S., U. Banerjee, R. Ravikesavan, K. Thiyagu, N.M. Boopathi, and S. Rajarathinam (2012). Association analysis of yield and fibre quality characters in interspecific population of cotton (*Gossypium* spp.). J. Crop Sci. Biotech. 15(3) : 239-243.

Murthy, M.S.S. (2001). Never say dye: the story of colored cotton. Resonance 6(12): 29-35.

Singh, R.K., and B.D. Chaudhary (1985). Biometrical methods in quantitative genetic analysis. Kalyani Publishers, New Delhi, Ludhiana, India.

Singh, V.V., P. Mohan, and R. Kothandaraman (1996). Naturally coloured linted genetic resources in national Cotton Gene Bank, their characteristics and utilization. J. Indian Soc. Cotton Improv. 21: 151-158.

Singh, P., V.V. Singh, and V.N. Waghmare (2000). Naturally Coloured Cotton. CICR Technical Bulletin, Central Institute for Cotton Research Nagpur 4: 1-10.

Sundarmurthy, V.T., A.R. Padmanabhan, and K.P. Janakiraman (1994). Colour fastness of naturally pigmented cotton. Indian Textile J. 105: 126-128.

Thiyagu, K., N. Nadarajan, S. Rajarathinam, D. Sudhakar, and K. Rajendran (2010). Association and Path analysis for seed cotton yield improvement in interspecific crosses of cotton (*Gossypium* spp). Electronic J. Plant Breeding 1(4): 1001-1005.

Wadeyar, B.S., and S.T. Kajjidoni (2014) Phenotypic and genotypic correlation and path analysis in the advance breeding lines of desi cotton. Mol. Plant Breed. 5(12): 1-4.

Waghmare, V.N. and K.D. Koranne (1998). Colored cotton: present status, problems and future potentials. Indian J. Genet. Plant Breed. 58(1): 1-15.