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Genetic and Environmental Variability in Yield, Yield Components and Lint Quality Traits of Cotton

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ABSTRACT

Five cotton genotypes introduced from Azerbaijan and two standard cotton varieties for the region were studied for genetic and environmental variability, broad sense heritability and correlation coefficients of seed cotton yield, yield component and lint quality traits. There were significant differences among the genotypes for most of the traits. Genotypic and phenotypic variances were highest for seed cotton yield followed by plant height, whereas the maximum genotypic and phenotypic coefficients of variability were found in number of monopodial branches, fiber strength, seed cotton yield and number of mature bolls. Broad sense heritability estimates ranged from very low to high. Heritability values were estimated maximum level for fiber strength (94.60%), fiber length (94.58%) and seed cotton weight (91.80%), while low level for 100-seed weight (6.67%) and plant height (20.60%). High heritability for fiber strength, fiber length and seed cotton weight indicated that these characteristics were affected less than the others by the environmental conditions. Positive correlations between seed cotton yield and plant height, number of sympodial branches, number of mature bolls, seed cotton weight, 100-seed weight, fiber length, fiber uniformity were found. Successful selection can be made on these characteristics for seed cotton yield.

Key Words: Cotton; Genetic and environmental variability; Heritability; Correlations

INTRODUCTION

Cotton (*Gossypium* spp.) is the most important fiber crop, which is used in textile industry around the globe including Turkey. Therefore, Turkey is among the countries, which have the highest amount of cotton production in the world (Killi & Aloğlu, 2000). It has 629 Mha under cotton cultivation, 898 metric tones of cotton fiber production annually and it has nearly 1324 kg ha^{-1} of lint cotton (Anonymous, 2003).

Cotton is highly responsive to changes in temperature, humidity, and soil moisture, which may affect its yield, yield components and fiber properties. Climatic, soil, insect, disease and cultural conditions differ from one place to another, and also differ from year to year at the same location. Therefore, genetic and environmental variability for cotton yield, yield components and lint quality traits should be estimated at different environments to conduct successful breeding program.

Various researchers have studied the genetic and non-genetic parameters, heritability, and direct and indirect relations between yield and yield components for yield improvement in cotton. Miller *et al.* (1958; 1959 & 1962) reported that genotype by environmental interactions are important for lint yield and yield components. Fairly small interaction components for fiber length and strength were reported by Abou-El-Fittouh *et al.* (1969). They also reported second-order interaction components were larger than the first-order ones for yield and fiber fineness. Sing *et al.* (1984) found dominant genotypic variance for number of sympodia, plant height, halo length, boll size, ginning outturn and seed index. Gill and Singh (1982) reported that environmental factors had effect on plant height. Numerous heritability studies for yield, yield components and lint properties indicated that the heritability was high for lint yield and quality (Verhalen & Murray, 1967; Quisenberry, 1975). In early study, Self and Henderson (1954) reported that the moderate heritability was estimated for fiber strength. Killi and Gencer (1994 & 1995) reported that variance components for yield and fiber properties were significant and broad sense heritability values for these characteristics ranged from 32% to 79%. Positive correlations exist between seed cotton yield and number of mature bolls (Sandhu *et al.,* 1986), number of fruiting branches (Sandhu *et al.,* 1986), boll weight (Kaynak, 1995), plant height (Al-Rawi *et al.,* 1989; Kaynak, 1995), seed cotton weight (Kaynak, 1995), fiber length (Kaynak, 1995). Ismail and Al-Enani (1986) and Killi (1995) reported that seed cotton yield was highly affected directly and indirectly by number of bolls per plant and seed cotton weight per boll. They also suggested that these two properties contributed significantly to seed cotton yield and could be used as selection criteria in cotton breeding for yield. The objective of this study was to estimate the genotypic and phenotypic variance components, heritability and correlation coefficients for yield, some yield components and lint quality traits.

MATERIAL AND METHODS

Seven cotton genotypes (Agdas-3, Agdas-6, Agdas-7, Agdas-17, Agdas-21, Sayar-314, & Maras-92) were evaluated for genetic parameters. Agdas cotton genotypes were introduced from Azerbaijan. Sayar-314 and Maras-92 (standard cotton variety) have been successfully grown under irrigated conditions in this region. These seven cotton genotypes were evaluated for plant height, number of monopodial and sympodial branches, number of mature bolls, seed cotton weight per boll, 100 seed weight, seed cotton yield, lint percentage, fiber length, micronaire, strength and uniformity in 1997, 1998, 1999 and 2000 growing seasons at the Agricultural Research Institute of Kahramanmaras. The soil was an alluvial clay loam with the following mean properties; pH = 7.5, organic matter = 1.7%, N = 0.05%, $CaCO_3$ = 19.8%, available P = 51.5 kg ha^{-1}, and available K = 73 kg ha^{-1}. Nitrogen and phosphorus at the rate of 80 kg N and P_2O_5 ha^{-1} were applied, respectively. Additional nitrogen (80 kg N ha^{-1}) was top dressed 50 days after planting (at first white flower; prior to first irrigation). Fertilizer application (nitrogenous & phosphorus), control of insects and weeds and furrow irrigation were practiced during the growth season according to the local recommendations.

The trials were arranged in a randomized complete block design with 4 replications. Each plot consisted of four rows (12 m long) and 70 cm distance between rows. Individual plots were spaced 2.8 m apart. The cotton seeds were sown by using cotton drill. Seed rate was approximately 50 kg per hectare. After emergence, plants were thinned to 20 cm in rows (five plants per meter) when the seedling had three true leaves. Ten plants from each plot were evaluated for plant height, number of monopodial and sympodial branches and number of mature bolls. Seed-cotton weight per boll was determined on 20 bolls sample from each plot. Seed-cotton yield was determined from an area 1.4 m wide and 10 m long of the centre two rows of each plot. Lint percentages were calculated after roller-ginning approximately 150-g samples of the harvested seed cotton. After ginning, 50 g lint samples were used for determination of various quality parameters. Lint quality parameters were determined in high volume instruments (HVI): (a) fiber length in millimeters measured as 2.5 (2.5% span length), (b) fiber uniformity determined as the ratio of the mean length to upper-half mean length expressed as a percentage, (c) fiber strength as force (g tex^{-1}) necessary to break the fiber bundle, (d) micronaire value as fineness of the fiber expressed in standard micronaire units. All fiber tests were carried out at the laboratories of Kipas yarn plant in Kahramanmaras province in Turkey.

In the experiments, plants were harvested two times by hands. The first harvest was commenced when the cotton bolls were approximately 70% open; the second harvest was taken three weeks later. Data on all indices were subjected to estimation of genetic parameters like genotypic and phenotypic variances, coefficients of genotypic and phenotypic variability and heritability according to Burton and Devane (1953). Correlation coefficients were conducted following the procedure developed by Wright (1921).

RESULTS AND DISCUSSION

The analysis of variance for yield, yield components and lint quality traits of cotton over 4 years indicated that there were significant differences ($P<0.01$) among the varieties and variety X year interactions for all traits except 100-seed weight. The effects of years on all characters were significant (Table I). The existence of variety X year interaction for investigated characteristics in this study indicates that the effect of years was different for cotton cultivars. Thus additional attention to response of cultivars is needed in cotton production systems where un-predictable environmental factors (temperature, rainfall, relative humidity) changed from one place of the region to another or from year to year.

The estimated variance components in Table II were calculated from the mean squares in Table I. Error variances for number of monopodial and sympodial branches, number of mature bolls, 100-seed weight, lint percentage and fiber uniformity were larger than those of the other components (Table II). Genotype and year interaction was high for seed cotton yield (1747.42) followed by plant height (48.27). Genotypic and phenotypic variances were high for fiber strength, fiber length and seed cotton weight. Phenotypic variances were larger as compared to genotypic variances for all the traits indicating the influence of environmental factors. The high genotypic and phenotypic coefficients of variation were found in number of monopodial branches (18.96 & 23.72), fiber strength (13.66 & 14.05), seed cotton yield (10.22 & 12.46), number of mature bolls (10.07 & 11.53) and seed cotton weight (9.78 & 10.21), respectively. Studies conducted by Miller *et al.* (1958; 1959 & 1962) indicated that genotype by environmental interactions were significant for lint yield and yield components. Sing *et al.* (1984) found predominant genotypic variance for number of sympodia, plant height, halo length, boll size, ginning outturn and seed index. Killi and Gencer (1994 & 1995), working with cotton, also found that variance components for yield and fiber properties were significant, and these results are in line with their findings.

Broad sense heritability estimates ranged from 6.67% (100-seed weight) to 94.60% (fiber strength). The heritability estimates for 100-seed weight (6.67%) and plant height (20.60%) were fairly low level. For these two traits the low heritability estimates were due to larger phenotypic variances. Gill and Singh (1982) reported that plant height was highly affected by environmental conditions. On the other hand, heritability degrees were estimated to high level for seed cotton weight (91.80%), fiber length (94.58%) and fiber strength (94.60%), while moderate level for monopodial branches (63.89%), sympodial branches (61.00%), lint percentage (55.56%) and fiber uniformity (54.43%). These results are in agreement with the result of Quisenberry (1975) and Paloma *et al.* (1977). The traits had

Table I. Analiysis of variance for yield, yield components and lint quality traits of cotton genotypes over 4 years

Traits	Source			
	Year	**Variety**	**Variety X year int.**	**Erorr**
Plant height (cm)	435.050**	290.030**	230.290**	37.210
Monopodial branches (no. plant^{-1})	3.641**	0.578**	0.208**	0.090
Sympodial branches (no. plant^{-1})	27.849**	16.866**	6.582**	1.485
Mature bolls (no. plant^{-1})	59.334**	46.556**	11.103**	2.491
Seed cotton weight (g boll^{-1})	0.772**	4.885**	0.403**	0.162
100 seed weight (g)	5.221*	0.478^{ns}	0.450^{ns}	0.356
Seed cotton yield (kg ha^{-1})	132106.454**	22166.432**	7240.426**	250.767
Lint percentage (%)	24.422**	13.686**	6.088**	2.975
Fiber length (mm)	5.104**	49.927**	2.715**	0.876
Fiber fineness (mic.)	0.790**	1.326**	0.352**	0.059
Fiber strength (g tex^{-1})	599.020**	218.231**	11.805**	2.045
Fiber uniformity (%)	10270.029**	9.032**	4.109**	1.021

ns, *, ** = not significant, significant at 5% and 1% level, respectively.

Table II. Genetic parameters for yield, yield components and lint quality traits of cotton genotypes

Traits	Mean	Variance components [a]						
		$\sigma^2 g$	$\sigma^2 gy$	$\sigma^2 e$	$\sigma^2 p$	GCV [b]	PCV [c]	H [d]
Plant height (cm)	77.97	3.734	48.270	37.21	18.127	2.478	5.460	20.60
Monopodial branches (no. plant^{-1})	0.80	0.029	0.029	0.09	0.036	18.957	23.717	63.89
Sympodial branches (no. plant^{-1})	12.63	0.643	1.274	1.48	1.054	6.348	8.128	61.00
Mature bolls (no. plant^{-1})	14.78	2.216	2.153	2.49	2.909	10.072	11.534	76.18
Seed cotton weight (g boll^{-1})	5.41	0.280	0.060	0.16	0.305	9.780	10.208	91.80
100 seed weight (g)	10.88	0.002	0.023	0.36	0.030	0.411	1.592	6.67
Seed cotton yield (kg ha^{-1})	2987.50	932.875	1747.415	250.77	1385.402	10.223	12.459	67.34
Lint percentage (%)	39.82	0.475	0.778	2.97	0.855	1.731	2.322	55.56
Fiber length (mm)	29.47	2.951	0.459	0.88	3.120	5.829	5.994	94.58
Fiber fineness (mic.)	4.73	0.061	0.073	0.06	0.083	5.221	6.091	73.49
Fiber strength (g tex^{-1})	26.29	12.902	2.440	2.04	13.639	13.663	14.047	94.60
Fiber uniformity (%)	68.56	0.307	0.772	1.02	0.564	0.808	1.095	54.43

a = genotypic variance *($\sigma^2 g$)*, genotype x year variance *($\sigma^2 gy$)*, error variance *($\sigma^2 e$)*, phenotypic variance *($\sigma^2 p$)*
b = Genotypic Coefficient of Variability
c = Phenotypic Coefficient of Variability
d = Broad-sense heritability

Table III. Simple correlation coefficients for yield, yield components and lint quality traits in cotton

Traits+	NMB	NSB	NMAB	SCW	100-SW	SCY	LP	FL	FF	FS	FU
PH	0.110	0.435**	0.270**	0.062	0.207*	0.229*	-0.041	0.377**	-0.170	0.324**	0.125
NMB		-0.025	0.333**	0.105	0.202*	0.038	0.147	0.101	0.182	-0.509**	0.137
NSB			0.238*	0.113	0.042	0.218*	0.365**	0.185	-0.232*	0.025	0.130
NMAB				0.161	0.246**	0.212*	-0.134	0.148	-0.215*	0.008	-0.177
SCW					-0.125	0.302**	0.329**	0.518**	0.314**	-0.375**	0.137
100-SW						0.200*	-0.275**	0.092	0.046	-0.198*	0.103
SCY							0.152	0.284**	0.102	0.178	0.221*
LP								-0.159	0.163	-0.013	0.343**
FL									-0.652**	0.692**	0.139
FF										-0.530**	0.017
FS											0.619**

*, ** Significant at 5% and 1% level respectively.
+ = Plant height (PH), number of monopodial branches (NMB), number of sympodial branches (NSB), number of mature bolls (NMAB), seed cotton weight (SCW),
100-seed weight (100-SW), seed cotton yield (SCY), lint percentage (LP), fiber length (PL), fiber fineness (FF), fiber strength (FS), fiber uniformity (FU)

low heritability can be affected more than the traits had high heritability by the environmental conditions. These results indicated that the improvement of the characteristics having low heritability can be done through pedigree selection or progeny test. On the other hand, high heritability for seed cotton weight, fiber length and fiber strength indicates the presence of additive genes effects, hence their improvement can be done through mass selection.

Simple correlation coefficients calculated among examined characteristics are shown in Table III. Significant and positive correlations of seed cotton yield with plant height (0.21), number of sympodial branches (0.22), number of mature bolls (0.21), seed cotton weight (0.30), 100-seed weight (0.20), fiber length (0.28) and fiber uniformity

(0.22), were found. There were positive correlations between number of mature bolls, plant height, number of monopodial and sympodial branches and 100-seed weight (Sandhu *et al.,* 1986; Al-Rawi *et al.,* 1989; Kaynak, 1995). Lint percentage was positively correlated with number of sympodial branches (0.37) and seed cotton weight (0.33), while negatively correlated with 100-seed weight (-0.28). The correlations between fiber length and plant height, seed cotton weight, seed cotton yield, fiber strength were found to be positive. Fiber fineness was negatively and significantly correlated with number of sympodial branches (-0.23), number of mature bolls (-0.22), fiber length (-0.65) and fiber strength (-0.53), but positively and significantly correlated with seed cotton weight (0.31). Fiber strength also showed negative and significant correlations with number of monopodial branches (-0.51), seed cotton weight (-0.38) and 100-seed weight (-0.20), and highly positive correlations with plant height (0.32) and fiber length (0.69). Correlations of fiber uniformity with lint percentage (0.34) and fiber strength (0.62) were also positive. The present results were in good agreement with the finding of Ismail and Al-Enani (1986), Killi (1995) and Kaynak (1995) it was found that the correlations between seed cotton yield and plant height, number of sympodial branches per plant, number of mature bolls per plant, seed cotton weight per boll, 100-seed weight, fiber length and fiber uniformity were positive. These characteristics contributed significantly to seed cotton yield. It is concluded that successful selection can be made on these characteristics for seed cotton yield.

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