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DIALLEL ANALYSIS FOR FIBER QUALITY PROPERTIES OF COTTON (*GOSSYPIUM HIRSUTUM* L.)

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Summary: The increasing demand for fiber quality in world cotton markets has increased the importance of fiber quality traits in cotton breeding programs. In this study, 6 cotton (*Gossypium hirsutum* L.) genotypes (VD-4, PAUM-15, Cukurova 1518, VD-18, Stoneville 468 and Nazilli 84S) were selected as parents and crossed in all possible combinations according to the half-diallel mating design. Parents and their 15 F_1 crosses were planted in a randomized complete block design with three replications at the experimental field of Cukurova University, Cotton Research and Application Center Adana/Turkey during the years 2008 - 2009.
The analysis of variance indicated that parents and their 15 F_1 crosses were significantly different for fiber length (FL), fineness (FF) and spinning consistency index (SCI), however, insignificant for fiber strength (FS). General combining ability (GCA) variances were significant for FL, FF and SCI at $P \leq 0.01$, but for FS at $P \leq 0.05$. However, specific combining ability (SCA) variances were insignificant for all tested properties. Components of variance showed that the GCA variance was higher than the SCA variance for all properties. These results demonstrated the predominance of additive gene effects for all observed properties. The parental genotypes VD-18 for FL, PAUM-15 for FS, Nazilli 84S for FF and VD-4 for SCI appeared to be the best general combiners, while crosses Cukurova 1518 x Nazilli 84S for FL and FF, VD-4 x Cukurova 1518 for FS and VD-18 x Stoneville 468 for SCI were found to be the best specific combiner. Therefore, these parents and cross combinations could be used in future studies to improve these characteristics.

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Keywords: Combining ability; fineness; length; strength.

Abbreviations: FL – fiber length; FS – fiber strength; FF – fineness; SCI – spinning consistency index; GCA – general combining ability; SCA – specific combining ability.

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INTRODUCTION

Cotton is the most important fiber crop in the world, as well as in Turkey. It is known as the king of natural fibers (Shaukat et al., 2013). The r*ising living standards* of consumers, globalization of cotton textile manufacturing, recent technological developments and adoption of high-speed fiber spinning machinery have increased the global demand for high-quality fibers. Hence, increasing pressure is being placed on cotton breeding programs to increase yields and *fiber quality* (Cambell et. al., 2011).

The first step for a successful breeding program is to select appropriate parents. The efficiency of a breeding program could be increased by a careful choice of parents. One of the most commonly used method for choosing parents is diallel cross, which informs us about the parents potential, and also about gene action involved in determining quantitative traits (Cruz and Vencovsky, 1989; Ramalho et al., 1993; Basal and Turgut, 2005; Verhalen and Murray, 1967). Diallel analysis is one of the efficient biometric methods that has been used frequently by researchers for creating and studying the pattern of heritable variation in the metric plant characters (Griffing, 1956).

Therefore, in this study, data of six parents and their 15 F_1 crosses were analyzed with Griffing´s (1956) approach to evaluate the gene actions and to select potential parents and crosses associated with the significant fiber properties tested.

MATERIALS AND METHODS

Six cotton (*Gossypium hirsutum* L.) genotypes (VD-4, PAUM-15, Cukurova 1518, VD-18, Stoneville 468 and Nazilli 84S) were selected as parents based on their different superior properties like yield, fiber quality, earliness, etc. The parents were (hand) crossed in all possible combinations according to the half diallel mating design in 2008.

Six parents and their fifteen F_1 crosses were sown in a randomized complete block design with three replications at the research and experimental field of Cukurova University, Cotton Research and Application Center in 2009. Plots of F_1 hybrids and their parents consisted of 12 m long that were spaced 20 cm within the rows. Spacing between rows was 70 cm. All recommended agronomic and plant protection practices were followed from sowing till harvesting of the cotton crop. Before harvest, boll samples were collected from the first position of middle fruiting branches of plants in the plots.

The boll samples were ginned with a single roller electrical gin and lint samples were obtained for fiber quality analysis. Before the fiber quality analysis, lint samples were conditioned at 21±1°C temperature and 65±2% relative humidity for 48 h in a controlled room. High Volume Instrument (HVI) 1000 (Uster, Switzerland) was used to analyze fiber quality properties and data on the most important cotton fiber properties, i.e. fiber length [mm], fiber strength [g tex^{-1}], fiber fineness [microner] and spinning consistency index were collected.

Data obtained from the six parents and their fifteen F_1 crosses were analyzed using the analysis of variance method. Estimates of general combining ability (GCA) and specific combining ability (SCA) effects were calculated by using SAS statistical computer software based on the Griffing's (1956) method II, model I (Zhang ve Kang, 2003; Akiscan, 2011).

RESULTS AND DISCUSSION

The analysis of variance indicated significant differences among parents and their F_1 crosses for all properties except for fiber strength (Table 1). A similar significant effect was also reported by Karademir (2005), Karademir et al. (2009) and Karademir and Gencer (2010) for fiber length and fineness. The analysis of variance for general and specific combining abilities revealed that GCA variances were statistically significant for fiber length, fineness and spinning consistency index at $P \leq 0.01$, but for fiber strength at $P \leq 0.05$. However, SCA variances were insignificant for all studied properties (Table 1). GCA variances were greater than SCA variances for all tested fiber quality properties (Table 1). Generally, the higher variance magnitude due to GCA effects compared to SCA effects indicates the importance of additive type of gene action (Mendez-Natera et. al., 2012). In this study, the results showed that all studied properties were controlled by additive genes as shown by Bolek et al. (2010). Similar results were also reported by Basal (2001), Gulyasar (1987), Kanoktip (1987), Temiz (2003), Karademir (2004) and Rauf et al. (2006). Iqbal et al. (2003) demonstrated that the properties controlled by additive gene action had high narrow-sense heritability. Falconer and Mackay (1996) suggested that segregating population might be more amenable to selection in the earlier segregating generations, such as F_{2-3}.

The positive combining ability effects are regarded desirable for fiber length, strength and spinning consistency index, but negative values for fiber fineness. Parental genotypes except for PAUM-15 had positive GCA effects for fiber length. Among these genotypes, VD-18 (0.712) showed the highest GCA effects. In addition, all progenies from the crosses VD-18 had positive SCA effects for fiber length (Table 3). Genotypes PAUM-15

Table 1. Analysis of variance for genotypes and combining ability effects in half diallel population of cotton.

Source of Variation	D. F.	Mean Squares			
		FL [mm]	FS [g tex^{-1}]	FF [microner]	SCI
Replications	2	0.22	0.70	0.01	64.00
Genotypes	20	4.50^{**}	4.94	0.30^{**}	146.68^{*}
Error	40	1.16	2.83	0.08	63.76
GCA	5	13.92^{**}	8.86^{*}	0.99^{**}	318.37^{**}
SCA	15	1.36	3.63	0.07	89.44
Error	40	1.16	2.83	0.08	63.76
GCA/SCA		10.24	2.44	14.14	3.56

$^{*,\ **}$Significant at the P≤0.05 and P≤0.01 probability levels, respectively.

FL: fiber length, FS: fiber strength, FF: fineness, SCI: spinning consistency index.

(0.561) and VD-4 (0.485) were good general combiners for fiber strength. For fiber fineness, genotypes Nazilli 84S (-0.134) and Stoneville 468 (-0.130) were proved to be good general combiners with a significant negative GCA effect. Based on spinning consistency index, genotypes VD-4 (4.038) and Stoneville 468 (3.019)

Table 2. General combining ability effects of parents for different properties.

Genotypes	FL	FS	FF	SCI
VD-4	0.371	0.485	-0.097	4.038**
PAUM-15	-1.480**	0.561	0.401**	-4.493**
Çukurova 1518	0.085	-1.059**	-0.006	-4.338**
VD-18	0.712**	0.013	-0.034	1.293
Stoneville 468	0.094	0.295	-0.130*	3.019*
Nazilli 84S	0.219	-0.296	-0.134*	0.480

*, **Significant at the P≤0.05 and P≤0.01 probability levels, respectively.
FL: fiber length, FS: fiber strength, FF: fineness, SCI: spinning consistency index.

Table 3. Specific combining ability effects of crosses for different properties.

Genotypes	FL	FS	FF	SCI
VD-4 x PAUM-15	-1.180*	0.119	-0.008	-4.113
VD-4 x Çukurova 1518	0.062	1.525	0.313*	6.549
VD-4 x VD-18	0.391	-1.501	0.077	-4.685
VD-4 x Stoneville 468	0.362	1.261	-0.106	3.966
VD-4 x Nazilli 84S	0.288	0.022	-0.016	-1.602
PAUM-15 x Çukurova 1518	0.503	0.809	0.041	2.314
PAUM-15 x VD-18	0.442	-0.180	0.075	4.016
PAUM-15 x Stoneville 468	0.720	-0.335	0.009	-0.746
PAUM-15 x Nazilli 84S	0.312	0.773	0.095	4.272
Çukurova 1518 x VD-18	0.177	0.343	0.134	1.668
Çukurova 1518 x Stoneville 468	-0.998	-0.335	0.162	-4.638
Çukurova 1518 x Nazilli 84S	0.740	0.589	-0.244	4.371
VD-18 x Stoneville 468	0.604	1.516	-0.137	7.734
VD-18 x Nazilli 84S	0.213	1.127	-0.147	5.160
Stoneville 468 x Nazilli 84S	0.161	0.132	0.166	3.307

*Significant at the P≤0.05 probability level.
FL: fiber length, FS: fiber strength, FF: fineness, SCI: spinning consistency index.

were good general combiners with a significant positive GCA effect. The rest genotypes were poor general combiners (Table 2).

Statistically insignificant but favorable SCA effects were observed for all tested fiber quality properties (Table 2). The SCA effects of the crosses for the properties tested are presented in Table 3. Crosses except for VD-4 x PAUM-15 and Çukurova 1518 x Stoneville 468 had positive SCA effects for fiber length. Among the crosses, Çukurova 1518 x Nazilli 84S (0.740) was the best specific combiner for fiber length, followed by PAUM-15 x Stoneville 468 (0.720) and VD-18 x Stoneville 468 (0.604). Crosses VD-4 x Çukurova 1518 (1.525) and VD-18 x Stoneville 468 (1.516) were good specific combiners for fiber strength. Based on fiber fineness, the cross combination Çukurova 1518 x Nazilli 84S (-0.244) was the best specific combiner with negative SCA effects. For spinning consistency index, the cross combination VD-18 x Stoneville 468 (7.734) showed the highest SCA effects, followed by VD-4 x Çukurova 1518 (6.549) and VD-18 x Nazilli 84S (5.16).

Our results indicated that none of the parental genotypes was a good general combiner for all properties tested. However, genotype VD-18 proved to be the best general combiner for fiber length, PAUM-15 for fiber strength, Nazilli 84S for fiber fineness, and VD-4 for spinning consistency index, while crosses Cukurova 1518 x Nazilli 84S, VD-4 x Cukurova 1518 and VD-18 x Stoneville 468 were found to be the best specific combiners for fiber length and fiber fineness, fiber strength and spinning consistency index, respectively. Therefore, these genotypes and cross combinations may be used in a program for improvement of cotton fiber quality.

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