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Gene Action and Useful Heterosis in Interspecific Cotton Crosses (*Gossypium hirsutum* L. x *Gossypium barbadense* L.)

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ABSTRACT

Conducted the breeding researches with interspecific cotton crosses are aimed to obtain genotypes have desired fiber characteristics like *Gossypium barbadense* L. and have high yields potential like *Gossypium hirsutum* L. In this study, gene action and useful heterosis were investigated for fiber quality and yield traits in interspecific cotton crosses. The 12 F_1's and their parents were evaluated in a Randomized Complete Block Design with four replications at the Nazilli Cotton Research Institute's fields during 2011 and 2012 cotton growing season. Claudia, Candia, Sahin 2000, BA 308, Naz 07 and Fantom (*Gossypium hirsutum* L.) were used as a female parents and Giza 45 and Avesto (*Gossypium barbadense* L.) used as a male parents. Non-additive gene effects for yields, fiber strength and fiber length were greater than additive gene effects. The useful heterosis were positively significant for fiber strength and fiber length. Candia x Giza 45 hybrid was promising hybrid for all observed characters.

Keywords: Cotton; Gene action; Heterosis; Yield; Fiber quality

Türler Arası Pamuk Melezlerinde (*Gossypium hirsutum* L. x *Gossypium barbadense* L.) Ekonomik Heterosis ve Kalıtımın İncelenmesi

ESER BİLGİSİ

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ÖZET

Türler arası melez pamuk populasyonları ile yürütülen ıslah çalışmalarında *Gossypium barbadense* L.'nin arzu edilen lif özelliklerine sahip ve *Gossypium hirsutum* L. gibi verimli genotiplerin elde edilmesi amaçlanmaktadır. Bu çalışmada, türler arası melez pamuk populasyonlarında lif kalitesi ve verim için kalıtım ve ekonomik heterosis değerleri incelenmiştir. 12 F_1 ve ebeveynleri 2011 ve 2012 yıllarında Nazilli Pamuk Araştırma Enstitüsü Müdürlüğü deneme tarlalarında tesadüf blokları deneme deseninde yetiştirilmiştir. Claudia, Candia, Sahin 2000, BA 308, Naz 07 ve Fantom (*Gossypium hirsutum* L.) çeşitleri ana, Giza 45 ve Avesto (*Gossypium barbadense* L.) çeşitleri baba olarak kullanılmıştır. Verim, lif

mukavemeti ve lif uzunluğu için eklemeli olmayan gen etkileri eklemeli gen etkilerinden daha büyük bulunmuştur. Lif mukavemeti ve lif uzunluğu bakımından ekonomik heterosis değerleri olumlu ve önemli bulunmuştur. Gözlemlenen özellikler bakımından Candia x Giza 45 melez kombinasyonu ümitvar melez kombinasyon olarak tespit edilmiştir.

Anahtar Kelimeler: Pamuk; Kalıtım; Heterosis; Verim; Lif kalitesi

1. Introduction

Upland cotton (*Gossypium hirsutum* L.) account for approximately 90% of the world cotton production. *Gossypium barbadense* L. with extra-long, strong and fine cotton is the second most cultivated species (Lacape et al 2007; Yu et al 2011). Interspecific crossing between *G. hirsutum* L. and *G. barbadense* L. is useful tool in increasing genetic diversity among elite germplasm for fiber traits such as fiber length and strength. Commercial potential of interspecific hybrids is greater than intraspecific hybrids and, less inbreeding depression in interspecific was determined (Baloch et al 1993). Berger et al (2011) revealed that although some interspecific crosses exhibited lower yield potential and lint percent than commercial cultivars, improvement in length and bundle strength were possibly the result of introgression from *G. barbadense* L. into *G. hirsutum* L.

Cotton breeders seriously face the problem of selecting suitable parents and promising crosses to breed high yielding and high quality cotton varieties. The line x tester analysis method introduced by Kempthorne (1957) is one of the powerful tools in selecting suitable parents and crosses for exploitation in pedigree breeding (Fellahi et al 2013). In interspecific hybrid populations (*G. hirsutum* L. x *G. barbadense* L.), both additive (Zangi 2010) and non-additive gene action (Tausif 2008) for seed cotton yield were found significant. Dhamayanthi (2011) reported that heterosis values were positive for seed cotton yield, whereas were mostly negative for ginning turn-out and fiber characteristics.

The general objectives of this study were to evaluate heterosis of hybrids and estimate gene action and selecting the superior hybrids that can be used in breeding program of cotton. The other; there is also need to develop new cotton varieties with high yield potential and desired fiber quality characteristics to cater the need of Turkish textile industry. Therefore, 12 F_1 hybrids obtained from six *G. hirsutum* L. female parent and two male genotypes of *G. barbadense* L. for developing extra long staple inter-specific hybrids, an attempt was made to find out the extent of heterosis for seed cotton yield and its components.

2. Material and Methods

2.1. Plant materials

The parental material for this study consisted of six *Gossypium hirsutum* L. genotypes Claudia, Candia, Sahin 2000, BA 308 Naz 07 and Fantom as line and two *Gossypium barbadense* L. testers such as Giza 45 and Avesto. Each line was crossed with each tester in a line x tester mating design Kempthorne (1957) during growing season 2011. Twenty genotypes, parents and their crosses, were sown in a randomized complete block design with four replications at Cotton Research Institute, Nazilli in 2012. Each parent and hybrid were raised in one row with a row length of 6 meter, 0.7 meter between rows and 0.2 meter between plants. Data were collected on ten randomly selected plants in each genotype for seed cotton yields (SCY, g $plant^{-1}$), ginning out turn (GOT, %), fiber length (FL, mm), fiber fineness (FF, micronaire) and fiber strength (FS, g tex^{-1}).

2.2. Data analysis

In the study, all observed characters were analyzed with TarPopGen, Jump and Excel program. Analysis of variance for combining abilities effects of some cotton characters were performed according to (Arunachalam 1974). The useful heterosis was calculated over standard check BA 308, the most

cultivated cultivars in Aegean Region in that years, by using mean values of hybrids over replications by Equation 1.

$$\text{Useful Heterosis} = [((F_1 - B_1)/B_1) \times 100] \quad (1)$$

Where; F_1, mean performance of a cross; B_1, mean performance of standard check.

3. Results and Discussion

The analysis of variance for different characters in interspecific crosses (*Gossypium hirsutum* L. x *Gossypium barbadense* L.) presents in (Table 1). The significant genotypic differences shown that interspecific populations had sufficient genetic variability for all observed character.

Mean squares parents (P) for all studied traits and crosses for all characters except FF were also found significant. Mean squares of P versus C was remarkable for all characters except for SCY. Although the differences among lines (L) was found significant for GOT and FS, Testers (T) was significant only for GOT. Mean squares of Lines x tester (L x T) effects were important for SCY and FL.

The variance due to general combining ability (s^2GCA) was lower than specific combining ability variance (s^2SCA) for all characters except GOT, suggesting the preponderance of non-additive gene action controlling these characters (Table 1). Additive gene action was only for GOT. Gad et al (1974) reported similar results for ginning outturn. Tausif (2008) reported the importance of non-additive gene action for seed cotton yield in inter-specific cotton hybrid populations.

Similarly, combining ability variance revealed that the variance due to s^2GCA was lower than s^2SCA indicating non-additive type of gene action was pre-dominant for fiber length, fiber fineness and fiber strength. It could be suggested that selection of superior plants for SCY, FL, FF and FS should be postponed to later generations.

The range of means among the cross combinations are represented in Table 2. Differences between the extreme mean values were 48.9 g plant^{-1} for SCY, 12.55% for GOT, 1.42 micronaire for FF, 11.90 g tex^{-1} for FS and 8.15 mm for FL. The differences between overall mean of parents and that of crosses indicated that fiber quality of crosses were 0.39 micronaire thinner, 4.13 g tex^{-1} stronger and 5.22 mm longer than parents.

The best seed cotton yielding parent was Naz 07 which was the highest GOT and FF. Testers, *Gossypium barbadense* L., Giza 45 and Avesto, were the lowest SCY and GOT. It can be speculated that lower yield and lint percentage but improvement

Table 1- Analysis of variance for different characters in inter-specific crosses (*Gossypium hirsutum* L. x *Gossypium barbadense* L.)

Df	*Df*	*SCY*	*GOT*	*FF*	*FS*	*FL*
Replicates	3	602.21*	2.80	0.07	6.44	3.37**
Genotypes	19	580.88*	55.30*	0.77*	37.86*	40.40*
Parents (P)	7	1004.19*	77.54*	1.32*	42.24*	30.13*
Crosses (C)	11	349.97*	17.93*	0.15	10.28**	3.81*
P versus C	1	157.67	310.73**	3.64*	310.57*	514.79*
Lines (L)	5	89.33	31.47**	0.22	19.02**	4.35
Testers (T)	1	466.25	25.81**	0.25	4.14	2.36
L x T	5	587.35*	2.82	0.06	2.77	3.55**
Error	57	73.85	3.61	0.14	4.51	1.22
s^2_{GCA}		-13.600	0.866	0.005	0.430	0.015
s^2_{SCA}		128.374	-0.197	-0.020	-0.433	0.581
s^2_{GCA}/s^2_{SCA}		-0.106	-4.396	-0.250	-0.993	0.026

*, significant at 5% level; **, significant at 1% level

Table 2- Means of the measured characters for 8 parents and their 12 F_1 hybrids

	SCY	*GOT*	*FF*	*FS*	*FL*
Lines					
Claudia	64.60 bc*	43.73 a	4.70 a	37.28 bc	31.65 c
Candia	61.70 bc	43.80 a	4.64 a	34.80 cd	29.85 cd
Sahin 2000	46.55 de	39.03 bc	3.43 c	30.25 f	29.66 d
BA 308	68.86 ab	41.93 ab	4.24 ab	31.45 ef	29.95 cd
Naz 07	83.70 a	43.63 a	4.59 a	34.30 d	30.73 cd
Fantom	52.70 cd	39.70 b	4.31 ab	33.05 de	29.53 d
Testers					
Giza 45	42.75 de	31.25 d	3.76 bc	40.10 a	37.34 a
Avesto	34.80 e	36.40 c	3.28 c	38.10 ab	34.13 b
LSD (0.05)	15.22	2.93	0.77	2.80	1.87
Lines x Testers					
Claudia x Giza 45	68.65 ab	35.90 bcd	3.87abc	39.20 abc	37.32 ab
Claudia x Avesto	59.75 bcd	37.30 ab	3.75 abc	39.38 abc	37.68 a
Candia x Giza 45	75.15 a	36.43 bc	3.97 ab	42.15 a	37.31 ab
Candia x Avesto	49.50 de	37.18 b	3.56 c	40.90 ab	37.40 ab
Sahin 2000 x Giza 45	63.40 bc	33.53 de	3.60 bc	37.33 c	36.24 ab
Sahin 2000 x Avesto	58.60 bcd	35.48 bcd	3.59 bc	37.03 c	37.31 ab
BA 308 x Giza 45	52.00 cde	31.53 e	3.70 abc	40.90 ab	37.42 ab
BA 308 x Avesto	63.35 bc	34.23 cd	3.56 bc	38.43 bc	36.96 ab
Naz 07 x Giza 45	67.15 ab	37.35 ab	3.50 c	37.33 c	37.25 ab
Naz 07 x Avesto	42.85 e	39.83 a	3.58 bc	38.43 bc	36.14 b
Fantom x Giza 45	51.30 de	36.33 bc	4.11 a	39.20 abc	34.12 c
Fantom x Avesto	66.20 ab	35.85 bcd	3.86 abc	38.28 bc	36.82 ab
LSD (0.05)	11.65	2.62	0.41	3.42	1.48

*, in a column values with different letters are significantly differs at 0.05 level

in fiber length and strength are possibly the result of introgression from barbadense into hirsutum (Berger et al 2011). In the crosses, SCY varied from 42.85 to 75.15 g plant^{-1} and Naz 07 x Avesto and Candia x Giza 45 represented lowest and highest yield, respectively.

Maximum GOT was recorded in cross Naz 07 x Avesto (39.83%). FF values varied from 3.50 to 4.11 micronaire and Naz 07 x Giza 45 and Fantom x Giza 45 represented lowest and highest, respectively. The strength of 37.68 g tex^{-1} was recorded by cross Claudia x Avesto. For FL varied from 34.12 (Fantom x Giza 45) to 37.68 mm (Claudia x Avesto) represented lowest and highest, respectively.

Useful heterosis is the process by which the performance of an F_1 is superior to that of the mean of the BA 308 (*Gossypium hirsutum* L.) parents in this study. Only one hybrid Candia x Giza 45 exhibited a non-significant positively useful heterosis for SCY (Table 3). Unfortunately, negative useful heterosis for GOT was estimated in all hybrids. The similar results reported by Güvercin (2011) for GOT. The data showed that all hybrids exhibited significant and substantial amount of useful heterosis for desired fiber quality traits such as FF, FS and FL.

According to Çoban (2013), the performance of all combinations for yield and fiber quality traits at F_1 generations showed that Claudia x Giza 45, Candia x

Table 3- Useful heterosis for 12 cotton hybrids

	SCY	*GOT*	*FF*	*FS*	*FL*
Claudia x Giza 45	-0.31	-14.37	-8.74**	24.64**	24.61**
Claudia x Avesto	-13.23	-11.03	-11.51**	25.20**	25.80**
Candia x Giza 45	9.13	-13.12	-6.32**	34.02**	24.55**
Candia x Avesto	-28.12	-11.33	-16.06**	30.05**	24.86**
Sahin 2000 x Giza 45	-7.93	-20.04	-14.94**	18.68*	20.99**
Sahin 2000 x Avesto	-14.9	-15.38	-15.35**	17.73*	24.57**
BA 308 x Giza 45	-24.49	-24.81*	-12.69**	30.05**	24.91**
BA 308 x Avesto	-8.01	-18.37	-15.94**	22.18**	23.39**
Naz 07 x Giza 45	-2.49	-10.91	-17.36**	18.68*	24.36**
Naz 07 x Avesto	-37.77	-5.01	-15.58**	22.18**	20.66**
Fantom x Giza 45	-25.5	-13.36	-3.01**	24.64**	13.91**
Fantom x Avesto	-3.87	-14.49	-8.97**	21.70*	22.94**

*, significant at 5% level; **, significant at 1% level

Giza 45, Sahin 2000 x Giza 45, BA 308 x Avesto, Naz 07 x Giza 45 and Fantom x Avesto hybrid populations would be used for partial bulk selection in order to improve cotton lines having enhanced for fiber length with acceptable yield potentials.

4. Conclusions

As a result, it is not possible to obtain new genotypes, which have superior fiber characteristics, high yields and high ginning outturn, from hybrid populations in this research. But it is possible to successful selection with acceptable yields and desired fiber quality traits from including *G. barbadense* L. Giza 45 variety hybrid populations especially in Candia x Giza 45 crosses combination. As a conclusion more than two genotypes to take place in same hybrid may be beneficial for combining yields and ginning outturn traits with desired fiber quality traits.

Abbreviations and Symbols	
SCY	Seed cotton yields, g plant^{-1}
GOT	Ginning out turn, %
FL	Fiber length, mm
FF	Fiber fineness, micronaire
FS	Fiber strength, g tex^{-1}
P	Parents
C	Crosses
L	Lines
T	testers

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