INHERITANCE OF YIELD AND YIELD COMPONENTS IN COTTON (*Gossypium hirsutum* L.)

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ABSTRACT

This study was conducted to investigate the inheritance of yield and yield components in cotton. Crosses between Sure Grow 125 and PAUM 401 (*Gossypium hirsutum* L.) in 2000, and backcrosses between F_1 and parents (Sure Grow 125 and PAUM 401) in 2001 were made under field conditions at Çukurova University, Cotton Research and Application Center, Adana. Four generations (F_1, F_2, B_1, and B_2, in which B_1 represents a backcross between F_1 and Sure Grow 125 and B_2 represents a backcross between F_1 and PAUM 401), and parents were tested at the same center in 2002. Generation mean analysis was used to estimate the type of gene action determining yield and yield components. It was concluded that additive, dominance and epistatic gene effects were responsible for the inheritance of lint yield, boll number per plant and lint percentage whereas only dominance effects were involved in inheritance of seed cotton weight per boll and 100 seed weight.

Key words: Gossypium hirsutum L. – inheritance – yield – yield components

INTRODUCTION

Cotton lint production in Turkey is about 880.000 tons from 689.000 hectares (Anonymous, 2002). This production does not satisfy the demand of 1.150.000 tons for cotton lint with good quality required for textile sectors (Anonymous, 2002). Recently, the production cost has increased to unacceptable levels in Turkey. Some cotton regions such as Çukurova have gone out of cotton production due to high production costs.

Cotton has been grown for its unique fibers since time immemorial. It is obvious that cotton improvement has been studied for years, and great contributions to yield and fiber quality have been made (Liu and Han, 1998; Murthy, 1998; Murthy and Ranganadhacharyulu, 1998; Tomar and Singh, 1996). However, reports on inheritance of yield and its components are inconsistent in the literature. Some studies have shown that lint yield and its components were controlled by additive and dominance effects (Liu and Han, 1998; Murthy, 1998; Murthy and Ranganadhacharyulu, 1998). On the other hand, Tomar and Singh (1996) reported that only additive gene effects were involved in the control of the lint yield and yield components.

The overall objective of cotton breeding is to improve agronomic characteristics of varieties, which contribute to lint yield. Lint yield is a function of boll number per plant, seed cotton weight per boll, 100 seed weight and lint percentage Kerr (1966). Information on the heritability of yield and yield components may provide valuable information to cotton breeders for developing new cultivars. Therefore, the main objective of this research was to investigate the genetic factors controlling the yield and yield components.

MATERIALS AND METHODS

The parents, Sure Grow 125 (P_1) and PAUM 401 (P_2) a long with F_1, F_2, B_1 and B_2 generations were used as genetic materials in this study. To initiate this study, Sure Grow 125 was crossed to PAUM 401. Crosses were made at Çukurova University, Cotton Research and Application Center, under field conditions, Adana, Turkey, in 2000. The F_1 plants produced from crosses between Sure Grow 125 and PAUM 401 were backcrossed to both parents in 2001 at Adana, Turkey. Seeds of parents (P_1 and P_2), F_1, F_2, B_1 (backcross between F_1 and Sure Grow 125), B_2 (backcross between F_1 and the PAUM 401) were planted on 7 May 2002 at Adana, Turkey.

A randomized complete block design with three replications was used. Plots were 5 m long and consisted of two rows, with a border plant at each end. The distance between rows was 0.70 m, and the distance between the plants within the row was 0.20 m. Plants were irrigated, fertilized and treated for pests according to common cultural practices throughout the growing season.

Plants were harvested by hand on 28 September. After that, seed cottons were weighed to determine for lint yield per plant and seed cotton weight per boll values, and ginned on a roller using a laboratory gin for lint percentage calculations (100 x lint weight/seed cotton weight) and 100-seed weight. After harvesting, the boll number per plant was determined.

Means and variances were estimated for every generation from individual plant data, and estimates of genetic effects were determined. Information on the nature of the gene effects involving yield and yield components was obtained by a weighted least square analysis with joint scaling test based on the methods reported by Singh and Chaudhary (1985). The parameters estimated were m, mean of the F_2; d, pooled additive effects; and h, pooled dominance effects. Parameters estimated were checked for their fit to the three-parameter model with the chi – square analysis.

When the three – parameter genetic model was not adequate to explain the data, another model fitting for epistasis was used (Singh and Chaudhary, 1985). The three parameters measuring epistatic effects were i, the pooled additive x additive effects; j, the pooled additive x dominance effects; and, l, the pooled dominance x dominance effects.

RESULTS

Generation mean of lint yield values and other descriptive statistics for the five traits evaluated are shown in Table 1. The mean value of the F_1 (30.67 ± 2.05) was 25.76 % higher than the mid-parent value (22.77 g) (Table 1). The mean lint yield value of the F_2 generation was 15.50 % lower than the mid-parent value. The backcross means were intermediate between F_1 and F_2 generations. The boll number per plant of F_1 generation was higher than the other generations. The mean values of the F_2 and backcrosses were lower than the mid-parent value. The seed cotton weight per boll and 100 seed weight of the F_1, F_2 and backcrosses were higher than mid-parent, while lint percentages of those generations were lower than mid-parent (Table 1).

Generation mean analyses tested three and six-parameter models for the best fit to explain genetic control of yield and yield components in Sure Grow 125 x PAUM 401 cross (Table 2). Effects were estimated, and chi-square values for three-parameter model were checked for the probability of obtaining a larger χ^2 value. The three-parameter model was found to be sufficient to explain control of seed cotton weight/boll and 100 seed weight but not lint yield, boll number per plant and lint percentage.

Table 1. Mean, standard error and range of yield and yield components for parents, F_1, F_2, B_1, and B_2 generations.

	Lint Yield (g/plant)			Boll Number/Plant (unit/plant)			Seed Cotton Weight/boll (g)			Lint Percentage (%)			100 Seed Weight (g)		
	Mean	SE	Range	Mean	SE	Range	Mean	SE	Range	Mean	SE	Range	Mean	SE	Range
P_1	21.50	1.96	17.90-28.70	18.00	1.64	15.00-24.00	3.01	0.02	2.95-3.07	39.60	0.28	38.80-40.40	9.10	0.06	8.92-9.28
P_2	24.05	1.19	20.50-27.90	16.40	0.81	14.00-19.00	3.53	0.02	3.46-3.60	41.50	0.29	40.60-42.30	10.50	0.07	10.30-10.70
F_1	30.67	2.05	16.50-46.20	18.60	1.24	10.00-28.00	4.19	0.03	3.98-4.40	39.30	0.26	37.40-41.30	10.40	0.07	9.83-10.90
F_2	19.24	1.38	6.56-37.10	11.84	0.78	4.00-23.00	4.08	0.13	2.53-7.04	39.90	0.40	36.00-51.60	10.70	0.15	7.50-12.30
B_1	25.01	1.40	11.10-33.30	13.50	0.76	6.00-18.00	4.59	0.03	4.36-4.82	40.30	0.27	38.30-42.40	11.20	0.07	10.60-11.80
B_2	19.39	1.03	5.51-40.40	10.57	0.56	3.00-22.00	4.32	0.02	4.11-4.54	42.30	0.17	40.20-44.40	10.50	0.04	9.93-11.00
MP	22.77			17.20			3.27			40.53			9.80		

P_1 = parental line 1 (Sure Grow 125), P_2 = parental line 2 (PAUM 401), B_1 (backcross between F_1 and Sure Grow 125), B_2 (backcross between F_1 and the P

AUM 401), MP = mid-parent mean

Table 2. Estimates of gene effects with standard errors for yield and yield components of cotton plants.

m = mean of F_2, d = sum of additive effects, h = sum of dominance effects, i = sum of additive

Model and effect	Lint Yield		Boll Number/Plant		Lint Percentage		Seed Cotton Weight/boll		100 Seed Weight	
Three - parameter	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
M	22.3	±0.15	16.76	±0.15	40.53	±0.15	3.32	±0.15	9.86	±0.15
D	-1.4	±0.15	0.80	±0.15	-0.86	±0.15	-0.29	±0.15	-0.73	±0.15
H	0.75	±0.44	-5.49	±0.44	-0.86	±0.44	1.54	±0.44	1.38	±0.44
χ^2	337.00		234.70		16.86		2.46		3.15	
P‡	< 0.05		< 0.05		< 0.05		>0.05		>0.05	
Six - parameter										
M	19.24	±1.38	11.84	±0.78	39.87	±0.40				
D	5.62	±1.74	2.18	±3.96	-1.96	±0.32				
H	19.73	±6.94	2.93	±0.94	4.62	±1.77				
I	11.83	±6.53	0.78	±3.65	5.79	±1.74				
J	4.35	±2.08	3.73	±1.31	-2.91	±0.38				
L	6.26	±10.04	22.68	±5.78	-11.34	±2.16				

x additive epistatic effects, j = sum of additive x dominance epistatic effects, and l = Sum of dominance x dominance epistatic effects. ‡P = probability of obtaining a large χ^2 value.

A three-parameter model satisfactorily explained the genetic differences for seed cotton weight per boll and 100 seed weight in Sure Grow 125 and PAUM 401 cross, indicating that epistasis was not involved in the heritance of the those traits (Table 2). Dominance effects were positive, and estimated values for seed cotton weight per boll and 100 seed cotton weight were 1.54 ± 0.44, 1.38 ± 0.44, respectively. The estimated dominance effects were higher than the estimated additive effects. Because epistatic effects were not present for seed cotton weight per boll and 100 seed weight, dominance effects appeared to be the most important factor contributing to the genetic control of those traits. The results of the three-parameter model analysis indicated that epistasis was present for lint yield, boll number per plant and lint percentage in Sure Grow 125 x PAUM 401 cross (Table 2). Therefore, the six-parameter model was fitted to determine the type and magnitude of gene effects involved in the inheritance of lint yield, boll number per plant and lint percentage in this cross. Additive, dominance, additive x additive, additive x dominance and dominance x dominance effects were positive and estimated value for lint yield were 5.62 ± 1.74, 19.73 ± 6.94, 11.83 ± 6.53, 4.35 ± 2.08 and 6.26 ± 10.04, respectively (Table 2).

The estimated dominance effects were higher than the estimated additive effects but both involved in the inheritance of lint yield. Dominance effects contributed to the inheritance of boll number per plant. Dominance x dominance effects (22.68 ± 5.78) was the highest epistatic effects. The dominance effects (4.62 ± 1.77) for lint percentage were higher than additive effects (-1.96 ± 0.32). The negative sign indicated for d, additive effects, was not important and had no significant meaning. Both dominance and epistatic effects (additive x additive and dominance x dominance) contributed significantly to the inheritance of lint percentage in Sure Grow 125 x PAUM 401.

DISCUSSION

The differences between parents for seed cotton weight per boll and 100 seed weight were low, implying that these parents did have genes with dominance effects for these traits. That is, as the differences in seed cotton weight per boll and 100 seed weight between parents decreased, the dominance effect increased. This result indicated that the magnitude of dominance effect was inversely proportional to parental difference. Rather high differences for lint yield and boll number per plant in the generation means between the F_1 and F_2 suggest that dominance or epistasis may play a role (Table 1). The results determined in this study are in agreement conducted by Verhalen et al. (1971).

The results of the present study indicated the prevailing dominance gene action for the expression of the lint yield, boll number/plant and lint percentage, and also the role of additive and epistatic gene action were also present in their inheritance. Therefore, a simple selection program in the segregating populations or a breeding program which may involve infusion of desirable genes in the population like diallel selective mating or multiple crossing would be used to develop high yielding genotypes with high boll number/plant and lint percentage.

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