INHERITANCE AND VARIABILITY OF SOME AGRONOMIC TRAITS IN GENETICALLY REMOTE HYBRIDIZATION OF COTTON

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Abstract

Cotton is an important fiber and oil crop in Uzbekistan. But, most of commercial varieties have a narrow genetic base. The objective of our research is to develop cotton breeding lines with a high percentage of (+)-gossypol in seeds for feed for non ruminant animals, and with good fiber quality and agronomic traits. Herein we report our results on the study of inheritance and variability of various agronomic traits. We found there was intermediate inheritance of fiber length, lint percent, and such components of productivity as weight of 1 boll and weight of 1000 seeds, and over dominance and intermediate inheritance of yield among crosses between genetically distant cottons. A positive transgression was observed among the segregating F2-F3 populations in such traits as yield, weight of one boll, and weight of 1000 seeds; positive and negative transgressions were observed in fiber length and lint percent. This work has allowed us to develop two breeding lines (L-404/405 and L-6970) that combine high fiber and yield parameters. These lines are currently being evaluated in variety testing conducted by the Uzbek Scientific Research Institute of Cotton Breeding and Seed Production. We are continuing to develop breeding materials with a high percentage of (+)- gossypol in seeds with good fiber quality and agronomic traits.

Introduction

Cotton is an important fiber and oil crop in Uzbekistan. However, most of commercial varieties in Uzbekistan have a narrow genetic base and there is a need to develop new varieties with a more diversified genetic background. An effective method to achieve genetic diversity is through crosses between plants that are only distantly related. The objective of our research is to develop initial cotton breeding lines with a high percentage of (+)- gossypol in seeds for feed to non-ruminant animals but also with good fiber quality and agronomic traits. In this regard, we are investigating the inheritance and variability of fiber quality and components of productivity among crosses developed between genetically different cotton accessions.

Materials and Methods

We are using cotton lines BC3S1-47-8-1-17 and BC3S1-1-6-3-15 provided by USDA-ARS. These lines exhibit a high percentage of (+)-gossypol in seeds and flower petals. They were crossed with Uzbek varieties S-6524, S-6530, and S-6532, and the inheritance of the progeny and the variability of some agronomic traits among F_1-F_3 progenies were investigated. The experiments were conducted in the greenhouse and under field conditions. The temperature in the greenhouse varied as follows: seedling to bud formation day: 34-36°C, night: 18-20°C; bud formation, flowerings and fruiting day: 26-28°C, night: 18-20°C; maturing phase day: 34-36°C, night: 25-28°C. The experimental plots have typical serozem soils with a low quantity of humus (up to 1.0 %) and deep ground water levels (7-8 m). Average precipitation is 360 mm^3 per year which occurs mainly in the autumn-winter-spring period. Sowing was done by hand in raised rows spaced 0.25 m apart with 0.60 m between rows. During the growing period plants were irrigated 3-4 times and fertilizers were applied at the following rates: N-240 kg/ha, P2O5-160 kg/ha, K2O-120 kg/ha. Cotton breeding materials were tested according to the methodology accepted in the Uzbek

Scientific Research Institute of Cotton Breeding and Seed Production (Belousov et al., 1973). Statistical analyzes were conducted according to Dospekhov (1985) and coefficient dominacy identified by the method of Beil and Atkins (1965).

Results & Discussion

We studied inheritance and variability of agronomic traits including fiber length, lint percent, weights of one boll and 1000 seeds, and productivity among the progeny resulting from crosses between these genetically diverse cotton accessions. For cotton profitability, fiber quality and yield are of paramount importance. In this regard, fiber length is an important trait that affects fiber quality. Others have observed that inheritance of traits such as fiber length, lint percent and productivity are of an intermediate type in F_1 crosses between genetically diverse populations. However, our research showed that among crosses between genetically distant cottons, fiber length and lint percent inheritance is best described as over dominance (Table- 1); the exceptions were crosses F_1BC_3S1-1-6-3-15 x S-6532 and F_1BC_3S1-1-6-3-15 x S-6530, which are best described as an intermediate type of inheritance. Weight of one boll also was inherited mostly as intermediate type. We found that yield and weight of 1000 seeds were inherited as over dominance and intermediate types.

Table-1. Inheritance of studied traits of F_1 crosses

№	Parental forms and progeny	Fiber length		Lint percent		Weight of 1 boll, g.		Weight of 1000 seeds, g.		Productivity of 1 Plant	
		X	hp	X	hp	X	hp	X	hp	X	hp
1	BC_3S1-47-8-1-17	28,64		35,4		2,7		111		37,76	
2	BC_3S1-1-6-3-15	30,26		37,8		2,53		106		40,11	
3	S-6524	33,1		35,3		4,98		125		44,2	
4	S-6530	32,5		36,0		5,10		128		46,3	
5	S-6532	32,3		36,3		5,23		124		51,32	
6	F_1BC_3S1-47-8-1-17 x S-6524	35,20	1,9	35,7	4,0	3,92	0,07	132	2,0	41,72	0,24
7	F_1BC_3S1-47-8-1-17 x S-6530	33,79	1,5	34,3	-4,0	3,70	-0,2	124	0,5	36,08	-1,37
8	F_1BC_3S1-47-8-1-17 x S-6532	32,80	1,3	37,7	3,8	4,01	0,04	132	2,1	40,03	-0,66
9	F_1BC_3S1-1-6-3-15 x S-6524	34,80	2,1	39,2	2,1	3,68	-0,09	122	0,7	86,39	-2,8
10	F_1BC_3S1-1-6-3-15 x S-6530	35,40	3,1	36,6	-0,3	4,42	0,47	124	0,6	48,59	1,74
11	F_1BC_3S1-1-6-3-15 x S-6532	31,29	0,09	40,42	4,2	3,89	0,01	102	-1,4	38,41	-1,30

Comparative analyses of local varieties, USA accessions and crosses showed that initial parental forms have stable parameters of fiber length and progeny of were distributed into 3 to 5 classes of variation (Table-2). However, the difference in distribution on fiber length of individual plants (IP) among segregation F_2 populations depended on the USA accession genotypes. That is, a comparatively wider variability was observed among crosses between USA accession $BC_3S_1$1-6-3-15 than with crosses between USA accession BC_3S_1-47-8-1-17. We found positive ($F_2BC_3S_1$1-6-3-15 x S-6530 and $F_2BC_3S_1$1-6-3-15 x S-6530) and negative ($F_2BC_3S_1$1-6-3-15 x S-6532) transgressions among different progeny from these accessions. The $F_2BC_3S_1$-6-3-15 x S-6530 and F_2BC_3S1-1-6-3-15 x S-6530 crosses showed comparatively wide variability of fiber length and less than one percent of plants among the F_2BC_3S1-47-8-1-17 x S-6532 fell into the 27.1-29.0 mm up to 39.1-41.0 mm classes and among the F_2 $BC_3S_1$1-6-3-15 x S-6532 crosses the same was true for the class 25.1-27.0 mm up to 33.1-35.0 mm. A comparatively high average fiber length (34.7 mm.) was observed with the F2BC3S11-6-3-15 x S-6530 cross and shorter fibers (28.7 mm.) were observed in the $F_2BC_3S_1$1-6-3-15 x S-6532 cross. Average fiber length for the remaining F_2 crosses ranged from 30.5 mm ($F_2BC_3S_1$-47-8-1-17 x S-6532) up to 32.4 mm ($F_2BC_3S_1$-47-8-1-17 x S-6530). Analysis of F_3 crosses showed a significant tendency toward a decrease of fiber length in all crosses except F_3S-6530 x $BC_3S_1$1-6-3-15. Among the F_3 populations of F_3BC_3S1-1-6-3-15 x S-6530 crosses we observed the comparatively most positive transgressions and recombinants had fiber length of more than 35.1-39.0 mm. Among F_3 progenies, a comparative high average fiber length (32.2 mm) was observed at $F_3BC_3S_1$-47-8-1-17 x S-6530, and a low one (29.8 mm) for the $F_3BC_3S_1$-47-8-1-17 x S-6524 crosses. The parameters of dispersion and variation of the fiber length trait among all F_3 crosses were comparatively lower than in the F_2 population, which showed a stabilization of fiber length in F_3 populations.

Table-2. Variability of fiber length in F_2- F_3 progeny

№	Parental forms and progeny	n	K=2,0								M±m	σ	V,%
			25,1-27,0	27,1-29,0	29,1-31,0	31,1-33,0	33,1-35,0	35,1-37,0	37,1-39,0	39,1-41,0			
	2008 y.												
1	BC_3S1-47-8-1-17	20			5	12	2				31.7±0.3	1.20	3.80
2	BC_3S1-1-6-3-15	20			2	10	8				32.6±0.3	1.32	4.05
3	S-6524	20			3	4	8	5			33.5±0.4	2.04	6.09
4	S-6530	20		1	3	9	6	1			32.2±0.4	1.86	5.78
5	S-6532	20		3	2	10	5				31.7±05	1.97	6.23
6	F_2 BC_3S1-47-8-1-17 x S-6524	40		3	13	15	7	3			31.7±0.3	2.07	6.55
7	F_2 BC_3S1-47-8-1-17 x S-6530	40			18	5	13	1	4		32.4±0.4	2.65	1.18
8	F_2BC_3S1-47-8-1-17 x S-6532	39		5	23	7	4				30.5±0.3	1.63	5.36
9	F_2BC_3S1-1-6-3-15 x S-6524	40		3	17	9	9	1	1		31.5±0.3	2.25	7.14
10	F_2BC_3S1-1-6-3-15 x S-6530	40		1	2	7	9	15	4	2	34.7±0.4	2.63	7.58
11	F_2BC_3S1-1-6-3-15 x S-6532	40	5	12	9	11	3				28.7±0.4	2.37	8.27
	2009 y.												
12	BC_3S1-47-8-1-17	20	3	11	4	2					30.6±0.4	1.64	5.37
13	BC_3S1-1-6-3-15	20	1	5	9	4	1				31.8±0.4	1.88	5.92
14	S-6524	20	1	3	10	6					32.1±0.4	1.65	5.14
15	S-6530	20	4	2	7	3	4				32.0±0.6	2.78	8.68
16	S-6532	20	1	6	8	5					31.7±0.4	1.75	5.25
17	F_33BC_3S1-47-8-1-17 x S-6524	57	15	26	15	1					30.1 ± 0.2	1.56	5.17
18	F_3BC_3S1-47-8-1-17 x S-6530	83	14	24	32	13					31.1 ± 0.2	1.91	6.75
19	F_3BC_3S1-47-8-1-17 x S-6532	30	5	19	5	1					30.1 ± 0.2	1.38	4.59
20	F_3BC_3S1-1-6-3-15 x S-6524	30	11	14	2	3					29.8 ± 0.3	1.84	6.19
21	F_3BC_3S1-1-6-3-15 x S-6530	57	2	16	20	15	1	2	1		32.2 ± 0.3	2.33	7.23
22	F_3BC_3S1-1-6-3-15 x S-6532	36	7	20	7	2					30.2 ± 0.3	1.57	5.19

Lint percent of local varieties and USA accessions were different and ranged from 35.7% up to 39.0% (S-6530 and BC_3S_11-6-3-15, respectively). The inheritance of lint percent among genetically remote F_1 crosses showed positive and negative over dominance inheritance in most of the crosses; the exception was the $F_2BC_3S_1$-47-8-1-17 x S-6530 cross that showed negative intermediate type of inheritance (hp=-0.3). Analyses among F_2 crosses showed positive and negative transgression among segregating populations in depending of hybrid pairs. Most of the plants with a high lint percent were observed in the $F_2BC_3S_11$-6-3-15 x S-6532 and $F_2BC_3S_11$-6-3-15 x S-6530 crosses. Among F_2 generations the higher fiber lint percentage were found among the $F_2BC_3S_11$-6-3-15 x S-6532, $F_2BC_3S_11$-6-3-15 x S-6524 and $F_2BC_3S_11$-6-3-15 x S-6532 crosses with a respective lint percent of 40.4%; 39,4% and 39.2%, respectively. A decrease in average fiber output was found among F_3 crosses in comparison with F_2. However, among F_3 progeny lint percent increased in plants classified in the ranges 43.1-45.0% and 45.1% and higher. Comparatively high average lint percent were found between $F_2BC_3S_1$-47-8-1-17 x S-6532 crosses (39.7%) and with $F_3BC_3S_11$-6-3-15 x S-6524 crosses (38.0%). Dispersion and variability of lint percent in most of F_3 crosses were higher than in F_2 populations.

Table-3. Variability of lint percent in F_2- F_3 crosses

№	Parental forms and progeny	n	К-2.0										M±m	σ	V,%
			27,1-29,0	29,1-31,0	31,1-33,0	33,1-35,0	35,1-37,0	37,1-39,0	39,0- 41,0	41,1-43,0	43,1-45,0	45,1 - <			
	2008 y.														
1	BC_3S1-47-8-1-17	20				5	6	5	3	1			36.7 ±0.5	2.34	6.36
2	BC_3S1-1-6-3-15	20					4	6	7	2	1		39.0 ±0.5	2.21	5.67
3	S-6524	20			2	2	9	4	3				36.4±0.51	2.30	6.33
4	S-6530	20		1	3	4	7	2	2				35.7±0.63	2.70	7.83
5	S-6532	20				2	4	8	5	1			37.9±0.47	2.10	5.54
6	F_2 BC_3S1-47-8-1-17 x S-6524	40		1	2	8	10	12	2	4	1		36.8 ±0.5	3.04	8.25
7	F_2 BC_3S1-47-8-1-17 x S-6530	40	3	5	7	8	13	1	3				33.9 ±0.5	3.18	9.39
8	F_2BC_3S1-47-8-1-17 x S-6532	39				3	9	7	6	10	4		39.2 ±0.5	3.10	7.92
9	F_2BC_3S1-1-6-3-15 x S-6524	40				2	5	12	10	9	1	2	39.4 ±0.4	2.80	7.10
10	F_2BC_3S1-1-6-3-15 x S-6530	40	2	1	4	10	9	9	3	2			35.6 ±0.5	3.28	9.22
11	F_2BC_3S1-1-6-3-15 x S-6532	40					5	7	10	11	3	4	40.6 ±0.5	2.91	7.18
	2009 y														
12	BC_3S1-47-8-1-17	20				4	9	5	2				36.5±0.40	1.82	5.0
13	BC_3S1-1-6-3-15	20					3	4	10	3			39.2±0.41	1.87	4.76
14	S-6524	20		1	1	4	9	5					35,5±0,5	2,11	5.94
15	S-6530	20			2	5	8	4	1				35.7±0.46	2.08	5.82
16	S-6532	20				2	3	8	5	2			38.2±0.50	2.23	5.86
17	$F_3$3BC_3S1-47-8-1-17 x S-6524	57	5	8	8	9	11	3	3	3	5	2	35.2±0.7	5.05	14.3
18	F_3BC_3S1-47-8-1-17 x S-6530	83	4	18	17	19	14	3	5	1	2		33.6±0.4	3.50	10.4
19	F_3BC_3S1-47-8-1-17 x S-6532	30		2	2	5	6	10	3	1	1		36.5±0.6	3.24	8.88
20	F_3BC_3S1-1-6-3-15 x S-6524	30		1	1	4	9	5	2	3	3	2	38.0±0.7	4.13	10.8
21	F_3BC_3S1-1-6-3-15 x S-6530	57	7	7	7	9	10	9	5	2	1		34.5±0.5	4.16	12.1
22	F_3BC_3S1-1-6-3-15 x S-6532	37		1	2	3	4	7	4	6	4	6	39.7±0.7	4.51	11.5

The investigation of inheritance and variability of yield and it components were also analyzed. This showed a comparative high weight of one boll among the local varieties S-6532, S-6530 and S-6524 with respective weights of 5.2; 5.1 and 5.0 g. Average weights for the USA accessions BC_3S_1-47-8-1-17 and $BC_3S_1$1-6-3-15 were 2.7 g. and 2.5 g., respectively. An analysis of boll weight in F_1 plants showed intermediate type inheritance with parameters of hp from -0.2 up to +0.47; this agrees with reports by other scientists. Average weights in F_1 progenies were between 3.7 g ($F_1BC_3S_1$1-6-3-15 x S-6524 and $F_2BC_3S_1$-47-8-1-17 x S-6530) and 4.4 g ($F_1BC_3S_1$1-6-3-15 x S-6530). The average weights of one boll among F_2 crosses increased in comparison with F_1 which ranged from 4.7g. ($F_2BC_3S_1$1-6-3-15 x S-6530) up to 5.9 g. ($F_2BC_3S_1$-47-8-1-17 x S-6532). These weights may be the result of positive transgressions among F_2 progenies. That is, plants with single boll weights of 7.1 g and higher, were observed in some crosses with the exception of the $F_2BC_3S_1$1-6-3-15 x S-6530 cross. Comparative higher variability (V=25.9% and V=20.5%) were observed for this trait among $F_2BC_3S_1$1-6-3-15 x S-6524 and $F_2BC_3S_1$1-6-3-15 x S-6530 crosses, respectively and low ones (V=15,3%) at $F_2BC_3S_1$-47-8-1-17 x S-6524. The average weight of one boll most of the F_3 crosses increased in comparison to the F_2 plants. Among these crosses only the $F_3BC_3S_1$-47-8-1-17 x S-6524 cross had smaller bolls (4.6 g.) and average weights for the remainder were higher than 5.1 g.

USA accessions BC3S1-47-8-1-17 and BC3S11-6-3-15 had lower average weights of 1000 seed (111 g. and 106 g., respectively) in comparison with local varieties S-6524 (125 g.), S-6530 (128 g) and S-6532 (124 g.). In F1 were observed over dominance and intermediate inheritance of this trait. There was a wide variation of 1000 seed weights in F2-F3 progenies. Among F2 progeny we observed positive transgressions (except for the F2BC3S11-6-3-15 x S-6532 cross). The average weights ranged from 109,0 g. (F2BC3S11-6-3-15 x S-6524) up to 127,8 g. (F2BC3S1-47-8-1-17 x S-6532). Among the F3 progenies F3BC3S1-47-8-1-17 x S-6524 and F3BC3S11-6-3-15 x S-6530 had larger seed. Crosses F3BC3S1-47-8-1-17 x S-6524, F3BC3S1-47-8-1-17 x S-6530 and F3BC3S11-6-3-15 x S-6532 had negative transgressions.

We found positive transgression among F2 crosses in yield (Table-4) with dates more than 100 g./plant. Comparatively higher average values for yield were observed between the F2BC3S11-6-3-15 x S-6532 cross and the F2BC3S1-47-8-1-17 x S-6532 cross (59.5 g. and 59.3 g., respectively) and lower yields between the F2BC3S11-6-3-15 x S-6530 and F2BC3S11-6-3-15 x S-6524 crosses (42.4 g. and 45.5 g, respectively). Both dispersion and variability of yield for the F2 and F3 crosses were similar.

Table 4. Inheritance of productivity in F_2- F_3 progeny

№	Parental forms and progeny	n	K = 10,0											M±m	S	V,%
			10,1-20,0	20,1-30,0	30,1-40,0	40,1-50,0	50,1-60,0	60,1-70,0	70,1-80,0	80,1-90,0	90,1-100,0	100,1-110	110,1 - <			
2008 y.																
1	BC_3S1-47-8-1-17	20	1	3	6	2	4	1	1	1	1			46.5±4.75	21.2	45.7
2	BC_3S1-1-6-3-15	20	2	3	6	3	2	1	1	1	1			44.0±4.93	22.0	50.2
3	S-6524	20		1	2	9	4	3	1					49.0±2.45	10.9	22.4
4	S-6530	20			5	8	7							46.0±0.76	7.88	17.1
5	S-6532	20			2	3	10	5						54.2±2.03	9.12	16.9
6	F_2 BC_3S1-47-8-1-17 x S-6524	40	8	6	7	5	6	4	2	1	1			45,5±3,4	21,8	52,6
7	F_2 BC_3S1-47-8-1-17 x S-6530	40	4	10	8	6	5	2	1	1	2	1		42,4±3,5	22,8	53,8
8	F_2BC_3S1-47-8-1-17 x S-6532	40	1	5	3	5	6	9	4	2	1	1	3	59,5±4,3	26,4	44,4
9	F_2BC_3S1-1-6-3-15 x S-6524	40	3	6	2	7	6	9	4	2	1			50,8±3,3	21,2	41,7
10	F_2BC_3S1-1-6-3-15 x S-6530	40		4	9	8	5	1	1	2	4	3	3	59,3±4,5	29,1	49,0
11	F_2BC_3S1-1-6-3-15 x S-6532	40	2	2	7	13	8	4	2	2				48,2±2,56	16,2	33,7
2009 y.																
12	BC_3S1-47-8-1-17	20			3	2	3	3	3	3		4		48.4-5.51	24.5	33.6
13	BC_3S1-1-6-3-15	20			3	2	8	4	3					51.6-4.84	19.7	44.2
14	S-6524	20		2	3	11	1	2						43.9-2.40	10.5	23.9
15	S-6530	20		1	2	10	5	2						47.5-2.16	9.7	20.4
16	S-6532	20		1	3	8	4	2	3					50.7-3.06	14.4	27.7
17	$F_3 3BC_3S1$-47-8-1-17 x S-6524	57	4	10	9	14	4	3	2	4	2	1	1	51.14-3.72	28.	55.0
18	F_3BC_3S1-47-8-1-17 x S-6530	83	12		14	26	10	9	5	4	2		1	48.1-2.37	21.2	4.4
19	F_3BC_3S1-47-8-1-17 x S-6532	30	1	10	4	4	2	2	2	1	1	1	2	49.7-5.41	29.7	59.8
20	F_3BC_3S1-1-6-3-15 x S-6524	30			10	6	4	3	5	2				52.7-3.18	17.5	33.2
21	F_3BC_3S1-1-6-3-15 x S-6530	57	4	5	16	14	10	4	4					43.6-2.04	15.4	35.4
22	F_3BC_3S1-1-6-3-15 x S-6532	36	1	3	6	4	4	4	4	1	1	1	2	57.2-4.8	26.8	46.9

Conclusions

1. There was intermediate inheritance of fiber length, lint percent, and such components as yield, weight of 1 boll and weight of 1000 seeds; over dominance and intermediate inheritance of yield was observed among crosses between genetically distant cottons.
2. A positive transgression was observed among the segregating F2-F3 populations in such traits as yield, weight of one boll, and weight of 1000 seeds; positive and negative transgressions were observed in fiber length and lint percent. These findings indicate the possibility of developing recombinants with superior agronomic traits derived from these genetically distant crosses through additional breeding.
3. This work resulted in the development of two breeding lines (L-404/405 and L-6970) that combine high fiber and yield parameters. These lines are currently being evaluated in variety testing conducted by the Uzbek Scientific Research Institute of Cotton Breeding and Seed Production.

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