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THE ESTIMATION OF NEW COTTON LINES OBTAINED WITH PARTICIPATION OF INTROGRESSIVE FORM

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Abstract

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Some of the main factors limiting the yield and output of high quality cotton fiber are: Verticillium wilt, pests and diseases, as well as stressful conditions for its cultivation, which go beyond the frames of the adaptive capabilities of the crops. Cotton is characterized by a large quantity of species, as well as the polymorphism of characteristics. Given that fact, the author explores the questions of the involvement, into the cotton breeding programme, of economically-valuable donors, by utilizing methods of remote hybridization. As a result of our many years of research, a row of the introgressive form of cotton obtained by the methods of hybridization of cultivated varieties with a wild diploid species, *G.trilobum Skovsted*, was created. The attraction of introgressive form into cotton breeding, has allowed the creation of new lines of upland cotton with an enriched genetic basis. The new lines are characterized with high quality fiber, resistance to *Verticillium dahliae Kleb*. and high yield compared to standard varieties.

Key words: cotton; remote hybridization; *G.hirsutum L.*; *G.trilobum Skovsted*; introgressive form; resistance towards *Verticillium dahliae Kleb.*; fiber quality; back-cross

Introduction

As it is known, wild diploid species of cotton possess high resistance towards diseases and pests (Ter-Avanesyan, 1973). They are a valuable source of germplasm, which is necessary for breeders in order to breed new cotton varieties. It is expected that the introgression of novel genes from exotic germplasm into cotton cultivars or breeding lines can increase genetic variation in the introgression populations for agronomic traits and fiber quality (Zeng, 2014).

To improve the resistance of cotton varieties to Verticillium wilt, productivity and fiber quality there is a need for further studies on the involvement in the breeding process of new donors not only the polyploid, but also wild diploid forms of cotton plant (Rizaeva, 1996; Brubaker et al., 2000; Shakhmedova, 2003; Anjum, 2017; Chao You, 2006)

Diploid AD hybrids, upon fertility restoration by doubling their chromosome complement, can be crossed with upland cotton. These are new genetic germplasm pools that can be mined by breeders for genes that can be used to improve and increase the genetic diversity of cotton, (Avila and Stewart, 2004).

Contrary to cultivated species, many wild species of cotton possess resistance towards diseases and insects (Meyer, 1972; Cooper, 1978; Jones et al., 2007; Dighe et al., 2008, Stoilova et. al., 2015).

The wild diploid species of cotton *G.trilobum Skovsted* according to Mauer (1954) is characterized by resistance towards populations of the fungus *V. dahliae Kleb*., and also has a range of other advantages (Smith, 1957; Makhmudov, 1979; Egamberdiev et al., 1979; Alikhodjayeva et al., 1992).

However, the potential of such diploid species is not used enough in the breeding programs, and that is related to the difficulty of crossing distant species and the sterility of ob-

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tained hybrids. As a result, limited use of the rich gene pool of species leads to genetic uniformity of varieties, which in turn has negative impact on plants immunity. By crossing wild diploid species of cotton *G.trilobum Skovsted* (2n=26) with natural tetraploid *G.hirsutum L.,* the variety C-4727 (2n=52), the triploid hybrid (2n=39) had been obtained (Semenikhina et. al., 1979) (see **s**cheme). Then by processing of point of increase of actively growing bines of sterile triploid with 0.1% dilution of colchicine, the productive hexaploid amphidiploids *G.hirsutum L*., the variety C-4727 x *G.trilobum Skovsted* (2n=78) were induced. The induced amphidiploids had inherited the features of the parental forms and turned out to be highly resistant towards Verticillium wilt. However, hexaploid amphidiploids, as well as their diploid parent, turned out to be strictly photo periodic. Besides, they had limited number of small bolls, and their fiber length and output did not correspond to the requirements of contemporary standards (Egamberdiev, 1984). To improve the significance of economically-valuable characteristics of amphidiploid, backcrossing with the recurrent variety C-4727 was carried out four times.

Thus, on the basis of the crossing of the cultivated type C-4727 with the wild diploid form *G.trilobum Skovsted* we obtained the introgressive form $F_{15}BC_4$ (*G.hirsutum L.*, the variety C -4727 X *G.trilobum Skovsted*) X C-4727, referred to as L-T, is resistant to *Verticillium dahliae* and which is characterized by the high quality fiber.

However, by the weight of bolls and seeds, the fiber length and gin turnout of this given form is inferior to commercial cotton varieties. Despite this, this breeding material (L-T) may serve as a basis for improvement of the genotype of cotton varieties for earliness, wilt-resistance and fiber quality.

For the purpose of an increase in the economically valuable characteristics of the introgressive form L- T in 2001, it was backcrossed with the commercial cotton variety Omad (*G.hirsutum L*).

Materials and Methods

The experiments were carried out in 2010-2011 in the National cotton breeding and seed production research institute in the Republic of Uzbekistan; 5 kilometers to the north-east from Tashkent. The weather conditions during the period of carrying out the experiments were close to an average multiyear. Planting was carried out in optimal terms, in a naturally infected with *Verticillium dahliae Kleb;* field. The scheme of planting: 60 cm x 20 cm x 1 plant.

The material for the study were the lines (F_9-F_{10}), obtained in the result of crossing of introgressive form L-T $F_{15}BC_4$ (*G. hirsutum L.*, the variety C-4727 x *G. trilobum Skovsted*) x C-4727 and the variety Omad (*G.hirsutum L.)*. Eight cotton lines had been studied. Each of them included 100-120 plants, as the standard varieties were chosen to be Namangan -77 and C-6524.

The assessment of plant affection with *Verticillium wilt* was carried out in the end of vegetation period using the cut of stalk near root collar method, of Dobrovolsky B.V.

In order to define the weight of boll, gin turnout and fiber quality, we collected 25 bolls from the first internodes of the second and the third sympodial branches. All this data was statistically analysed according to the methodology of B.A. Dospekhov. The analysis of fiber quality was defined by High Volume Instrument (HVI).

Results and Discussion

From the results of multiyear selections on wilt infected fields we created introgressive forms with euploid (2n=52) number of chromosomes. They combined characteristics of tetraploid species and properties of *G.trilobum Skovsted*: high quality of fiber and resistance to Verticillium wilt. Among those was the form L-T – $F_{15}BC_4$ (*G. hirsutum L*. the variety C-4727 x *G. trilobum Skovsted*) x C-4727. However, the plants were late maturing and the weight of the seeds of that form conceded to the indices of cultivated varieties. In relation to this, we decided to backcross this introgressive form with the variety Omad 5 times and further individual plant selections within 10 years.

The earliest maturing were the cotton lines L-244, L-248 and L-250: their bolls were ripening approximately within the period of 110-111 days, and that is 3-3.5 days earlier than standards (Table 1). The other lines had a maturity period from 111.3 (the line L-249) to 116.3 (the line L-247) days. In comparison to the previous year in 2011 the duration of the vegetative period of the new lines was 4-10 days earlier. These lines had ripening of first bolls in about 102-107 days. The standard varieties Namangan-77 and C-6524 had ripening of first bolls in 107 and 105 days, respectively.

Among the studied cotton lines in 2010, the best ones according to the weight of boll were the lines: L-241 (7.2 g.), L-244 (6.8 g.) and L-250 (6.5 g.). With the other lines that property was within 5.8 - 6.4 gr. In F_{10} lines the highest indices on those characteristics were the lines L-249 (8.0 gr.) and L-248 (6.2 g.).

The weight of 1000 seeds with tested F_9 lines was 120-140 g, the exception being the line L-244 (110 g.). For the majority of lines in 2011, this characteristic was 130-135 g.

Table 1

The scheme for obtaining of new varieties and cotton lines on the basis of crossing of cultivated species *G.hirsutum L.* with wild diploid species *G. trilobum Skovsted*

Crossing *G. hisutum L.*, the variety C-4227 (2n=52) x *G. trilobum Skovsted* (2n=26)	
Amphihaploid F_1 (2n=39)	The sum of chromosomes of two haploids. The plant is sterile.
Doubling of chromosome number of amphihaploid by colchicine of point of growth of germs and obtaining of amphidiploids (2n=78).	The sum of chromosomes of two diploids. The plants are fruitful, wilt resistant, with late maturation.
1-st backcrossing of amphidiploids with the variety C-4727. Selection of wilt resistant, cultural type plants.	Pentaploids (2n=65). The plants are fruitful, wilt resistant, with medium-late maturation.
2-nd backcrossing of pentaploid with the variety C-4727. Selection of wilt resistant highly productive plants.	The plants are fruitful, wilt resistant, with different number of chromosomes (2n=52; 2n=54; 2n=58) and the others.
3-rd backcrossing of hybrids with the variety C-4727. Carrying out selection according the complex of characteristics.	The plants are highly fruitful, of medium-early maturity, wilt resistant, number of chromosomes 2n=52.
4-th backcrossing of hybrids with the variety C-4727. Carrying out selection according the complex of characteristics.	The families are highly fruitful, wilt resistant and early maturity, with increase fiber quality.
Multiyear selections of the best plants and families	Introgressive form L-T and families, wilt resistant with quality fiber.
5-th backcrossing of the form L-T with larger boll variety of cotton of the species *G. hirsutum L.* Multiyear selections of wilt resistant plants and families on strongly affected by the fungus *V. dahliae Kleb*,	New highly productive, resistant lines with increased gin turnout and high quality fiber.

The tested lines in 2011 had a gin turnout from 37.5 to 43.7%. With six lines that index exceeded or was equal to 40%.

As shown in Table 1 in 2010, all the tested cotton lines had micronaire from 4.2 to 4.6, except L-250. In standard varieties micronaire was 4.9 (Namangan – 77) and 4.6 (C-6524). The strength of fiber of all cotton lines was within 32.0 – 35.3 g/tex, which is very high. The fiber lengths of new cotton lines in 2010 were high except line L-249, which was 1.14 inch. The qualities of fiber of the new lines are nearing the indices of long-staple cotton varieties.

It should be noted that in 2011 the abnormal hot summer had led to early accumulation of efficient temperatures and consequently earlier maturation of cotton plants. This led to some increase of fiber micronaire.

The most resistant to *Verticillium wilt* were the lines: L-241, L-243, L-244, L-247, L-248 and L-251, their plants were not affected in strong degree, which corresponds from 1.9 to 9.4% of plants (Table 2). The standard variety Namangan - 77 was affected from 28.8% until 48.0%; and the variety C-6524 was affected from 16.9% till 35.7%.

Table 2

Indices of economically-valuable characteristics of new cotton lines

Standart varieties and lines	Weight of boll, gr		Weight of 1000 seeds, gr		G.T.O. %		Len, inch		Str, g/tex		Mic		Maturity (no. of days for first boll to open)	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
St. Namangan - 77	6.2	6	130	130	36.1	37.3	1.16	1.11	31.5	28.8	4.9	5.3	113.5	107.3
St. C-6524	6.1	6.1	140	138	36.2	38.1	1.2	1.14	33	33.8	4.6	5.1	113.1	105.5
L-241	7.2	6.5	140	130	36.7	40.4	1.29	1.27	35.4	34.4	4.1	4.6	113.8	106.1
L-243	5.8	5.6	120	130	37.6	39.7	1.19	1.16	32.4	33.9	4.3	4.4	114.1	102.9
L-244	6.4	6.4	110	136	39.3	41.4	1.27	1.22	34.8	33.8	4.2	4.4	110	102.7
L-247	6.8	6.4	130	134	40.3	43.3	1.27	1.22	35.4	31.8	4.4	4.9	116.3	105.5
L-248	6.2	7.1	130	128	39.7	42.8	1.27	1.27	33.7	34.5	4.6	4.9	110.7	106.7
L-249	6	8	120	140	37.3	37.5	1.14	1.23	32	33	4.5	4.8	111.3	107.3
L-250	6.5	6.3	120	130	40.8	41.6	1.23	1.22	32.4	32.8	5	5.1	110.8	103.8
L-251	6.4	6.4	120	135	37.3	43.7	1.18	1.18	33.2	37	4.3	4.9	112.6	102.4

Table 3
Affection of new cotton lines with Verticillium wilt (2011)

№ of line	n	Degree of affection according cut of root collar, %	
		Strong	General
St. Namangan- 77	120	28.8	48
St. C-6524	116	16.9	35.7
L-241	90	0	0
L-243	85	0	1.9
L-244	80	0	6.9
L-247	72	0	8.7
L-248	77	0	6.7
L-249	67	0	20
L-250	67	2.1	9.4
L-251	72	0	2.5

We evaluated the correlation relationships in 8 cotton lines derived from participation of introgressive form L-T based on 6 breeding and valuable features during 2010-2011. Significant positive relationships are of particular interest, as it is known, these links make selection work easy.

The correlation coefficient of raw cotton weight of one boll to the weight of 1000 seed pieces was in the range of 0.15 to 0.38 (Table 3). Raw cotton weight of one boll with gin turnout correlated weakly because moderate negative correlation was observed.

The vast majority of the studied lines between the weight of 1000 seed pieces with gin turnout showed negative correlation. Very rarely - weak positive.

More often weak correlations close to 0 or negative ones were observed between the gin turnout and length. In single lines, such as L-248, the correlation between the length and yield is positive in F_{10}. This relationship is kept in next generations.

Between the length and strength of fiber moderate correlation is seen in many lines. Between this pair of signs a positive relationship remains stable and even slightly increases with generations. This dependence shows: the greater the length of the fiber, the higher its strength.

It should be noted that between the fiber length and micronaire the vast majority of the lines show negative or weak positive correlation. That is, the greater the length, the lower micronaire of fibers is. That is what the breeder needs. In the process of homozygotization correlations in some signs remained stable, while in others they varied. Being aware of the correlation dependence in lines, we can purposefully conduct selection work on a set of signs.

In 2010 the line L-243, among 8 selected lines, was the most productive and has an average of 4.78 t/ha (Table 4 and 5). The lines L-250, L-244, L-241 had the productivity above

Table 5
Comparative yields of new lines and standard varieties (2010), (tonnes/ha)

№ of line	Replication				Average	Standard deviation	
	I	II	III	IV	tonnes/ha	t/ha	%
L-250	4.31	4.45	4.53	4.12	4.35	1.01	30.2
L-244	4.38	4.32	4.25	4.29	4.31	0.97	29
L-241	4.12	4.34	4.27	4.01	4.18	0.84	25.1
L-243	4.84	4.87	4.77	4.64	4.78	1.44	43.1
L-247	3.95	4.06	4.17	4.11	4.07	0.73	21.8
L-248	2.97	3.35	3.13	3.47	3.23	-0.11	-3.3
L-249	3.17	2.91	3.09	2.98	3.03	-0.31	-9.3
L-251	2.95	3.07	3.17	2.74	2.98	-0.36	-10.7
St.Namangan-77	3.25	3.17	3.12	3.08	3.15	-0.19	-5.7
St. C-6524	3.38	3.32	3.25	3.43	3.34		

LSD (0.5) = 1.89

Table 4
Correlations of some economic traits of new cotton lines (2010-2011)

2010	weight of boll	weight of 1000 seeds	G.T.O.	Len	Str	Mic
weight of boll	1					
weight of 1000 seeds	0.382112816	1				
G.T.O.	-0.018404505	-0.451320221	1			
Len	0.055520168	-0.343691363	0.253855807	1		
Str	-0.129151078	-0.010114586	-0.02904464	-0.834664567	1	
Mic	0.08145723	0.43765625	-0.489707745	-0.63579692	0.19020186	1
2011	weight of boll	weight of 1000 seeds	G.T.O.	Len	Str	Mic
weight of boll	1					
weight of 1000 seeds	0.159225801	1				
G.T.O.	-0.373271442	-0.375767838	1			
Len	-0.14640983	0.330271815	0.432029173	1		
Str	-0.102903689	0.375187681	0.25724761	0.339441236	1	
Mic	-0.366672676	-0.293168688	0.044879453	-0.254993073	-0.713580475	1

4.0 t/ha. At the same time the yield of standard variety Namangan-77 was reaching 3.15 t/ha, and the variety C-6524 – 3.34 t/ha.

Genetic erosion, or the reduction in genetic diversity in crop plants, takes on various shapes depending on one's standpoint, including the reduction in the number of different crop species being grown and the decrease in genetic diversity within crop species (Collins and Qualset, 1999) in particular of Upland cotton (Paterson et al., 2004; Van Esbroeck et al., 1998; Wallace et al., 2009).

Using a limited number of elite parental lines for population to breed improved cotton cultivars has led to a narrow genetic base of the Upland cotton germplasm (Wendel et al., 1992; Brubaker and Wendel, 1994; Iqbal et al., 2001). Analyses of cotton yield data for cultivars released in the last 2 decades indicated that genetic gain in lint yield has declined over the past several years (Meredith, 2006). Many researchers recognized that retaining sufficient genetic diversity in the Upland cotton gene pool is essential for its continual genetic improvement (Zhang et al., 2011). Germplasm of wild diploid species of cotton are an important source of useful genetic variability (McCarty et al., 1998).

The crossing of the introgressive form with early maturity and large weight of bolls variety Omad (*G.hirsutum L.*) extends the possibility for selection of valuable forms. The new cotton lines turned out to be resistant towards Verticillium wilt, of higher productive potential, with combination of other economically-valuable characteristics. In their genotype, there are combined characteristics of cultivated variety and introgressive form L-T. The new lines have larger bolls in comparison to standard varieties. They are characterized by high gin turnout, good micronaire and very high strength and fiber length. Thus, on the bases of methodology, we obtained cotton lines on new genetic basis that predominate standard varieties with a complex of positive properties.

Conclusions

It was deduced that the introgressive form L-T ($F_{15}BC_4$ (*G.hirsutum L.*, the variety C-4727 x *G.trilobum Skovsted*) x C-4727) is the donor of resistance towards Verticillium wilt and high fiber quality.

The efficiency of crossing the introgressive form L-T with the variety Omad in the creation of valuable breeding lines of cotton has been proved. The obtained lines L-250, L-244, L-241, L-243, L-247, L-249, and L-251 possess the complex of economically-valuable characteristics, especially high wilt resistance and unique indices of fiber quality.

Comparing the yields of standard varieties with the new cotton lines has shown that the latter has an advantage according those characteristics. The high productivity of line L- T x Omad is explained by larger boll, greater weight of 1000 seeds and by resistance of plants to Verticillium wilt.

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