J. Cotton Res. Dev. **33** (1) 1-10 (January, 2019) **ISSN No. 0972-8619**

Variability of fiber yield and length in parental lines, F1 hybrids and introgression lines of cotton in response to two spotted spider mite infestation

A. A. AZIMOV AND R.M.USMANOV*

Institute of Genetics and Plants Experimental Biology, Uzbek Academy of Sciences, Yukori-Yuz, 111 226, Kibray, Tashkent Region, Uzbekistan

****E-mail : usmanov_rustam51@mail.ru***

ABSTRACT : Two spotted spider mite (*Tetranychus urticae* (Koch)) (TSSM) adversely affect the growth and development of cotton and has a detrimental effect on a number of economically important traits of cotton.Plants infested with spider mites in June lose upto 50-60 per cent of yield, in July upto 25 -40 per cent and in August 2-6 per cent.The study of the variability of cotton fiber yield and fiber length in parental lines, reciprocal F1 hybrids, and cotton variety AN-Bayut 2, were conducted by artificial infestation of plants with spider mites in a greenhouse. Introgression cotton lines developed by interspecific hybridization of wild cotton *Gossypium trilobum* Skovsted revealed a high level of resistance to spider mite.

Key words : Cotton, fiber length, fiber yield, inheritance, two spotted spider mite

In Uzbekistan, cotton (*Gossypium* spp.) is the main fiber producing crop grown in between 37 and 43 N^0 latitude, primarily in river valleys on serozem and meadow soils.Cotton,like other crops is affected by insects pest (spider mite, thrips, aphids, bollworms, cutworms, etc. and microorganisms (causing *Verticillium* and *Fusarium* wilts, root rot, and bacterial blight diseases). Two spotted spider mite is (TSSM) the main insect pest in many cotton growing areas. Spider mites are usually found in colonies on the underside of the leaves and on the bract.Colonies frequently consist of hundreds, and sometimes thousands, of individuals. Infestations caused by TSSM can have dramatic effects on plant growth resulting in reduced crop yield, fiber quality, germination success, and oil content of seeds (Abdurakhmonov *et al.,* 2008).

In past decade the number of acres sprayed in Mississippi has more than doubled since 2005. In arid environments such as California and Australia, more than 90 per cent of yield losses have been observed from spider mite infestations (Orellana, 2014). A considerable number of studies agree that early infestation of mites result in increased crop damage and yield loss (Rijal *et al.,* 2016).In Uzbekistan, plants infested by the TSSM in June lose, on average, 50-60 per cent of their yield, while those attacked in July and August suffer a 25-40 per cent and 2-6 per cent reduction in yield, respectively.Spider mites can be difficult to control with normal pesticide application and over reliance on pesticides for their control has led to pesticide resistance. Widely adopted genetic traits such as *Bt* that controls bollworm

has no effect on mites or other sucking pests, so researchers are evaluating other methods of non pesticide control (Guo *et al.,* 2016).

Numerous scientists have worked on interspecific hybridization for transferring resistant genes for favorable traits from wild diploid species into tetraploid cultivated cotton (Ahmad *et al.,* 2011).The wild species of *Gossypium* are considered to be a rich source of genetic variability which can be effectively utilized for the improvement of cotton (Abdurakhmonov *et al.,* 2008; Campbell *et al.,* 2010). These wild species have great potential as genetic resources for transferring stress tolerance and pest resistance into cultivated commercial cotton.In Uzbekistan, researchers developed a number of inter specific and intra specific cotton hybrids and lines with improved fiber traits and resistance to biotic stresses.

The objective of this study was to evaluate fiber length and fiber yield variability in parental lines, F1 cotton hybrids and introgression lines under the artificial infestation with two spotted spider mite.

MATERIALS AND METHODS

Plant materials : Five cotton accessions (KS 1,AN 14,IL 296,IL 1378,IL 32), their F_1 hybrids and commercial variety AN Bayaut 2 were used fore valuations of fiber yield and length under controlled infestation by TSSM.

Cotton variety KS 1 (short stemed) was developed by crossing the radiation mutant M 281 with the cultivated *Verticillium* wilt resistant commercial variety Tashkent 1. Distinctive features of the KS 1 are high resistance to lodging, early ripening, high yield and good fiber quality. The variety is susceptible to *Verticillium* wilt and insect pests.

The cotton variety AN 14 was developed from crossing of radiation mutant M 29 with the wild species of *G.hirsutum* sp *mexicanum* (Tod.) and with further repeated backcrossing with the M 281 mutant line. The variety has a high yield, a tendency to natural early leaf defoliation, and good fiber quality traits.The variety is not resistant to *Verticillium* wilt and pests.

IL 296 line was isolated from F_4 progeny of interspecific hybrid [*G.hirsutum* L. var.S 4727 x (*G.hirsutum* L. var.C 4727 x *G. trilobum* Skovsted)]. The line is highly tolerant to some pests (aphids, thrips, mites) and has a white, strong and silky fiber.

IL 1378 line was isolated fromF_5progeny of interspecific hybrid [(*G.hirsutum* L.var. C 4727 x*G.Trilobum* Skovsted) x *G. hirsutum* L. var. Tashkent 1].The line is tolerant to some pests (aphids, thrips, mites) and characterized by hairless, anthocyanin colored stem, without monopodial branches, resistant to lodging.

IL 32 line was isolated from F_5progeny of interspecific hybrid [(*G.hirsutum* L., var.C 4727 x *G. trilobum* Skovsted) x *G. hirsutum* L. var.C 4727]. The line is resistant to lodging, highly tolerant to*Verticillium* wilt, thrips, aphids and spider mites.

Population assessment of spider mites : Analyses of morpho biological characteristics of these selected cotton germplasm accessions and cultivars were performed in the greenhouse of IG and PEB, Tashkent, Uzbekistan in 2010.Plant plots were arranged in a complete randomized block design with 4 replications for each treatment. Standard irrigation and

agronomic technologies were used for growing cultivars in the greenhouse cultivation environment.

Cotton plants were artificially infested with TSSM at fourth and sixth true leaf stage. Mites were reared in a greenhouse on green beans (*Phaseolus vulgaris* L.). One bean mite infected plant was used to inoculate H" 36 cm of a cotton row with between 2-3 mites/cm^2. During the investigated period, no chemical treatment against the pests was performed on the experimental site.

Fiber length and other fiber quality traits of studied cotton accessions were measured by High Volume Instrument (HVI) of the certified "SIFAT" agency, Tashkent, Uzbekistan.Fiber or lint yield is quantified in kg/ha and was determined according to formula: Lint yield = [(Seeds/ha)(Weight of fiber/seed)].

In order to study the resistance of the parent plants and the reciprocal F1hybrids to the spider mites during the vegetative period, the number of individual spider mite released on the leaf laminas of the registered plants isolated with special gauze cages was counted. During the investigated period, no chemical treatment against the pests was performed on the experimental site. All counting and phenological observations of the proliferation and population density of spider mites on the plants of parent lines and F1 hybrids were carried out according to the "Methodological instruction for assessing the resistance of cotton to melon and alfalfa aphids" developed by All Union Academy of Agricultural Sciences, All Russian Institute of Plant Protection (Leningrad). Observation and counting of pests on the cotton leaves were carried out every 7-10 days during periods of rapid proliferation *i.e.* May to September.

Accounting results on the individual plants of the original parents and F1, F2 hybrids were averaged.

To assess the degree of damage of the cotton leaves by spider mites 4 point scale was used.

RESULTS AND DISCUSSION

The most promising direction to reduce the impact of these factors, in particular pests, is the breeding and widespread introduction of new cotton varieties into agricultural production, developed by hybridization with wild cotton species, a potential source of resistance genes. In the process of long term selection, directed to a high productivity and quality, the genetic base of cultivated plants has been depleted in genes controlling the resistance traits to biotic and abiotic factors that were preserved in wild species (Campbell *et al.,* 2010). By means of interspecific and introgression hybridization, the gene transfer from wild cotton species into cultivated varieties of *G.hirsutum* (which potential is probably not sufficient to increase resistance while preserve all other valuable traits under changing conditions) and subsequent backcrosses of hybrids with one of the parental species, a commercial cotton varieties resistant to pests can be developed.

It has been shown that breeding programs that involves wild cotton species are aimed to transfer useful genes into cultivated varieties (Wendel *et al.,* 2010). The importance of the world cotton biological diversity and cotton germplasm collections as a source of useful traits and their introgression by intergenomic

hybridization previously reported byWendel *et al.,* (2010) and Campbell *et al.,* (2010).

Conducted studies showed that artificial infestation with the two spotted spider mite, their quantity on the plants of original parental lines, first generation of reciprocal hybrids, and also on the AN Bayaut 2 control variety had mixed characteristics.

Thus, the number of spider mites/plant in the period from June 15 to 30 on parental varieties KS 1, AN 14 and control cotton variety AN Bayaut 2, ranged from 11 to 23 pcs, 15 to 34 pcs and17 to 31 pcs, respectively, while in the introgression parent IL 296, IL 1378, IL 32 lines it ranged from 10 to 16 pcs, in the first generation of reciprocal hybrids it varied from 10 to 24 pcs; in KS 1, AN 14, AN Bayaut 2 in the period of phenological observationsfrom July 7 to July 19 it ranged from 87 to 267, 77 to 263 and 73 to 291 pcs , respectively; in IL 296, IL 1378, IL 32 line sit varied from 17 to 20, 17 to 31 and 13 to 21 pcs, respectively. In the plants of first generation reciprocal hybrids number of spider mite/plant varied from 15 to 32. In the period from July 26 to August 9 in the parental varieties KS 1, AN 14, and also in the control variety AN Bayaut 2 this parameter ranged from 13 to 149, 24 to 127 and 43 to 149, respectively, while in the introgression IL 296, IL 1378, IL 32 lines from 0 to 3, in plants of some ingressive lines spider mites were not found (Fig. 1).

Data obtained from our study showed that on the background of artificial infestation, the population density of spider mites on the plants of the introgression parental lines IL 296, IL 1378, IL 32 and first generation reciprocal hybrids was significantly lower.

On the background of artificial infestation with spider mites, their maximum number on the plants of the parent lines KS 1, AN 14, first generation of reciprocal hybrids, and also on the control varietyAN Bayaut 2 was observed on the date of July 19 of registration, and for introgression parents, IL 296, IL 1378 and IL 32 on the accounting date of July 12. At the same time, the number of spider mites/plant significantly differed for the initial parent lines KS 1, AN 14, IL 296, IL 1378, IL 32, and the cotton variety AN Bayaut 2 there were 267, 263, 20, 30, 11, 291 pcs, respectively, and in the first generation of reciprocal hybrids the number of mites ranged from 13 to 32 pcs.

The results of our studies of the effect of artificial infestation with spider mite on the fiber yield of parental lines, AN Bayaut 2 and reciprocal F1 hybrids are given (Table 2 and Fig. 2).

Cotton fiber yield in parent lines varied from 35 to 35.9 per cent, while in F1 hybrids rangedfrom 36 to 36.9 per cent. A wide variation of fiber length observed in the parent lines. The highest fiber length observed in the AN 14 variety (35-35.9), in KS 1 fiber length raged from 34-34.9, and the introgression lines had a relatively low fiber length. In the line IL 1378 fiber length varied from 33 to 33.9 per cent, and in two lines this parameter was 32-32.9 per cent.

By the range of fiber length variability, the parent lines, and F_1 B C progeny are divided into 3 classes with a variation from 32 to 34.9 mm. The AN Bayaut 2 variety, according to this parameter was divided into 2 classes with a variation from 31 to 33.9 mm. Twelve F_1BC progenywere divided into 3 classes with a variation from 32 to 34.9 mm. Moreover, a larger number of the examined parent plants of lines

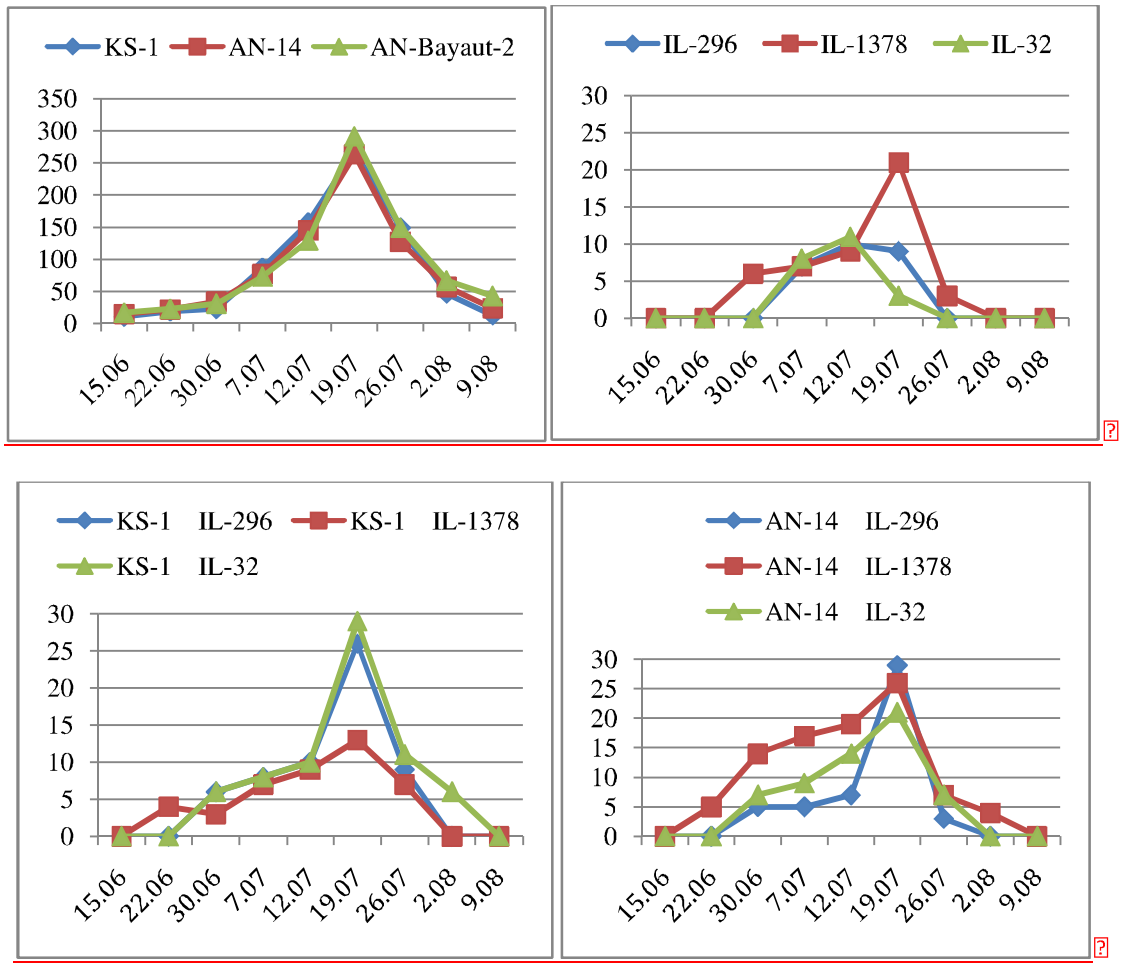

Fig. 1. The number of spider mites per plant according to the dates of registration of the parent lines and their hybrids of the first generation, pcs.(date of registration from June 15 – August 09 every 10 days).

KS 1, AN 14, IL 1378 belongs to the class 33 - 33.9 mm of the fiber length, the rest of the parents, IL 296, IL 32 belonged to the class 32-32.9 mm.(Fig. 3).

By the range of fiber yield variability, the parent lines KS 1, AN 14, IL 296, IL 1378, IL 32, as well as F_1BC progeny are divided into 3 classes with a variation from 34 to 36.9 per cent. The fiber yield of the cotton variety AN Bayaut 2 ranged from 33 to 36.9 per cent. A larger number of the examined parent plants KS 1, IL 296, IL 1378 belonged to the class of 36-36.9 per cent, AN 14 belonged to the classes 36-36, 9 and 37-37.9 per cent and IL 32 belonged to the classes 34-34.9 and 36-36.9 per cent of the fiber yield. First generation of reciprocal hybrids basically, belonged to the 36-36.9 per cent and 37-37.9 of fiber yield class.

The average fiber yield in the parental lines, F_1BC, and AN Bayaut 2 had similar values. Thus, fiber yield in lines KS 1, AN 14, IL 296, IL 1378, IL 32, and control variety AN Bayaut 2, was 36.9 ± 0.73; 37.1 ± 0.69; 35.6 ± 0.59; 34.9 ± 0.64; 34.4 ± 0.55; 35.3 ± 0.58 per cent, respectively. In F_1BC progeny it varied from 36.4 to 37.6 per cent.

On the background of artificial infestation with a spider mite, the coefficient of dominance of the fiber yield in F_1BC varied in a fairly wide range: in 3 reciprocal hybrids it was zero (0), in 4 cases it was positive with a variation from 0.29 to 2.5 and in 5 reciprocal hybrids it was negative and varied from -0.20 to-3.0.

Our results suggest that artificial infestation with spider mites did not have a noticeable negative effect on the variability range of average fiber yield parental lines and reciprocal F1 hybrids.

The wild diploid (2n = 26) *G.trilobum* Skovsted that has been used in interspecies hybridization has a number of valuable features. Cotton breeders utilized the material obtained

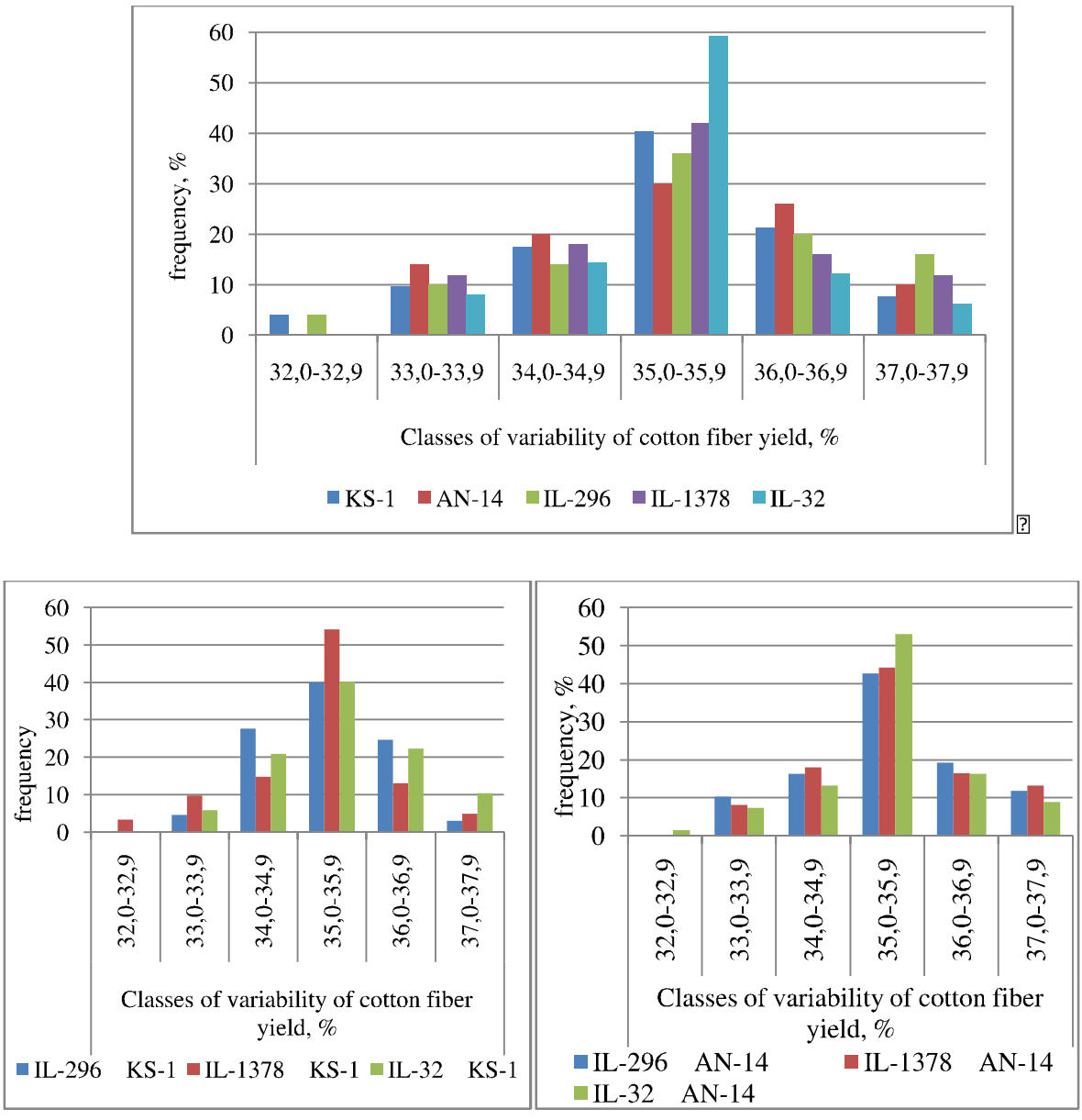

Fig. 2. The variability in classesofcotton fiber yieldin parent lines and F1 hybrids

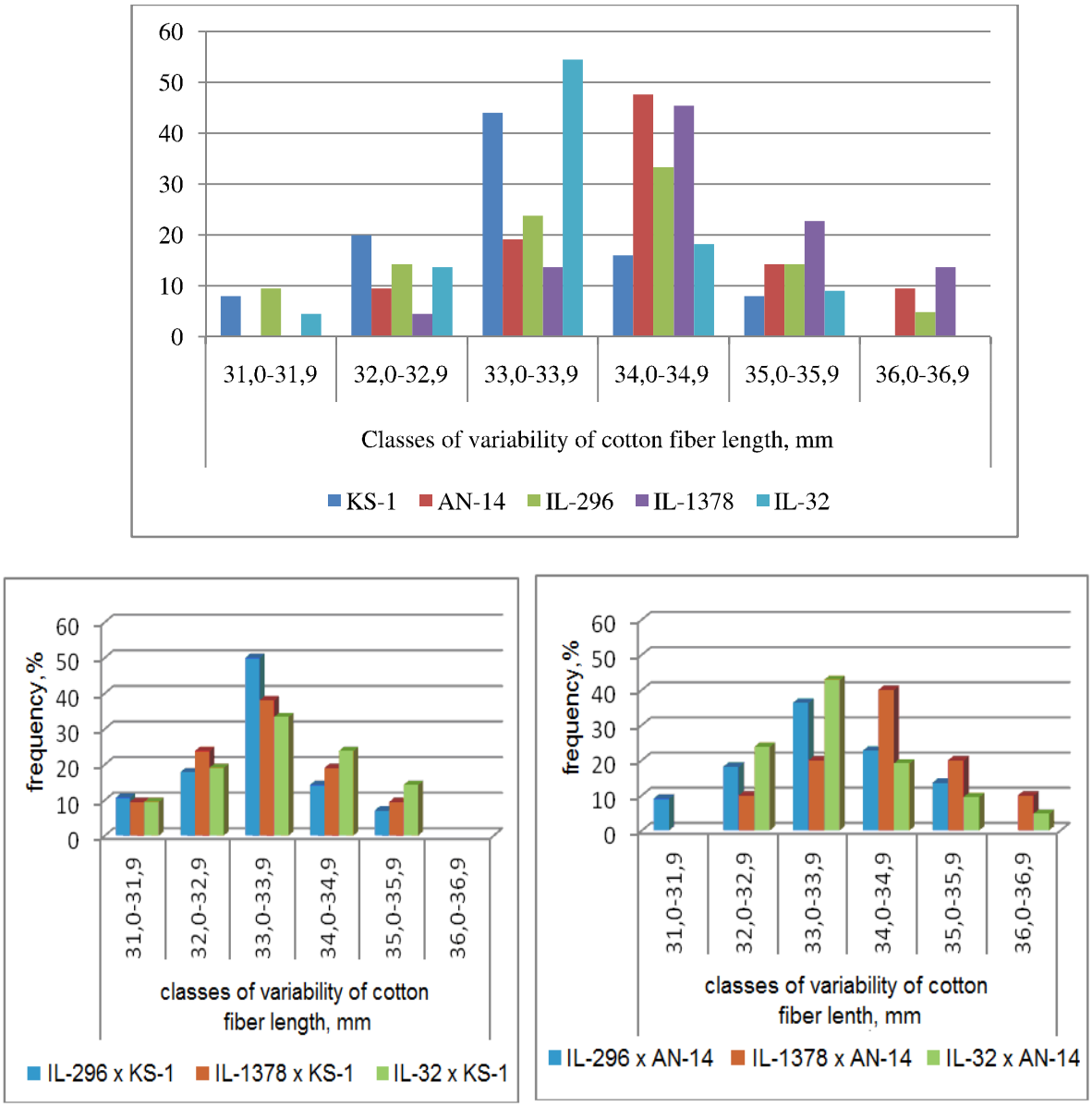

Fig. 3. The variability in classescotton fiber length in parent lines and F1 hybrids.

by crossing of cultivated maternal tetraploid (*G.hirsutum*, 2n = 52) with a paternal wild diploid species (*G.trilobum* Skovsted, 2n = 26). Sterile triploid (2n = 39) F1 hybrids were created, from which by using conventional breeding methods fertile synthetic hexaploids (2n = 78) were derived.Further backcrossing of this synthetic hexaploid with the original cultivated polyploid form, synthetic introgression-backcrossed, intergenic lines were developed that were well capable of interbreeding with tetraploid varieties of *G.hirsutum* and *G.barbadense* species and possessing many economically valuable traits. From them, introgression parent lines IL 296, IL 1378 and IL 32 were developed that possess complex resistance to diseases, insect pests and

high productivity traits.

A very little research has been done regarding the influence of a spider mite on the fiber yield and quality, as well as on other economically useful traits of lines created by breeding that involves usage of introgression hybrids.As a result of long term individual selection on the artificial infectious background with *Fusarium* wilt conducted by Egamberdieva (2017), ten cotton lines were developed as a result of crossing the introgression form LT-F15BC4 (*G.hirsutum* L., variety C 4727 x *G.trilobum* Skovsted) x C -4727 and *G.hirsutum L.* varieties. During 6 years of observations these lines showed advantages in number of bolls, fiber yield and quality, and other useful traits in comparison with the standard line.

A study of the efficiency of lines developed on the basis of *G.tomentosum* and *G.hirsutum* showed that interspecific hybrids are valuable recombinants and they are amenable to selection. In the results of selection and effective transgression of unique traits of a wild cotton species characterized by a high degree of leaf pubescence, varieties with a set of valuable traits and endurance to sucking pests were developed on the basis of hybrids derived with involvement of *G.tomentosum* and G.*hirsutum L.* Families, lines and varieties with a set of economically valuable traits, including fiber quality, precocity, yield and resistance to major sucking pests, were created on the basis of high generations of hybrids involving wild polyploid cotton (Khalikova *et al.,* 2017).

However, along with positive ones, they have some negative traits, such as a small bolls, a low yield and a short fiber length, which prevent their wide usage in agricultural production.

Therefore, we utilized them in hybridization with medium fiber cotton varieties KC 1 and AN 14, and studied their resistance to the spider mites, variability and inheritance of economically important trait son background of the artificial infestation with spider mite.

As a result, an increasing transgression of fiber length and yield was established in reciprocal hybrids. The transition of valuable traits of the best parent to the offspring of hybrids and in some cases exceeding the traits of the best parent have been observed.

Our results suggest that spider mites after artificial infestation are developing better on the plants of parent varieties KS 1, AN 14, and also on the control variety AN Bayaut 2, than on the introgression plants of IL 296, IL 1378, IL 32, parent lines and first generation reciprocal hybrids.

It is well known that the crop losses depends on the number of spider mites and the duration of their stay on the plants. With a period of stay for ten days upto 163 mites/100 leaves of affected plants (biological threshold of damage), the mite does not cause crop losses.

We found that the introgression parental lines showed relatively high resistance to aphids and spider mites, in comparison to the original parent cotton varieties.

F1plants, according to the population density of spider mites, clearly tend to behave towards their initial introgression parent cotton lines resistant to the pests.

The absence of a significant difference concerning fiber length and yield in the experiment appears due to the discrepancy between the period of the maximum pest amount and the fiber formation. In addition, the

dominance of resistance is likely to be expressed in the first generation or the amount of spider mites during the ripening of the cotton bolls and fiber formation is below of the damage threshold.

Experimental data allow to suggest that the introgression parent cotton lines IL 296, IL 1378, IL 32, highly resistant to spider mite, possess dominant resistant alleles inherited from wild diploid (2n = 26) *G.trilobum* Skovsted species. It is possible that the transition from the absolutely healthy offspring of *G.trilobum* Skovsted, to the mainly healthy plants of introgression initial lines, is explained by a shift from full dominance to incomplete dominance, since the parent domesticated cotton varieties KC 1, AN 14, in the homozygous state are carriers of corresponding recessive alleles of resistance to *Verticillium* wilt and pests such as aphids and spider mite.

REFERENCES

Abdurakhmonov, I., Kohel, R.J., Yu, J.Z., Pepper, A.E. , Abdullaev, A.A., Kushanov, F.N., Salakhutdinov, I.B. , Buriev, Z.T., Saha, S., Scheffler, B.E., Jenkins, J.N., Abdukarimov, A. 2008. Molecular diversity and association mapping of fiber quality traits in exotic *G. hirsutum* L. germplasm. *Genomics* **3 :** 574927.

Ahmad, S., Mahmood, K., Hanif, M. and Nazeer, W., 2011. Introgression of cotton leaf curl virus-resistant genes from Asiatic cotton (*Gossypium arboreum*) into upland cotton (*G. hirsutum*). *Genet. Mol. Res.* **10 :** 2404-14.

Campbell, B., Saha, S., Percy, R.,Constable, G., Dillon, S., Abdurakhmonov, I., Abdukarimov, A., Rizaeva, S., Adullaev, A., Barroso, P., Padua, J., Hoffmann. L. and Podolnaya, L. 2010. Status of the global cotton germplasm resources. *Crop Sci.* **50 :** 1161–79.

Campbell, B. T., Chee, P. W. and Lubbers, E. 2011. Genetic Improvement of the Pee Dee Cotton Germplasm Collection following Seventy Years of Plant Breeding. *Crop Sci.* **51 :** 955-68.

Egamberdieva, S. 2017. Characteristics of the new cotton lines developed with the involvement of the introgression form. III International Conference *"Gene pool and plant breeding"*, dedicated to the 130th anniversary of N.I. Vavilov, Novosibirsk, : 84-86.

Guo, Y.Y., Tian J.C. and Shi W.P. 2016. The interaction of two-spotted spider mite, Tetranychus urticae Koch, with Cry protein production and predation by Amblyseius andersoni (Chant) in Cry1Ac/Cry2Ab cotton and Cry1F maize. *Transgenic Res.* **25 :** 33-44.

Khalikova, M., Saydaliev, H. and Shodieva O. 2017. T. Genetic potential of wild polyploid species of cotton *G. tomentosum*. III International Conference *"Gene pool and plant breeding"*, dedicated to the 130th anniversary of N.I. Vavilov, Novosibirsk: 73.74.

Miyazaki, J., Wilson, L., and Stiller, W. 2016. Fitness of two spotted spider mite is more affected by constitutive than induced resistance traits in cotton (*Gossypium* spp.) *Pest Manag Sci.* **69 :** 1187–97.

Orellana Jimenez, Luis, 2016. Impact of Early Infestation of Two-Spotted Spider Mites (Tetranychus urticae) on Cotton Growth and Yield. *Thesis* and *Dissertations*.

Rijal, J.P., Wilson, R. and Godfrey, L.D. 2016. Characterization of spatial distribution of Tetranychus urticae in peppermint in California and implication for improving sampling plan// *Exp. Appl. Acarol.* **68 :** 155-71.

Wendel, J. F., Brubaker, C. L. and Seelanan, T. 2010. *The origin and Evolution of Gossypium.* Pp 1-18 in: Stewart, J.M.; Oosterhuis, D.; Heitholt, J.J.; Mauney, J.R. (Eds.), Physiology of cotton, Springer, Netherlands.

Received for publication : June 16, 2018
Accepted for publication : November 18, 2018