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Ecological Genetic Study of Fiber Qualitative Parameters in Lines of Medium Staple Cotton

Saida Egamberdieva*, *Uktam* Kurbanov, and *Akbar* Karimov

Cotton Breeding, Seed Production, and Agrotechnologies Research Institute, Tashkent, Uzbekistan

Abstract. The quality of the fiber in the lines of medium staple cotton in 2018-2020 was assessed. in Tashkent, Fergana and Kashkadarya regions of the Republic of Uzbekistan. 10 lines of different genetic origin were tested. The influence of the genotype and the environment on the manifestation of the qualitative parameters of the fiber (length, specific breaking load, micronaire) was studied. As a result of three years of experiments, it was found that the length of the fiber is equally affected by both the genotype and the environment (up to 40%). The genotype significantly affects the specific breaking load of the fiber (68%). The variability of the micronaire fiber was more dependent on the genotype from 35 to 48.4%, the contribution of the environment was from 2.6 to 16%.
Keywords: Gossypium hirsutum, genotype, environment, fiber quality, selection.

1 Introduction

Researchers both in our country and abroad are studying the ecological aspects of the yield of raw cotton and other quantitative characteristics. Variety testing for yield and stability provides information for agronomic recommendations and cotton breeding [1-6]. The main issue of selection for adaptability is the problem of taking into account the influence of the genotype and the environment on the realization of quantitative traits, as well as their interaction [7]. Tests of genotypes in various environments make it possible to identify forms with the widest adaptive capabilities, as well as to obtain information about environments as backgrounds for selection.

1.1 Purpose of research

To study the implementation of fiber quality parameters in an ecological test, as well as to determine the influence of genotype and environment on their overall phenotypic variability.

* Corresponding author: saida-68@mail.ru

2 Materials and methods

An assessment was made of the quality parameters of the fiber in cotton lines grown in the Tashkent, Fergana and Kashkadarya regions of the Republic of Uzbekistan for three years 2018-2020 [8].

We used 10 lines of G. hirsutum L. cotton, obtained on the basis of introgressive forms involving the wild species G. trilobum Skovsted and the ruderal form G. Harknessii Brandg. as well as varieties of foreign selection from the collection of NIISSAVKh. Experiments were set up randomly, in four repetitions.

The data of field experiments on studying the influence of the genotype and the environment on the studied traits were processed by the method of two-factor analysis of variance with repetitions. Fiber quality analyzes were determined on an HVI instrument according to Oz DSt 604-2001 [9].

3 Results and discussion

The most important characteristics of the fiber are the length, micronaire and specific breaking load of the fiber [10]. Of all the quality features, the length of the fiber is of the greatest importance in determining its technological value. To characterize this indicator on the HVI device (High Volume Instrument), the parameter “upper half-average length” was adopted. According to the upper semi-average length, the type and code of the fiber are determined, which determine the price of the fiber.

Table 1 shows that the average fiber lengths of lines in different regions ranged from 1.12 inches (line L-782) to 1.22 inches (line L-655). The long fiber was synthesized by lines L-481 and L-595 1.21 inches. It should be noted that the fiber length of the lines varied depending on the region of cultivation. Thus, the line L-481 had the largest length in the Tashkent region 1.25 inches and the smallest in Kashkadarya 1.18 inches. The same trend was observed in most of the studied lines. Comparative analysis of line groups by regions showed the best results in terms of fiber length in the Tashkent region on average 1.22 inches and smaller results in the other two regions on average 1.15 inches.

A two-way ANOVA analysis of fiber length in 2018 showed that the genotype and environment approximately equally significantly affect the variability of the trait by 37.3 and 38.4%, respectively (Table 2). Their interaction turned out to be insignificant. The share of unaccounted for factors influencing the manifestation of the fiber length turned out to be 19%.

In 2019, the L-705 line synthesized the shortest fiber; its fiber length was 1.10, 1.11, and 1.16 inches, respectively, by region (Table 1). A long fiber was observed in line L-655 - 1.17, 1.20 and 1.25 inches, as well as in line L-595. In the Ferghana and Kashkadarya regions, its fiber length reached 1.22 inches. In the Tashkent region - 1.14 inches. The degree of fiber length variation in the studied lines was small, from 1.25 to 3.42%.

Significant differences in fiber length were identified between lines and groups of lines by region in 2019. The share of the influence of the genotype on the length of the fiber was 34%, the share of the influence of the environmental factor was 29% (Table 2). The difference between the groups in relation to the interaction of genotype-environment factors turned out to be insignificant, just as in the previous year. The share of influence of unaccounted factors was equal to 28%.

The fiber length of the studied lines in 2020 corresponded to type III and ranged from 1.19 to 1.22 inches (Table 1). The exception was lines L-655 - 1.16 inches and L-782 - 1.17 inches, which corresponds to type IV fiber. The average fiber lengths of the groups of lines tested in the Tashkent and Ferghana regions were equal (1.18 inches each). In the Kashkadarya region, this trait was significantly higher than the average fiber length of the group was 1.24 inches. For many lines, the fiber length varied in different regions of cultivation.

A two-way analysis of variance revealed significant differences both between lines and between groups by region along the length of the fiber. The share of influence of the genotype on the variability of the trait in this experiment was 14.3%. The share of environmental influence is 30.9%. The joint action of genotype-environment (GE) factors significantly affected the trait – its share was 22.9%. The contribution of unaccounted factors was also significant – 31.9%. This experience indicates a wide reaction rate of this trait and its variation depending on environmental conditions.

The specific breaking load in 2018 of the fiber was not so high for the studied lines, however, it met the standards for fiber quality. Thus, the highest breaking load was noted for line L-681 - 34.5 gf/tex (Table 1). The lowest values were noted for lines L-998 and L-956, 28.3 and 28.8 gs/tex, respectively. The indicators of the remaining lines in terms of specific breaking load were in the range of 29.0 - 32.7 gf/tex. Most of the lines showed the stability of the trait across regions. Comparison of groups by regions shows insignificant differences in traits within 29.7-30.6 gs/tex. The maximum average indicator was noted in the Fergana region. Analysis of variance revealed significant differences between the studied lines among themselves and between groups in terms of the specific breaking load of the fiber in 2018. However, the share of the influence of the genotype on the variability of the trait turned out to be much higher than the share of the influence of the environment, 68.3 and 3.1%, respectively (Table 3). The influence of the genotype-environment in this experiment turned out to be insignificant. The share of unaccounted factors was 23.3%.

In all three regions, the maximum indicators of the specific breaking load of the fiber in 2019 were observed for the L-681 line - 34.1, 34.8, 36.6 gs/tex. The lowest specific breaking load of the fiber appeared in the L-998 line - 30.2, 28.9, and 30.7, which nevertheless meets the quality standards. Lines L-481, L-695 and L-655 showed the greatest variability in the specific breaking load of the fiber. In 2019, the differences between the lines in terms of the specific breaking load of the fiber turned out to be significant, the share of the influence of the genotype on the specific breaking load of the fiber was 47%. The share of environmental influence on this trait is 12%. The genotype-environment interaction in this case turned out to be insignificant. The share of unaccounted factors that influenced the trait was 33%.

In the studied lines in 2020, the average (for three regions) indicator of the specific breaking load of the fiber varied slightly. With the exception of two lines L-705 and L-752, whose performance was equal to 28.6 gs/tex, the breaking load of the remaining lines was in the range of 30.5–32.6 gs/tex, which corresponds to the fiber quality standard. The maximum average indicator for groups was noted in the Kashkadarya region - an average of 32.0 gs/tex. Analysis of variance showed a significant effect of the genotype and environment, as well as their interaction on the specific breaking load of the fiber in the experiments of 2020. The genotype factor affected the variability of the specific breaking load of the fiber by 26% (Table 3). The contribution of the environment was 9.1%. The share of the factor of joint influence of the genotype and the environment was 19%. The remaining 45.9% of the contribution fell on unaccounted factors.

Thus, the experiments showed that the manifestation of the specific breaking load of the fiber is largely influenced by the genotype of the line.

In 2018, in the studied lines, the average fiber microneure index by region differed significantly and ranged from 3.9 (for the L-765 line) to 4.8 µg/in (for the L-752 line) (Table 1). That is, most of the studied lines have an optimal fiber micronaire. Many lines showed relative stability of the trait across regions. No difference was observed between the groups of lines tested in different regions. The average micronaire for the regions was 4.4 – 4.5 µg/in. A two-way analysis of variance of micronaire fiber in 2018 showed

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significant differences in lines both by genotype and between groups of lines by region. However, the proportion of the influence of the genotype on the variability of the micronaire, as well as in the case of the specific breaking load of the fiber, turned out to be higher than 48.4% (Table 4). The influence of environmental conditions on the trait expression was 2.6%. The influence of unaccounted factors on the fiber micronaire turned out to be significant - 36.3% [11].

The smallest fiber micronaire in 2019 was noted at line L-765 - 4.3, 4.0 and 3.6, respectively, in Tashkent, Fergana and Kashkadarya regions. Line L-752 synthesized the coarsest fiber. Her microneure index was the highest in all three regions - 5.0, 5.1 and 4.9 µg/in.

The highest variability of the micronaire fiber trait was observed in line L-765 up to 10.7%. Some lines showed minor variations of the trait across regions. Statistical analysis of micronaire fiber in 2019 showed significant differences between lines and groups by region. Thus, the share of the influence of the genotype on the micronaire was 35%, the share of the influence of the environment was 16%. The p-value for the dual influence of genotype-environment factors was greater than 0.05, i.e. the GS factor did not affect the manifestation of the micronaire fiber trait. The share of influence of unaccounted factors was equal to 41%.

Analysis of variance showed significant differences in fiber microneur between lines in 2020. The share of genotype influence on the trait variability was 35%. The environment affected the trait much less (3.6%). The influence of the factor of interaction between the genotype and the environment turned out to be unreliable in this experiment. The share of unaccounted factors reached 51%.

It can be seen from the data in Table 1 that the average microneure indices in the studied lines in three regions in 2020 varied from 3.6 µg/in for the L-655 line to 4.3 µg/in for the L-705 line. On the whole, of course, such limits testify to the high quality of the fiber lines. Comparative evaluation of microneur by regions showed no significant differences between groups of lines. Fiber micronair in Tashkent and Ferghana regions averaged 3.9 µg/in for the group, and 4.0 µg/in in Kashkadarya region. Most of the lines showed the stability of the trait across regions.

Table 1. Fiber quality indicators for cotton lines (2018-2020)

	№ Line	Len (inch)			Str (gs/tex)			Mic (μg/in)		
		2018	**2019**	**2020**	**2018**	**2019**	**2020**	**2018**	**2019**	**2020**
Tashkent (Salar)	481	1.25	1.16	1.18	28.8	31.4	31.0	4.5	4.9	4.1
	595	1.26	1.14	1.20	31.5	31.6	31.6	4.5	4.7	3.8
	655	1.27	1.17	1.11	29.5	32.0	30.8	4.1	4.8	3.6
	681	1.23	1.16	1.18	34.2	34.1	31.3	4.3	4.8	3.7
	705	1.19	1.10	1.14	29.4	30.3	28.8	4.2	4.7	4.2
	752	1.20	1.11	1.24	29.5	30.4	28.0	4.8	5.0	4.0
	765	1.21	1.16	1.17	29.3	31.2	31.1	3.7	4.3	3.7
	782	1.18	1.11	1.18	28.4	31.7	32.5	4.8	4.7	3.7
	956	1.21	1.14	1.20	28.5	30.6	28.0	4.7	4.5	4.1
	998	1.18	1.12	1.18	27.5	30.2	31.0	4.0	4.7	3.7
Fergana (Kuva)	481	1.19	1.18	1.18	31.8	30.2	30.0	4.3	4.5	4.0
	595	1.19	1.22	1.18	34.8	34.1	31.8	4.4	4.3	3.9
	655	1.19	1.20	1.21	31.9	30.0	31.5	4.5	4.3	3.6
	681	1.17	1.17	1.21	35.2	34.8	32.1	4.6	4.5	3.6

	705	1.10	1.11	1.17	31.0	29.4	27.9	4.6	4.4	4.3
	752	1.13	1.13	1.18	30.5	29.3	26.7	4.9	5.1	4.1
	765	1.16	1.13	1.17	31.3	29.0	32.1	4.2	4.0	3.5
	782	1.13	1.14	1.11	31.0	31.5	31.1	4.6	4.5	3.7
	956	1.13	1.17	1.18	29.8	30.7	30.4	4.8	4.5	3.8
	998	1.13	1.13	1.18	30.9	28.9	29.5	4.4	4.1	3.8
Kashkadarya (Casby)	481	1.18	1.21	1.25	29.5	32.1	31.7	4.2	4.4	4.2
	595	1.17	1.22	1.27	33.0	35.2	32.1	4.6	4.4	3.9
	655	1.20	1.25	1.16	30.3	31.3	31.0	4.4	4.1	3.8
	681	1.17	1.18	1.23	35.3	36.6	34.1	4.4	4.5	4.1
	705	1.11	1.16	1.24	28.2	32.2	29.1	4.3	4.3	4.3
	752	1.15	1.17	1.24	29.7	31.3	31.2	4.8	4.9	4.0
	765	1.17	1.21	1.26	28.7	32.6	28.7	3.8	3.6	4.0
	782	1.07	1.17	1.23	29.0	32.1	34.3	4.5	4.4	3.7
	956	1.16	1.20	1.24	29.5	31.6	33.1	4.6	4.5	4.1
	998	1.13	1.18	1.22	27.7	30.7	35.4	4.4	4.3	4.0

Table 2. Results of a Two-way ANOVA Analysis of Fiber Length in Cotton Lines

Source of Variation	Genotype			Environment			Interaction (HS)			Random deviations		
	2018	**2019**	**2020**	**2018**	**2019**	**2020**	**2018**	**2019**	**2020**	**2018**	**2019**	**2020**
MS	0.013435	0.008519	0.00439	0.062238	0.032794	0.042563	0.000966	0.001065	0.003503	0.000678	0.000711	0.000979
F actual	19.80345	11.98236	4.48479	91.74185	46.12838	43.48089	1.424302	1.49777	3.578128	-	-	-
P- value	7.05E-18	3.21E-12	4.48479	1.9E-22	1.62E-14	6.11E-14	0.13969	0.109345	2.99E-05	-	-	-
Share of influence of factors , %	**37.3%**	**34%**	**14.3%**	**38.4%**	**29%**	**30.9%**	**5.4%**	**9%**	**22.9%**	**18.9%**	**28%**	**31.9%**

Table 3. The results of two-way analysis of variance of the specific breaking load of the fiber in cotton lines

Source of Variation	Genotype			Environment			Interaction (HS)			Random deviations		
	2018	**2019**	**2020**	**2018**	**2019**	**2020**	**2018**	**2019**	**2020**	**2018**	**2019**	**2020**
MS	45.29441	31.04426	24.5386	9.264	34.38158	38.52008	1.746963	2.719731	8.975824	1.545833	2.162389	4.338083
F actual	29.30096	14.35646	5.656554	5.992884	15.89982	8.879517	1.130111	1.257744	2.069076	-	-	-
P- value	4.09E-23	4.14E-14	3.51E-06	0.003603	1.22E-06	0.000302	0.337654	0.235319	0.013295	-	-	-
Share of effects studies , %	**68.3%**	**47.0%**	**26.0%**	**3.1%**	**12.0%**	**9.1%**	**5.3%**	**8.0%**	**19.0%**	**23.3%**	**33.0%**	**45.9%**

Table 4. Results of two-way analysis of variance of micronaire fiber in cotton lines

Source of Variation	Genotype			Environment			Interaction (HS)			Random deviations		
	2018	**2019**	**2020**	**2018**	**2019**	**2020**	**2018**	**2019**	**2020**	**2018**	**2019**	**2020**
MS	0.805836	0.784037	0.562723	0.193661	1.613543	0.263649	0.106141	0.083181	0.080855	0.060345	0.090909	0.08236
F actual	13.35381	8.62437	6.832486	3.209227	17.7489	3.201174	1.758909	0.914992	0.981733	-	-	-

P-value	2.48E-13	3.23E-09	1.98E-07	0.045051	3.18E-07	0.045391	0.043283	0.562747	0.487477	-	-	-
Share of influence of factors , %	**48.4%**	**35.0%**	**35.0%**	**2.6%**	**16.0%**	**3.6%**	**12.8%**	**8.0%**	**10.1%**	**36.3%**	**41.0%**	**51.3%**

4 Conclusion

1. Two-way analysis of variance revealed that genotype and environment approximately in equal shares (up to 40%) affect the length of the fiber.

2. It is shown that the medium has little effect on the specific breaking load of the fiber. And the genotype influences significantly and significantly up to 68.3%. In this regard, we can conclude that the reaction norm of this trait is narrow and, as a result, it varies slightly depending on environmental conditions.

3. The share of the influence of the genetic factor on the variability of the microneura fiber was from 35 to 48.4%, and the contribution of the environment to the manifestation of the trait in this experiment was insignificant from 2.6 to 16%.

4. The results of three years of experiments allow us to conclude that when selecting for fiber quality, it should be taken into account that the genotype has a greater effect on the specific breaking load and micronaire of the fiber than on the length.

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