Selection of Cotton Varieties in a Competitive Nursery in the South of Kazakhstan

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Abstract: - The Turkestan region is a cotton-growing zone in the south of Kazakhstan, which is the northernmost cotton-growing zone in the world. 115-125 thousand hectares of medium-staple cotton (Gossypium hirsutum L.) are cultivated here annually, of which 80-85 thousand hectares are sown in the Maktaaral and Zhetysay districts. This region is highly susceptible to salinity, drought, invasion of dangerous pests (cotton budworm, beet borer, spider mites, aphids), and diseases (fusarium blight (wilt), gummosis). Considering the high salt content in the arable soil horizon, the aridity of the climate of the Turkestan region are the main limiting factor of the region, and selection and genetic methods is the most effective and economical way to reduce their negative impacts on cultivated vegetation, then research work on the study and creation of new resistant cotton varieties in these soil and climatic conditions are relevant. Considering all the above problems, scientists of the Agricultural Experimental Station of Cotton and Melon Growing LLP have set themselves the goal of creating heat- and drought-resistant, precocious cotton varieties with high productivity, resistance to salinization, diseases, pests, possessing high technological qualities as the yield and quality of fiber of types III-IV, based on previously obtained ones during hybridization of intraspecific and interspecific lines of families. For 30 years, scientist-breeders of Kazakhstan have created 13 varieties of medium-fiber cotton, of which 8 are approved for use in the Turkestan region in the Republic of Kazakhstan. The research method is based on hybridization, multiple selection, and testing of offspring by the half method, according to the full diallel scheme (first Griffing model for F_1).

The created seven varieties PA-3031, PA-3044, M-4005, M-4007, M-4011, Bereke-07, Myrzashol-80, and M-4017 are zoned for more than 92% of the acreage in cotton-growing farms in the south of Kazakhstan, for the variety M-5027, which is resistant to pests, the patent has been issued 2021 and in 2022 it is planned to enter it into the register of approved varieties.

Key-Words: - Fiber yield, fiber length, strength, micronaire, breaking length, variety, disease resistance, cotton, yield.

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1 Introduction

Cotton is an economically important crop, being a source of textile fiber and vegetable oil/protein used as animal feed, [4], [27], [28]. India, China, USA, and Brazil produce 75% of the world's cotton. This crop can be classified as cosmopolitan, as it grows not only in tropical and subtropical regions, but is currently grown on all continents except Antarctica, [1]. According to Statista, 2021, cotton is the most widely planted profitable industrial crop, accounting for over 20% of the global share of all fiber use and is a global income for more than 250 million people worldwide. The cotton industry has an estimated $500 billion in global economic impact each year, [30].

For example, in Australia, the only cotton breeding enterprise is the Commonwealth Scientific and Industrial Research Organization (CSIRO), which is engaged in the creation of high-yielding cotton varieties not only for the local industry. Their varieties are widely used and distributed in North America, South America, and Europe. This program is unique compared to many other public and commercial breeding programs, because it focuses on diverse and complex research with commercial results, [7].

In the Republic of Kazakhstan, the only scientific institution engaged in full-scale cotton breeding is the Agricultural Experimental Station of Cotton and Melon Growing LLP, which is also the holder of the

National Cotton Gene Pool in the amount of 635 samples.

The cotton-growing zone of the south of Kazakhstan is the northernmost cotton-growing zone in the world. The Turkestan region annually sows about 115-125 thousand hectares of medium-staple cotton (Gossypium hirsutum L.).

The climatic conditions of the Turkestan region are characterized by sharp continentality, winters are very cold up to -25°C, and summers up to +45°C. The annual amount of precipitation ranges from 210 to 400 mm. Most of the precipitation falls in the form of rain.

Spring is characterized by an intensive increase in temperatures and maximum precipitation, usually warm, short, and relatively wet. In spring, the air temperature usually reaches +13-15°C, in April the temperature is +15.3°C.

Relative humidity is in the range of 55-60%, and the end of spring goes down to 52-53%. The average daily temperature in summer varies between +24.2-25.6°C, in July it can reach up to 47°C.

In autumn, the air temperature is +12.5°C, autumn frosts stop the cotton growing cotton, and this occurs in late October or early November.

As noted above, the Turkestan region is the northernmost region of cotton growing, with the early onset of low temperatures in autumn, cotton does not ripen. Thereby, the main task of breeders is the breeding of precocious varieties with an early ripening period of 105-115 days.

The agricultural plant breeding program in Kazakhstan is carried out with the financial support of the Ministry of Agriculture within the framework of program-targeted funding. The main cotton breeding strategies used in this program are developed from classical breeding methods based on intraspecific hybridization followed by individual selection for phenotype and genotype. An important step in the hybridization process is the selection of highly effective and adapted parental forms, therefore, high priority is given to maintaining germ plasm diversity. Our breeding programs use germplasm from many sources, and some of the most successful parents come from large cotton gene banks in China, the USA, Uzbekistan, Pakistan, and India, [14, 15]. The genetic collection is constantly updated by other programs. Notable among these are the cotton gene banks managed by international organizations such as the Consultative Group on International Agricultural Research (CGIAR), which coordinates 16 international scientific organizations.

As it is known, cotton is a facultative self-pollinating plant, and its biological response depends on the genetic structure of the population, population homeostasis, as well as natural and artificial selection in specific growing conditions. It is shown that intra-variety cotton crossing is one of the strong factors in improving plant vitality, contributing to intensive growth and development, and increasing heterosis capacity in the first and to a certain extent in subsequent generations.

The results of numerous studies show that the use of both natural and artificial selection is especially effective about hybrid populations, since they have a large variety of plant forms due to heterozygous origin, [17], [18], [16], [5]. The sharp differences of hybrid plants in the population composition in winter hardiness, foliage, bushiness, branchiness, disease resistance, nutrient content, growth rates, longevity, and, ultimately, productivity are usually a reflection of genotypic differences inherited from the original parent forms. Therefore, a hybrid material with a not yet established hereditary basis carries not only the traits and properties of parents but also its characteristics, as a result of a specific combination of genes determining the appearance of new properties. Naturally, such hybrids are promising for targeted selection.

Kasyanenko et al. write that to implement the genetic breeding material studied in various regions of Southern Russia, the authors have developed and are implementing a breeding program aimed at creating new Russian varieties adapted to the harsh conditions of Southern Russia and meeting the following requirements, [11]:

- resistance to low temperatures;
- resistance to droughts, and strong winds;
- resistance to diseases (root rot, wilt, gummosis, viruses);
- high potential productivity;
- precocity, early laying of fruit elements, friendly ripening of bolls;
- high fiber quality (fiber length and yield, strength, micronaire);
- tolerance to pests (thrips, aphids, mites);
- adaptability to different types of soil moisture availability, absence of the "vigorous growth" effect;
- adaptability to the mechanized cycle of cultivation;
- absence of defects at all stages of processing, manufacturability from raw cotton collection in the field to fabric dyeing.

The authors managed to create a series of new varieties Yugtex-1, Yugtex-2, Yugtex-3, Yugtex-4. The varieties created by them, kind of, in the process of testing in different regions, have retained their productivity and high fiber quality. Bio-damage is one of the weaknesses of cotton fiber. Economic losses from damage to cotton caused by microorganisms are significant. The degree of biological damage to cotton depends on the selected variety, types of cultivation, storage conditions, and other factors. One of the directions in cotton breeding is the selection of colored cotton, which is resistant to the effects of microorganisms, and some varieties inhibit the growth of mold fungi, that is, it has high bio-resistance, which allows the production of hypoallergenic, environmentally friendly textile, [13].

Akhmedov notes that by researching control backgrounds and artificially infected pathogen Th. bazicola, it is possible to isolate individual varieties and interspecific hybrids F_1–F_3, combining high resistance to the disease with the necessary set of traits for the breeder. As a result of his research, he created two lines L-3442 and L-6071, which had advantages over the Namangan-77 standard variety, [2].

In addition, there are various factors affecting yield, such factors are pests that harm the bolls to a greater extent than leaves, stems, and roots. In Egypt, cotton is harmed by arthropods causing huge crop losses. The damage caused to the crop by arthropod pests affects the oil quality in the seeds. Losses from cotton pests annually amount to about a million hectares, and these areas are treated annually with pesticides, which entails huge costs. Problematic issues are being combated by improving control approaches and methods, monitoring, biological methods of control, genetic aspects, bioinsecticides, and a set of measures to regulate main cotton pests, [3].

Urazaliev notes that it is necessary and it is needed to create new, better varieties that differ from the previous ones with high yield potential, resistance to abiotic environmental factors, and resistance to pests and diseases, [23]. One of the factors that are being considered when creating a new variety is the agroecological condition of growth. The variety must combine the traits of productivity, resistance to diseases, and pests that are necessary for production.

A necessary element in breeding is the selection of parent forms, which will ensure success in crossing and obtaining a hybrid combination. The use of the genotype-environment mathematical model is necessary.

Modern genetics and breeding of crops, including cotton, has several theoretically and practically acute relevant fundamental and applied developments, methodological approaches, methods, and techniques that are successfully applied by qualified breeders and seed growers, [12], [10], [23], [24]. Thus, Umbetaev et al. (2021) [20] believe that one of the methods for unlocking the genetic potential of cotton varieties is the method of selecting parent pairs for crossing according to the principle of the origin of genotypes, intra-varietal, inter-varietal, and complex hybridization, which will make it possible to create new varieties of medium fiber cotton purposefully, most adapted to the soil and climatic conditions of the Turkestan region. Similar studies can be found in [21], [22], [25], [26]. The main breeding material is a variety of mutations, genetic combinations, and recombination of genes. Knowledge of genetics laws is the basis for the creation and maintenance of collections used by breeders, and the allocation of valuable forms from the species gene pool. Direct selection can be carried out only with knowledge of the patterns of genetic processes in the populations of agricultural crops, including cotton. High cotton yield and fine quality can be achieved by using appropriate cotton varieties and agronomic techniques to regulate plant growth and development and aging and maturity because efficient and rational regulation of plant senescence by varieties and agronomic techniques will optimize the use of light, heat, water and other natural resources during the limited growing season for cotton to develop a normal maturity, [8].

Thus, a literature review showed that the ecological flexibility of G. hirsutum allows it to grow widely around the world, [29]. Nevertheless, the constant pressure of rigid selection for certain traits has led to the limitation of genetic diversity, which is a serious problem that may lead to the unification of the cotton germ plasm in the future, [29]. This creates a huge problem for breeding new varieties. In this regard, the conservation, use, and mobilization of genetic resources is one of the most important priorities in addressing the food security of any state.

2 Materials and methods

The object of the study was 15 medium-staple varieties of cotton G. Hirsutum, in comparison with the control standard variety M-4005. To achieve the goals and objectives in 2019-2021, the following work was carried out in the competitive nursery on a total area of 1.8 hectares: - sowing was carried out in 2019 on April 19; April 22, 2020; April 26, 2021; - sowing scheme 90x1-2x25, row spacing 90 cm, 25 cm 1-2 plants in a row. On one running meter 9.25 plants x 11111 meters/ha with 90cm row spacing = 102777 plants per 1/ha of plants (density).

The estimated area of the plots is 72 m2, with four rows 20.0 m long, and the distance between the tiers 2.0 m. The placement of variants is a randomized method in threefold repetition. Row sowing was carried out with a selective seeder. Phenological observations were carried out in the following phases: - emergence of seedlings - accounting was carried out at the emergence of 50 and 100% on the accounting plot in terms of the total sowing density; -formation of true leaves; 50 and 100%; - budding - the formation of fruit branches and the appearance of the first buds - accounting is carried out at the beginning of phase appearance in days; - flowering - the beginning of 50 and 100% flowering on accounting plants; - fruit formation - ripening and opening of boxes. Maturity was considered until the onset of 50% of plants with open bolls.

The yield was determined by the collection from the plot of 72 m^2 in all three repetitions, according to the formula

U = Ud x 10000/Sd x 100,

Where U – yield, c/ha; Ud – raw cotton yield from the plot, kg; Sd – plot area, m^2

100 – conversion factor per c/ha

Phenological observations were carried out according to the methodology of experimental work in cotton growing, [19]. Mathematical data were processed according to Dospekhov's method, [9]. Experimental data processing was carried out in MS Excel.

The soils are light-medium loamy serozems, moderately saline in places within the range of 1-2 mg-eq. per 100 g of soil in terms of chlorine, with a groundwater depth of 1.5-2.0 m. The experiment was laid on the 44th branch, 3rd map, the fifth year after the plowing of alfalfa, in the field. Soil cultivation was carried out by standard methods: in the autumn-winter period, autumn plowing was carried out to a depth of 35-38 cm with a double-depth plow, the field was prepared for winter washing irrigation, furrow cutting, and temporary cart irrigation, and soil washing irrigation with an irrigation rate of more than 1800 m3 of water. In the spring period, furrow spreading and temporary kart irrigators for the first spring harrowing, 2-fold harrowing, and chiselling of the field were carried out, to a depth of about 15-18 cm. During the periods of experiments on competitive variety testing, the following measures were carried out: - four weedings; - inter-row cultivation: the first - without fertilizing to a depth of 10-12 cm, the second and third to a depth of the central organ of 15-18 cm, with the introduction of ammonium nitrate (220 kg/ha in fertilizers); - the first thinning of cotton was carried out with the formation of 1-2 true leaves, the second thinning according to the scheme 90 x 1-2 x 20, leaving 7-8 plants per linear meter, which is 85-90 thousand pieces/ha. All technological indicators of the fiber were carried out after ginning (separation of the fiber from the seed) on the J-10 device, the fiber was evaluated for technological qualities on the LPS-4, Micronaire, and KX-730 devices for determining the length of the fiber.

3 Results and discussion

In the competitive variety testing nursery, on an area of 1.8 hectares the number of samples was 15 pieces, the standard variety used was the Maktaaral-4005 variety zoned in the Turkestan region. The growing season of the tested varieties was considered on 200 plants, considering all phases of development on cotton. The flowering phase of cotton varieties was noted at the onset of 50% of flowering, when observing varieties M-4019, M-4015, M-4017, M-4021, the flowering phase about the standard variety M-4005 was 2-6 days ahead, and varieties M-4026, M-4006, M-4010 lagged from the standard grade M-4005 for 2-5 days. The remaining tested grades M-4009, M-4012, M-4018, M-4025, M-4030 M-4001, M-4003, and M-4004 were at the level of the standard grade M-4005 with a value of 126 days. (Table 1)

Observations showed that the precocious varieties were M-4010 – 117.0 days, M-4003 – 117.0 days, M-4001 – 120.0 days, and M-4026 – 116.0 days.

In terms of yield, the varieties also had differences depending on biological characteristics. The most productive varieties were M-4003 – 44.5; M-4019 – 45.2; M-4009 – 45.1, and M-4017 – 45.7 c/ha, which exceeded the standard variety M-4005 by 5.6-6.2 c/ha. Varieties M-4026, M-4018, M-4030, M-4025, M-4010, M-4015, and M-4006 also had an advantage over the standard by 2.1-4.6 c/ha more yield. In the varieties M-4004, M-4012, and M-4021, the yield was at the level of the standard variety M-4005 with a reading of 39.5 c/ha.

Table 1. Growing season and yield of cotton varieties (average for 2019-2021)

Varieties	Growing season				Yield, c/ha			
	2019	2020	2021	average for 3 years	2019	2020	2021	average for 3 years
M-4001	120.0	121.0	119.0	120.0	43.2	42.4	42.1	42.5
M-4003	117.0	117.0	118.0	117.3	45.4	43.6	44.5	44.5
M-4004	123.0	124.0	126.0	124.3	39.9	39.4	38.2	39.1
M-4006	119.0	120.0	121.0	120.0	44.7	44.3	43.4	44.1
M-4009	124.0	124.0	123.0	123.7	45.5	44.7	45.0	45.1
M-4010	118.0	118.0	117.0	117.7	43.6	42.5	42.8	42.9
M-4012	124.0	127.0	126.0	125.7	41.0	40.3	39.7	40.3
M-4015	120.0	119.0	121.0	120.0	44.2	44.6	43.3	44.0
M-4017	120.0	121.0	119.0	120.0	46.4	45.7	45.2	45.7
M-4018	122.0	122.0	121.0	121.7	42.0	41.8	41.4	41.7
M-4019	121.0	123.0	120.0	121.3	45.6	45.2	44.8	45.2
M-4021	122.0	124.0	121.0	122.3	41.4	40.7	39.3	40.4
M-4025	120.0	120.0	122.0	120.7	43.1	43.9	42.6	43.2
M-4026	117.0	117.0	116.0	116.7	42.3	41.7	40.9	41.6
M-4030	128.0	126.0	127.0	127.0	40.7	42.5	41.7	41.6
M-4005 St	126.0	125.0	127.0	126.0	40.2	39.6	38.8	39.5
Less significant difference LSD_{05}				1.77				0.85
Experiment accuracy, %				0.51				0.68

During the growing season, during phenological observations, the height of the main stem was noted, with a reading of 107 cm about the standard variety M-4005, the height exceeded the varieties M-4003, M-4006, M-4012, M-4030 by 3.0-10 cm. The remaining varieties had a lag of 8.4-17.2 cm. Practically all samples about the standard grade M-4005 exceeded the number of sympodial branches and internodes were shortened.

Varieties M-4017, M-4019, and M-4009 in productivity on the bush exceeded the standard variety M-4005 (Figure 1), all other tested samples were at the level of the standard variety.

Promising cotton variety Maktaral-4017	Promising cotton variety Maktaral-4019	Promising cotton variety Maktaral-4009

Figure 1. Cotton cultivars of the Agricultural Experimental Station of Cotton and Melon Growing LLP

One of the important indicators is the rate of boll opening in the bush. The opening; maturation of the pods and harvesting of cotton are the final stages of the growing season of cotton. This period is characterized by a weakening of the intensity of plant life processes and a decrease in the rate of accumulation of organic substances in the boxes. At the beginning of this period, when the leaves of the first formed boxes dry out and open, in many other boxes, the physiological processes of formation and maturation of seeds and fibers are still going on. The process of cracking the flaps in biologically mature boxes is physical. The rate of opening (maturation) of the pods depends on the impact of a complex of environmental factors. Plant senescence and maturity performance are complex processes regulated by both internal and external factors. Like cereal crops with determinate growth, cotton can also have normal maturity, premature senescence, and late maturity performance [8].

As can be seen from the data in Table 2, normally, the genotypes of cotton studied by us differed markedly from each other in terms of the number of open boxes, while the largest number of full-fledged boxes were observed in the M-4017 variety. Varieties M-4025, M-4006, and M-4019 exceeded the standard grade M-4005 in terms of opening by 8.9, 14.5, and 15.0%. The opening rate of the boxes was 67.6%, while the standard had this indicator twice less. In experiments, in those plants that had 6-7 boxes left on the bush, the mass of raw cotton of one box increased by 7.5 g-66.7%, and in plants with 3-4 boxes - by 33.9 g-77.2%.

According to the mass index of one box, the grades M-4009, M-4019, and M-4017 were significantly higher than the values of the standard grade M-4005. Very low indicators for this feature were noted in the varieties M-4004g and M-4021, which indicates their low productivity. In other varieties, this trait was closer to the standard variety (Table 2).

Table 2. Valuable cotton indicators (average for 2019-2021)

Varieties	Weight of one boll, g				Fiber yield, %				Fiber length, mm			
	2019	2020	2021	Average for 3 years	2019	2020	2021	Average for 3 years	2019	2020	2021	Average for 3 years
M-4001	5.9	5.9	6.0	5.9	38.7	38.5	38.4	38.5	32.9	32.8	33.0	32.9
M-4003	5.9	5.8	6.0	5.9	37.9	38.3	38.1	38.1	33.0	33.0	33.1	33.0
M-4004	5.8	5.7	5.6	5.7	39.6	38.1	39.1	38.9	33.0	32.8	32.9	32.9
M-4006	6.0	6.1	5.9	6.0	38.7	38.0	38.3	38.3	34.1	33.4	33.3	33.6
M-4009	6.2	6.2	6.3	6.2	37.9	37.8	38.0	37.9	33.0	33.1	33.2	33.1
M-4010	6.0	6.1	6.1	6.0	38.9	38.6	38.4	38.6	33.1	32.9	33.0	33.0
M-4012	5.9	5.6	5.8	5.7	40.1	38.1	39.2	39.1	32.8	32.6	32.7	32.7
M-4015	6.1	6.0	5.9	6.0	40.3	38.6	39.7	39.5	33.7	33.1	33.4	33.4
M-4017	6.2	6.1	6.4	6.2	39.4	39.8	40.0	39.7	33.3	33.0	33.5	33.2
M-4018	6.0	5.9	6.1	6.0	38.7	38.9	38.6	38.7	34.1	32.9	33.3	33.4
M-4019	6.2	6.1	6.3	6.2	39.2	39.0	39.4	39.2	32.9	32.8	33.0	32.9
M-4021	5.9	5.7	5.7	5.7	38.1	38.4	38.2	38.2	33.4	32.7	33.1	33.0
M-4025	6.0	5.9	5.8	5.9	38.7	38.2	38.5	38.4	33.8	33.0	33.3	33.3
M-4026	5.9	5.8	5.7	5.8	38.9	38.0	38.4	38.4	32.9	32.9	33.1	32.9
M-4030	5.9	5.9	5.8	5.8	39.3	39.7	39.5	39.5	33.0	33.1	33.2	33.1
M-4005, St	5.8	5.7	5.9	5.8	37.8	37.8	38.0	37.8	32.8	32.7	32.9	32.8
LSD_{05}				0.17				0.67				0.37
Experiment accuracy, %				1.01				0.59				0.39

In terms of fiber yield, M-4009, M-4003, M-4021, M-4006, M-4010, M-4001, M-4026, M-4025, and M-4018 turned out to be close to the standard, other varieties M-4004, M-4012, M-4019, M-4030 noticeably surpass in this trait. The highest fiber yield was distinguished by varieties M-4015 – 39.5% and M-4017 – 39.7%, which exceeded the standard by 1.7-1.9% more fiber (Table 2).

In terms of fiber length, the grades M–4015, M–4018, and M–4006 distinguished themselves, which significantly exceeded the standard in terms of LSD. The remaining grades slightly exceeded the standard or were close to the standard. High values of microns were noted in varieties M-4003; M-4025; M-4001; M-4006; and M-4026, significantly exceeding the standard by 20-25%. In the varieties M-4021 and M-4030, this indicator was at the standard level.

In terms of breaking load, the fibers of the M-4003, M-4004, M-4015, and M-4017 grades were ahead of the standard M-4005 grade by 0.6-1.0 g.s, and the M-4012 and M-4019 grades were at the level of the standard (Tables 3, 4).

Table 3. Technological properties of cotton varieties fiber in the competitive variety testing on the standard background (average for 2019-2021)

Samples	Micronaire readings				variety				Breaking load in g.s.			
	2019	2020	2021	average for 3 years	2019	2020	2021	average for 3 years	2019	2020	2021	average for 3 years
M-4001	4.5	4.6	4.6	4.5	1	Sel.	1	1	4.8	4.9	4.8	4.8
M-4003	4.6	4.6	4.5	4.5	Sel.	Sel.	Sel.	Sel.	4.9	4.9	4.9	4.9
M-4004	4.6	4.8	4.7	4.7	Sel.	1	Sel.	Sel.	5.0	4.8	4.9	4.9
M-4006	4.7	4.7	4.6	4.6	1	1	1	1	4.9	4.8	4.8	4.8
M-4009	4.8	4.6	4.7	4.7	1	Sel.	1	1	4.8	4.9	4.8	4.8
M-4010	4.5	4.5	4.6	4.5	1	Sel.	1	1	4.9	4.9	4.9	4.9
M-4012	4.8	4.8	4.7	4.7	1	1	1	1	4.7	4.7	4.7	4.7
M-4015	4.6	4.6	4.6	4.6	Sel.	Sel.	Sel.	Sel.	5.1	5.1	4.9	5.0
M-4017	4.8	4.6	4.6	4.6	1	Sel.	Sel.	Sel.	4.9	4.9	4.9	4.9
M-4018	4.5	4.7	4.6	4.6	1	1	1	1	4.8	4.8	4.8	4.8
M-4019	4.7	4.7	4.6	4.6	1	1	1	1	4.8	4.8	4.7	4.7
M-4021	4.8	4.8	4.8	4.8	1	1	1	1	4.7	4.7	4.8	4.7
M-4025	4.6	4.6	4.5	4.5	Sel.	Sel.	Sel.	Sel.	4.9	4.9	4.9	4.9
M-4026	4.7	4.7	4.6	4.6	1	1	1	1	4.9	4.7	4.8	4.8
M-4030	4.8	4.8	4.8	4.8	1	1	1	1	4.8	4.8	4.8	4.8
M-4005, St	4.8	4.8	4.8	4.8	1	1	1	1	4.7	4.7	4.7	4.7
LSD_{05}				0.11								0.09
Experiment accuracy, %				0.79								0.66

The studied cotton varieties were superior to the standard variety in almost all parameters.

Thus, the provision of the textile industry with raw materials in the required assortment depends on which varieties with what fiber quality will be sown in production. The quality of cotton products is the main indicator of the evaluation of breeding varieties.

Table 4. Indications of technological qualities of fiber (average for 2019-2021)

Samples	Degree of fineness indicators				Fiber maturity				Breaking length, km			
	2019	2020	2021	average for 3 years	2019	2020	2021	average for 3 years	2019	2020	2021	average for 3 years
M-4001	5400	5300	5350	5350	2.1	2.1	2.1	2.1	25.9	26.0	25.6	25.8
M-4003	5340	5320	5360	5340	2.1	2.1	2.2	2.1	26.2	26.1	26.2	26.1
M-4004	5260	5390	5380	5343.3	2.1	2.1	2.2	2.1	26.3	25.9	26.3	26.1
M-4006	5320	5370	5360	5350	2.1	2.1	2.2	2.1	26.1	25.8	25.7	25.8
M-4009	5360	5310	5400	5356.6	2.1	2.1	2.1	2.1	25.7	26.0	25.9	25.8
M-4010	5270	5270	5300	5280	2.1	2.1	2.0	2.1	25.8	25.8	25.9	25.8
M-4012	5450	5430	5440	5440	2.0	2.0	2.1	2.0	25.6	25.5	25.5	25.5
M-4015	5180	5160	5320	5220	2.2	2.2	2.2	2.2	26.4	26.3	26.6	26.4
M-4017	5340	5310	5410	5353.3	2.1	2.1	2.1	2.1	26.2	26.0	26.5	26.2
M-4018	5400	5380	5380	5386.6	2.1	2.1	2.0	2.1	25.9	25.8	25.8	25.8
M-4019	5400	5360	5450	5403.3	2.1	2.1	2.1	2.1	25.9	25.7	25.6	25.7
M-4021	5460	5440	5300	5400	2.0	2.0	2.0	2.0	25.6	25.6	25.4	25.5
M-4025	5270	5310	5300	5293.3	2.1	2.1	2.2	2.1	26.3	26.0	25.9	26.0
M-4026	5320	5420	5400	5380	2.1	2.0	2.1	2.1	26.1	25.5	25.9	25.8
M-4030	5400	5380	5420	5400	2.1	2.1	2.0	2.1	25.9	25.8	26.0	25.9
M-4005 St	5410	5430	5420	5420	2.0	2.0	2.0	2.0	25.4	25.5	25.4	25.4
LSD_{05}				76.33				0.072				0.29
Experiment accuracy, %				0.49				1.2				0.39

In this regard, new medium-fiber cotton varieties M-4003, M-4015, and M-4017 have positive economic and valuable indicators. The fiber yield, length, boll weight, and technological qualities of these tested varieties exceed the standard grade M-4005 with a great advantage.

The relationship between traits plays an important role in the choice of plant material for future breeding. Evaluation of genotypic and phenotypic correlations between traits helps to initiate breeding programs. If the correlation between two traits is positive and significant, improving one trait will have a significant impact on the other. Therefore, selection for one trait will improve other probably related traits.

Today, cotton growing needs high-quality fiber. For this purpose, breeding programs must develop cotton varieties (*Gossypium hirsutum* L.) that overcome the negative relationship between agronomic performance and fiber quality. Since 1935, the USDA-ARS Pee Dee Germ Plasm Improvement Program has prioritized improving fiber quality while maintaining or improving agronomic performance. This program showed that the negative relationship between agronomic performance and fiber quality is most often caused by a genetic link that can be overcome. It was found that three Pee Dee germ plasm lines previously identified as rare recombinants could generate populations with a reduced negative relation between agronomic performance and fiber quality, [6]. In a study by Song et al. 2015, significant positive correlations were observed between fiber traits. Nevertheless, in their study, fiber length showed a significant negative correlation with other fiber quality characteristics. The correlation analysis results suggest that raw cotton yield and fiber yield can be improved in combination with boll weight, boll count, and pile percentage independently of other fiber quality indicators.

In our study, the yield showed a high positive correlation with one boll weight, as well as a significant relationship between the fiber breaking load and the fiber-breaking length. The growing season showed a medium and strong positive correlation with such traits as one boll weight, fiber length, micronaire, fiber breaking load, and fiber maturity coefficient.

The one boll weight had a strong relationship with fiber yield, micronaire, fiber maturity coefficient, average positive relationship with fiber metric number, and fiber breaking length. Fiber yield had a high correlation with fiber length, fiber breaking load, fiber metric number, fiber breaking length, and above average positive correlation with fiber maturity index trait.

Fiber length was directly correlated with a high relationship with micronaire, fiber breaking load, fiber metric number, and a positive significant relationship with fiber breaking length trait.

The micronaire index had a high relationship with fiber-breaking load readings, a significant relationship was also found with fiber maturity ratio readings.

Fiber breaking load had a high positive relationship with fiber metric number and above average relationship with fiber maturity ratio, and fiber breaking length. It was found that the fiber metric number had a high correlation with the fiber breaking length, which in turn positively correlates with the fiber maturity coefficient.

Long-term studies have shown that plant height has the only positive correlation with the growing season duration. We have not found significant correlations of this feature with fiber quality. Particular attention should be paid to such a trait as "bush compactness", which has a significant positive correlation with the trait "accelerated friendly boll opening" (r-0.745). The more compact the bush, the greater the incidence of light rays on the leaf surface. Due to the bush compactness, it is possible to increase the density of plants per 1 hectare to 170-180 thousand, while with standard sowing, the density is 120 thousand/ha, which allows increasing the yield to 60-70 centners/ha.

Thus, the results of this study showed a strong positive relationship only between the yield and the weight of one boll - $r = 0.779$, a linear relationship is expressed by the equation $U = 0.0684x + 3.033$. A positive mean correlation was found between yield, breaking load, and fiber length (Table 5). For example, in the studies of Shevkiyev et al. (2022), the correlation coefficient between the studied traits and the yield of cotton seeds showed that all traits positively correlate with the yield of seeds both under normal conditions and under drought stress. In the studies of Rahman et al. (2020), the yield of cotton seeds is positively related to the plant height, the number of pods on the plant, the number of sympodial branches on the plant, fiber length, and fiber strength, respectively.

Table 5. Correlation analysis of qualitative and quantitative traits of the cotton plant (*Gossypium hirsutumL.)*

Traits	Y	VP	WOB	FO	LF	M	BLF	MFN	CFM	BLF
Y	-									
VP	-0.491	-								
WOB	0.779**	0.732	-							
FO	0.146	0.354	0.797	-						
LF	0.345	0.437	0.345	0.785	-					
M	-0.376	0.785	0.726	0.218	0.774	-				
BLF	0.423*	0.435	0.341	0.745	0.718	0.724	-			
MFN	-0.332	0.382	0.424	0.728	0.712	0.325	0.727	-		
CFM	0.401	0.793	0.784	0.425	0.215	0.544	0.548	0.278	-	
BLF	0.426*	0.743	0.453	0.741	0.427	0.247	0.674	0.748	0.714	-

Note: r is the correlation coefficient (r < 0.3 – the correlation dependence between the traits is weak, with r = 0.3 - 0.7 – medium, with r > 0.7 – strong.); Y – yield, VP – vegetation period; WOB – weight of one boll; FO – fiber output; LF – length of the fiber; M – micronaire; BLF – breaking load of the fiber; MFN – metric fiber number; CFM – coefficient of fiber maturity; BLF – breaking length of the fiber;
Standard Error -1.34; Student's criterion $t_{fact.} > t_{theor}$; **: Highly significant ($P \leq 0.01$), *: Significant ($P \leq 0.05$))

Thus, these yield-related traits should be considered as the main selection criteria for genotype to increase yield, in combination with high fiber quality. The remaining technological properties of the fiber of cotton varieties weakly correlate with yield – r = 0.146 (Figure 2).

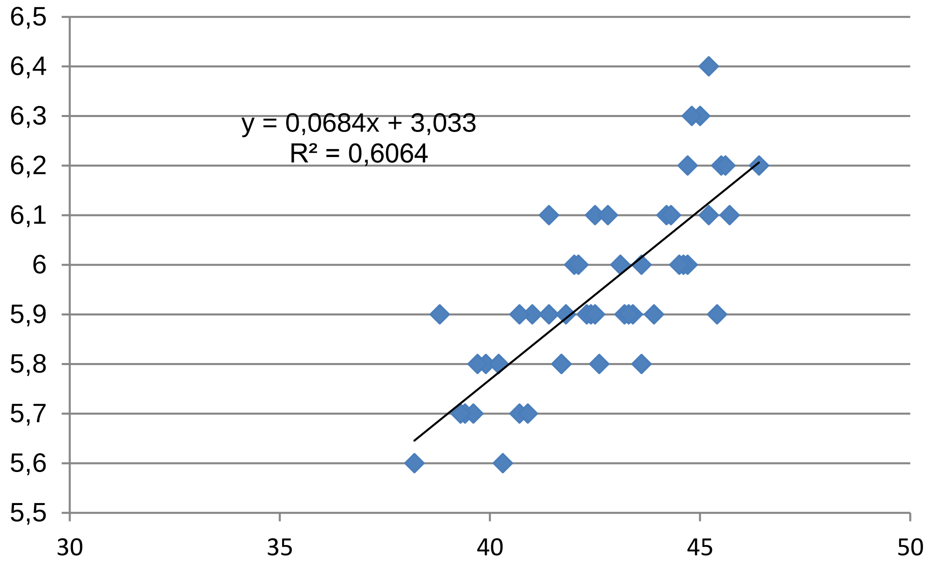

Figure 2. Scattering diagram of traits by the values of the correlation coefficient

In general, the analysis showed that parental lines, for example, M-4003, M-4006, M-4015, and M-4017 can be used in hybridization programs to improve yield and fiber quality. High economic and valuable indicators and technological qualities of the fiber of the tested varieties will allow to obtain high yields in the conditions of the Turkestan region, thereby increasing the profitability of cotton growing in the region due to high yields. Many of the tested varieties will be introduced into the breeding process to obtain new highly productive cotton varieties.

4 Conclusions

Based on practical developments, we selected new forms of medium-sized, precocious, highly productive, fork-resistant cotton plants that have a growing season of 118-122 days, a high rate of boll opening, fiber yield of 38.0-39.4%, and fiber quality of type IV-IV that meets the requirements of the textile industry. Selected breeding cotton varieties M-4003, M-4006, M-4015, and M-4017 in the conditions of competitive variety testing exceeded the standard variety in almost all parameters.

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The authors have no conflicts of interest to declare that are relevant to the content of this article.