Online ISSN: 2588-3526
Journal of Wildlife and Biodiversity
*Volume 8(4): 119-128 (2024) (*http://www.wildlife-biodiversity.com/*)*
Research Article

The diversity and breeding potential of *G. hirsutum* L. genotypes based on the Uzbekistan cotton gene bank collection

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Received: 29 June 2024 / Revised: 19 September 2024 / Accepted: 21 September 2024/ Published online: 22 September 2024.

How to cite: Samanov, S.H., Arslanov, D., Ernazarova, Z., Iskandarov, A., Muhammad, X., Bunyod, G., Gulomov, G., Sirojjodinov, B., Dusmatova, G., Shavkiev, J. (2024). Characterization of morpho-biological and economic characteristics of interspecific cotton hybrid and degree of dominance, Journal of Wildlife and Biodiversity, 8(4), 119-128. **DOI**: https://doi.org/10.5281/zenodo.13823671

Abstract

This article aimed to assess the genetic and selection potential of varietal diversity of tetraploid cultivated species of genus *Gossypium* L. from various ecological and geographical groups. The article presents data from the results of comparative studies of some morpho-yield traits, such as the boll weight cotton and 1000 seed weight, the length and fiber yield of 2308 samples of *G.hirsutum* L. belonging to 7 ecotypes from 64 countries. For study samples of the Central Asian ecotype, the boll weight was 5.4-6.3 g, for the Asian ecotype 5.7-6.9 g, for the Eurasian ecotype 3.5-5.7 g, for the European ecotype 3.8-6.4 g, in the American ecotype 5.5-6.4 g, in the African ecotype 5.5-6.5 g, in the Australian ecotype 5.4-7.1 g, also the highest figure was found among Australian samples ecotype. Regarding 1000 seed weight, the highest values were observed in samples of Asian ecotypes 123.0-140.0 g, and African ecotypes 106.0-139.0 g. Presents fiber length for samples of the Central Asian ecotype was 30.2-32.5 mm, for samples of the Asian ecotype 28.7-33.7 mm, for samples of the Eurasian ecotype 26.3-32.8 mm, for samples of the European ecotype 25.0- 35.0 mm, for samples of the American ecotype 29.9-32.9 mm, for samples of the African ecotype 30.0-32.4 mm, for samples of the Australian ecotype 30.2-33.8 mm. The highest rate was found in samples of the European ecotype. Regarding fiber yield, the highest indicators were observed in samples of Central Asian 34.0-38.1 %, European 34.2-40.8%, and American ecotypes 35.9-39.5 %. As a result of studies to assess the economically valuable traits of the world diversity of *G. hirsutum* L. samples, it was revealed that the highest indicators in traits of boll weight are observed in samples of the Australian ecotype, weight of 1000 seeds in samples of the Asian, fiber length samples of the African ecotypes and fiber yield in European ecotypes. Selected collection samples are recommended for use in cotton breeding.

Keywords: *G.hirsutum* L., cotton, ecotype, boll, seeds, fiber, yield

Introduction

The presence of the richest collection of the cotton gene pool (Institute of Genetic and Experimental Plant Biology of the Academy of Sciences of the Republic of Uzbekistan) is recognized by the international community as one of the most unique in terms of diversity of the cotton gene pool (Abdullaev et al., 2010; Campbell et al., 2010; Abdullaev et al., 2013; Abdurakhmonov et al., 2014;

Amanov et al., 2020; Sanaev et al., 2021; Kushanov et al., 2021; Narimonov et al., 2023; Makamov et al., 2023;), where specimens from various agro-ecosystems of the world are preserved in a viable state, which means a huge biodiversity of species and forms with a wide polymorphism of characteristics and properties. Gossypium L. ensures the success of applied research and the production of promising lines and varieties. Campbell et al. (2010), noting the high economic importance of cotton fiber for the national economy, indicate that over the past 100 years, coordinated efforts to collect and preserve cotton genetic resources have intensified. The authors note that without global collaborative efforts, the rarest and most unique cotton germplasm resources will be in danger of extinction.

The cotton gene pool collection of Uzbekistan is one of the largest in the world collections, representing samples and species with wide geographical and environmental niches and a large amplitude of morphological and genetic diversity. Using the resources of the gene pool of Uzbek cotton, a wide range of lines and varieties with useful agrotechnical traits such as early ripening, long fiber, high yield and resistance to various agricultural diseases have been created (Shavkiev et al., 2020; Abdullaev et al., 2021; Ergashev et al., 2021; Shavkiev et al., 2023). The basis of the cotton gene pool consists of cultivated tetraploid (2n=52) and diploid (2n=26) representatives of the genus *Gossypium* L.: *G.hirsutum* L., *G.barbadense* L., *G.herbaceum* L. and *G.arboreum* L.

Currently, *G.hirsutum* L. and *G.barbadense* L. are the main cultivated cotton species, with *G.hirsutum* L. accounting for 90 % of world production (Mithil et al., 2016; Shavkiev et al., 2021; Zhou et al., 2022; Shavkiev et al., 2022; Tian et al., 2023; Joshi et al., 2023; Zakirov et al., 2024). Thanks to the resistance to biotic stress, diseases, and pests, ecological plasticity, as well as productivity and fiber, the varietal diversity of the tetraploid species *G. hirsutum* L. is a valuable genetic resource for reducing the vulnerability of agricultural production (Amanov et al., 2022; Matniyazova et al., 2022). Notably, this species' varietal agro-biodiversity is characterized by remarkable polymorphism and a wide range of hereditary traits and properties variability. Therefore, it is the most valuable source material for developing improved varieties (Mauer, 1954). To a certain extent, a variety belonging to a specific agroecological group determines its main biological characteristics and its relationship to the main factors that make up the agroecological complex: climatic, soil, biotic, and agrotechnical conditions. The purpose is to determine the plant breeding (selection) potential of cotton collection samples belonging to the *G. hirsutum* L. species in different ecosystems.

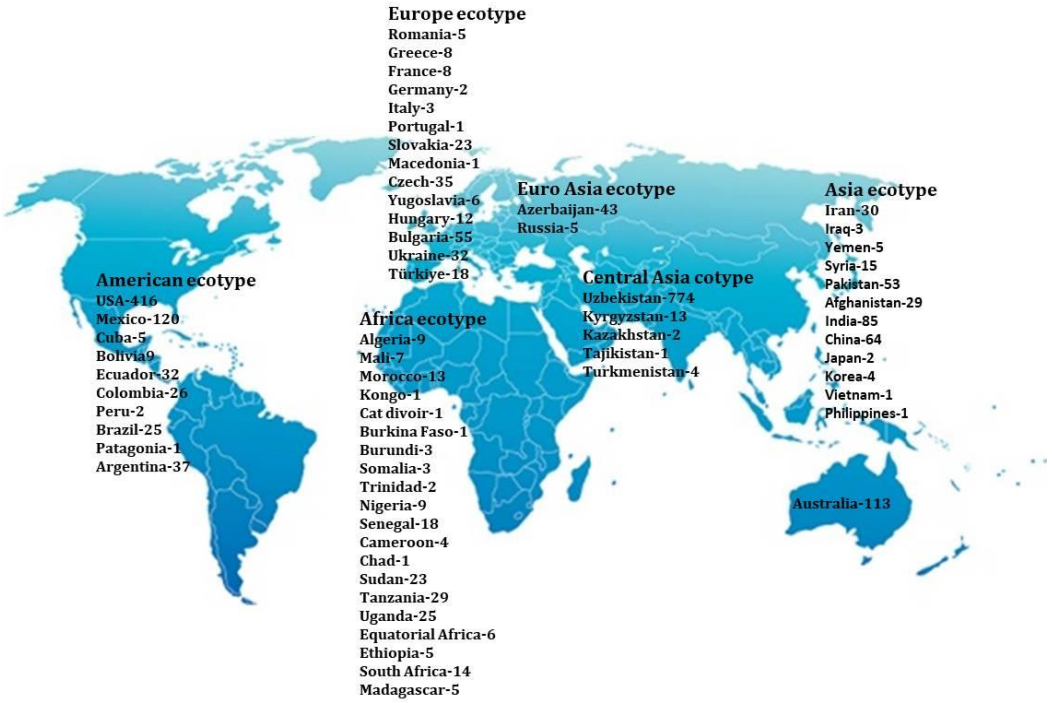

Figure 1. Geographic distribution of the diversity of genotypes belonging to the species *G. hirsutum* L.

Material and methods

Experimental studies were carried out in the laboratory of experimental polyploidy and phylogeny of cotton at the Institute of Genetics and Experimental Plant Biology of the Academy of Sciences of the Republic of Uzbekistan. The object of research is the varietal diversity of tetraploid cotton species *G. hirsutum* L. of various ecological and geographical origins. For period 2015-2022, in the conditions of Uzbekistan, the morpho-yield characteristics of more than 2308 varieties were assessed.

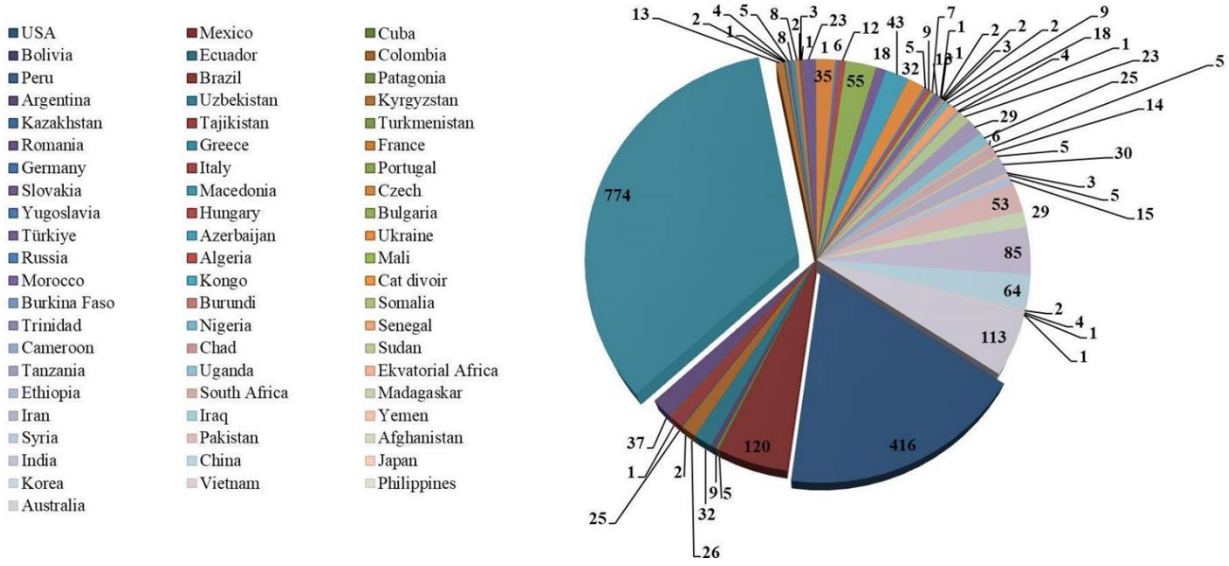

Figure 2. Origin and number of samples of *G.hirsutum* L. (2015-2022 yy).

Accepted guidelines and requirements were followed for preparing material for sowing, phenological observations, botanical descriptions, field records, laboratory analyses, and agrotechnical measures (Lemeshev *et al.,* 1989). The obtained long-term data were analyzed using modern software for one-way and multivariate variance (ANOVA), and economically valuable traits of cotton were analyzed using modern software (Origin Pro, 2021).

Results

Environmental tests conducted in Uzbekistan from 2015 to 2022 assessed the economically valuable varietal diversity traits of the cultivated tetraploid species *G. hirsutum* L. in more than 2308 cultivar samples from various ecological settings. These traits are most valuable as donors of useful traits for use in geographic groups and genetic breeding projects. Varieties from Uzbekistan, Kyrgyzstan, Turkmenistan, Kazakhstan, and Tajikistan represent the Central Asian ecological and geographical group of Mexican cotton. The varietal diversity of these countries revealed distinctive and similar results in terms of economically valuable characteristics (weight of raw cotton of one boll and 1000 seeds, length, and fiber yield). The average weight of raw cotton per boll for varieties from Uzbekistan was 5.4-6.3 g, weight of 1000 seeds 115.3-126.1 g, fiber yield 36.1-37.6 %, fiber length 30.2-32.5 mm. In varieties from Kyrgyzstan, a large amplitude of variability is observed in the weight of raw cotton of one boll and 1000 seeds in length and fiber yield. The average weight of raw cotton per boll was 4.7-6.7 g, the weight of 1000 seeds was 103.0-133.5 g, the fiber length was 30.1-35.6 mm, and the fiber yield was 34.0-38.1 %.

In varieties from Turkmenistan, more uniform indicators were revealed for the weight of raw cotton per boll (4.9-5.1 g) and fiber length (28.0-31.2 mm), a high amplitude of variability in the weight of 1000 seeds (120.0- 127.0 g), fiber yield 34.2-39.4 %. Samples from Kazakhstan and Tajikistan are characterized by relatively equal average indicators for all studied economic characteristics (Fig. 3). It should be noted that among the studied set of samples of these ecotypes, varieties with high indicators of economically valuable traits were identified: with a raw cotton weight of one boll of more than 6.6-7.0 g (A-2164, A-2114, A-2153, etc.); the weight of 1000 seeds (136.0-142.0 g), with a high fiber length of more than 37 mm (A-935, A-753, A-522, etc.) and a yield of more than 40.7-44.1 % (A-570, A-681; A-2155, etc.) (Fig. 3).

Varieties from Uzbekistan, Kyrgyzstan, Turkmenistan, Kazakhstan, and Tajikistan represent the Central Asian ecological and geographical group of Mexican cotton. The varietal diversity of these countries revealed distinctive and similar results in terms of economically valuable characteristics (boll weight, 1000 seed weight, length and fiber yield). The average boll weight for varieties from Uzbekistan was 5.4-6.3 g, weight of 1000 seeds 115.3-126.1 g, fiber yield 36.1-37.6 %, fiber length 30.2-32.5 mm. In varieties from Kyrgyzstan, a large amplitude of variability is observed in the boll weight, 1000 seed weight, length and fiber yield. The average boll weight was 4.7-6.7 g, the weight of 1000 seeds was 103.0-133.5 g, the fiber length was 30.1-35.6 mm, fiber yield was 34.0-38.1 %.

In Turkmenistan varieties, more uniform indicators were revealed for the boll weight (4.9-5.1 g) and fiber length (28.0-31.2 mm), a high amplitude of variability in the weight of 1000 seeds (120.0-127.0 g), and fiber yield 34.2-39.4 %. Samples from Kazakhstan and Tajikistan are characterized by relatively equal average indicators for all studied economic characteristics (Fig. 3). It should be noted that among the studied set of samples of these ecotypes, varieties with high indicators of economically valuable traits were identified: with boll weight of more than 6.6-7.0 g (A-2164, A-2114, A-2153, etc.), the weight of 1000 seeds (136.0-142.0 g), with a high fiber length of more than

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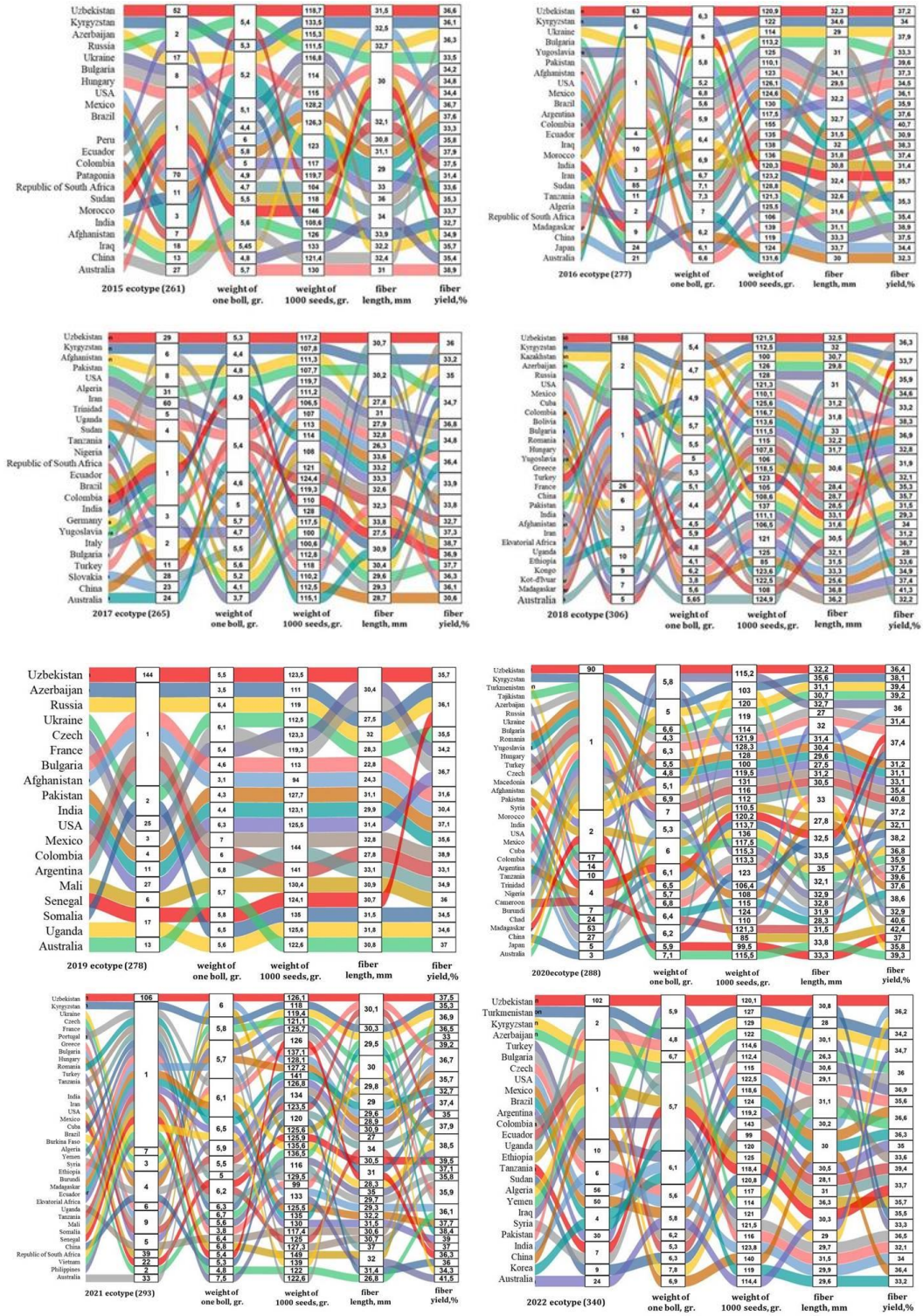

Figure 3. Indicators of economically valuable traits of samples of the *G. hirsutum* L., collection of the cotton gene pool from various ecotypes (2015-2022).

Among the studied samples from Russia, varieties with high indicators of economically valuable traits were identified: with a boll weight of 5.5-6.4 g (A-1256, A-2994, A-1035), 1000 seeds 119,

0-121.0 g. (A-1256, A-2994, A-692), fiber length 31.0-32.0 mm. (A-1256, A-2994, A-1035) and fiber yield 33.2-36.1% (A-1256, A-2994, A-1035). Among the samples from Azerbaijan, varieties with a boll weight of 6.4-7.4g were identified. (A-1655, A-1656, A-1763), weighing 1000 seeds 124.0-138.0 g (A-2498, A-1609, A-1655), fiber length 35.1-36.0 mm (A-603, A-1708, A-4017), and a fiber yield of 39.1-39.8 % (A-603, A-2994, A-1612, A-1624). Varieties from Romania, France, Greece, Germany, Italy, Portugal, Slovakia, Macedonia, the Czech Republic, Yugoslavia, Hungary, Bulgaria, Turkey and Ukraine represent the European ecological-geographical group. The largest number of varieties studied were from Slovakia (23), Czech Republic (35), Bulgaria (55), Turkey (18) and Ukraine (32).

It should be noted that the variety of samples from Slovakia had a large amplitude of variability for all economically valuable traits. By weight of boll (3.8-6.4 g), by weight of 1000 seeds (82.0-133.0 g), by fiber length (25.0-35.0 mm), and by fiber yield (27.4- 45.6 %). Samples from the Czech Republic were characterized by relatively equal indicators in weight of 1000 seeds (115.0-123.3 g) and fiber length (30.0-31.1 mm). In traits of the mass of boll (5.4-7.0 g) and fiber yield (34.2-40.8 %), they had high rates and variability amplitude. Varietal samples with high indicators of economically valuable traits were identified with a weight of boll of 7.0-7.8g. (A-848, A-1312, A-2252, A-4277, A-4282, A-4250), weight of 1000 seeds was 141-162g. (A-1590, A-1284, A-4249, A-3568, A-2897), along the fiber length 34.0-37.0mm (A-2170, A-4247, A-2247, A-3569), fiber yield 40.3-45.6% (A-1600, A-4282, A-4253, A-3084). (Fig.3)

The American ecological-geographical group is represented by specimen varieties from the USA, Brazil, Mexico, Colombia, Peru, Argentina, Cuba, Bolivia, Patagonia and Ecuador. The largest number of varieties studied were from the USA (416), Mexico (120), Ecuador (32), Colombia (26), Brazil (25), Argentina (37).

The varieties from the USA were characterized by relatively average equalized indicators for the weight of the boll (5.5-6.4 g), for the weight of 1000 seeds (115.1-128.3 g), for the length of the fiber (29.9-32.9 mm) and fiber yield (36.2-38.6 %). Varieties from Mexico were characterized by high rates and amplitude of variability in the weight of boll (5.0-7.0 g), in the weight of 1000 seeds (110.2-144.0 g), and fiber yield (35.9-39.5 %). It should be noted that varieties from Bolivia were distinguished by high rates and amplitude of variability in fiber yield (32.3-43.9 %), and varieties from Colombia were distinguished by the weight of boll (4.9-7.1 g) and by weight of 1000 seeds (106.4-155.0 g). The lowest indicators of the studied economically valuable traits were characterized by varieties from Patagonia, where the weight of the boll was 4.7 g, the weight of 1000 seeds was 4.0g, the fiber length was 34.0mm, and the fiber yield was 31.4 %.

Among them, varieties with high indicators of economically valuable traits were identified: with a boll weight of 7.9-8.7 g (A-409, A-2521, A-2706, A-2476, A-3562, A -3567, A-3987), by weight of 1000 seeds 143.0-169.0 g (A-1970, A-2194, A-6078, A-3987, A-4074), by fiber length 33.8-44.3 mm, (A-2188, A-1962, A-1724, A-2400, A-2221, A-4651, A-3870, A-2181), fiber yield 38.9-43.0 % (A-3878, A-2431, A-6062, A-4066, A-4081, A-4269, A-3709, A-4075, A-3663, A-3877, A-3891, A-3902, A-4287, A- 3648). The African eco-geographical group is represented by varieties from Sudan, Mali, Senegal, Somalia, Uganda, Burkina Faso, Tanzania, Algeria, Morrocco, South Africa, Madagascar, Congo, Ethiopia, Trinidad, Nigeria, Cameroon, Burundi, Chad and Africa. The largest number of accessory varieties were studied from the African Ecological Group: Senegal (18),

Sudan (23), Tanzania (29), and Uganda (25). Varieties from Sudan, Tanzania, Uganda, Senegal, and Algeria had a high amplitude of variability for all studied economically valuable traits.

The varieties from South Africa (14) were characterized by relatively average indicators in traits of the weight of boll (5.5-6.5 g), weight of 1000 seeds (106.0-139.0 g), fiber length (30.0-32 .4mm) and fiber yield (32.7-34.5 %). Among the studied samples of the African ecological-geographical group, varieties with high indicators of economically valuable traits were identified with a weight of boll of 7.8-8.3 g (A-2619, A-3417, A-3424, A-3433, A-3143, A-4030, A-2605, A-2622, A-2727), by weight of 1000 seeds 139-152 g. (A-1445, A-2964, A-3141, A-4030, A-4101, A-3572, A-1032), along the fiber length 35.9-39.6 mm (A-2006, A-2733, A-2984, A-4185, A-6141, A-3564, A-4008), fiber yield 37.5-44.2% (A-4185, A-3417, A-3144, A-1923, A -2592, A-2603, A-2636). 113 varieties from the Australian Ecological-Geographical Group were studied. For the studied varieties, the weight of the boll was 5.4-7.1 g, the weight of 1000 seeds was 114.5-131.7 g, the fiber length was 30.2-33.8 mm, and the fiber yield was 32.2-39.3 %.

Among them, varieties with high indicators of economically valuable traits were identified: with a weight of boll of 7.3-8.2 g (A-2424, A-1312, A-2439, A-1042, A-3733), weighing 1000 seeds 140.0-155.0 g (A-2441, A-2967, A-3602, A-3620), fiber length 34.3-37.8 mm (A-2366, A-3037, A- 2968, A-4034, A-3604), fiber yield 38.5-42.0 % (A-3041, A-3631, A-3618, A-3734).

Discussion

Environmental tests were carried out in the period 2015-2022; an assessment was made of some economically valuable characteristics of samples belonging to the species *G.hirsutum* L. from the collection of the cotton gene pool - 2308 samples belonging to 7 ecotypes from 64 countries:

• Central Asian Environmental Group (Uzbekistan-774, Kyrgyzstan-13, Kazakhstan-2, Tajikistan-1, Turkmenistan-4)

• Asian Ecological and Geographical Group (Iran-30, Iraq-3, Yemen-5, Syria-15, Pakistan-53, Afghanistan-29, India-85, China-64, Japan-2, Korea-4, Vietnam-1, Philippines-1)

• Euro-Asian Ecological-Geographical Group (Azerbaijan-43, Russia-5)

• European Eco-Geographical Group (Romania-5, Greece-8, France-8, Germany-2, Italy-3, Portugal-1, Slovakia-23, Macedonia-1, Czech-35, Yugoslavia-6, Hungary-12, Bulgaria-55, Turkey-18, Ukraine-32).

• American Ecological-Geographical Group (USA-416, Mexico-120, Cuba-5, Bolivia-9, Ecuador-32, Colombia-26, Peru-2, Brazil-25, Patagonia-1, Argentina-37)

• African Ecological-Geographical Group (Algeria-9, Mali-7, Morocco-13, Kongo-1, Kot-d'Ivoire-1, Burkina Faso-2, Burundi-1, Somalia-3, Trinidad-2, Nigeria- 9, Senegal-18, Cameroon-4, Chad-1, Sudan-23, Tanzania-29, Uganda-25, Ekvatorial Africa-6, Efiopiya-5, Republic of South Africa-14, Madagaskar-5)

• Australian Eco-Geographic Group (113) samples.

Throughout several years (2015-2022), such quantitative characteristics as the weight of the boll, the weight of 1000 seeds, fiber length and yield were studied in G.hirsutum L. samples.

For samples of the Central Asian ecotype, the mass of boll was 5.4-6.3 g, for the Asian ecotype 5.7-6.9 g, for the Eurasian ecotype 3.5-5.7 g, for the European ecotype 3,8-6.4 g, in the American ecotype 5.5-6.4 g, in the African ecotype 5.5-6.5 g, in the Australian ecotype 5.4-7.1 g, the highest figure was found among samples of the Australian ecotype.

The weight of 1000 seeds for samples of the Central Asian ecotype was 115.3-126.1 g, for the Asian ecotype 123.0-140.0 g, for the Euro-Asian ecotype 107.8-126.0 g, for the European ecotype 82.0-133.0 g, in the American ecotype 115.1-128.3 g, in the African ecotype 106.0-139.0 g, in the Australian ecotype 114 5-131.7 g. The highest indicator was found in samples of Asian and African ecotypes. The fiber length for samples of the Central Asian ecotype was 30.2-32.5 mm; for samples of the Asian ecotype, 28.7-33.7 mm; for samples of the Eurasian ecotype, 26.3-32.8 mm; for samples of the European ecotype, 25.0-35.0 mm, for samples of the American ecotype 29.9-32.9 mm, for samples of the African ecotype 30.0-32.4 mm, for samples of the Australian ecotype 30.2-33.8mm. The highest rate was found in samples of the European ecotype. The fiber yield for samples of the Central Asian ecotype was 34.0-38.1 %; for samples of the Asian ecotype 30.6-36.4 %; for samples of the Eurasian ecotype, 31.4-36.1 %; for samples of the European ecotype 34.2- 40.8 %, for samples of the American ecotype 35.9-39.5 %, for samples of the African ecotype 32.7-34.5 %, for samples of the Australian ecotype 32.2-39.3 %. The highest rate was found in samples of the European ecotype. Studies to assess the economically valuable traits of the world diversity of G.hirsutum L. samples revealed that the highest indicators of boll weight are observed in samples of the Australian ecotype, weight of 1000 seeds in Asian and African ecotypes, and length and fiber yield in European ecotypes. Selected collection samples are recommended for use in cotton breeding. The effective use of the cotton gene pool depends on the scale and depth of assessment of its quality, the long-term objectives of cotton growing, and the level of organization and efficiency of the breeding process (Abdullaev et al., 2010). It is necessary to constantly study the cotton gene pool and reveal its qualitative and quantitative characteristics because it will solve new problems in the region (Rizayeva et al., 2013; Muminov et al., 2023).

Conclusion

Based on the research results, it can be said that the variety of genotypes of *G. hirsutum* L type differs in terms of pod weight, 1000 seed weight, fiber length, and yield based on geographical origin. As a study result of the research conducted on evaluating the economically valuable characteristics of the world diversity of *G. hirsutum* L., it was found that the highest indicators of boll weight are observed in Australian ecotype samples, 1000 seed weight in Asian and African ecotypes, and length and fiber yield in European ecotypes.

Acknowledgments

The authors are grateful to the Zangi-ota Experimental Field Station for providing space and resources for this work.

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