RESEARCH ARTICLE

SABRAO Journal of Breeding and Genetics
55 (3) 760-777, 2023
http://doi.org/10.54910/sabrao2023.55.3.14
http://sabraojournal.org/
pISSN 1029-7073; eISSN 2224-8978

# ASSESSMENT OF BOTANICAL AND GENETIC COLLECTION OF SOYBEAN FOR MORPHOLOGICAL AND YIELD ATTRIBUTES AND THEIR IMPACT ON NODULE-ASSOCIATED BACTERIA AND SOIL FERTILITY

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## SUMMARY

Assessment of botanical and genetic collection of soybean cultivars transpired during 2021–2022, for morphological and yield-related traits and their impact on nodule bacteria and soil fertility, at the Dormon Scientific Experimental Station, Institute of Genetics, Academy of Sciences of the Republic of Uzbekistan, District Kibray, Tashkent region, Uzbekistan. The soybean cultivars, grown in a randomized complete block design, had a factorial arrangement with three replications. Results revealed that in the botanical collection, the highest seed yield per plant came from the soybean cultivar K-2600 (48.3 ± 1.30 g), 1000-grain weight from Bk-105 (215.9 ± 0.15 g), and the number of grains per plant from the genotype K-2600 (346.4 ± 6.48). Moreover, in the genetic collection, the high oil content resulted in the genotypes Gen-15 (20.11%), Gen-13 (19.46%), and Gen-11 (19.40%). The higher values of the total protein content emerged in the soybean cultivars, Ehtiyozh (34.09%) and Gen-9 (33.74%), Gen-19 (34.72%), and Gen-26 (33.08%). Among the two types of soybean collections studied, the most substantial number of root nodules appeared in the cultivar Sochilmas (96.65 ± 0.11) during the pod formation phase. The recorded highest amount of soil microelements, according to soil analysis, was at the sowing site of the soybean cultivar, Genetic-1 and on average, the soil samples contained N-$NO_3$ (28 mg/kg), mobile $P_2O$ (212.3 mg/kg), and volatile trace element $K_2O_5$ (36 mg/kg), found to remain in the soil after crop harvesting. The conclusion based on the results indicates that the local soybean cultivar Genetik-1 has a more positive effect on improving soil fertility versus the other genotypes in both collections.

**Keywords**: Soybean (*Glycine max* L.), soil composition, macro-elements, botanical and genetic collections, morphology, yield attributes, oil and protein content, productivity

**Key findings:** Based on the presented findings, in the botanical collection, the highest grain yield per plant came from soybean cultivar K-2600, 1000-grain weight from Bk-105, and the highest number of grains per plant from the genotype K-2600. In the genetic collection, the highest oil content occurred

**Citation:** Kurbanbaev I, Abdushukirova S, Toshmatov Z, Amanov A, Azimov A, Shavkiev J (2023). Assessment of botanical and genetic collection of soybean for morphological and yield attributes and their impact on nodule-associated bacteria and soil fertility. *SABRAO J. Breed. Genet.* 55(3): 760-777. http://doi.org/10.54910/sabrao2023.55.3.14.

in the genotypes Gen-15, Gen-13, and Gen-11. The highest total protein content emerged in the soybean cultivars Gen-19 (34.72%), Ehtiyozh (34.09%), Gen-9 (33.74%), and Gen-26 (33.08%). The cultivar Sochilmas collected the most nodule bacteria in the soil.

Communicating Editor: Dr. Samrin Gul

Manuscript received: February 7, 2023; Accepted: May 5, 2023.


## INTRODUCTION

Soybean (*Glycine max* L. Merr.) belongs to the legume family Fabaceae and includes more than 40 species. Soy is an annual herbaceous plant with a height ranging from 25 to 200 cm. The human body's need for protein can mainly come from soybean meal as it contains up to 52% protein, 25% oil, and various vitamins. Soybean is a potentially important plant, ensuring the country's food security. Given the higher protein and oil contents in its seed, it is grown in 122 million ha in more than 20 countries worldwide (Atabaeva, 2004). Soybean has the second largest planted area in the world, being the fourth most vital crop after wheat, rice, and corn. The leading countries growing it are Brazil (34 million ha), the USA (31 million ha), Argentina (18 million ha), India (11 million ha), and China (nine million ha).

Soybean's larger growing areas in various countries might be due to the nutritious qualities of its grain and green mass, which can serve as food, feed, technical, and medical fields (Sichkar, 1987; Bhartiya *et al*., 2012). Based on the soybean genotypes and environmental conditions, its grain oil and protein vary from 17% to 26% and 30% to 55%, respectively. The soybean grain also contains carbohydrates (20%–25%), macro- and micro-elements including Ca, P, K, Na, Mo (4%–5%), and I and vitamins (E, $B_1$, $B_2$, $B_6$) (Nesterin and Skurikhin, 1979; Rasyad *et al*., 2018). Soybean is one of the main crops in the by-product of food protein, oil, cottonseed meal, and forages, with more than 1,000 products obtained (Sichkar, 1987; Kuswantoro *et al*., 2020).

According to the Food and Agriculture Organization (FAO) and the World Health Organization (WHO), the world currently has about 840 million undernourished people. In addition, more than 30% of the world's population suffers from malnutrition and lack of the most basic trace elements and vitamins, which clearly shows how relevant the issue of food security is. The population's need for food has posed present concerns for the food industry because of the rapid population growth in the world, including Uzbekistan. Thus, they provide the population with environmentally friendly agricultural products, improve the fodder base of animal husbandry, and organize the rational use of land and water resources (Khudaikulov and Atabaeva, 2021).

It is already known that agriculture, the food industry, animal husbandry, and poultry farming are important economic sectors of the republic. According to the State Committee of the Republic of Uzbekistan dated 01 October 2022, statistics showed 35.8 million permanent residents in the republic. Therefore, the issue of providing the population with high-grade food urgently needs addressing. Based on this, enhancing the above principal agriculture economic sectors is a current issue requiring immediate action.

In Uzbekistan, expanding the area under soybean and enhancing product outputs are vital for satisfying the population's requirements for oil products and consistently developing animal husbandry. Nowadays, developing the food industry, poultry, and livestock earnestly requires necessary measures to increase soybean production. Soybean is rich in protein and also has a large number of essential amino acids. Soybeans contain 14 times more protein than chicken, four times more than eggs, and 3.5 times more than beef. In soybean oil, protein reaches 75%, called soy isolate, which is used in preparing various sausages.

For sowing soybean, as the prime, secondary, and mixed crop, the growing season can have the following divisions, i.e., earliest-ripening (75–80 days), early-ripening (85–90 days), early medium-ripening (95–110 days), medium- ripening (110–120 days), late medium-ripening (130–140 days), and late-ripening (150–180 days) periods. The soybean plant has thousands of years of history and is grown in various environmental and soil conditions. After seed planting in the ground, its germination, growth, flowering, and maturation stages depend upon environmental factors. For the germination of soybean seeds, the optimum temperature is 18 °C–20 °C, while the minimum temperature is 6 °C–8 °C (Atabaeva, 2004).

Soybean plays a vital role in improving soil fertility, which demands focus, with its use in crop rotation showing excellent results. Soybean absorbs pure atmospheric nitrogen through nitrogen-fixing bacteria found in their root nodules and enriches the soil (Irene *et al.,* 2009; Huicui *et al.,* 2016; Ke *et al.,* 2019). During the growing period, the soybean plants keep a certain amount of nitrogen for themselves and the following crop. It also improves the composition of the soil and enhances the activity of biological and physiological processes. In the soybean fields, the soil microflora improves, creating a natural and ecological system in the ground. Additionally, creating a favorable environment benefits the life of earthworms, rhizobial bacteria, and other beneficial organisms (Babich, 2010).

The extensive cultivation of soybean in different geographical regions is due to its being a less demanding crop in the soil, growing well, and developing on loams with a 5 to 8 ph (Atabaeva, 2004). Past studies on the mechanism of free atmospheric nitrogen fixation by living organisms revealed the role of rhododendron bacteria in the roots of leguminous plants in enriching the soil with nitrogen (Zhang *et al.,* 2019; Teng-Xiang *et al.,* 2017; Xi-En *et al.,* 2018; Rui *et al.,* 2017). Based on the above discussion, the presented study aimed to assess soybean cultivars' botanical and genetic collections for morphological and yield-related traits and their impact on nodule bacteria and soil fertility.

## MATERIAL AND METHODS

The field experimentation transpired during 2021-2022 at the Dormon Scientific Experimental Station, Institute of Genetics, Academy of Sciences, District Kibray, Tashkent region, Uzbekistan. The two types of breeding material, i.e., a) botanical and b) genetic collection of soybeans, were available in the Laboratory of Genetics, Selection and Breeding of Legumes, Oilseeds, and Medicinal Plants and served as research material (Table 1). Soil samples collected for agrochemical analysis came from the experimental fields. Determining the nitrogen (N) in soil used the Kjeldahl method, while in the plant leaves, the chlorophyll content determination used the process of Hiscox and Israelstam (1979).

### Oil content determination in soybean grains

Determining the oil content in soybean genotypes consisted of 1 g of each sample ground in a simple mortar, weighed on an analytical balance, placed in unique filter paper bags, and weighed again with the bag. Separating the oils was first in acetone (analytical grade) and then in diethyl ether (analytical grade) for 48 h (in each solvent) using a Soxhlet apparatus. The free oiling grade samples gained first drying under a fume hood, then weighed together with the packaging on an analytical balance. The computed difference between the mass of samples of the cultivar before the free oiling and the weight of the package and cultivar samples after the free oiling ensued, with the percentage determined. The equipment used included the Analytical balance model CY224S (RR/readability 220 g/0.1 mg, internal calibration [Manufacturer: ACZET Pvt. Ltd.]) and Soxhlet Apparatus Model SOX406 (Manufacturer: ACZET Pvt. Ltd.) (Bobkov *et al.*, 2015; Broshko and Lushnikov 2020).

**Table 1.** The soybean cultivars used in the study.

| No. | Cultivars | Collection | Geographical region | No. | Cultivars | Collection | Geographical region |
|---|---|---|---|---|---|---|---|
| 1 | Orzu | botanic | Uzbekistan | 28 | Bk 105 | botanic | Unknown |
| 2 | Nena | botanic | Kazakhstan | 29 | K 90.20 | botanic | Unknown |
| 3 | Nofer | botanic | Uzbekistan | 30 | K-2600 | botanic | USA |
| 4 | Oyjamol | botanic | Uzbekistan | 31 | Ya 04565 | botanic | Japan |
| 5 | Pripiyat | botanic | Belarus | 32 | Kol-17 | botanic | Unknown |
| 6 | Sava | botanic | Hungry | 33 | Kol-27 | botanic | Unknown |
| 7 | Argentina | botanic | Argentina | 34 | Gavhar | botanic | Uzbekistan |
| 8 | Ehtijozh | botanic | Uzbekistan | 35 | Vilana | botanic | Russia |
| 9 | Sochilmas | botanic | Uzbekistan | 36 | Hosildor | botanic | Uzbekistan |
| 10 | Khotira | botanic | Uzbekistan | 37 | Slaviya | botanic | Russia |
| 11 | Khotira 2 | botanic | Uzbekistan | 38 | Baraka | botanic | Uzbekistan |
| 12 | Genetic-1 | botanic | Uzbekistan | 39 | Viktoriya | botanic | Russia |
| 13 | Bk 6 | botanic | USA | 40 | Tomaris 60 | botanic | Uzbekistan |
| 14 | Bk 9 | botanic | Canada | 41 | Amigo | botanic | Russia |
| 15 | Bk 18 | botanic | Australia | 42 | Selekta302 | botanic | Russia |
| 16 | Bk 24 | botanic | Uzbekistan | 43 | Kol-ya 6 | botanic | Unknown |
| 17 | Bk 79 | botanic | USA | 44 | Kol-ya 14 | botanic | Unknown |
| 18 | Bk 80 | botanic | Ukraine | 45 | Gen-6 | genetic | USA |
| 19 | Bk 81 | botanic | Belarus | 46 | Gen-8 | genetic | Yugoslavia |
| 20 | Bk 83 | botanic | China | 47 | Gen-9 | genetic | USA |
| 21 | Bk 84 | botanic | France | 48 | Gen-11 | genetic | Ukraine |
| 22 | Bk 85 | botanic | Belarus | 49 | Gen-13 | genetic | USA |
| 23 | Bk 87 | botanic | Russia | 50 | Gen-15 | genetic | Australia |
| 24 | Bk 90 | botanic | Canada | 51 | Gen-19 | genetic | Australia |
| 25 | Bk 96 | botanic | Unknown | 52 | Gen-26 | genetic | Uzbekistan |
| 26 | Bk 98 | botanic | Unknown | 53 | Gen-40 | genetic | Unknown |
| 27 | Bk 104 | botanic | Unknown | | | | |

**Protein amount determination in soybeans**

One gram sample of oil-extracted soybean genotypes was weighed on an analytical balance. The first step of the Kjeldahl method comprised 25 ml of concentrate per hydrolysis sample, reagents: sulfuric acid (analytical grade), 1 g copper sulfate (analytical grade), and 5 g sodium sulfate (analytical grade) (Figure 1). The second step used 0.1 n sulfuric acid (analytical grade), 40% sodium hydroxide (analytical grade), and methyl orange indicator for each sample. Titration included 0.1 N sodium hydroxide solutions (analytical grade). An automatic distillation unit K9840 model for Kjeldahl analysis (Manufacturer: ACZET Pvt. Ltd.) was used (Saraeva and Adamovich, 2022; Zhou *et al.,* 2021). Calculating the final data using the following formula:

$$X=V_1-V_2 \times 0.0014 \times 100\% / m \ ; \quad X \times 5.37$$

**Experimental conditions and statistical analysis**

The soil samples, taken before the research at the Dormon Scientific Experimental Station, had their agrochemical properties of the typical gray and irrigated soil determined in the Kibray region (Table 2). The major elements established in the soil were nitrogen (0.098%), phosphorus (0.176%), potassium (0.58%), and humus (1.720%). All the experiments had three replications, with the results analyzed using Fisher's multivariate test of variance (ANOVA). The significance level calculation was between $P < 0.05$ and $P < 0.01$(Steel and Torrie, 1984).

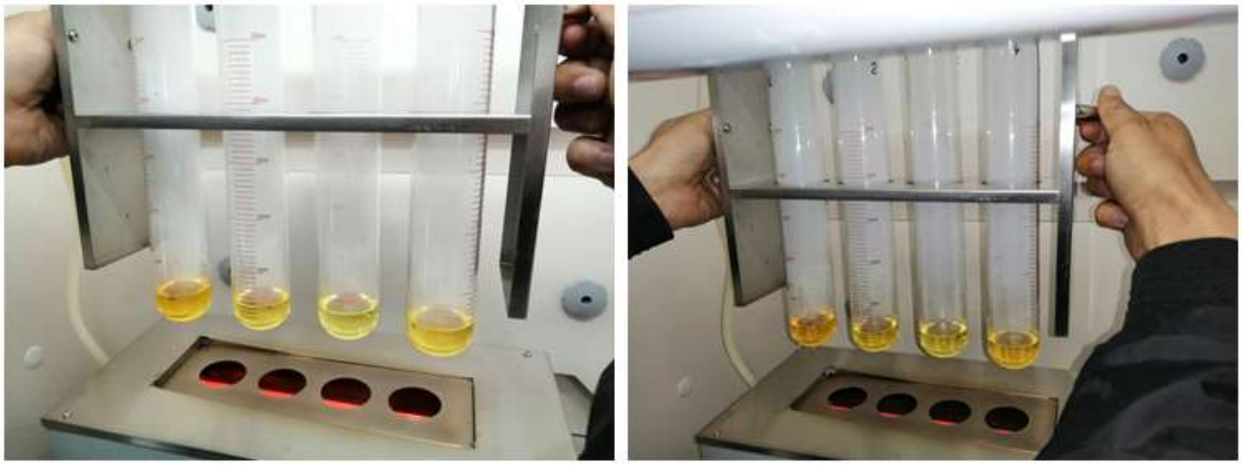

**Figure 1.** Work process on Kjeldahl equipment.

**Table 2.** Agrochemical properties of a typical gray and irrigated soil of the Kibray region.

| Soil | Active form, mg/kg | | $N\text{-}NO_3$, mg/kg | General, % | | N, % | Humus, % | C, % |
|---|---|---|---|---|---|---|---|---|
| | $P_2O_5$ | $K_2O$ | | $P_2O_5$ | $K_2O$ | | | |
| Typical gray soil | 28.06 | 368.00 | 50.18 | 0.176 | 0.58 | 0.098 | 1.720 | 0.998 |

**RESULTS AND DISCUSSION**

**Morphological and yield attributes**

The study included newly developed soybean cultivars Genetic-1 and Sochilmas of the Dormon Scientific Experimental Station, Institute of Breeding and Demonstration Nurseries, and the genotypes Khatira, Ekhtiyazh, and Mardzhon created in the research team's laboratory along with botanical and genetic collections of soybeans. In the seed nursery, original seed propagation of zonal and newly developed soybean cultivars proceeded. Screening the seed nursery had the non-specific plants of the soybean genotypes rejected. Simultaneously, the sown soybean botanical and genetic collections underwent phenological observations to study morphological and yield-related traits during the growing season.

Forty-four soybean cultivars obtained from the botanical collection were planted and studied to replenish the genetic compilation. The phonological observations continued during the shooting, flowering, and pod drop rates of the different cultivars of the botanical collection (Figure 2). In this study, analysis of the main morphological and yield-related traits of the soybean cultivars centered on plant height, number of joints per plant, number of branches and pods per plant, and growing season (Table 3).

The results revealed that the highest recorded values for the plant height were in the soybean cultivars, i.e., Bk 9, Bk 18, Bk 24, Bk 96, K 90.20, and K-2600, ranging from 161.5 ± 0.36 cm to 193.0 ± 0.73 cm. However, the tallest plants appeared in the cultivar Bk 9 (193.0 ± 0.73 cm). In the botanical collection, the noticeable shortest plants were cultivars Nofer, Pripyat, Sava, Ya 04565, and Amigo, ranging from 58.0 ± 1.08 cm to 79.0 ± 0.48 cm. Although, the least plant height showed in the cultivar Pripyat (58.0 ± 1.08 cm).

In the field experiments, carrying out phenological observations studied the number of nodes per plant in soybean genotypes. The greater the number of nodes per plant, the higher the number of pods and, eventually, the higher the grain yield per plant. In the botanical collection, a substantial number of nodes per plant emerged in the soybean cultivars, i.e., Marzhon, Bk-9, Bk-18, Bk-96, K-90.20, K-2600, and Tomaris 60, ranging from

**Table 3.** Morphological parameters of the botanical collection of soybean during the pod formation period.

| No. | Cultivars | Plant height (cm) | | | Nodes plant$^{-1}$ | | | Pods plant$^{-1}$ | | | Branches plant$^{-1}$ | | | Veg. period |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean±SE | SD | V % | Mean±SE | SD | V % | Mean±SE | SD | V % | Mean±SE | SD | V % | |
| 1 | Orzu | 82.5±0.53 | 3.54 | 4.29 | 20.6±0.08 | 0.52 | 2.51 | 89.2±4.61 | 30.55 | 34.25 | 3.4±0.18 | 1.17 | 34.52 | 133 |
| 2 | Nena | 93.5±0.94 | 6.26 | 6.69 | 19.3±0.20 | 1.34 | 6.93 | 69.4±2.23 | 14.78 | 21.30 | 1.33±0.08 | 0.50 | 37.50 | 139 |
| 3 | Nofer | 66.6±0.80 | 5.27 | 7.92 | 12.3±0.07 | 0.48 | 3.93 | 56.3±2.31 | 15.35 | 26.27 | 3.0±0.10 | 0.67 | 22.22 | 120 |
| 4 | Oyjamol | 125.0±1.51 | 10.00 | 8.00 | 24.2±0.12 | 0.79 | 3.26 | 97.2±2.42 | 16.05 | 17.31 | 3.7±0.12 | 0.82 | 22.25 | 157 |
| 5 | Pripiyat | 58.0±1.08 | 7.15 | 12.33 | 11.8±0.16 | 1.03 | 8.75 | 71.4±2.22 | 14.76 | 20.67 | 3.4±0.27 | 1.78 | 52.25 | 132 |
| 6 | Sava | 79.0±0.48 | 3.16 | 4.00 | 17.7±0.10 | 0.67 | 3.81 | 89.8±1.98 | 13.11 | 14.60 | 2.3±0.07 | 0.48 | 21.00 | 132 |
| 7 | Argentina | 8.5±1.28 | 8.51 | 9.62 | 19.5±0.13 | 0.85 | 4.36 | 70.8±3.02 | 20.02 | 28.28 | 3.9±0.09 | 0.57 | 14.56 | 137 |
| 8 | Ehtijozh | 136.5±0.87 | 5.80 | 4.25 | 26.1±0.09 | 0.57 | 2.17 | 95.8±2.74 | 18.19 | 18.99 | 2.9±0.15 | 0.99 | 34.29 | 157 |
| 9 | Sochilmas | 73.0±1.43 | 9.49 | 13.00 | 17.0±0.17 | 1.15 | 6.79 | 46.3±1.43 | 9.49 | 20.49 | 2.1±0.09 | 0.57 | 27.03 | 134 |
| 10 | Khotira | 159.0±0.78 | 5.16 | 3.25 | 26.4±0.11 | 0.70 | 2.65 | 79.4±1.24 | 8.21 | 10.34 | 1.9±0.09 | 0.57 | 29.88 | 157 |
| 11 | Khotira 2 | 169.0±0.48 | 3.16 | 1.87 | 29.4±0.11 | 0.70 | 2.38 | 151.1±178 | 11.84 | 7.83 | 3.7±0.12 | 0.82 | 22.25 | 160 |
| 12 | Genetic-1 | 59.0±0.48 | 3.16 | 5.36 | 11.0±0.10 | 0.67 | 6.06 | 63.0±3.16 | 20.98 | 33.3 | 4.1±0.15 | 0.99 | 24.25 | 117 |
| 13 | Bk-6 | 134.0±0.59 | 3.94 | 2.94 | 27.9±0.05 | 0.32 | 1.13 | 73.8±1.71 | 11.33 | 15.35 | 2.6±0.13 | 0.84 | 32.43 | 157 |
| 14 | Bk-9 | 193.0±0.73 | 4.83 | 2.50 | 31.6±0.13 | 0.84 | 2.67 | 57.8±1.04 | 6.92 | 11.98 | 2.9±0.09 | 0.57 | 19.57 | 160 |
| 15 | Bk-18 | 161.5±0.36 | 2.42 | 1.50 | 30.1±0.05 | 0.32 | 1.05 | 73.6±1.79 | 11.88 | 16.14 | 2.4±0.08 | 0.52 | 21.52 | 160 |
| 16 | Bk-24 | 162.0±0.39 | 2.58 | 1.59 | 28.6±0.19 | 1.26 | 4.42 | 84.7±4.17 | 27.69 | 33.90 | 2.5±0.08 | 0.53 | 21.08 | 160 |
| 17 | Bk-79 | 116.0±0.48 | 3.16 | 2.73 | 21.3±0.12 | 0.82 | 3.87 | 85.0±2.70 | 17.91 | 21.07 | 2.9±0.15 | 0.99 | 34.29 | 126 |
| 18 | Bk-80 | 89.5±0.56 | 3.69 | 4.12 | 21.7±0.07 | 0.48 | 2.23 | 90.8±2.50 | 16.59 | 18.27 | 4.0±0.12 | 0.82 | 20.41 | 126 |
| 19 | Bk-81 | 81.0±1.05 | 6.99 | 8.63 | 17.8±0.06 | 0.42 | 2.37 | 54.4±1.83 | 12.15 | 21.54 | 1.7±0.07 | 0.48 | 28.41 | 126 |
| 20 | Bk-83 | 107.5±2.05 | 13.59 | 12.64 | 20.3±0.17 | 1.16 | 5.71 | 90.1±4.60 | 30.51 | 33.86 | 2.4±0.11 | 0.70 | 29.13 | 120 |
| 21 | Bk-84 | 115.0±1.78 | 11.79 | 10.25 | 19.3±0.20 | 1.34 | 6.93 | 48.8±1.15 | 7.60 | 15.57 | 2.0±0.21 | 1.41 | 70.71 | 130 |
| 22 | Bk-85 | 116.0±0.69 | 4.59 | 3.96 | 20.4±0.08 | 0.52 | 2.53 | 47.5±2.23 | 14.81 | 31.18 | 1.56±0.08 | 0.56 | 33.88 | 122 |
| 23 | Bk-87 | 90.0±0.50 | 3.33 | 3.70 | 18.2±0.12 | 0.79 | 4.33 | 41.3±1.21 | 8.00 | 19.37 | 1.2±0.06 | 0.42 | 35.14 | 125 |
| 24 | Bk-90 | 124.5±0.24 | 1.58 | 1.27 | 20.4±0.15 | 0.97 | 4.74 | 106.5±2.5 | 17.12 | 16.08 | 4.2±0.21 | 1.40 | 33.30 | 135 |
| 25 | Bk-96 | 161.5±0.36 | 2.42 | 1.50 | 29.0±0.12 | 0.82 | 2.82 | 81.7±1.20 | 8.08 | 9.89 | 2.6±0.08 | 0.52 | 19.86 | 158 |
| 26 | Bk-98 | 102.0±1.39 | 9.19 | 9.01 | 18.1±0.09 | 0.57 | 3.14 | 68.4±1.80 | 11.96 | 17.49 | 2.1±0.13 | 0.88 | 41.70 | 133 |
| 27 | Bk-104 | 114.0±1.54 | 10.22 | 8.96 | 19.1±0.11 | 0.74 | 3.86 | 70.5±2.16 | 14.34 | 20.34 | 2.1±0.18 | 1.20 | 57.01 | 132 |
| 28 | Bk-105 | 90.7±0.28 | 1.89 | 2.08 | 21.1±0.10 | 0.69 | 3.26 | 77.14±1.5 | 10.19 | 13.21 | 3.71±0.07 | 0.49 | 13.14 | 158 |
| 29 | K 90.20 | 172.0±0.53 | 3.50 | 2.03 | 30.5±0.08 | 0.53 | 1.73 | 7.5±1.79 | 11.90 | 15.76 | 6.9±0.17 | 1.10 | 15.95 | 164 |
| 30 | K-2600 | 167.0±0.53 | 3.50 | 2.09 | 31.4±0.18 | 1.17 | 3.74 | 148.4±2.5 | 17.12 | 11.54 | 6.9±0.24 | 1.60 | 23.12 | 143 |
| 31 | Ya 04565 | 62.0±0.39 | 2.58 | 4.16 | 13.4±0.13 | 0.84 | 6.29 | 55.5±0.87 | 6.42 | 11.56 | 1.67±0.18 | 1.21 | 72.66 | 127 |
| 32 | Kol-17 | 141.5±0.36 | 2.42 | 1.71 | 281.0±0.1 | 0.32 | 1.13 | 124.8±3.1 | 20.48 | 16.41 | 5.3±0.28 | 1.89 | 35.63 | 164 |
| 33 | Kol-27 | 125.5±0.43 | 2.84 | 2.26 | 26.5±0.11 | 0.71 | 2.67 | 94.4±1.50 | 9.96 | 10.55 | 2.2±0.10 | 0.63 | 28.75 | 164 |
| 34 | Gavhar | 94.5±0.90 | 5.99 | 6.33 | 17.5±0.11 | 0.71 | 4.04 | 51.1±1.85 | 12.24 | 23.96 | 1.7±0.07 | 0.48 | 28.41 | 126 |
| 35 | Vilana | 128.5±0.62 | 4.12 | 3.29 | 19.9±0.13 | 0.88 | 4.40 | 53.3±0.77 | 5.12 | 9.61 | 1.25±0.08 | 0.50 | 40.00 | 126 |
| 36 | Hosildor | 123.0±1.08 | 7.15 | 5.81 | 22.5±0.13 | 0.85 | 3.78 | 80.9±1.82 | 12.06 | 14.91 | 1.5±0.08 | 0.53 | 35.14 | 161 |
| 37 | Slaviya | 115.0±0.79 | 5.27 | 4.58 | 18.2±0.23 | 1.55 | 8.51 | 43.3±1.85 | 12.29 | 28.39 | 1.1±0.05 | 0.32 | 28.75 | 121 |
| 38 | Baraka | 149.0±0.32 | 2.11 | 1.41 | 27.6±0.11 | 0.70 | 2.53 | 80.7±1.36 | 8.99 | 11.15 | 1.4±0.08 | 0.52 | 36.89 | 161 |
| 39 | Viktoriya | 129.5±0.43 | 2.84 | 2.19 | 21.6±0.08 | 0.52 | 2.39 | 69.7±1.89 | 12.54 | 18.08 | 2.8±0.10 | 0.63 | 22.59 | 127 |
| 40 | Tomaris 60 | 127.0±0.53 | 3.50 | 2.75 | 29.0±0.17 | 1.15 | 3.98 | 104.6±3.1 | 20.41 | 19.52 | 3.5±0.08 | 0.53 | 15.06 | 145 |
| 41 | Amigo | 76.5±1.18 | 7.84 | 10.24 | 16.3±0.07 | 0.48 | 2.96 | 62.3±3.80 | 25.18 | 40.42 | 4.4±0.15 | 1.00 | 22.73 | 120 |
| 42 | Selekta 302 | 108.0±0.73 | 4.83 | 4.47 | 22.6±0.18 | 1.17 | 5.19 | 59.5±1.47 | 9.76 | 16.40 | 1.5±0.08 | 0.53 | 35.14 | 127 |
| 43 | Kol-ya 6 | 89.0±0.48 | 3.16 | 3.55 | 21.4±0.11 | 0.70 | 3.27 | 59.4±2.61 | 17.32 | 29.15 | 2.1±0.11 | 0.74 | 35.14 | 124 |
| 44 | Kol-ya 14 | 112.5±0.40 | 2.64 | 2.34 | 20.4±0.08 | 0.52 | 2.53 | 57.7±1.49 | 9.91 | 17.18 | 1.5±0.10 | 0.84 | 55.78 | 156 |

**Figure 2.** Shooting phase of the soybean cultivars Genetic -1, Sochilmas, and Orzu in the experimental field.

29.4 ± 0.11 to 31.6 ± 0.13. However, relatively low values for the said trait showed in cultivars Nofer (12.3 ± 0.07), Pripyat (11.8 ± 0.16), and Ya 04565 (13.4 ± 0.13).

More pods on a soybean plant also signify a higher yield. For this purpose, assessing the trait number of pods per plant occurred in the botanical collection during the reporting period. Results revealed that the highest number of pods per plant resulted in the cultivars Marzhon (151.1 ± 178), K-2600 (148.4 ± 2.58), and Kol-17 (124.8 ± 3.09). Relatively, the lowest values for the said trait came from the cultivars Bk-85, Bk-87, and Slavia, ranging from 41.3 ± 1.21 to 47.5 ± 2.23. In addition, the characteristics of the number of branches and the duration of the growing season also gained analysis, and the cultivars with high and low values appear in Table 3.

In the genetic collection of soybean genotypes, i.e., Gen-6, Gen-8, Gen-9, Gen-11, Gen-13, Gen-15, Gen-19, Gen-26, and Gen-40, the traits, viz., plant height, the number of nodes per plant, the number of branches and pods per plant, and the length of the growing season were also analyzed during the reporting period (Table 4). According to the results, in nine soybean genotypes of the genetic collection, the highest values of plant height were in the genotype Gen-8 (159.0 ± 0.32 cm), while low-growing plants belonged to Gen-40 (81.5 ± 0.36 cm). The recorded highest values for plant height, number of nodes, seedlings, and branches were with cultivars Gen-8 (159.0 ± 0.32 cm), Gen-13 (29.4 ± 0.11 pcs), Gen-9 (75.8 ± 1.74 pcs), and Gen-6 (6.4 ± 0.18 pcs).

Gathering the ripened plants of the soybean cultivars of botanical and genetic collections under laboratory conditions, the yield-related traits analysis ensued for the total number of grains per plant, grain weight per plant, and the 1000-grain weight (Tables 5 and 6). The number of grains per plant is one of the crucial economic indicators and an indicator of grain yield. In the botanical collection, the highest number of grains per plant occurred in the soybean cultivars Sava (204.2 ± 4.04 pcs), Bk-80 (220.5 ± 6.37 pcs), Bk-90 (211.8 ± 8.62 pcs), K-2600 (346.4 ± 6.48 pcs), Collection 17 (235.4 ± 9.26 pcs), and Tomari-60 (220.3 ± 5.94 pcs) (Table 5). However, the least number of grains per plant was with soybean cultivars Bk-84 (90.0 ± 4.73 pcs), Bk-85 (98.9 ± 4.64 pcs), Bk-87 (89.9 ± 4.86 pcs), I 04565 (96.4 ± 4.41 pcs), and Slavia (99.4 ± 3.11 pcs).

**Table 4.** Morphological indicators of genetic collection of soybean during the pod formation period.

| No. | Cultivars | Plant height (cm) | | | Nodes plant$^{-1}$ | | | Pods plant$^{-1}$ | | | Branches plant$^{-1}$ | | | Veg. period |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean±SE | SD | V % | Mean±SE | SD | V % | Mean±SE | SD | V % | Mean±SE | SD | V % | |
| 1 | Gen-6 | 125.5±0.83 | 5.50 | 4.38 | 21.3±0.19 | 1.25 | 5.88 | 56.3±1.15 | 7.63 | 13.55 | 6.4±0.18 | 1.17 | 18.34 | 156 |
| 2 | Gen-8 | 159.0±0.32 | 2.11 | 1.33 | 27.8±0.06 | 0.42 | 1.52 | 60.3±0.93 | 6.17 | 10.22 | 2.5±0.08 | 0.53 | 21.08 | 156 |
| 3 | Gen-9 | 117.0±0.39 | 2.58 | 2.21 | 26.4±0.08 | 0.52 | 1.96 | 75.8±1.74 | 11.54 | 15.20 | 2.3±0.07 | 0.48 | 21.00 | 156 |
| 4 | Gen-11 | 144.5±0.66 | 4.38 | 3.03 | 26.2±0.06 | 0.42 | 1.61 | 52.1±1.45 | 9.62 | 18.46 | 1.3±0.08 | 0.30 | 37.50 | 156 |
| 5 | Gen-13 | 141.5±0.36 | 2.42 | 0.71 | 29.4±0.11 | 0.70 | 2.38 | 73.8±1.45 | 9.64 | 13.06 | 1.9±0.11 | 0.74 | 38.83 | 156 |
| 6 | Gen-15 | 128.3±0.75 | 4.95 | 3.85 | 24.6±0.08 | 0.52 | 2.10 | 63.4±1.14 | 7.59 | 11.97 | 1.5±0.08 | 0.52 | 36.89 | 156 |
| 7 | Gen-19 | 129.5±0.56 | 3.69 | 2.85 | 21.3±0.10 | 0.67 | 3.17 | 39.0±0.88 | 5.85 | 15.00 | 5.5±0.16 | 1.08 | 19.64 | 156 |
| 8 | Gen-26 | 133.0±0.39 | 2.58 | 1.94 | 27.2±0.06 | 0.42 | 1.55 | 52.7±1.04 | 6.91 | 13.12 | 2.1±0.09 | 0.57 | 27.03 | 156 |
| 9 | Gen-40 | 81.5±0.36 | 2.42 | 2.96 | 15.3±0.07 | 0.48 | 3.46 | 70.98±0.9 | 6.53 | 9.33 | 3.7±0.07 | 0.48 | 13.06 | 125 |

**Table 5.** Indicators of yield attributes in soybean cultivars of botanical collection.

| No. | Cultivars | Total grain weight per plant (g) | | | 1000-grain weight (g) | | | Total number of grains per plant, pcs | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean±SE | SD | V % | Mean±SE | SD | V % | Mean±SE | SD | V % |
| 1 | Orzu | 24.0±1.31 | 8.71 | 36.28 | 119.8±0.44 | 2.91 | 2.43 | 200.3±10.84 | 71.90 | 35.90 |
| 2 | Nena | 19.4±0.71 | 4.70 | 24.24 | 130.9±4.34 | 128.77 | 29.91 | 159.5±5.93 | 39.32 | 29.65 |
| 3 | Nofer | 19.1±0.76 | 5.04 | 26.38 | 155.9±0.37 | 2.44 | 1.57 | 122.9±5.10 | 33.80 | 27.50 |
| 4 | Oyjamol | 35.4±0.50 | 3.28 | 9.29 | 181.6±1.62 | 4.03 | 2.22 | 194.6±2.59 | 17.21 | 8.85 |
| 5 | Pripyat | 24.9±0.85 | 5.65 | 22.75 | 152.5±0.71 | 4.72 | 3.09 | 162.5±5.13 | 34.03 | 24.94 |
| 6 | Sava | 29.6±0.56 | 3.60 | 12.15 | 145.3±0.66 | 4.37 | 3.01 | 204.2±4.04 | 26.78 | 13.12 |
| 7 | Argentina | 19.1±1.13 | 7.48 | 39.14 | 21.5±2.00 | 13.30 | 10.95 | 155.8±7.45 | 49.43 | 31.71 |
| 8 | Ehtijozh | 24.5±0.80 | 5.28 | 21.59 | 112.6±0.42 | 2.78 | 2.47 | 217.4±6.62 | 43.92 | 20.20 |
| 9 | Sochilmas | 11.7±0.36 | 2.41 | 20.67 | 110.1±0.13 | 0.84 | 0.76 | 105.9±3.29 | 21.81 | 20.59 |
| 10 | Khotira | 24.1±0.31 | 2.04 | 8.48 | 171.3±0.53 | 3.50 | 2.04 | 137.9±1.19 | 7.92 | 5.75 |
| 11 | Khotira 2 | 34.6±0.56 | 3.72 | 10.77 | 148.7±0.41 | 2.73 | 1.84 | 232.7±3.56 | 23.60 | 10.14 |
| 12 | Genetic-1 | 22.1±0.94 | 6.25 | 28.29 | 138.0±1.64 | 10.87 | 7.88 | 154.3±6.70 | 44.42 | 28.78 |
| 13 | Bk-6 | 24.3±0.56 | 3.73 | 15.36 | 145.2±0.50 | 3.29 | 2.27 | 167.1±3.62 | 24.02 | 14.37 |
| 14 | Bk-9 | 19.1±0.52 | 3.45 | 18.09 | 149.1±0.45 | 3.01 | 2.02 | 120.0±1.44 | 9.55 | 7.95 |
| 15 | Bk-18 | 17.8±0.14 | 0.90 | 5.05 | 111.8±0.48 | 3.16 | 2.83 | 158.9±1.23 | 8.17 | 5.14 |
| 16 | Bk-24 | 21.0±0.36 | 2.39 | 11.39 | 114.4±0.23 | 1.52 | 1.33 | 181.7±2.94 | 19.49 | 10.73 |
| 17 | Bk-79 | 31.1±0.98 | 6.49 | 20.89 | 156.9±1.20 | 7.95 | 5.08 | 198.2±6.51 | 43.18 | 21.79 |
| 18 | Bk-80 | 35.7±1.3 | 8.65 | 24.22 | 160.0±1.06 | 7.04 | 4.40 | 220.5±6.37 | 42.24 | 19.16 |
| 19 | Bk-81 | 21.1±0.69 | 4.58 | 21.75 | 197.9±8.95 | 59.35 | 29.98 | 104.1±5.67 | 37.58 | 36.10 |
| 20 | Bk-83 | 28.9±1.49 | 9.89 | 34.18 | 162.4±2.46 | 16.32 | 10.05 | 180.4±9.53 | 63.19 | 35.02 |
| 21 | Bk-84 | 15.8±0.52 | 3.46 | 21.91 | 150.6±1.02 | 6.75 | 4.48 | 90.0±4.73 | 31.37 | 34.85 |
| 22 | Bk-85 | 16.4±0.86 | 4.50 | 27.53 | 167.4±2.76 | 18.29 | 10.93 | 98.9±4.64 | 30.81 | 31.15 |

**Table 5.** (cont'd.)

| No. | Cultivars | Total grain weight per plant (g) | | | 1000-grain weight (g) | | | Total number of grains per plant, pcs | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean±SE | SD | V % | Mean±SE | SD | V % | Mean±SE | SD | V % |
| 23 | Bk-87 | 21.5±2.55 | 16.94 | 78.88 | 169.9±3.09 | 20.51 | 12.08 | 89.9±4.86 | 32.20 | 35.84 |
| 24 | Bk-90 | 36.5±1.59 | 10.56 | 29.20 | 169.5±1.52 | 10.08 | 5.95 | 211.8±8.62 | 5.21 | 27.01 |
| 25 | Bk-96 | 28.0±0.41 | 2.70 | 9.65 | 147.4±0.41 | 2.75 | 1.85 | 189.5±2.33 | 15.49 | 8.17 |
| 26 | Bk-98 | 26.7±0.78 | 5.18 | 19.30 | 180.0±0.14 | 0.94 | 0.52 | 156.9±4.13 | 27.42 | 17.48 |
| 27 | Bk-104 | 25.4±0.89 | 5.93 | 23.40 | 148.9±1.39 | 9.23 | 6.20 | 172.0±6.96 | 46.18 | 26.85 |
| 28 | Bk-105 | 34.6±0.49 | 3.25 | 9.40 | 215.9±0.15 | 1.29 | 0.90 | 160.4±2.42 | 16.05 | 10.00 |
| 29 | K 90 .20 | 25.9±1.07 | 7.08 | 27.37 | 172.9±0.19 | 1.25 | 0.72 | 139.2±2.84 | 18.85 | 13.49 |
| 30 | K-2600 | 48.3±1.30 | 8.62 | 17.83 | 136.4±0.69 | 4.56 | 3.34 | 346.4±6.48 | 43.01 | 12.42 |
| 31 | Ya 04565 | 13.7±0.83 | 5.49 | 40.12 | 138.5±2.76 | 18.29 | 13.20 | 96.4±4.41 | 29.23 | 30.32 |
| 32 | Kollektsiya 17 | 38.5±1.59 | 10.55 | 27.40 | 164.8±0.70 | 4.66 | 2.84 | 235.4±9.26 | 61.44 | 26.10 |
| 33 | Kollektsiya 27 | 41.6±0.74 | 4.90 | 11.77 | 213.9±0.12 | 0.82 | 0.38 | 195.0±3.57 | 23.69 | 12.15 |
| 34 | Gavhar | 23.8±3.88 | 25.73 | 108.1 | 130.1±0.13 | 0.83 | 0.64 | 116.2±4.25 | 28.17 | 24.24 |
| 35 | Vilana | 17.9±0.27 | 1.78 | 9.93 | 146.9±0.08 | 0.52 | 0.35 | 121.9±1.80 | 11.97 | 9.82 |
| 36 | Hosildor | 30.9±0.69 | 4.59 | 14.85 | 164.9±0.32 | 2.11 | 1.28 | 187.3±4.21 | 27.90 | 14.90 |
| 37 | Slaviya | 15.1±0.53 | 3.54 | 23.41 | 152.7±2.07 | 13.73 | 8.99 | 99.4±3.11 | 20.66 | 20.79 |
| 38 | Baraka | 24.7±0.67 | 4.44 | 17.97 | 134.4±0.20 | 1.33 | 0.99 | 183.4±4.9 | 32.52 | 17.73 |
| 39 | Viktoriya | 20.5±0.54 | 3.56 | 17.33 | 128.7±0.14 | 0.93 | 0.72 | 159.6±4.28 | 28.41 | 17.80 |
| 40 | Tomaris-60 | 31.3±0.97 | 6.44 | 20.58 | 141.9±1.58 | 10.47 | 7.38 | 220.3±5.94 | 39.39 | 17.88 |
| 41 | Amigo | 22.6±0.92 | 6.08 | 26.92 | 98.6±2.25 | 14.95 | 15.16 | 155.7±7.46 | 49.51 | 31.80 |
| 42 | Slekta302 | 23.3±0.53 | 3.52 | 15.12 | 172.9±0.79 | 5.22 | 3.02 | 133.7±3.88 | 19.13 | 3.31 |
| 43 | Kollektsiya 6 | 15.1±0.55 | 3.64 | 24.04 | 135.5±1.26 | 8.34 | 6.16 | 119.4±4.42 | 29.32 | 24.55 |
| 44 | Kollektsiya 14 | 17.8±0.89 | 5.90 | 33.21 | 129.5±0.11 | 0.72 | 0.56 | 116.4±4.19 | 27.88 | 23.88 |

**Table 6.** Indicators of yield attributes in the genetic collection of soybean cultivars.

| No. | Cultivars | Total grain weight per plant (g) | | | 1000-grain weight (g) | | | Total number of grains (pcs) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean±SE | SD | V % | Mean±SE | SD | V % | Mean±SE | SD | V % |
| 1 | Gen-6 | 14.8±0.35 | 2.30 | 15.54 | 116.0±0.37 | 2.43 | 2.09 | 130.4±2.90 | 19.23 | 14.75 |
| 2 | Gen-8 | 20.6±0.39 | 2.59 | 12.36 | 147.9±0.34 | 2.26 | 1.53 | 139.1±2.21 | 14.64 | 10.52 |
| 3 | Gen-9 | 18.4±0.45 | 3.41 | 16.35 | 121.5±0.40 | 2.64 | 2.17 | 153.6±3.89 | 25.83 | 16.82 |
| 4 | Gen-11 | 15.6±0.32 | 2.14 | 13.75 | 152.7±0.32 | 2.09 | 1.37 | 101.7±2.16 | 14.33 | 14.09 |
| 5 | Gen-13 | 20.9±0.70 | 4.61 | 22.08 | 166.8±0.23 | 1.53 | 0.92 | 120.8±2.87 | 19.03 | 15.75 |
| 6 | Gen-15 | 21.0±0.39 | 2.61 | 12.42 | 145.5±0.33 | 2.22 | 1.52 | 144.1±2.88 | 19.12 | 13.27 |
| 7 | Gen-19 | 10.7±0.21 | 1.38 | 12.94 | 135.7±0.42 | 2.81 | 2.07 | 79.4±1.63 | 10.79 | 13.59 |
| 8 | Gen-26 | 12.5±0.24 | 1.61 | 12.89 | 123.8±0.15 | 0.99 | 0.80 | 101.2±1.88 | 12.49 | 12.34 |
| 9 | Gen-40 | 32.9±0.47 | 3.11 | 9.42 | 205.0±0.10 | 0.66 | 0.32 | 160.8±2.27 | 15.03 | 9.35 |

Based on the results, the highest grain weight per plant was in the soybean cultivars of the botanical collection, i.e., Collection 27 (41.6 ± 0.74 g) and K-2600 (48.3 ± 1.30 g). Notably, the least grain weight per plant was in cultivars Bk 84, Ya 04565, Slavia, and Collection 6, ranging from 13.7 ± 0.83 to 15.8 ± 0.52 g (Table 5). The 1000-grain weight is one of the valuable economic indicators and is considered the basis of productivity. In this regard, the highest 1000-grain weight came from the soybean cultivars of the botanical collection, viz., Bk 81, Bk 105, and Collection 27, amounting to 197.9 ± 8.95 g, 215.9 ± 0.15 g, and 213.9 ± 0.12 g, respectively. Inversely, the cultivars Argentina and Amigo of the botanical collection recorded with low 1000-grain weights, which amounted to 21.5 ± 2.00 and 98.6 ± 2.25 g, respectively. The rest of the genotypes displayed moderate values (Table 5).

In the genetic collection (Gen-6, Gen-8, Gen-9, Gen-11, Gen-13, Gen-15, Gen-19, Gen-26, and Gen-40), the yield-related traits, i.e., the total number and weight of grains per plant, and 1000-grain weight were also analyzed under laboratory conditions. Results revealed the soybean genotype Gen-40 was with the highest values for three traits, i.e., the number and weight of grains per plant and 1000-grain weight, with values of 160.8 ± 2.27 pcs, 32.9 ± 0.47 g, and 205.0 ± 0.10 g, respectively (Table 6). However, the rest of the genotypes had average and relatively low values for the said traits.

Thus, during the reporting period, the study of the botanical and genetic collections of soybean cultivars focused on plant height, number of nodes, number of pods, number of harvest branches, and duration of the growing season, with the botanical collection excelling over the genetic assortment of soybean genotypes for morphological and yield-related traits. Based on the results, the soybean cultivars belonging to the botanical compilation with better performance and high indices included, i.e., Bk-9, Bk-18, Bk-24, Bk-80, Bk-90, Bk-96, K-90.20, K-2600, NC-17480, and Ya-04565.

**Oil and protein content determination**

Based on past and present studies, the soybean genotypes differed in oil and protein content due to varied genetic makeup and environmental conditions. Diverse values of crude protein (total nitrogen content multiplied by 6.25), ranging from 36.3% to 48%, and extracted proteins – from 28.3% to 35.9%, were recorded in various soybean genotypes (Petibskaya, 2012). According to Toshkhuzhaev *et al.* (2015), the protein determined by the Kalkar method in different local soybean cultivars ranged from 14.40% (Orzu) to 34.06% (530536). Based on the above information, an analysis occurred for the oil and protein content in the grain of soybean cultivars of botanical and genetic collections, which were available at the Institute of Genetics and Experimental Plant Biology, Academy of Sciences, Republic of Uzbekistan. The results obtained are in Table 5.

Soybean is well-known for oil and protein richness and, thus, is an essential source for developing the food, poultry, and livestock industries. In this regard, comparatively analyzing these traits transpired to select promising genotypes from the botanical and genetic collections of soybeans and involve them in future breeding to develop the genotypes with high oil and protein content. According to the results, the high oil content showed in the seeds of soybean genotypes, viz., Gen-11, Gen-13, and Gen-15, with values of 19.40%, 19.46%, and 20.11%, respectively. However, low values for oil content came from the soybean genotypes, i.e., Gen-9, Gen-19, and Gen-26, ranging from 15.26% to 15.71%. The higher values of the total protein content emerged in the soybean cultivars Ehtiyozh (34.09%), Gen-9 (33.74%), Gen-19 (34.72%), and Gen-26 (33.08%). However, obtaining relatively the lowest values for the said traits were in the genotypes, viz., Gen-11 (27.43%), Gen-13 (27.51%), and Gen-15 (27.09%) (Table 7).

**Table 7.** Indicators of oil and protein content in the seeds of the genetic and botanical collections of soybean cultivars.

| No. | Cultivars | Oil content (%) | Protein content (%) | No. | Cultivars | Oily (%) | Protein content (%) |
|---|---|---|---|---|---|---|---|
| 1 | Gen-6 | 17.66 | 28.73 | 20 | Bk-91 | 16.78 | 31.42 |
| 2 | Gen-8 | 17.96 | 28.27 | 21 | Bk-96 | 16.89 | 31.50 |
| 3 | Gen-9 | 15.71 | 33.74 | 22 | Bk–98 | 18.66 | 28.10 |
| 4 | Gen-11 | 19.40 | 27.43 | 23 | Bk–104 | 17.79 | 28.55 |
| 5 | Gen-13 | 19.46 | 27.51 | 24 | Bk–105 | 17.52 | 29.34 |
| 6 | Gen-15 | 20.11 | 27.09 | 25 | Kol–17 | 18.78 | 28.26 |
| 7 | Gen-17 | 17.85 | 28.95 | 26 | Kol–27 | 17.87 | 28.65 |
| 8 | Gen-19 | 15.26 | 34.72 | 27 | K–9020 | 17.06 | 28.85 |
| 9 | Gen-26 | 15.41 | 33.08 | 28 | Ya.04.565 | 19.28 | 26.71 |
| 10 | Gen-40 | 17.53 | 29.07 | 29 | K2600 | 17.03 | 28.76 |
| 11 | Bk-6 | 18.14 | 29.35 | 30 | Nofer | 17.15 | 27.64 |
| 12 | Bk-9 | 17.61 | 28.86 | 31 | Sava | 15.65 | 33.93 |
| 13 | Bk-24 | 17.06 | 30.80 | 32 | Pripyat | 16.42 | 31.65 |
| 14 | Bk-79 | 17.88 | 28.61 | 33 | Argentina | 17.11 | 28.52 |
| 15 | Bk-80 | 18.54 | 28.32 | 34 | Nena | 17.57 | 29.19 |
| 16 | Bk-81 | 17.00 | 28.68 | 35 | Sochilmas | 18.59 | 28.01 |
| 17 | Bk-83 | 17.06 | 30.78 | 36 | Ehtijozh | 16.05 | 34.09 |
| 18 | Bk-84 | 16.98 | 31.09 | 37 | Oyjamol | 17.23 | 28.85 |
| 19 | Bk-87 | 18.75 | 28.55 | 38 | Orzu | 16.40 | 32.60 |

**Table 8.** General average morphological indicators and the number of nodule bacteria of soybean cultivars during the shooting period.

| No. | Soybean cultivars | Plant growth (cm) | Number of nodes | Number of root nodules |
|---|---|---|---|---|
| | | Mean±SE | Mean±SE | Mean±SE |
| 1 | Genetic-1 | 26.50±0.25 | 6.00±0.05 | 17.10±0.35 |
| 2 | Sochilmas | 17.10±0.17 | 4.80±0.12 | 16.05±0.11 |
| 3 | Orzu | 19.00±0.24 | 5.40±0.08 | 17.65±0.14 |

The presented studies further revealed that botanical and genetic collection of soybean genotypes owned a wide range of biodiversity in terms of oil and protein content in the grains. Several soybean cultivars with a high oil and protein content in the grain have been identified, with the soybean genetic collection enriched. These findings can serve as a valid basis for developing high-yielding and early-maturing soybean cultivars with high oil and protein in the grains. Phenological observations in soybean cultivars for vegetative growth proceeded in four periods. At the same time, the number of bacteria in their root nodules was also counted. It should be noted that after 7–10 days of soybean germination, the bacterium *Rhizobium japonicum* begins to appear in its root nodules, which absorb free atmospheric nitrogen (Leshchenko *et al.,* 1987). Phenological observations during the shooting period also corresponded to the end of May and the beginning of June.

The results of the average morphological indicators of soybean cultivars during the shooting period for plant height in soybean cultivars were in Genetic-1 (26.5 ± 0.25 cm), Sochilmas (17.1 ± 0.17 cm), and cultivar Orzu (19.0 ± 0.24 cm) (Table 8). In soybean, the number of nodes for early-maturing cultivar Genetic-1, Sochilmas, and Orzu, was 6.0 ± 0, 4.8 ± 0.12, and 5.4 ± 0.08 pcs, respectively. Numerous studies at the Institute of Genetics and Experimental Plant Biology revealed that in different phases of soybean growth and development, morphological and economic characteristics, the amount of chlorophyll in the leaves, oil, and protein content, and isoenzyme markers

*A* *B*

**Figure 3.** Root nodules soybean cultivars Genetik-1 (A) and Orzu (B) in the shooting phase.

A B

**Figure 4.** Root nodules in the shooting phase of soybean Genetic -1 (A) and Sochilmas (B) cultivars.

differed with different degrees in grains of soybean germplasm (Yunuskhanov *et al.,* 2007, 2019; Kurbanbaev *et al.,* 2008; Abdurazakova *et al.,* 2020a, b; Fayziev *et al.,* 2020; Marguba *et al.,* 2020; Matniyazova *et al.,* 2022; Makamov *et al.,* 2023).

During the shooting period, the various soybean cultivars with the number of nodules were Genetic-1 (17.10 ± 0.35 pcs), Sochilmas (16.05 ± 0.11 pcs), and Orzu (17.65 ± 0.14 pcs) (Figures 3 and 4). However, it is notable that soybean cultivars did not differ significantly from each other regarding nodule formation at the time of shooting (Table 8). The second growing season was the flowering phase, the plant life's lengthy period. For 30–35 days of flowering, the plant grew by 1.5–2.0 cm per day and gave one new leaf. In addition, secondary roots also appeared, with the primary and lateral roots showing the maximum number of nitrogen-fixing nodules (Yormatova, 1987; Patricia *et al.,* 2011; Ran *et al.,* 2013; Zhao *et al.,* 2015; Wu *et al.*, 2017; Shuaimin *et al.,* 2019; Teng-Xiang *et al.,* 2019; Yangquanwei *et al.,* 2020; Yu *et al.*, 2022).

During the flowering period, the increased values of average plant height displayed in various soybean cultivars, i.e., Genetic-1 (56.0 ± 0.78 cm), Sochilmas (77.5 ± 0.4 cm), and Orzu (69.0 ± 0.32 cm). Comparatively, the cultivar Genetic-1 occurred shorter than the other cultivars, Sochilmas and Orzu (Table 9). During the flowering phase, no significant difference in the number of nodes per plant surfaced for most soybean genotypes. However, the numerical values for the cultivars Genetic-1, Sochilmas, and Orzu were almost the same for the number of nodes per plant, ranging from 11.50 ± 0.08 to 12.70 ± 0.07 pcs. On the number of nodules in the roots at the flowering phase, the soybean cultivars produced almost the same number of nodules, i.e., Genetic-1 (46.75 ± 0.32 pcs), Sochilmas (45.05 ± 0.11 pcs), and Orzu (46.50 ± 0.14 pcs) (Table 9).

The third period in soybeans was the fruiting and pod formation. The period of flowering and pod formation is a simultaneous process because the flowering continues from the bottom to the top of the plant, with the pod formation the same way. However, when the pods in the lower layer of the plant begin to run out, flowering continues in the upper layer. Results of the morphological and yield-related traits of soybean cultivars in the pod formation phase that include plant height and the number of nodes were in cultivar Genetik-1 (60.5 ± 0.24 cm and 11.7±0.07 pcs), cultivar Sochilmas (85.5 ± 0.66 cm and 16.7 ± 0.07 pcs), and cultivar Orzu (111.0 ± 0.69 cm and 17.4 ± 0.08 pcs). It clearly shows the soybean cultivar Genetik-1 is shorter in the pod formation phase than the Sochilmas and Orzu cultivars (Table 10).

For the number of nodules during the pod formation period, the soybean cultivars produced 86.75 ± 0.35 pcs for Genetik-1, 96.65 ± 0.11 pcs for Sochilmas, and 87.55 ± 0.14 pcs for cultivar Orzu. Generally, the cultivars developed almost the same number of nodules while in the pod phase (Table 10). During the soybean-ripening period, the plants seize the vegetative growth, with the pods beginning to ripen. Leaves turn yellow and fall off, and the water in the stem slowly decreases.

During the ripening period, the plant height in various soybean cultivars showed 60.5 ± 0.24 cm for Genetic 1, 85.5 ± 0.66 cm for Sochilmas, and 110.0 ± 0.71 cm for Orzu, with the cultivar Orzu being taller than the other cultivars (Table 11). According to the number of nodes, soybean cultivars showed non-significant differences for the said trait, ranging from 11.7 ± 0.07 to 17.4 ± 0.08. In various soybean genotypes, the same number of nodes per plant might be due to the plants' arrested growth during the pod's formation, spending all their energy on pod ripening.

Still, during the ripening period, the soybean cultivars showed a similar number of nodules per plant, i.e., Genetic-1 (6.75 ± 0.35), Sochilmas (5.50 ± 0.11), and Orzu (7.65 ± 0.14). At the maturity stage, the number of nodes was almost the same and naturally decreased because the nodes completed their activity and mixed with the soil composition (Figure 5). In the past studies of Umarov (2019a, b), the observed inoculation of soybean with various fungi also increased the plant height (85%) in the greenhouse conditions. The amount of macro-elements, i.e., nitrogen, phosphorus, and potassium, further increased in the plant tissues. In addition, under water deficit conditions, the soybean plants showed a sharp reduction in growth traits and root nodules (Umarov, 2019a, b).

After harvesting, analysis of the soybean plants of all the genotypes continued in the laboratory. Results of the analysis revealed the bulkiest number of grains per plant was in the cultivar Orzu (173.6 ± 7.31 pcs), followed by Sochilmas (149.7 ± 2.95 pcs), and Genetic-1 (89.4 ± 2.45 pcs). For 1000-grain weight, the soybean cultivar Sochilmas leads with the highest 1000-grain weight (15.4 ± 0.01 g), followed by Genetik-1 (12.97 ± 0.02 g), and Orzu (11.14 ± 0.01 g).

**Table 9.** General average morphological indicators of soybean cultivars during the flowering period.

| No. | Soybean cultivars | Plant height (cm) Mean±SE | Number of nodes (pcs) Mean±SE | Number of nodules (pcs) Mean±SE |
|---|---|---|---|---|
| 1 | Genetic-1 | 56.00±0.78 | 11.50±0.08 | 46.75±0.32 |
| 2 | Sochilmas | 77.50±0.40 | 12.70±0.07 | 45.05±0.11 |
| 3 | Orzu | 69.00±0.32 | 11.50±0.08 | 46.50±0.14 |

**Table 10.** Average morphological indicators of soybean cultivars during the pod formation period.

| No. | Soybean cultivars | Plant height (cm) Mean±SE | Number of nodes (pcs) Mean±SE | Number of nodules (pcs) Mean±SE |
|---|---|---|---|---|
| 1 | Genetic-1 | 60.5±0.24 | 11.7±0.07 | 86.75±0.35 |
| 2 | Sochilmas | 85.5±0.66 | 16.7±0.07 | 96.65±0.11 |
| 3 | Orzu | 111.0±0.69 | 17.4±0.08 | 87.55±0.14 |

**Table 11.** Average morphological and yield-related traits of soybean cultivars during ripening period.

| No. | Soybean cultivars | Plant height (cm) Mean±SE | The number of syllables (pcs) Mean±SE | Number of nodules (pcs) Mean±SE | Total number of grains Mean±SE | 1000-grain weight (g) Mean±SE | Total grain weight (g) Mean±SE |
|---|---|---|---|---|---|---|---|
| 1 | Genetic-1 | 60.5±0.24 | 11.7±0.07 | 6.75±0.35 | 89.4±2.45 | 12.97±0.02 | 11.65±0.34 |
| 2 | Sochilmas | 85.5±0.66 | 16.7±0.07 | 5.50±0.11 | 149.7±2.95 | 15.4±0.01 | 23.04±0.45 |
| 3 | Orzu | 110.0±0.71 | 17.4±0.08 | 7.65±0.14 | 173.6±7.31 | 11.14±0.01 | 20.59±1.06 |

**Figure 5.** A sharp decrease in the number of nodules in soybean roots during the ripening phase.

Nitrogen is one of the crucial nutrients for plants. In plant nutrition, nitrogen source is ammonium salts ($NH^+$) and nitrates ($NO^-$). With a lack of phosphorus in the nutrient medium, the plant stem and leaves stop growing, and as an external sign, the leaf edges become purple. However, under natural conditions, orthophosphoric acid salts serve as a source of plant nutrition (Musaev, 2001: Ramazonov *et al.,* 2020). The trace element potassium also plays an imperative role in plant life. As a result of potassium deficiency, the conversion of simple carbohydrates into more complex carbohydrates (di- and polysaccharides) slows down, disturbing the carbohydrate and protein metabolism Sufficient potassium nutrition enhances plant resistance to various diseases (Musaev, 2001).

Before sowing, soil samples taken from 0 to 30 cm layer of the arable layer used the envelope method to determine the soil composition of the experimental fields prepared for sowing (Table 12). The soil sample analysis showed that the soil content of plot 12 had the lowest values of P2O5 (12 mg/kg), K2O (158.9 mg/kg), and N (1.30 mg/kg). In these fields, the humus and carbon contents were also low (0.076% and 0.624%, respectively). Next season, after collecting the plants, the soil sampling underwent analysis, as seen in Table 13. Results showed the P2O5 and carbon increased in all the plots after the soybean harvest, with the amount of K2O also accumulating except for plots 3 and 11. The amount of humus was reversed, indicating a decrease in all the plots except plots 3 and 11.

**Table 12.** Chemical analysis of the soil composition before planting.

| No. | Section | Layer thickness (cm) | $P_2O_5$ (mg/kg) | $K_2O$ (mg/kg) | $N\text{-}NO_3$. (mg/kg) | Total (%) P | Total (%) K | N (%) | Humus (%) | Carbon (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Genetic-1, Plot 1 | 0-30 | 21.0 | 207.1 | 3.28 | 0.150 | 0.87 | 0.060 | 0.802 | 0.465 |
| 2 | Sochilmas, Plot 2 | 0-30 | 15.0 | 158.9 | 3.05 | 0.136 | 0.66 | 0.054 | 0.717 | 0.416 |
| 3 | Sochilmas, Plot 5 | 0-30 | 16.0 | 168.5 | 4.29 | 0.160 | 0.69 | 0.056 | 0.781 | 0.453 |
| 4 | Genetic-1, Plot 12 | 0-30 | 12.0 | 158.9 | 1.30 | 0.108 | 0.20 | 0.050 | 0.633 | 0.367 |
| 5 | Sochilmas, Plot 15 | 0-30 | 18.0 | 187.8 | 8.70 | 0.124 | 0.37 | 0.069 | 0.992 | 0.575 |
| 6 | Orzu, Plot 3 | 0-30 | 15.0 | 178.2 | 2.15 | 0.104 | 0.54 | 0.063 | 0.823 | 0.477 |
| 7 | Orzu, Plot 11 | 0-30 | 17.0 | 197.5 | 1.80 | 0.076 | 0.54 | 0.052 | 0.696 | 0.404 |

**Table 13.** Chemical analysis of the soil composition after soybean harvesting.

| No. | Section | $P_2O_5$ mg/kg | $K_2O$ mg/kg | $N\text{-}NO_3$, (mg/kg) | Total (%) P | Total (%) K | N (%) | Humus % | Carbon % |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Genetic -1, Plot 1 | 36.0 | 216.7 | 27.5 | 0.145 | 0.81 | 0.081 | 0.118 | 0.648 |
| 2 | Sochilmas, Plot 2 | 38.5 | 207.1 | 26.0 | 0.190 | 0.66 | 0.092 | 1.308 | 0.759 |
| 3 | Sochilmas, Plot 5 | 40.0 | 216.7 | 28.0 | 0.160 | 0.66 | 0.166 | 1.561 | 0.905 |
| 4 | Genetic-1, Plot 12 | 36.0 | 207.9 | 28.5 | 0.150 | 0.81 | 0.072 | 0.076 | 0.624 |
| 5 | Sochilmas, Plot 15 | 50.0 | 197.5 | 29.0 | 0.136 | 0.60 | 0.072 | 0.055 | 0.612 |
| 6 | Orzu, Plot 3 | 29.0 | 158.2 | 21.5 | 0.141 | 0.75 | 0.097 | 1.329 | 0.771 |
| 7 | Orzu, Plot 11 | 33.0 | 168.5 | 22.5 | 0.141 | 0.60 | 0.072 | 1.097 | 0.636 |

## CONCLUSIONS

Based on the presented findings, soybean cultivars of the botanical collection, i.e., Bk-9, Bk-18, Bk-24, Bk-80, Bk-90, Bk-96, K-90.20, K-2600, NC-17480, and Ya-04565, showed remarkable performance for morpho-yield traits and, hence, were selected and isolated to enrich the genetic collection. In the botanical collection, the highest grain yield per plant came from soybean cultivar K-2600 (48.3 ± 1.30 g.), 1000-grain weight from Bk-105 (215.9 ± 0.15 g), and the highest number of grains per plant from the genotype K-2600

(346.4 ± 6.48 pcs). In the genetic collection, the highest oil content occurred in the genotypes Gen-15 (20.11%), Gen-13 (19.46%), and Gen-11 (19.40%). The highest total protein content emerged in the soybean cultivars Gen-19 (34.72%), Ehtiyozh (34.09%), Gen-9 (33.74%), and Gen-26 (33.08%). The cultivar Sochilmas collected the most nodule bacteria in the soil (96.65 ± 0.11). After maturity, the plant released the bacteria and mixed it with the earth. According to soil analysis, the $K_2O$ element was inversely proportional to humus. After harvesting, the $K_2O$ content decreased in plots 3 and 11, while the humus content in these variants enhanced.

**ACKNOWLEDGMENTS**

The authors are grateful to researchers at the Institute of Genetics and Plant Experimental Biology and the Laboratory of Ecological Genetics and Plant Physiology, Academy of Sciences, Uzbekistan.

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