

Indicators of the Morpho-Economic Traits of the Daikon Plant Grown in Various Ecological Regions of Our Republic

Navruzбек Khusanov^{1,*}, Sayfulla Boboev², Shoirа Norkobilova³, Bonu Ibrokhimova⁴, Gulnora Uzokova⁵

¹Doctoral Student, Research Institute of Environment and Nature Conservation Technologies, Tashkent, Uzbekistan

²Professor, Head of the Department of Genetics, National University of Uzbekistan, Tashkent, Uzbekistan

³Researcher, Department of Genetics, National University of Uzbekistan, Tashkent, Uzbekistan

⁴Master's Degree, Department of Genetics, National University of Uzbekistan, Tashkent, Uzbekistan

⁵Teacher, 44th Comprehensive School, Yakkabag, Uzbekistan

Abstract The article presents research on the morpho-economic traits of daikon plant varieties and hybrids grown in the soil and climatic conditions of the Botanical Garden of the National University of Uzbekistan in Tashkent city, the Qibray district of the Tashkent region (Tashkent Thermal Power Plant), and the Muynoq district of the Republic of Karakalpakstan. The study examines the changes in the morpho-economic traits of these plants, with the results analyzed. It was found that the same seeds of varieties and hybrids showed different characteristics based on the soil and climatic conditions of different regions. The Sodiқ variety and the Cheong Du and Big Time hybrids had the highest morpho-economic indicators in the Botanical Garden of Tashkent city, while the lowest results were recorded in the Muynoq district of the Republic of Karakalpakstan. The study scientifically substantiates the significant impact of various ecological conditions on the morpho-economic traits of the plant.

Keywords Daikon plant, Ecological region, Morphological traits, Economic traits, Variety and hybrid, Trait variation, Yield indicators

1. Introduction

Radish (*Raphanus sativus* L.), belonging to the Brassicaceae family, is widely used around the world for vegetable production, animal feed, and oil extraction. Its thick root-crop and green leaves are consumed in various ways, including raw, pickled, dried, boiled, sprouted, and fermented as kimchi (a traditional Korean dish). Radishes are divided into five types based on their morphological and agronomic characteristics [1,2,10,11]: *Raphanus sativus* var. *sativus* L. (syn. var. *radicular* Pers.) (small European radish), var. *hortensis* Becker (large East Asian long radish), var. *niger* Kerner (black Spanish radish), var. *chinensis* Gallizioli (Chinese oil radish), and var. *caudatus* Hooker & Anderson (tail radish or forage radish).

Radishes were introduced to China via the Silk Road around 2,500 years ago and to Japan and Korea about 1,300 years ago [1-4]. Various radish varieties have developed in China since their introduction, leading to the differentiation of Chinese radishes into four ecotypes: Southern China,

Central China, Northern China, and the Western Plateau types [5,6]. Southern China radishes tend to have white skin, low starch content, and early flowering. Some Central Chinese varieties have red skins and white roots similar to Southern China types. Northern Chinese radishes are small, green, and have high starch content, while Western Plateau types are late-flowering radishes [6]. Japanese radishes are divided into five main groups: Minowase, Nerima, Miyashige, Shogoin, and Ninengo [7]. Korean radishes are believed to have originated from Southern and Northern Chinese varieties [4], and Japanese varieties, such as Minongjoseng (Minowase), Gungjung (Miyashige), Seonghowon (Shogoin), and Shimu (Tokinashi), were later introduced to Korea. Popular Korean varieties like Seoulbom, Uiseong, and Songjeongjikori were also developed. The first commercial F₁ variety, Bulamdaehyungbommu (Bulam spring large radish) was produced in 1967 and CO₂ was used to prevent autoinfection. followed by the development of many excellent F₁ hybrid varieties suited to different seasons (autumn, winter, spring, and summer) and consumer preferences (large root, small root, young leaves, and processing). Various F₁ hybrid varieties have also been developed for the Japanese market and exported to Japan since the 1970s. Currently, radish seeds are the largest export in Korea's vegetable seed market [12].

* Corresponding author:

navruzbekxusanov@mail.ru (Navruzбек Khusanov)

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The material for such research is obtained from the global collection of root crops of *Raphanus sativus* stored at the VIR genebank in the Russian Federation. The global collection of *Raphanus L.* root crops stored at the VIR genebank includes 2,810 samples from 75 countries, of which 2,800 samples (1,600 small radishes, 1,200 large radishes) belong to the species *R. sativus*, three to *Raphanus raphanistrum*, three to *Raphanus landra*, and four to *Raphanus caudatus*. The VIR collection is updated annually with modern breeding materials, primarily from countries like China, Japan, the Netherlands, Russia, as well as samples collected from Central Asia and Transcaucasia. New samples include local populations, breeding varieties, genetic lines, and F1 hybrids [8]. According to the European Plant Genetic Resources Catalogue, the *Raphanus sativus* collection in European genebanks contained 3,513 samples in 2021 [9]. The largest collections are in the UK genebank (WARGRU Warwick) with 1,350 samples, the German genebank (IPK–Gatersleben) with 661 samples, and the Dutch genebank (CGN–Wageningen) with 308 samples. The Japanese genebank (NARO Genebank) holds 441 samples, the US genebank (U.S. National Plant Germplasm System) holds 687 samples, and about 300 samples are stored in India. The largest collection of *Raphanus* is held in China's Plant and Flower Genetic Genebank, with more than 2,600 samples, including local varieties and F1 hybrids.

2. Materials and Methods

The Sodiq variety (Uzbekistan), Cheong Du (Korea), and Big Time (Korea) hybrids of the daikon plant were used as research objects. Experiments were conducted in the Botanical Garden of the National University of Uzbekistan (NUU), the Qibray district of the Tashkent region (Tashkent Thermal Power Plant), and the Muynoq district of the Republic of Karakalpakstan. The morpho-economic traits were analyzed using generally accepted methods for plant studies.

3. Results and Analysis

Varieties and hybrids of agricultural crops differ from each other in terms of morphological characteristics, which serve as important distinguishing features. By analyzing these morphological traits, it is possible to differentiate between varieties and hybrids, providing a basis for conclusions about their characteristics. The morpho-economic traits of varieties and hybrids can also vary depending on ecological conditions, requiring special attention. Taking these factors into account, the Sodiq variety, Cheong Du hybrid, and Big Time hybrid were planted in different ecological regions, and their morphological traits were analyzed. Five plants of each variety and hybrid were tagged, and all morphological traits were studied for each.

When analyzing plants grown in the Botanical Garden of

the National University of Uzbekistan (NUU) in Tashkent city, the number of leaves per plant for the Sodiq variety ranged from 20 to 28, with an average of 23.6 leaves per plant. In the Cheong Du hybrid plants, the number of leaves was slightly lower, ranging from 17 to 22, with an average of 19.2 leaves per plant. The Big Time hybrid had an average of 22.8 leaves per plant, confirming that there is a difference in the number of leaves between varieties and hybrids. The Sodiq variety had light green leaves, while the two hybrids had dark green leaves.

The number of leaflets per plant also varied, with the Sodiq variety averaging 10 leaflets, while the Cheong Du and Big Time hybrids averaged 6.8 leaflets. When measuring leaf length, the Sodiq variety had leaves ranging from 23 to 40 cm in length, with an average leaf length of 29.5 cm. In the Cheong Du hybrid, leaf length was smaller, ranging from 14.5 to 25.1 cm, with an average length of 20.6 cm. The Big Time hybrid plants had medium-sized leaves, with a length ranging from 17.5 to 35.0 cm, and an average leaf length of 26.1 cm (Table 1).

Leaf hairiness is also considered important, as the degree of hairiness is often an indicator of a plant's resistance to insects. In the studied Sodiq variety, the leaves were mainly hairy on the underside, while the Cheong Du and Big Time hybrid plants were found to have fully hairy leaves on both the upper and lower surfaces. In terms of leaf shape, all the varieties and hybrids studied showed the same characteristic, with leaves having a pinnate shape. Correspondingly, it was also determined that the leaf venation in all three objects was palmate.

The main fruit of the daikon plant is its root crop. When analyzing the length of the root crop, it was found that the Sodiq variety had a root crop length ranging from 29 to 35 cm, with an average length of 32.2 cm. The root crop length of the Cheong Du and Big Time hybrids was 20 cm and 22.8 cm, respectively, which was significantly lower than the Sodiq variety. In terms of root crop diameter, the Sodiq variety had a relatively smaller diameter, with an average diameter of 22.1 cm per root. The Cheong Du hybrid had an average root crop diameter of 25.9 cm, while the Big Time hybrid had a root crop diameter of 28.4 cm. This shows that the Sodiq variety had longer and relatively thinner roots, whereas the Cheong Du and Big Time hybrids had shorter and thicker roots.

In line with these indicators, the weight of the root crop was analyzed. According to the results, the root crop of the Sodiq variety ranged from 850 to 920 grams in the five studied plants, with an average weight of 896.4 grams per root. The Cheong Du hybrid recorded the lowest result in terms of root crop weight, with a range of 695 to 795 grams, and an average weight of 738 grams per root. The best result was observed in the Big Time hybrid, with root crops ranging from 950 to 1035 grams, and an average weight of 1002 grams per root. This confirms that the Big Time hybrid achieved the best result in terms of root crop weight, which is one of the main indicators of yield.

Table 1. Some morphological indicators of varieties and hybrids of daikon in the Botanical Garden of the NUU of Tashkent

Sort and hybrids	Number of leaves	Color of leaves	Number of leaf segments	Barg boyi (sm)	Leaf pubescence	Leaf shape	Leaf venation	Root length	Root diameter	Root weight
Variety of Daikon's Sodi (Uzbekistan) Botanical Garden of the NUU of Tashkent										
1	25	light green	14	40	hairy underneath	Uneven Pinnate	Palmate	34	24	915
2	23	light green	10	28	hairy underneath	Uneven Pinnate	Palmate	32	21.9	902
3	22	light green	8	23	hairy underneath	Uneven Pinnate	Palmate	31	21	895
4	28	light green	9	24.5	hairy underneath	Uneven Pinnate	Palmate	35	25	920
5	20	light green	9	32	hairy underneath	Uneven Pinnate	Palmate	29	18.5	850
Average	23.6		10	29.5				32.2	22.08	896.4
Hybrid of Daikon's Cheong Du (Korea) Botanical Garden of the NUU of Tashkent										
1	18	Dark green	5	14.5	Hairy	Uneven Pinnate	Palmate	20	28	760
2	22	Dark green	7	21.5	Hairy	Uneven Pinnate	Palmate	22	29.5	795
3	20	Dark green	6	25.1	Hairy	Uneven Pinnate	Palmate	21	26	730
4	17	Dark green	6	23	Hairy	Uneven Pinnate	Palmate	18	22	695
5	19	Dark green	10	19.1	Hairy	Uneven Pinnate	Palmate	19	24	710
Average	19.2		6.8	20.64				20	25.9	738
Hybrid of Daikon's Big Time (Korea) Botanical Garden of the NUU of Tashkent										
1	23	Dark green	8	35	Hairy	Uneven Pinnate	Palmate	24	30	1020
2	26	Dark green	7	31	Hairy	Uneven Pinnate	Palmate	25	30.9	1035
3	21	Dark green	6	27	Hairy	Uneven Pinnate	Palmate	22	28	995
4	24	Dark green	7	17.5	Hairy	Uneven Pinnate	Palmate	23	29	1010
5	20	Dark green	6	20	Hairy	Uneven Pinnate	Palmate	20	25.8	950
Average	22.8		6.8	26.1				22.8	28.74	1.002

The second experimental area was located in the Qibray district of the Tashkent region (Tashkent Thermal Power Plant), where the indicators for leaf color, hairiness, shape, and venation were similar to those of the first experimental area, though differences in other morphological traits were observed. In terms of the number of leaves per plant, the Sodi variety had the highest indicator, with an average of 22.4 leaves per plant. The Cheong Du hybrid had between 15 and 20 leaves per plant, with an average of 17.6 leaves, while the Big Time hybrid had between 18 and 22 leaves per plant, averaging 20 leaves. The Sodi variety had an average of 6.4 leaf segments, the Cheong Du hybrid had 5.8 segments, and the Big Time hybrid had 4.4 segments. It was found that the number of leaf segments in the second experimental area

differed significantly from those observed in the Botanical Garden of NUU (National University of Uzbekistan).

The leaf length in the Sodi variety ranged from 15.5 to 22.0 cm, with an average leaf length of 18.58 cm. The Cheong Du hybrid had a slightly higher average leaf length of 20.14 cm. The Big Time hybrid had leaves ranging from 14.2 to 16.4 cm in length, with an average length of 15.22 cm. It was also noted that the leaf length in the second experimental area was significantly lower. Based on the results, significant differences were found in the number of leaves per plant, the number of leaf segments, and leaf size between the first and second experimental areas, showing that the morphological traits of the same varieties and hybrids change when grown in different ecological zones (Table 2).

Further studies focused on root crop analysis, and in this area, the Sodiq variety again showed the highest result in terms of root crop length, with lengths ranging from 25 to 32 cm and an average length of 28.4 cm. The root crop length of the Cheong Du hybrid was slightly longer than in the first experimental area, with an average length of 23.38 cm. A positive change was also observed in the Big Time hybrid, where the root crop length ranged from 24 to 27 cm, with an average length of 25.2 cm.

The largest root crop diameter was recorded for the Big Time hybrid, with the diameter of the plant's root crop being 24.24 cm. In comparison, the root crop diameters for the Sodiq variety and the Cheong Du hybrid were 19.3 cm and

19.04 cm, respectively, which were lower than the figures recorded in the first ecological area. There was also a significant difference in root crop weight compared to the first area, specifically a decrease. The weight of the root crop for the Sodiq variety ranged from 480 to 670 grams, with an average of 569 grams. The Cheong Du hybrid's root crop weight ranged from 390 to 560 grams, with an average of 475 grams. The Big Time hybrid recorded the best result, with root crop weights ranging from 550 to 705 grams and an average weight of 617 grams. Overall, it was found that several indicators in the second area were lower compared to those in the first experimental field, confirming that these differences are linked to the ecological environment.

Table 2. Some morphological indicators of Daikon varieties and hybrids in the conditions of the territory of Kybrai district (Tashkent Thermal Power Plant) of Tashkent region

Sort and hybrids	Number of leaves	Color of leaves	Number of leaf segments	Barg boyi (sm)	Leaf pubescence	Leaf shape	Leaf venation	Root length	Root diameter	Root weight
Variety of Daikon's Sodiq (Uzbekistan) Kybrai district (The vicinity of Tashkent Thermal Power Plant) of Tashkent region										
1	20	Light green	8	18	Hairy underneath	Uneven Pinnate	Palmate	25	16	480
2	23	Light green	8	18	Hairy underneath	Uneven Pinnate	Palmate	27	18	530
3	23	Light green	5	19.4	Hairy underneath	Uneven Pinnate	Palmate	28	18.9	555
4	22	Light green	6	15.5	Hairy underneath	Uneven Pinnate	Palmate	30	21	610
5	24	Light green	5	22	Hairy underneath	Uneven Pinnate	Palmate	32	22.6	670
Average	22.4		6.4	18.58				28.4	19.3	569
Hybrid of Daikon's Cheong Du (Korea) Kybrai district (The vicinity of Tashkent Thermal Power Plant) of Tashkent region										
1	15	Dark green	6	25.6	hairy	Uneven Pinnate	Palmate	22	17	390
2	18	Dark green	5	18.4	hairy	Uneven Pinnate	Palmate	23.4	19.2	475
3	19	Dark green	5	17.5	hairy	Uneven Pinnate	Palmate	24	20	520
4	16	Dark green	7	18.6	hairy	Uneven Pinnate	Palmate	22.5	18	430
5	20	Dark green	6	20.6	hairy	Uneven Pinnate	Palmate	25	21	560
Average	17.6		5.8	20.14				23.38	19.04	475
Hybrid of Daikon's Big Time (Korea) Kybrai district (The vicinity of Tashkent Thermal Power Plant) of Tashkent region										
1	18	Dark green	5	15	hairy	Uneven Pinnate	Palmate	24	23	550
2	20	Dark green	4	15.4	hairy	Uneven Pinnate	Palmate	26	25	665
3	21	Dark green	4	15.1	hairy	Uneven Pinnate	Palmate	25	24	605
4	19	Dark green	5	14.2	hairy	Uneven Pinnate	Palmate	24	23.2	560
5	22	Dark green	4	16.4	hairy	Uneven Pinnate	Palmate	27	26	705
Average	20		4.4	15.22				25.2	24.24	617

Table 3. Some Morphological Characteristics of Daikon Varieties and Hybrids Grown in the Conditions of Muynak District, Republic of Karakalpakstan

Sort and hybrids	Number of leaves	Color of leaves	Number of leaf segments	Barg boyi (sm)	Leaf pubescence	Leaf shape	Leaf venation	Root length	Root diameter	Root weight
Variety of Daikon's Sodiq (Uzbekistan) Muynak district, Republic of Karakalpakstan										
1	20	Light green	6	27	Hairy underneath	Uneven Pinnate	Palmate	23	14	420
2	18	Light green	5	17.2	Hairy underneath	Uneven Pinnate	Palmate	22	13.2	398
3	16	Light green	7	16	Hairy underneath	Uneven Pinnate	Palmate	20.8	11.9	375
4	19	Light green	8	13.4	Hairy underneath	Uneven Pinnate	Palmate	23	14.2	425
5	18	Light green	5	13	Hairy underneath	Uneven Pinnate	Palmate	19.5	10.5	360
Average	18.2		6.2	17.32				21.66	12.76	395.6
Hybrid of Daikon's Cheong Du (Korea) Muynak district, Republic of Karakalpakstan										
1	14	Dark green	5	13.3	hairy	Uneven Pinnate	Palmate	22	17	400
2	14	Dark green	6	16	hairy	Uneven Pinnate	Palmate	23	17.8	420
3	11	Dark green	7	10.2	hairy	Uneven Pinnate	Palmate	22	13.2	398
4	13	Dark green	6	12.1	hairy	Uneven Pinnate	Palmate	20	10.5	362
5	15	Dark green	7	12.2	hairy	Uneven Pinnate	Palmate	24	18.2	431
Average	13.4		6.2	12.76				22.2	15.34	402.2
Hybrid of Daikon's Big Time (Korea) Muynak district, Republic of Karakalpakstan										
1	17	Dark green	5	11.2	hairy	Uneven Pinnate	Palmate	24	23	550
2	17	Dark green	6	10.6	hairy	Uneven Pinnate	Palmate	23	22	530
3	16	Dark green	6	8.4	hairy	Uneven Pinnate	Palmate	21.3	20.6	502
4	18	Dark green	5	9	hairy	Uneven Pinnate	Palmate	24.1	20.8	556
5	15	Dark green	5	10	hairy	Uneven Pinnate	Panjasimon	20.5	18.9	480
Average	16.6		5.4	9.84				22.58	21.06	523.6

The third experimental site was located in the more ecologically challenging district of Muynak in the Republic of Karakalpakstan, where certain morphological traits of the daikon plant varieties and hybrids were identified. As in the previous two regions, no changes were observed in the studied varieties and hybrids regarding leaf color, hairiness, shape, and venation. That is, the Sodiq variety had light green leaves, while the Cheong Du and Big Time hybrids had relatively dark green leaves. Leaf hairiness, shape, and venation were consistent with the results from the first and second experimental fields. However, significant decreases in other traits were observed, especially when compared to

the results from the Botanical Garden of NUU in Tashkent. This clearly demonstrates the impact of the ecological environment on the changes in morphological traits.

In terms of the number of leaves per plant, the Sodiq variety had between 16 and 20 leaves, with an average of 18.2 leaves per plant. The Cheong Du hybrid had 11 to 15 leaves per plant, with an average of 13.4 leaves, while the Big Time hybrid had between 15 and 18 leaves per plant, with an average of 16.6 leaves. According to the research, the Cheong Du hybrid had relatively fewer leaves per plant. In terms of leaf segments, there were no drastic differences. Both the Sodiq variety and the Cheong Du hybrid had an

average of 6.2 segments, while the Big Time hybrid had 5.4 segments. The leaf length for the Sodiq variety ranged from 13 to 27 cm, with an average length of 17.3 cm, while the Cheong Du hybrid had leaf lengths ranging from 10.2 to 16 cm, with an average of 12.76 cm. The Big Time hybrid had leaf lengths ranging from 8.4 to 11.2 cm, with an average of 9.84 cm. It was found that the leaf length for plants grown in Muynak conditions was significantly lower compared to plants grown in Tashkent and the Tashkent region, showing the high impact of the ecological environment on the development of morphological traits (Table 3).

Along with these traits, the root crop of the daikon plants grown in Muynak conditions was also found to be relatively smaller. First, the root crop length was determined: for the Sodiq variety, the root crop length ranged from 19.5 to 23 cm, with an average of 21.6 cm. For the Cheong Du hybrid, the root crop length ranged from 22 to 24 cm, with an average of 22.2 cm. The Big Time hybrid had root crop lengths ranging from 20.5 to 24.1 cm, with an average length of 22.5 cm. There was no significant difference in root crop length between the varieties and hybrids. The second characteristic was root crop diameter, with the Sodiq variety having a relatively thinner root crop, with an average diameter of 12.76 cm. The Cheong Du hybrid had a slightly larger average diameter of 15.34 cm, while the Big Time hybrid had a significantly thicker root crop, with an average diameter of 21.06 cm. However, the root crop diameters were found to be lower than those recorded in the first two experimental fields.

It was also found that the weight of the root crop in Muynak district conditions was significantly lower compared to those grown in Tashkent city and Tashkent region. When grown in the Muynak district, the weight of one root crop of the Sodiq variety ranged from 360 to 425 grams, with the average weight of one root crop being 395.6 grams. It is worth mentioning that when this variety was grown in the conditions of the Botanical Garden of the National University of Uzbekistan (NUU) in Tashkent, the weight of one root was 896.4 grams, while in the Qibray district it was 569 grams. These figures confirm that the weight of the daikon root crop is greatly influenced by different environmental conditions. In the conditions of Muynak district, the weight of one root of the Cheong Du hybrid ranged from 362 to 431 grams, with the average weight being 402.2 grams. For the Big Time hybrid, the weight of one root crop ranged from 480 to 556 grams, with an average of 526.6 grams. It can be observed that the weight of one root in the studied varieties and hybrids has decreased by up to 2 times compared to those grown in the Botanical Garden of NUU in Tashkent. The weight of one root crop is a key indicator of yield, and a significant decline in this indicator was observed in the conditions of Muynak district, showing that the yield is relatively low in this region. Therefore, it is advisable to increase the number of daikon plants per hectare in the conditions of the Muynak district.

4. Conclusions

The morpho-economic traits of the daikon plant were analyzed in various ecological regions of our republic. According to the results obtained, it was found that the same seeds of varieties and hybrids show different traits depending on the soil and climate conditions of different regions.

Based on the results of studying the Sodiq variety and Cheong Du and Big Time hybrids in three ecological zones, it was revealed that the morphological traits of the plants and the lower root crop and yield were more pronounced in the Cheong Du hybrid.

When analyzing the regions, it was found that the morpho-economic indicators of the Sodiq variety and the Cheong Du and Big Time hybrids were highest in the conditions of the Botanical Garden of NUU in Tashkent, while the lowest results were observed in the conditions of Muynak district in the Republic of Karakalpakstan. The sharp decline in the weight of one root crop, which determines yield, was observed in the conditions of Muynak, confirming that the yield is relatively low in this region. This clearly confirms the strong influence of different environmental conditions on the morpho-economic traits of the plant.

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