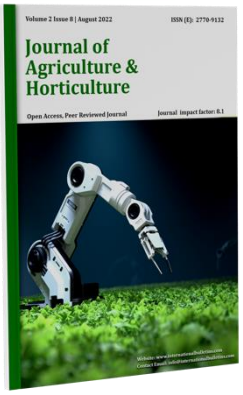

CHARACTERISTICS OF GARLIC CULTIVATION IN THE SOUTHERN REGIONS OF THE REPUBLIC OF KARAKALPAKSTAN

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https://doi.org/10.5281/zenodo.15751589

This article presents the technological features of garlic cultivation in the southern regions of the Republic of Karakalpakstan. Eight garlic varieties were evaluated based on key agronomic traits, and the high-yielding varieties were identified and selected. The study also determined the advantages of garlic cultivation in this region, including early maturity, productivity, and the impact of local environmental conditions on yield and quality.

Keywords: garlic, varietal samples, southern region, cultivation, bulb, stem, leaf,yield.

Introduction

Garlic (*Allium sativum L.*), one of the most valuable vegetable crops globally, is cultivated on a total area of 1.664 million hectares worldwide, according to the United Nations. The average yield is approximately 17.0 tons per hectare, with a total global production reaching 28.3 million tons. China holds the leading position in garlic production, cultivating 831.8 thousand hectares and producing 20.5 million tons of garlic. India ranks second, with 392.0 thousand hectares under cultivation and a total yield of 3.1 million tons. Other major garlic-producing countries with high total outputs include Bangladesh, Egypt, and Spain. In Uzbekistan, the total production stands at 195 thousand tons, with 6.1 thousand hectares of cultivated land and an average yield of 32.0 tons per hectare.

In many countries, garlic is traditionally valued not only as a culinary ingredient but also as a medicinal plant rich in essential vitamins and bioactive compounds. However, under the influence of global climate change, many vegetable-producing countries are experiencing a significant decline in crop yields due to the negative effects of both abiotic and biotic stress factors. This trend has also affected garlic productivity.

Currently, researchers around the world are actively engaged in the development, introduction, and cultivation of new garlic varieties that are high-yielding, early-maturing, disease-resistant, tolerant to adverse environmental conditions, and rich in nutrients.

In recent years, increased attention has been given to garlic cultivation in Uzbekistan, largely due to its partial immune-boosting effects, particularly relevant since the emergence of the COVID-19 pandemic in 2019. This situation has led to increased demand and consumption of garlic, prompting a need for the introduction and environmental adaptation of new varieties. In particular, the northern region of Uzbekistan — the Republic of Karakalpakstan

— lacks comprehensive scientific research on selecting high-yielding garlic varieties, adapting them to local conditions, and optimizing sowing times and cultivation methods. Therefore, developing and scientifically validating the technological elements of garlic cultivation in this region has become a critical issue.

In line with national efforts to ensure food security, meet the growing demand for vegetables, and diversify vegetable production, Uzbekistan has implemented several strategic initiatives. These include Presidential Decree No. PF-5853 of October 23, 2019, "On Approving the Strategy for the Development of Agriculture of the Republic of Uzbekistan for 2020–2030," Resolution No. PQ-4863 of October 15, 2020, "On Measures to Expand the Cultivation and Export of Garlic and Off-Season Vegetables," and Decree No. 60 of January 29, 2022, "On the Development Strategy of New Uzbekistan for 2022–2026." These documents emphasize the adoption of intensive farming technologies, improvement of food safety, enhancement of nutritional quality, and the implementation of innovative, resource-efficient agrotechnologies.

Given its medicinal properties, richness in phytoncides, vitamins, and carbohydrates, garlic is recognized as a functional food that strengthens the immune system. Promoting its cultivation and increasing its consumption is an urgent priority in today's health-conscious world.

Methodology

This scientific study was conducted during 2022–2024 by the Department of Pomology, Vegetable and Melon Crops of the Karakalpakstan Institute of Agriculture and Agrotechnologies, and in the territories of Kholimbeg Rural Citizens' Assembly and Bogh Mahalla Citizens' Assembly of Amudarya District, Republic of Karakalpakstan.

Given the agro-bioecological and farming characteristics of Karakalpakstan, the territory is divided into two parts: the southern districts occupy 16.3 thousand km^2, while the northern districts are spread over 143.2 thousand km^2.

In the southern region of Karakalpakstan, the growth and development of garlic plants are closely related to air and soil temperature, which plays a critical role in determining the optimal planting time for cloves. During the growing period, fluctuations in daily air temperature, soil temperature, precipitation, and bulb formation are considered the key factors influencing plant development. These factors ensure the achievement of high-quality and abundant garlic yield.

In this experiment, 8 garlic variety samples were planted in open fields from cloves during the third ten-day period of August and were evaluated based on a complex of valuable agronomic traits. Among them, 3 local varieties and 5 clones were compared. The variety "Mayskiy VIR," registered in the national varietal registry, was used as the standard for comparison. The experiment was arranged in four replications with a planting area of 11.2 m^2. Garlic cloves were planted using a three-row band method at a spacing of 40+15+15/3×10 cm. The total experimental area was 358 m^2, with plot dimensions of 8 m in length and 1.4 m in width, containing 480 plants per plot.

During the field trials, phenological observations, biometric measurements, biochemical analysis of bulbs, and economic efficiency assessments were carried out following several established methodologies. These included:

- "Methodology for State Variety Testing of Agricultural Crops," Volume IV: Potatoes, Melons, and Vegetables (Moscow: Kolos, 1975);
- "Field Experiment Methodology" (Dospekhov B.A., 1985);

• "Experimental Methods in Vegetable and Melon Crops" (Belik V.F., 1992);

• OST-4671-78: Compilation of Regulatory Documents for Vegetable Crop Seeds and Planting Materials (Moscow, VNIISSOK, 1997);

• "Methodology of Conducting Experiments in Vegetable, Melon and Potato Cultivation" (A. Azimov et al., 2002).

To determine the economic efficiency of garlic cultivation technology, the guidebook titled "Model Technological Maps for the Cultivation and Production of Agricultural Crops for 2020–2025," Part II (Tashkent: Ministry of Agriculture of Uzbekistan, 2020) was used.

Research Results

Eight garlic variety samples were planted in open field conditions during the third ten-day period of August. The germination, phenological development phases, and their durations were identified for each garlic variety in the experiment. The following stages were monitored: the emergence of seedlings after planting, field germination rate of cloves, appearance of the second and third true leaves, bulb formation, yellowing of the stems, physiological maturity of the bulbs, harvest time, and the overall duration of the growing period (see Table 1).

In this scientific study, the seedling emergence period among the garlic varieties ranged from 14 to 18 days. The standard variety *Mayskiy VIR* showed emergence on the 18th day, while *Yuzhno-Fioletoviy* and clone *K22-1* exhibited the same result (18 days). The remaining varieties emerged 1–4 days earlier than the standard. The earliest emergence (14 days) was recorded in clones *K22-3* and *K22-4*.

Field germination rates of garlic cloves varied from 85.7% to 97.5%. The highest germination was observed in clones *K22-4* and *K22-5*, with 95.0%–97.5% emergence. The lowest rates were found in *Yuzhno-Fioletoviy* and *K22-1*, ranging between 85.7% and 86.0%, indicating relatively poor germination capacity in these samples.

The appearance of the second and third true leaves was also monitored after seedling emergence. This phase showed little variation between varieties, occurring within 13 to 15 days. However, significant differences were observed during the bulb formation phase, which ranged from 194 to 203 days among the varieties. In the standard variety *Mayskiy VIR*, bulbs began forming on day 199. In comparison, the *Chidamli* variety and clones *K22-4* and *K22-5* began bulb formation 3–5 days earlier (194–196 days). Conversely, clones *K22-2* and *K22-5* formed bulbs later than the standard (203 days).

The yellowing of garlic stems also differed among the tested varieties. One of the critical indicators—technical maturity of the bulbs—showed the following results: in the standard variety *Mayskiy VIR*, bulbs reached technical maturity on day 235.

Table 1

Germination and Duration of Developmental Phenophases of Garlic Varieties (2022–2024).

№	Variety Sample	Days to Full Seedling Emergence	Field Germination Rate (%)	From the full maturity of the seedlings to..., days					Growth period, days
				Appearance of 2-3 true leaves	Bulb formation	Yellowing of the stems	The technical maturity of the bulbs	Harvesting the yield	
1	Mayensky VIR-st	18	87,5	15	199	223	235	238	256
2	Yuzhno-Fioletoviy	18	85,7	15	201	229	240	246	264
3	Chidamli	16	90,0	14	195	228	234	240	256
4	$K_{22}-1$	18	86,0	15	200	228	239	242	260
5	$K_{22}-2$	17	88,7	14	203	231	242	247	264
6	$K_{22}-3$	14	93,0	13	194	233	230	234	248
7	$K_{22}-4$	14	97,5	13	196	235	232	235	249
8	$K_{22}-5$	16	95,0	14	203	230	243	250	266

Compared to the standard cultivar, the *Chidamli* variety matured 1 day earlier, while the *K22-3* and *K22-4* clones matured 5 and 3 days earlier, respectively. In contrast, the *K22-2* and *K22-5* clones exhibited a delayed maturation, reaching full maturity 7–8 days later than the standard.

During the harvest phase, the control cultivar *Maisky VIR* was harvested at 238 days after planting. In the other cultivars, the harvesting period ranged from 234 to 250 days. Notably, the *K22-3* and *K22-4* clones were harvested 3–4 days earlier (234–235 days), whereas the *Yuzhno-Fioletovy*, *K22-2*, and *K22-5* clones were harvested later (246–250 days) compared to the standard. These differences are indicative of the morphological, biological, and developmental characteristics specific to each genotype.

In this experiment conducted in the southern region of the Republic of Karakalpakstan, the total vegetative period of garlic was determined. The standard *Maisky VIR* cultivar had a vegetative period of 256 days. Other cultivars ranged from 248 to 266 days. Among them, the *K22-5* clone showed the longest vegetative period, being 10 days longer than the standard.

As part of the study, biometric measurements were carried out to evaluate the vegetative growth of garlic plants. Parameters measured included the number of true leaves per plant, leaf length, leaf width, pseudostem height, pseudostem diameter, and the average weight of the pseudostem per plant (Table 2). These measurements were conducted twice annually: once during the first ten days of November, and again during the last ten days of May.

According to the obtained results, the above-ground vegetative growth was comparatively lower during the first measurement and increased significantly in the second. Analyzing the second measurement data presented in Table 2, the number of true leaves per plant varied from 7.2 to 8.3. Both the *Maisky VIR* and *Yuzhno-Fioletovy* cultivars had 7.2 leaves

per plant. All other genotypes showed higher leaf numbers, exceeding the standard by 0.2 to 1.1 leaves. The highest values were recorded in the *K22-3* and *K22-4* clones, with 8.2 and 8.3 leaves, respectively.

Leaf length in the second measurement ranged between 44.6 cm and 52.7 cm. The shortest leaves were observed in the *Maisky VIR* control (44.6 cm), while all other genotypes surpassed this value. The longest leaves were recorded in *K22-3* and *K22-4*, reaching 52.5 and 52.7 cm, respectively. Leaf width across genotypes ranged from 2.2 cm to 2.8 cm.

Pseudostem height, measured during the last ten days of May, was 58.5 cm in the standard cultivar. Only the *Yuzhno-Fioletovy* cultivar had a lower height (57.0 cm). All other genotypes exceeded the standard, with *K22-3* and *K22-4* demonstrating the highest pseudostem heights of 64.0 and 64.7 cm, respectively. The diameter of the pseudostem varied between 2.0 cm and 2.4 cm, with minor variation among the cultivars.

The average pseudostem weight per plant, measured in the third decade of May, also showed notable differences. The lowest weight (210 grams) was recorded in the standard *Maisky VIR* cultivar. Other genotypes showed weights 7 to 30 grams higher than the control. The *Yuzhno-Fioletovy* cultivar had a weight close to the standard (217 g), whereas the highest weights were observed in *K22-3* and *K22-4*, with 236 g and 240 g, respectively.

These results clearly indicate that under the agro-ecological conditions of southern Karakalpakstan, the *K22-3* and *K22-4* clones exhibit superior vegetative growth among all tested garlic cultivar

Table 2

Vegetative Growth and Biometric Measurements of Garlic Cultivars (2022-2024)

№	Variety Samples	Number of true leaves per plant, pieces		Leaf length, cm		Leaf width, cm	Pseudostem height, cm		Pseudostem diameter, cm		Average weight of a single pseudostem, g	
		IX-I	V-III	IX-I	V-III	V-III	IX-I	V-III	IX-I	V-III	IX-I	V-III
1	Mayensky VIR-st	3,2	7,2	9,5	44,6	2,3	12,0	58,5	1,2	2,2	35	210
2	Yuzhno-Fioletoviy	3,2	7,2	10,2	45,0	2,2	12,5	57,0	1,0	2,0	38	217
3	Chidamli	4,0	7,6	12,5	50,2	2,8	14,6	62,4	1,3	2,2	41	232
4	K_{22} - 1	3,8	7,4	10,0	49,0	2,4	14,1	60,9	1,0	2,2	34	224
5	K_{22} - 2	3,4	7,4	10,7	48,4	2,5	14,3	61,0	1,2	2,0	35	225
6	K_{22}- 3	4,2	8,2	13,8	52,7	2,8	16,2	64,0	1,2	2,4	38	236
7	K_{22}- 4	4,2	8,3	14,0	52,5	2,8	16,3	64,7	1,3	2,3	40	240
8	K_{22}- 5	4,0	7,6	11,2	50,1	2,6	13,8	63,6	1,0	2,0	37	228

In the conducted research, yield indicators of garlic bulb varieties were calculated over the years. The total yield of garlic, marketable yield, the share of marketable yield, and the ratio of marketable yield to the standard variety were determined (Table 3). According to the results, the average total yield collected from the standard variety was 24.8 t/ha. In comparison to the standard variety, the Southern Violet variety and the K22-5 clone yielded similarly (25.0–

26.4 t/ha). This result was deemed statistically significant with a minimal difference of 0.76 t/ha, indicating equivalence to the standard variety. Other varieties showed relatively higher yields (26.9–30.0 t/ha). The highest yields were recorded in the K22-3 and K22-4 clones, with 29.9–30.0 t/ha.

The experiment also distinguished between marketable and non-marketable yields, with the marketable yield ranging between 23.5 t/ha and 29.2 t/ha across the various varieties. In the standard variety (Mayak VIR), the marketable yield was 23.5 t/ha, and due to the minimal significant difference of 0.51 t/ha, the Southern Violet variety also showed equivalent yields (23.8 t/ha). The highest yield was again observed in the K22-3 and K22-4 clones, which produced 29.2 t/ha, marking them as high-yielding varieties.

When analyzing the share of marketable yield, it was found that the standard variety accounted for 94.8%. However, all other varieties showed higher percentages. Notably, the highest shares of marketable yield were observed in the varieties "Chidamli," K22-3, and K22-4, with percentages ranging between 97.0% and 97.6%.

The conducted research also revealed that garlic cultivation in the southern region of the Republic of Karakalpakstan yielded higher productivity in some varieties compared to the standard. Among the 8 varieties tested, the K22-3 and K22-4 clones produced 24% more yield compared to the standard variety, while the "Chidamli" variety and K22-2 clone showed 14-15% higher yields. Other varieties exhibited yields closer to those of the standard variety. The highest overall yield was obtained from the K22-3 and K22-4 clones, marking them as the most productive varieties.

Table 3

Yield performance indicators of garlic varieties (2022-2024).

Variety Samples	Total yield, t/ha				Marketable yield, t/ha				Marketable yield share, %	Relative to standard, %
	2022 year.	2023 year.	2024 year.	Average	2022 й.	2023 year.	2024 year.	Average		
Mayensky VIR-st	24,2	24,8	25,5	24,8	23,0	23,7	23,8	23,5	94,8	100
Yuzhno-Fioletoviy	24,8	25,6	25,8	25,0	23,8	22,6	25,0	23,8	95,4	101
Chidamli	27,3	27,9	28,2	27,8	26,2	26,9	27,9	27,0	97,0	115
K_{22} - 1	26,8	26,5	27,6	26,9	24,4	26,3	27,2	25,9	96,4	110
K_{22} - 2	28,0	27,8	28,5	28,1	25,9	26,3	27,9	26,7	95,2	114
K_{22}- 3	29,3	30,0	30,8	30,0	28,5	29,2	29,9	29,2	97,4	124
K_{22}- 4	29,4	30,1	30,4	29,9	28,4	28,9	30,3	29,2	97,6	124
K_{22}- 5	26,3	26,4	26,6	26,4	25,2	24,5	26,8	25,5	96,7	108
EKMF $_{05}$				0,76				0,51		
S%				3,2				3,0		

In the experiment, the bulb height, diameter, shape, and weight, as well as the number and weight of cloves of garlic cultivars, were determined (Table 4).

Table 4

Weight, Number, and Shape Index Indicators of Garlic Cultivars Bulbs (2022-2024).

№	Variety samples	Bulbs				Cloves	
		Height, cm	Diameter, cm	Shape index	Weight, g	Number, pieces	Weight, g
1	Mayensky VIR-st	3,7	5,2	0,7	54	13	4,1
2	Yuzhno-Fioletoviy	3,8	5,3	0,7	59	14	4,2
3	Chidamli	4,0	5,4	0,7	64	12	5,3
4	K_{22} - 1	3,8	5,2	0,7	60	12	5,0
5	K_{22} - 2	3,9	5,3	0,7	62	13	4,7
6	K_{22}- 3	4,4	5,5	0,8	70	10	7,0
7	K_{22}- 4	4,3	5,5	0,8	68	11	6,1
8	K_{22}- 5	3,9	5,4	0,7	63	12	5,2
	EKMF $_{05}$				5,2		0,5
	S%				4,2		3,8

According to the results obtained, the height of the garlic bulbs ranged from 3.7 cm to 4.4 cm, with the highest values observed in the K22-3 and K22-4 clones, which measured 4.3–4.4 cm. The diameter of the bulbs ranged from 5.2 cm to 5.5 cm. In the experiment, the shape index of the garlic bulbs remained almost consistent, ranging from 0.7 to 0.8. Regarding the weight of the main bulbs, the standard variety, Mayskiy VIR, had an average weight of 54 grams, which was the same as the variety South Violet (Yuzhno-Fioletovyy). The minimum significant difference in the experiment was 5.2 grams, indicating that the standard variety also had a weight of 59 grams, the same as the South Violet variety. All other cultivar samples exhibited higher weights (60–70 g).

In the conducted experiment, the number and weight of garlic cloves were also determined. The number of cloves ranged from 10 to 14 cloves per bulb. The highest values were observed in the South Violet variety, K22-2 clone, and the standard Mayskiy VIR variety, which produced 13–14 cloves, indicating the presence of smaller cloves. From these measurements, it can be concluded that garlic cultivars with fewer cloves (K22-3 and K22-4 clones) had larger and heavier cloves.

As for the weight of the cloves, this indicator ranged from 4.1 grams to 7.0 grams among the cultivar samples. The garlic cultivars with larger and heavier cloves were K22-3 and K22-4 clones, which had clove weights ranging from 6.1 to 7.0 grams.

Conclusion:

1. In the southern region of the Republic of Karakalpakstan, the harvest time for garlic was determined to be 238 days for the standard variety, Mayskiy VIR. In comparison to the standard, the K22-3 and K22-4 clones had their harvests 3–4 days earlier, at 234–235 days.
2. The growth duration for garlic in the standard variety, Mayskiy VIR, was 256 days. However, the growth period for the K22-5 clone was found to be 10 days longer (266 days) than that of the standard variety.
3. In terms of vegetative growth, the K22-3 and K22-4 clones were identified as strong growers compared to the other garlic cultivar samples.

When growing garlic in the southern region of the Republic of Karakalpakstan, the K22-3 and K22-4 clones were found to be the most productive, yielding 24% higher than the standard variety. Additionally, the Chidamli variety and K22-2 clone produced 14–15% higher yields than the standard variety.

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