Efficiency of Silicon-Containing Fertilizers in the Adaptive Technology of Muscat Pumpkin Cultivation in the South of Ukraine

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Abstract. The study investigates the effectiveness of silicon-containing fertilizers in adaptive muscat pumpkin cultivation in southern Ukraine. Field, laboratory, and statistical methods were used. Results show that silicon fertilizers enhance nutrient availability in the soil, increase leaf surface area, and improve pumpkin yield and quality. Specifically, applying silicon fertilizers at sowing and in the 4-5 leaf phase raised mobile phosphorus content in the topsoil to 46.2 mg/kg. The largest leaf surface area (20,123 m²/ha) was observed with a recommended feeding system plus silicon fertilizers. The highest yield (22.9 t/ha) and best fruit quality were obtained with a combination of seed priming, post-sowing application, and foliar fertilization. In this variant, dry matter was 8.3%, total sugars 6.3%, carotene 15.0 mg/100 g, and vitamin C 4.7 mg/100 g. Economically, this approach proved profitable, with a net income of USD 1180/ha and a 119% profitability rate, at a cost of USD 43/t.

1 Introduction

Pumpkin is an ancient vegetable crop that has long been widespread in Ukraine. The optimal combination of heat and solar radiation resources, as well as sandy and sandy loam soil granulometric composition, created the basic conditions for obtaining high-quality vegetable crops, including pumpkin, in the southern regions of Ukraine [1]. However, climate change, intensive use of soils without replenishing nutrients leads to gradual soil degradation, a decrease in crop yields and product quality [2].

An increase in average annual and maximum air temperatures, a decrease in precipitation, especially in the summer, necessitate revising existing and developing new cultivation technologies that take into account both the biological characteristics of nutmeg pumpkin and modern environmental conditions. Therefore, there is an urgent need for modern adapted cultivation technologies based on innovative approaches, including optimization of fertilization systems, soil cultivation and plant protection [3].

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One of the effective methods for increasing the yield and quality of agricultural crops is balanced plant nutrition. Many years of extensive research have proven the high efficiency of using organic and mineral fertilizers in growing vegetables and melons [4, 5, 6]. Silicon is an important supplementary element in the mineral nutrition of agricultural crops. Experimental studies have shown that silicon-containing mixtures promote growth, extend the flowering period of plants, and reduce the incidence of powdery mildew. These mixtures also have a prolonged effect [7].

Research has highlighted the significant potential of silicon in vegetable crop cultivation, particularly pumpkins. Silicon accumulation in cucumbers and pumpkins has played an essential role in improving quality and extending storage duration [8]. Silicon is a biologically important element for both plants and all living organisms. The average silicon content in plant biomass is 0.02-0.15%. To preserve the optimal water balance in plant cells, the content of silicon in the epidermis of plant leaves plays a significant role, which, as is known, forms a cuticular-silicon wall in the cells of the epidermis of leaves, walls, and roots, which protects plants from severe moisture loss and regulates water absorption [9]. A significant increase in lettuce yield compared to controls was observed by Serbian scientists following the application of silicon fertilizers [10, 11]. In China, studies showed that introducing silicon into the soil increased tomato fruit yields by 8.7–15.9%, with an average increase of 12.0% compared to untreated controls [12]. In an experiment conducted in Poland, spraying lettuce seeds with 0.2% alkaline K+Si (0.51% Si) increased yield and improved seed quality, including the mass of 1,000 seeds and germination rate [13].

The research results from scientists across various countries demonstrate silicon's significant role in helping plants adapt to unfavorable environmental changes, both in natural ecosystems and agroecosystems, which are increasingly affected by anthropogenic pressure and global climate change predictions [14]. Therefore, selecting effective silicon-containing fertilizers for adaptive agricultural technologies, including muscat pumpkin cultivation, is a highly relevant issue.

Research Objective. The aim of the study is to investigate and select effective silicon-containing fertilizers for the adaptive technology of growing muscat pumpkin under the conditions of southern Ukraine

2 Materials and Methods

The research was conducted between 2021 and 2024 at the experimental field of the Institute of Climate-Oriented Agriculture, National Academy of Sciences. The soil in the experimental field consists of southern heavy-loam chernozem on pale-brown loess, with a humus content of 3.5%. The compaction density of the 0-30 cm soil layer ranges from 1.31 to 1.36 g/cm^3, and the soil reaction is neutral (pH 6.8-7.2). The topography of the area is flat with slight undulations. The experiment design includes four different pumpkin cultivation technologies, each differing in the mineral nutrition system used (Table 1).

Variant 1 – (control I) pumpkin growing technology without fertilizer application.

Variant 2 – (control II) pumpkin growing technology with the recommended level of mineral nutrition (according to STATE STANDARD (DSTU 5045:2008).

Variant 3 – recommended fertilizer dose, silicon-containing fertilizer Nano-Silicon granulated (10 kg/ha active substance) was applied simultaneously with pumpkin sowing.

Variant 4 – applying the recommended dose of mineral fertilizers, involved the comprehensive use of silicon-containing fertilizers for pumpkins:

a) pre-sowing soaking of seeds in a 10% solution of the Bai-Si preparation for 8 hours;

b) pre-sowing application of silicon-containing fertilizer Nano-Silicon granulated (10 kg/ha active substance);

c) foliar treatment of pumpkin crops with a 10% solution of the silicon-containing fertilizer Bai-Si during the 4-5 leaf stage, at the beginning of stem formation, and at the beginning of flowering with female flowers. The total area of the experiment is 3360 m². The area of the elementary experimental plot is 210 m². The accounting area is 100 m². The experiment was repeated four times. The pumpkin variety used is Novinka. The sowing scheme for pumpkins is 2.10×1.0 m. Phenological observations were conducted. The phases of growth and development of plants were determined based on the investigated factors. The beginning of each phase was recorded when it was observed in 10% of plants in the plot, and mass observations were noted at 75% of plants. Dates of sowing, emergence, formation of 4-5 leaves, beginning of the formation of the ovary, flowering of female flowers, formation of fruits, and harvesting were recorded.

Table 1. Scheme of the experiment.

Variant	Mineral nutrition system	Dose of fertilizers, kg/ha d.r.	Including, kg/ha d.r.			
			Basic application	Sowing application	Root feeding	Foliar
1	Without fertilizers (control I)	Without fertilizer	-	-	-	-
2	Recommended dose fertilizers (control II) (according to STATE STANDARD 5045:2008)	$N_{60}P_{90}K_{60}$	$N_{30}P_{80}K_{60}$	P_{10}	N_{30}	-
3	Recommended dose fertilizers + silicon when sowing	$N_{60}P_{90}K_{60}$	$N_{30}P_{80}K_{60}$	$P_{10}+Si_{10}$	N_{30}	-
4	Recommended dose fertilizers + silicon complex	$N_{60}P_{90}K_{60}$	$N_{30}P_{80}K_{60}$	$P_{10}+Si_{10}$	N_{30}	Si_3

Source: *compiled by the authors*

Biometric measurements were conducted periodically (every 10-20 days). For this, in 3-4 repetitions of each experimental variant, 10 plants were selected diagonally from three locations within the plot. The plants in each sample were selected sequentially, excluding those with visible damage from diseases and pests. The plants in the sample had the same feeding area. Biometric measurements were taken during the growth and development phases of the pumpkin plants: the leaf stage (4-5 leaves), flowering of female flowers, and fruit formation.

Leaf area measurements (Cutting Method) were carried out using a cork borer with a diameter of 10 mm to take 100 leaf cuttings, which were weighed immediately. The total area of the cuttings was calculated, and then the leaf area from one plant was determined using the formula:

$$S = \frac{M1 \cdot S1}{M2}$$

where S – leaf area from one plant, cm²;
M1 – mass of the leaves from one plant, cm²;
M2 – mass of 100 cuttings;
S1 – area of 100 cuttings, cm².

The obtained data were converted to the leaf surface area formed by the pumpkin plants over an area of 1 ha (m²/ha). The accounting was conducted during the following growth and development phases: leaf stage (4-5 leaves), flowering, and ripening.

Statistical processing of the obtained data was carried out using the analysis of variance method with the computer program “Statistics.”

Biochemical analyses. The quality of the fruits of watermelon, melon, and pumpkin was assessed in a certified laboratory. For the analyses, fruits were sampled during the biological ripeness phase with no less than two repetitions, consisting of 5 pieces each.

The fruit quality was determined for the content of: Vitamin C (ascorbic acid) according to GOST 24556-89; total sugars using the cyanide method according to STATE STANDARD 4954:2008; soluble dry substances using the refractometric method according to GOST 28562-90; nitrates using the ionometric method according to STATE STANDARD 4948:2008.

Economic efficiency. Based on the research results, the following were determined: fruit yield (t/ha), total production costs for growing and harvesting (UAH), and the value of gross production (UAH). The direct costs indicator was used for the economic assessment of the technology. The economic assessment of the cultivation technology and the calculation of the economic efficiency of the results were based on the main indicators: yield level, gross production in monetary terms, labor productivity, production cost, conditional net profit, and level of production profitability.

During the research, the authors adhered to the standards of the Convention on Biological Diversity [19] and the Convention on International Trade in Endangered Species of Wild Fauna and Flora [20].

Nano-Silicon Granulated ("Haitor", China) - a fertilizer and ameliorant. Composition: SiO_2 – 30%; K_2O – 30%, MgO - 5%.

Bai-Si (LLC "AVANTE", Ukraine, Kyiv) – a silicon-based immunoprotector. Composition**:** SiO2 - 5-7%; K_2O - 2,2-3,3 %, mass fraction: SiO_2 - 99,7%, CuO - 0,54%, FeO - 0,24%, ZnO – 0,1%. (LLC "AVANTE", Ukraine, Kyiv).

Results. The mineral fertilizers applied according to the experimental scheme had an impact on increasing the nutrient content in the arable layer of the soil. An increase was observed in the variants with the application of the recommended dose of mineral fertilizers compared to the control. Significant reserves of nitrate nitrogen were found in the variants where mineral fertilizers were applied. If before sowing pumpkins the nitrate nitrogen content in the absolute control was 22.8 mg/kg of absolutely dry soil, then in the variants where the recommended rate of mineral fertilizers was applied in the fall, its content increased to 42.2 mg/kg of absolutely dry soil (Table 2).

Table 2. Content of mobile forms of nutrient elements in the arable layer of soil in musky pumpkin crops of the Novinka variety, mg/kg of absolutely dry soil (average for 2021-2024).

Variant	Feeding system	Before sowing			Phase 4-5 leaves			Fruit formation		
		N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
1	Control I (without fertilizers)	22.8	42.2	75.9	18.8	34.9	67.8	14.9	28.4	56.2
2	Control II (Recommended dose fertilizers)	42.2	58.0	94.3	32.8	43.6	86.2	36.3	39.4	65.8
3	Recommended dose fertilizers + silicon at sowing	42.2	58.0	94.3	34.7	46.2	81.1	36.8	44.8	64.1
4	Recommended dose fertilizers + silicon complex	42.2	58.0	94.3	34.2	45.8	81.1	36.9	43.2	63.8

Source: *compiled by the authors*

The assessment of nutrient reserves in the topsoil during the 4-5 leaf stage of the pumpkin indicated a decrease in the corresponding experimental variants compared to the analysis results conducted before sowing. The highest amount of available nitrogen at the 4-5 leaf stage was found in the variants with the recommended level of mineral nutrition, ranging from 32.8 to 34.7 mg/kg of absolutely dry soil, while in the control I, its content was 18.8 mg/kg of absolutely dry soil.

With the recommended level of mineral nutrition for pumpkins at the 4-5 leaf stage, the additional application of silicon fertilizers in the soil affected the content of mobile forms of nutrient elements. Specifically, the amount of nitrates in the arable layer of soil in experimental variants 3 and 4, where silicon was additionally applied at sowing, was 34.2 and 34.7 mg/kg of absolutely dry soil, respectively, which was slightly higher than in variant 2 (32.8 mg/kg). A similar trend was observed regarding mobile phosphorus. In experimental variants 3 and 4, with the use of silicon-containing fertilizers during pumpkin sowing, the content of mobile phosphorus in the arable layer of soil at the 4-5 leaf stage was 46.2 and 45.8 mg/kg of absolutely dry soil, respectively, while in the variant without fertilizer application it was 43.6 mg/kg. At the same time, regarding exchangeable potassium, its amount at the 4-5 leaf stage of pumpkins in experimental variants 3 and 4 showed that pre-sowing application of silicon fertilizers contributed to a decrease in the content of this microelement compared to the variant without fertilizer.

In the 4-5 leaf stage, in experimental variants 2, 3, and 4, according to the recommended system of mineral nutrition, nitrogen fertilizers were applied as a root dressing for pumpkin plants, so by the fruit formation phase, the nitrate nitrogen content in the arable layer of soil remained almost at the same level as during the 4-5 leaf stage. However, in variant 1 (without fertilizers), there was a predictable decrease in nitrogen to 14.9 mg/kg during this period. The dynamics of the content of mobile phosphorus compounds in the soil exhibited the same patterns as those characteristic for nitrate nitrogen. With average potassium availability in the soil, its available amount also depended on the use of fertilizers. According to the phenological observations of musky pumpkin plants, it was established that in variant 4, where seeds were pre-soaked, emergence occurred 3 days earlier than in the other experimental variants. Complete emergence of pumpkins from primed seeds was achieved on May 24, which is 6 days after sowing, while in the other experimental variants, it occurred after 9 days (Table 3).

Table 3. Date of occurrence of the full phenological development phase of musky pumpkin plants of the Novinka variety (average for 2021-2024).

Variant	Nutrient System	Sowing	Sprout	4-5 leaf	Formation of side shoot	Flowering	Fruit formation	Ripening
1	Control I (without fertilizers)	18.05	27.05	10.06	24.06	10.07	14.07	24.08
2	Control II (Recommended dose fertilizers)	18.05	27.05	10.06	22.06	8.07	11.07	20.08
3	Recommended dose fertilizers + Silicon at sowing	18.05	27.05	10.06	22.06	8.07	11.07	20.08
4	Recommended dose fertilizers + Silicon Complex	18.05	24.05	7.06	19.06	5.07	8.07	17.08

Source: *compiled by the authors*

Pumpkin plants in the control I variant of the experiment (without fertilizers) significantly lagged in growth and development starting from the stem formation phase compared to plants in other variants with fertilizer application. As a result, the ripening of pumpkin fruits in the "without fertilizers" variant was observed 4 days later than in the recommended nutrition level (variant 2, control II) and in variant 3 (recommended nutrition system + silicon at sowing). In the experimental variants where different mineral nutrition systems were applied, only in variant 4, where seed priming was performed, did the next developmental phase and the ripening of fruits occur 3 days earlier.

Pumpkins in the experiment responded positively to the application of mineral fertilizers, under the influence of which the plants developed more intensively and formed a larger assimilatory surface area. Specifically, while the formation of leaf area by pumpkin plants until the 4-5 leaf phase in the experimental variants with the recommended level of mineral nutrition occurred similarly (176-179 m²/ha), in the variant without fertilizer application, this indicator was significantly lower at 162 m²/ha (Table 4).

According to the results of measuring the leaf area of pumpkin plants in subsequent growth and development phases, it was established that by applying the recommended dose of mineral and silicon-containing fertilizers in the researched pumpkin cultivation technologies (seed priming, pre-sowing application, foliar feeding), it is possible to manage the formation and increase of the plants' assimilatory surface area. Therefore, to achieve maximum yield of pumpkin fruits, it is essential to form an optimal leaf area to ensure better photosynthetic productivity of the crop. The largest leaf area by the time of fruit ripening was formed by pumpkin plants grown under the technology that involved the use of the recommended nutrition system plus comprehensive application of silicon-containing fertilizers, reaching 20,123 m²/ha. In comparison, under the recommended level, this figure was 18,512 m²/ha. The technology of pumpkin cultivation, where silicon fertilizer was applied together with the recommended dose of fertilizers at sowing, also proved to be quite effective. Here, by the time of fruit ripening, pumpkin plants formed a leaf area of 18,911 m²/ha.

Table 4. Formation of leaf area by musky pumpkin plants of the Novinka variety (average for 2021-2024).

Variant	Mineral nutrition system	The leaf area by developmental phases of plant, m²/ha		
		4-5 Leaves	Flowering	Fruit Ripening
1	Control I (without fertilizers)	162	12164	15136
2	Control II (Recommended dose fertilizers)	176	14568	18522
3	Recommended dose fertilizers + silicon at sowing	176	14625	18911
4	Recommended + silicon complex	179	15624	20123

Source: *compiled by the authors*

Given the better growing conditions for pumpkin plants achieved through the application of silicon-containing fertilizers alongside the recommended dose of mineral fertilizers, higher fruit yield figures were obtained compared to the base technology (control II). It is important to note that silicon-containing fertilizers were effective in pumpkin cultivation regardless of the application method. The studies confirmed the effectiveness of using silicon-containing fertilizers in pumpkin cultivation technology. It was proven that pre-sowing application of granular silicon-containing fertilizer under pumpkin, against the background of the recommended dose of mineral fertilizers, increases the yield of the crop to 20.1 t/ha, which is 0.8 t/ha more than without silicon fertilizers (Table 5).

Table 5. Yield of musky pumpkin Novinka variety under different cultivation technologies (average for 2021-2024).

Mineral nutrition system	Yield of fruits, t/ha				
	Replicates				Average
	I	II	III	IV	
Without fertilizers (control I)	16.8	15.8	16.0	17.0	16.4
Recommended dose fertilizers (control II)	20.1	18.9	19.7	18.5	19.3
Recommended dose fertilizers + silicon at sowing	20.3	19.8	20.8	19.5	20.1
Recommended dose fertilizers + complex silicon	21.9	23.5	24.6	21.6	22.9
LSD_{05}, t/ha	0.38				

Source: *compiled by the authors*

However, as in previous years of research, the greatest influence on the yield level of pumpkins was noted with the comprehensive application of silicon-containing fertilizers (seed priming + pre-sowing application + foliar feeding) in the technology of growing this crop. In this experimental variant, this year's research results indicated the highest pumpkin yield of 22.9 t/ha, which was 3.6 t/ha, or 18.6%, higher than the base technology with the recommended level of mineral nutrition.

A sufficiently high efficiency was observed with the recommended system of mineral nutrition at 19.3 t/ha, while in control I (without fertilizers), it was 16.4 t/ha.

The use of silicon-containing fertilizers positively affected the quality of pumpkin fruits. Specifically, the main quality indicators—dry soluble substances, total sugars, and carotene - increased both under the recommended dose of mineral fertilizers and the studied silicon-containing fertilizers.

The fruits of pumpkin with the best biochemical quality indicators were obtained in the variant with comprehensive application of silicon-containing fertilizers, where dry soluble substances were 8.3%, total sugars were 6.3%, carotene was 15.0 mg/100 g, and vitamin C was 4.7 mg/100 g. In control I, these values were 7.8%, 6.0%, 12.0 mg/100 g, and 4.3 mg/100 g, respectively (Table 6).

Table 6. Quality indicators of musky pumpkin variety Novinka fruits obtained under different cultivation technologies (average for 2021-2024).

Mineral nutrition system	Content in fruits				
	Dry soluble substances, %	Total sugars, %	Carotene, mg/100 g	Vitamin C, mg/100 g	Nitrates, mg/kg
Control I (without fertilizers)	7.8	6.0	12.0	4.3	26.0
Control II (Recommended dose fertilizers)	8.1	6.2	14.6	4.5	27.0
Recommended dose fertilizers + Silicon at Sowing	8.1	6.2	14.8	4.5	26.0
Recommended dose fertilizers + comprehensive silicon	8.3	6.3	15.0	4.7	29.0

Source: *compiled by the authors*

The application of silicon fertilizers to the soil at the same time as sowing pumpkin improved the quality indicators of the fruits compared to the recommended system of mineral nutrition. The nitrate content in the pumpkin fruits across all experimental variants was significantly lower than the maximum permissible concentration (up to 200 mg/kg).

For the rational implementation of agricultural crop cultivation technologies, economic efficiency indicators are crucial as they allow comparison with the baseline technology and determine the ratio of additional financial costs to profits.

The relatively high purchase price of pumpkin fruits (4000 UAH/t) at the time of product realization ensured a corresponding economic effect from the cultivation of this crop. A high economic effect was achieved in the reporting year from growing pumpkin using technology that did not involve the use of fertilizers. Calculations confirmed a fairly high economic effect from applying mineral fertilizers at the recommended dose; however, in terms of production cost and level of profitability, this experimental variant slightly lagged behind the technology of growing pumpkins without fertilizers. At the same time, the additional application of silicon fertilizers alongside the recommended dose of mineral fertilizers contributed to an increase in key indicators of economic efficiency while reducing production costs compared to the recommended nutrition (control II).

The gross profit obtained from growing any agricultural crop directly depends on its yield. The highest gross profit indicators from pumpkin cultivation were obtained in the variant with comprehensive application of silicon fertilizers alongside the recommended dose of mineral fertilizers, totaling 91,600 UAH/ha, which is 14,400 UAH/ha more than in the variant with the recommended nutrition level (control II) (Table 7).

Table 7. Economic efficiency of the investigated technologies for growing muscat pumpkin (average for 2021-2024).

Cultivation technology (nutritional system)	Yield, t/ha	Production costs, UAH/ha	Cost price, UAH/t	Value of gross production, UAH/ha	Conditional net income, UAH/ha	Profitability level, %
Control I (without fertilizers)	16.4	32644	1990	65600	32956	101
Control II (Recommended dose fertilizers)	19.3	40688	2108	77200	36512	90
Recommended dose fertilizers + silicon at sowing	20.1	40893	2034	80400	39507	97
Recommended + comprehensive silicon application	22.9	41776	1824	91600	49824	119

Source: *compiled by the authors*

The pre-sowing application of silicon fertilizers alongside the recommended dose of mineral fertilizers was also economically justified, with the gross value of production in this experimental variant increasing by 3200 UAH/ha compared to the recommended nutrient level (control II).

According to the experimental scheme, the variants of pumpkin cultivation technologies differed only in their nutrient systems, and thus the difference in production costs was due to the cost of fertilizers, their transportation, and application. The production costs for pumpkin cultivation using the no-fertilizer technology (control I) amounted to 32,644 UAH/ha. The application of the recommended dose of mineral fertilizers increased production costs by 8044 UAH/ha, totaling 40,688 UAH/ha. Additional application of granular fertilizers at sowing, alongside the recommended fertilizers, raised production costs by 205 UAH/ha to 40,893 UAH/ha. The highest production costs for pumpkin cultivation were incurred in the variant with the comprehensive application of silicon fertilizers alongside the recommended mineral fertilizer dose, totaling 41,776 UAH/ha, which is 1088 UAH/ha more than the variant with the recommended nutrient level (control II).

The highest conditional net profit from pumpkin cultivation, amounting to 49,824 UAH/ha, was obtained in the variant with the highest production costs, specifically with the comprehensive application of silicon fertilizers alongside the recommended mineral fertilizer dose, while in control II (recommended fertilizer dose), this figure was 36,512 UAH/ha. In this experimental variant, relatively low costs for applying silicon fertilizers resulted in an additional 13,312 UAH/ha of conditional net profit. The return on investment for the comprehensive application of silicon fertilizers was 12.2 UAH, meaning that for every 1 UAH spent on additional fertilizer costs, 12.2 UAH in profit was generated. In variant 3, the additional application of granular fertilizers at sowing alongside the recommended dose increased production costs by 205 UAH/ha but allowed for an additional 2995 UAH/ha of conditional net profit. The return on investment for the pre-sowing application of silicon fertilizers was 14.6 UAH, indicating that for every 1 UAH spent on additional fertilizer costs, 14.6 UAH in profit was earned.

The lowest cost of production, amounting to 1824 UAH/t, was achieved in the pumpkin cultivation technology variant with comprehensive application of silicon fertilizers alongside the recommended mineral fertilizer dose, whereas in control II (recommended fertilizer dose), this figure was 2108 UAH/t. In variant 3, the additional application of granular fertilizers at sowing alongside the recommended dose contributed to a reduction in the cost of production by 74 UAH/t.

The highest profitability of pumpkin production was achieved with the cultivation technology that included the comprehensive application of silicon fertilizers alongside the recommended mineral fertilizer dose, resulting in a profitability rate of 119%, compared to 90% in control 2 (recommended fertilizer dose). The increase in profitability to 97% was also achieved through the additional pre-sowing application of silicon fertilizers alongside the recommended dose of mineral fertilizers.

3 Conclusions

The research findings indicate that the additional application of silicon fertilizers simultaneously with pumpkin sowing, alongside the recommended nutrient system, increases the content of mobile phosphorus in the arable soil layer to 46.2 mg/kg of absolutely dry soil. The largest leaf area was formed by the muscat pumpkin plants under the comprehensive use of the recommended nutrient system and silicon fertilizers, reaching 20,123 m^2/ha. It was established that the pre-sowing application of granular silicon fertilizer, in conjunction with the recommended dose of mineral fertilizers, boosts fruit yield to 20.1 t/ha. The highest pumpkin yield was achieved through the comprehensive application of silicon fertilizers (seed priming + pre-sowing application + foliar feeding), amounting to 22.9 t/ha. The best quality of muscat pumpkin fruits was obtained in the variant with comprehensive application of silicon fertilizers, where the content of soluble solids was 8.3%, total sugars 6.3%, carotene 15.0 mg/100 g, and vitamin C 4.7 mg/100 g. In contrast, control 1 showed values of 7.8%, 6.0%, 14.6 mg/100 g, and 4.5 mg/100 g, respectively. The highest economic effect from pumpkin production was achieved using an adaptive cultivation technology that included the recommended mineral nutrient system along with comprehensive application of silicon fertilizers. The conditional net profit in this variant was 49,824 UAH/ha, with a profitability of 119% and a production cost of 1,824 UAH/t. In comparison, under the recommended nutrient system alone, the figures were 36,512 UAH/ha, 90%, and 2,108 UAH/t, respectively.

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