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RESEARCH ARTICLE
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Effects of Organic Foliar Fertilizers on Vegetable Crop Productivity and Biochemical Composition

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ABSTRACT

The cultivation of vegetable crops under organic conditions is becoming very popular worldwide. The use of organic preparations in the cultivation technique contributes not only to the reduction of pesticide pollution, but also to the enrichment of plant products with bioelements through the introduction of essential trace elements that promote the biosynthesis and accumulation of micronutrients and biologically active substances. The results of studies conducted in 2022-2023 in the soil and climatic conditions of Moscow on the basis of the Federal State Educational Institution of Higher Professional Education named after K.A. Timiryazev of the Russian State Agricultural Academy to study the effect of treatments with organic preparations without root on the yield and quality of vegetable crops are presented. The research subjects were late cabbage (*Brassica oleraceae* L.), early potatoes (*Solanum tuberosum* L.), garlic (*Allium sativum* L.), organic preparations of Rostovit, OMEK-7 and Aminozol. It was found that foliar fertilization with an aqueous solution of the Rostovit preparation increased marketable products in white cabbage by 18% compared to the control, including a 16% increase in head weight. In garlic, foliar fertilization with OMEK-7 increased the marketable products by 35%. The tested preparations had a positive effect on the biochemical and elemental composition of white cabbage and garlic products (increase in iron (Fe), zinc (Zn) and vitamin (C) content), and in tomatoes (increase in potassium (K), ascorbic acid (vitamin C), iron (Fe) and copper (Cu)).

Keywords: Organic vegetable cultivation, Foliar treatments, Micronutrients, Organic preparations, Yeast extract, White cabbage, Garlic, Tomato, Yield, Product quality.

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INTRODUCTION

Organic farming is currently practiced in 179 countries, and 89 countries have developed a legal framework for the production and sale of organic products (Young et al., 2015). In conventional agriculture, high doses of nitrogen, phosphorus and potash fertilizers are used in the cultivation of plant products, which help to maximize yields but also increases the risk of a negative impact of fertilizers on product quality. Consequently, the consumption of such products contributes to a deficiency of macro- and micronutrients in the human body (Gromova et al., 2010; Gromova et al., 2012; Kodentsova & Pogozheva, 2020). This problem was identified as a priority task in the concept of state policy in the field of healthy nutrition of the population of the Russian Federation, since the insufficient content of vitamins and micronutrients in the human body is a factor in the development of many diseases, such as obesity, diabetes mellitus, the development of cardiovascular diseases and hypertension (Kodentsova, 2016; Kodentsova et al., 2017; Goman et al., 2019a). The daily diet of an adult, which comprises approx. 2,500kcal, is 20% deficient in most vitamins (Beketova et al., 2016).

Consequently, public awareness of the negative effects of intensively grown vegetable products on the human body is increasing every year. Thus, the need for organic products has increased. Fresh consumption of such products is a health problem, as nitrate content can disrupt the functions of the respiratory, central nervous, and cardiovascular systems (Organic Agriculture, 2019). The use of increased doses of fertilizers against the background

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of synthetic growth regulators with a rapid increase in biomass contributes to a decrease in biologically active substances, which causes a decrease in the antioxidant status of plants; however, this problem does not manifest itself in organic culture (Experimental Business Methods, 1992). The application of high doses of mineral fertilizers changes the properties of the soil, particularly the acidity, salinity, and abnormal accumulation of nitrogen, phosphorus and potassium (The Strategy, 2016; Kharchenko et al., 2023). This significantly affects the soil microbiota and nutrient absorption. When inorganic salts are introduced into the soil alone or in combination with other fertilizers, both the fixation of elements and antagonism between them occur (Ahmed et al., 2011). Excess phosphorus (P) accumulates in the soil, where it forms chemical bonds with calcium (Ca), magnesium (Mg), iron (Fe) and zinc (Zn) and becomes inaccessible to plants (Bindraban et al., 2015). The assimilation of mineral elements contained in soil fertilizers is influenced by several factors, including temperature, humidity, salinity, and microbiota (Al-Yafeai & Böhm, 2018). In this regard, effective options for applying batteries in the form of environmentally friendly preparations and in low doses per unit area should be considered (Carr & Frei, 1999).

Fertilizer application methods can be divided into root and non-root methods, depending on how crops absorb nutrients. The advantages of foliar top dressing are that it is possible to deliver nutrients directly to the target through the aboveground parts of the plants, quickly obtaining the desired effect (Cai, 2019). Traditionally, foliar fertilization has been used as an additional measure to eliminate nutrient deficiencies, but there is currently a trend towards the widespread use of foliar treatments with various fertilizer types (Carr et al., 2015). The advantages of non-root fertilization are that it can be absorbed directly through the leaves and transported to various organs of the plant (Dyikanova et al., 2023), replenishing nutrients faster and more efficiently than soil fertilizers.

Second, using non-root treatments, it is easier to carry them out at optimal times and concentrations in accordance with the needs of various vegetable plants at different growth and development stages.

There is some evidence in the literature that non-root treatments with macro- or microelements, amino acids, and chelate complexes not only effectively eliminate nutrient deficiency in plants, but also increase the content of trace elements and biologically active compounds in leaves and fruits, increasing yield without compromising quality (El-Tohamy et al., 2008; Fernández & Eichert, 2009; Ezzo et al., 2012; Fernández & Brown, 2013).

Thus, it is necessary to develop alternative strategies to effectively provide plants with accessible macro- and microelements. A solution to this problem will allow for a harmonious combination of acceptable yields, high-quality products, and environmental concerns. Organic agriculture, unlike its traditional counterpart, does not use synthetically produced fertilizers and pesticides, according to regulations. In this regard, the use of fertilizers in new forms and methods is relevant and timely (Resolution No. 31, 2013).

In this regard, the transition to organic fertilizers helps reduce pesticide load and enrich vegetable products with bio-elements by introducing essential trace elements that promote the biosynthesis and accumulation of micronutrients and biologically active substances (Pogozheva et al., 2015). Thus, the search for and application of organic (environmentally friendly) fertilizers of natural origin, natural biostimulators, has become a modern agricultural task. Numerous studies have shown the positive effects of using organic preparations based on yeast extract on vegetative growth, yield, and product quality of cucumber (Pizarro et al., 2016), lettuce (Troesch et al., 2012), potatoes (Wessels & Brown, 2012), eggplant (Xiao et al., 2018), and turnips (Yu et al., 2005). The purpose of this research was to study the effect of foliar top dressing, with preparations promising for organic farming, on yield and product quality.

MATERIALS & METHODS

Research Materials

Late cabbage (*Brassica oleraceae* L.), garlic (*Allium sativum* L.) and tomato (*Lecopersicum esculentum* L.).

Preparations

Rostovit is an organic product of Agrocycling Group LLC yeast extract, composed of 89% trace elements (N, F, K, Fe, Mg, Ca), trace elements (Mn, Mo, Na, Cu, Si, Zn, B, Ni), and organic matter (from dry residue). OMEK-7 is an organic preparation of Bioamide JSC, composition: a homogeneous mixture of chelated compounds of iron, manganese, zinc, cobalt, copper with L – aspartic amino acid, iodized by the protein part of baking yeast. Aminozol is an organic nitrogen-potash fertilizer manufactured by Laiminer, with a 9.4% total mass fraction of nitrogen (N) of 116g/L, and 58% organic substances (amino acids) of 713g/L.

In the open ground, experiments were conducted in 2022-2023 in accordance with laboratory and field methods (small-scale experiments) with generally accepted recommendations for research on vegetable crops (Methodological Recommendations MR 2.3.1.0253-21, 2021).

The weather conditions in 2022 were less favorable for plants than those in 2023; in June and July, they were characterized by a lack of moisture and high temperatures during the growing season (28-33°C). Spring of 2023 is warm and early. The average temperature in summer was 18.3°C, which is 0.2°C higher than the annual average temperature. The hottest month was August, when the temperature was 2°C above normal. The amount of precipitation in the summer was 119% of the annual average. The largest number occurred in July (178%).

The soil of the experimental plots was medium-loamy and corresponded to the following characteristics: pH 6.7, Pr–1.1mg/eq, Ph_2O_5–45mg/100g of soil, and K_2O–35mg/100g of soil.

Three non-root treatments were performed for all vegetable crops. The preparations were used in the form of aqueous solutions to vegetate plants. The 1st foliar treatment was performed at the beginning of growth, the 2nd and 3rd treatments were performed at the beginning of the formation and active growth of the food body. The 1st foliar treatment was carried out 14 days after the seedlings were planted in the field, the 2nd and 3rd foliar treatments were carried out at an interval of 3 weeks.

Experiment Scheme

Option I Control – treatment with distilled water
Option II – Rostovit 1mg/1L
Option III – OMEK 1mg/1L
Option IV – Aminozol 1ml/1L

The registered areas of the experimental plots were $10m^2$ of garlic and $25m^2$ of white cabbage. In all cultures, the variants were repeated 4-fold.

In protected soil, the research was carried out in 2022-2023 in a spring film greenhouse at the Educational, Scientific, and Production Center for Horticulture and Vegetable Growing, named after V.I. Edelstein.

The research was carried out in accordance with laboratory and field methods (small-scale experiments) with generally accepted recommendations for research on vegetable crops in protected soils (Vashchenko & Nabatova, 1992). The preparations were used in the form of aqueous solutions to vegetate plants. In tomato, the 1st foliar treatment was carried out by opening 3-4 flowers in the first inflorescence. The 2nd and 3rd non-root treatments were carried out at an interval of 3 weeks.

Experiment Scheme

Option I Control – distilled water treatment
Option II Rostovit 1mg/1L
Option III – Aminozol 1mg/1L

The option was placed in a film-unheated greenhouse. The repetition was 3-fold, the area of the accounting plot was $3.3m^2$. The harvest dynamics were recorded, weighing fruits from each plot at each harvest, followed by conversion into kilograms from $1m^2$ (Methodological Recommendations MR 2.3.1.0253-21, 2021).The quality of the products was determined in the CCU of the FSBEI HE Russian State Agrarian University-Moscow Agriculture Academy named after K.A. Timiryazev: total acidity, mmol/100mL – GOST ISO 750-2013; nitrates, mg/kg – GOST 34570-2019; vitamin C, % GOST 24556-89 (cl. 2); total sugar, % GOST 8756.13-87 (cl. 2); content of macro-microelements (Ca, Fe, Mg, Cu, Zn, K) – PND F 16.2.2:2.3.71-2011. The analytical equipment used was an AA-7000 double-beam atomic absorption spectrophotometer, UV-1900i double-beam spectrophotometer, UDK 159 automatic nitrogen/protein analyzer with an automatic digester DKL 20, Sherwood Model 410 flame photometer and Ionometer Metrohm 781 pH/Ion Meter. Auxiliary equipment: MARS 6 microwave sample preparation system, Sartorius MA160 moisture meter, Stegler SB–22 shaker thermostat, MICROTRON MB 550 laboratory blender, Mettler Toledo ME204T/A00 analytical scales, and Binder FD-53 drying cabinet.

The contents of dry matter, carotenoids, and chlorophylls were determined in the analytical laboratory of the FSBSI Federal Scientific Center for Vegetable Growing, and the dry matter content was determined by gravimetric drying of samples at 70°C to a constant mass – GOST 28561-90 (cl. 2). The polyphenol content was determined spectrophotometrically on a Unico spectrophotometer (USA) using the Folin-Ciocalteu reagent (Golubkina et al., 2020) on alcoholic extracts of dried plants (70% ethanol, 80°C, 1h). Gallic acid was used as a standard. The results are expressed in mg eq of gallic acid/g d.m. (mg eq GA/g d.m.). The level of antioxidant activity (AOA) was determined titrometrically using a 0.01N solution of potassium permanganate. The results of the determination were expressed in mg eq of gallic acid/g d.m. The carotenoid content was determined spectrophotometrically using quantitative thin-layer chromatography for the separation of carotenoids on chromatographic paper Watman 3A in a hexane system (for the separation of beta-carotene, zeta-carotene) and hexane-acetone, 10:1 (for the separation of lycopene and lutein). The contents of individual carotenoids were calculated using the specific absorption of beta-carotene, zeta-carotene, lutein, and lycopene. Chlorophyll was also isolated from brown tomatoes by quantitative thin-layer chromatography by eluting a chlorophyll stain from chromatographic paper using ethyl alcohol. The chlorophyll a and chlorophyll b contents were calculated according to the Lichtentailer formula based on the absorption of alcohol extracts at 649 and 664nm (Golubkina et al., 2020).

Agricultural technology was used in the experiment. Seedlings were grown in the seedling compartment of a multi-row greenhouse in the Richelle 9.6 SR series. The seeds were sown on March 24, 2023, and the plants were removed on September 15, 2023.

Young plants were grown in peat in cassettes with a cell size of 5x5x5cm, volume $125cm^3$. Sprouts were observed on the 8th day after sowing. Transfer was carried out on the 20th day from sprouts to pots with a volume of 0.8 liters. When the leaves were closed, a single seedling arrangement of 20 plants/m^2 was performed. The average daily temperatures were set according to plant conditions and schedules.

Before planting the seedlings, the soil in the greenhouse was mulched with a black nonwoven material. The seedlings were planted in an unheated film greenhouse on May 22. The density of the standing plants was 2.5 plant/m^2. Plant care consisted of twisting the main stem and removing leaves and lateral shoots, after the 4th inflorescence, an additional shoot was left in the small-fruited tomato hybrids. When the brown color of the fruits appeared on the first brush, they began to remove the lower leaves and three leaves at a time.

Top dressing was carried out with a complex fertilizer Yara Kristalon 18.18.18 + 3 at an interval of 5 days, and the first top dressing was carried out 5 days after the seedlings were planted. Irrigation was performed via sprinkling during the growing season. When the temperature in the greenhouse exceeded 30°C, refreshing waterings were used. Statistical data processing was performed using the Excel 2010 software. The text and tables show the arithmetic averages of the parameters and their confidence intervals at a 95% significance level.

RESULTS & DISCUSSION

The evaluation of the yield of winter garlic bulbs showed (Table 1) that the maximum bulb weight increased to 97.1g/unit in the OMEK-7 treatment option compared to 72g in the control and that the yield increased from 19.9t/ha in the control to 26.9 t/ha after treatment with OMEK-7. This effect in the two years of observation can be explained by the effect of copper salts, which are a component of the OMEK-7 preparation. Copper is known to have certain functions in nitrogen metabolism and is a component of nitrite reductase, hyponitrite reductase and nitric oxide reductase. Due to the influence of copper on the activity of enzyme systems, these enzymes improve the binding of molecular nitrogen from the air and the assimilation of soil nitrogen and fertilizers, which ultimately leads to higher yields. The effect of copper on the water permeability of the xylem vessels and thus on the moisture balance is considerable. In addition to copper, the preparation also contains L-aspartic acid, which serves as a favorable source of nitrogen and is well absorbed in combination with copper. The use of the preparation Rostovit was less effective, the increase in onion weight was 11.1g compared to the control, and a yield increase of 13 was observed. The effect of the preparation Aminozol on garlic was the least effective, and with an increase in onion weight to 81.1g, the yield increased by 10%.

Table 1: The effect of foliar top dressing with organic preparations on bulb structure, weight, and yield of winter garlic variety 'Strelets'

No.	Treatment	Bulb Weight (g)	Yield (t/ha)	Increase Compared to Control	
				t/ha	%
1	Control	72.0	19.9	–	100
2	Rostovit	81.1	22.5	2.6	113
3	OMEK-7	97.1	26.9	7.0	135
4	Aminozol	79.2	21.9	2.0	110

$LSD_{0.5}$: Bulb weight – 6.5 (2022), 7.1 (2023); Yield – 4.8 (2022), 4.7 (2023)

In experiments with white cabbage, the maximum result, as well as on potato, was obtained with the use of the preparation Rostovit, the head weight increased by 0.4kg compared with the control, and the yield increased from 89.2 to 105.8t/ha, which is 18% higher than that of the control. After the application of Aminozol, the yield was 98.1t/ha, and after the application of OMEK-7 94.0t/ha, which is respectively 10 and 5% more than in the control (Table 2).

Table 2: The effect of foliar top dressing with organic preparations on the yield of white cabbage variety 'Podarok'

No.	Treatment	Head Weight (kg)	Yield (t/ha)	Increase Compared to Control	
				(t/ha)	(%)
1	Control	2.5	89.2	–	100
2	Rostovit	2.9	105.8	16.6	118
3	OMEK-7	2.6	94.0	4.8	105
4	Aminozol	2.7	98.1	8.9	110

$LSD_{0.5}$: Head weight – 0.2 (2022), 0.1 (2023); Yield – 4.8 (2022), 4.7 (2023)

Thus, the individual reaction of crops to the preparations revealed that OMEK-7 was more effective on garlic, and Rostovit was more effective on white cabbage. Accounting for the yield of tomato fruits, the maximum yield was obtained from the use of Aminozol preparation in the hybrid F_1 Chernysh. The weight of the fruit increased by 6g, and the yield increased by 31% compared with the control. The Rostovit preparation was less effective, with an increase in fruit weight of 4g, and the yield increased by 28%. There was no significant difference after 3-fold treatment with organic preparations Rostovit and Aminozol on fruit weight and yield of hybrids F_1 DRK 564 and F_1 Belido (Table 3).

Due to the widespread prevalence of multiple micronutrient deficiencies in the population, and also considering that for the biological action of certain elements, such as iron, an adequate supply of other micronutrients is necessary for the body (manganese, copper, molybdenum, chromium, iodine, and vitamins C, $_{B2}$, $_{B6}$) (Pogozheva & Kodentsova, 2020), we conducted research on the elemental composition of white cabbage and garlic products.

The ascorbic acid content of the heads was determined during the phase of full technical ripeness (Table 4). The pleiotropic role of vitamin C in human health and disease is widely known as it regulates many genes in the body (Guoxi, 2007). For normal functioning, the physiological requirement for vitamin C is 100mg/day for adults and 30–90mg/day for children (Hurrell, 2021). Scientific reviews contain data on vitamin C deficiency in the populations of many countries of the world (Kodentsova & Pogozheva, 2020; Ke et al., 2022) and the replenishment of the daily requirement for this vitamin in the human body depends only on food intake, primarily plant-based. A number of researchers (Lenucci et al., 2006) noted a 1.2-2.1-fold decrease in the concentration of ascorbic acid in products after treatment with humic preparations compared to the version without fertilizers, explaining this by the "dilution effect" when yields increase significantly, but the concentration of vitamin C in cabbage does not change significantly, and in this regard, there is a decrease in the vitamin C content in the marketable products. However, no such pattern was observed in our study. The vitamin C content was 1.1–1.2 times higher than that in the control, with the highest yield in option 2 after treatment with Rostovit (Table 3). We assumed that the use of copper in the composition of preparations had a positive effect on the synthesis of ascorbic acid, which is consistent with the data of Goman et al. (2019b).

Foliar treatments with organic preparations had a positive effect on the intake of Fe, both in the experiment with white cabbage and in the experiment with garlic in variants where the maximum concentration of vitamin C was recorded (Table 4). The data obtained are consistent with the work of Pizarro et al. (2016) and Hurrell (2021), in which the authors noted that ascorbic acid from fruits and vegetables, as well as peptides from partially digested muscle tissues of meat, fish, and poultry, enhance iron absorption.

The use of Rostovit and OMEK-7 significantly increased (by 1.8-1.9 times) the Zn content in garlic (options 2 and 3) compared with the control. It should be noted that the organic preparations had no noticeable effect on the nitrate content of white cabbage and garlic products. The content was within the acceptable range for all study options. Nevertheless, a significant decrease in

Table 3: The effect of foliar top dressing with organic preparations on tomato yield

Options	Fruit weight, g	Yield kg/m^2	Increase to control	
			kg/m^2	%
F_1 DRK 564				
Option I Control – distilled water treatment	11.28	5.51	-	-
Option II – Rostovit 1mg/1l	12.30	6.02	0.516	109.3
Option III Aminozol 1mg/1l	11.98	5.94	0.427	107.8
LSD_{05}	F act < F table	F act < F table		
F_1 Belido				
Option I Control – distilled water treatment	13.23	7.49	-	-
Option II – Rostovit 1mg/1l	14.01	8.07	0.571	107.7
Option III Aminozol 1mg/1l	13.89	7.91	0.416	105.6
LSD_{05}	F act < F table	F act < F table		
F_1 Chernysh				
Option I Control – distilled water treatment	64.0	6.4	-	-
Option II – Rostovit 1mg/1l	68.0	8.2	1.8	128.1
Option III Aminozol 1mg/1l	70.0	8.4	2.0	131.2
LSD_{05}	0.5	1.8		

Table 4: Biochemical and elemental composition of vegetable crop products with foliar top dressing using organic preparations

Treatments	Nitrates, mg/kg	Protein nitrogen, %	Vitamin C, mg/100g of fresh product	Total sugar, %	Dry matter, %	mg/100g of fresh product					
						Ca	Fe	Mg	Cu	K	Zn
White cabbage F_1 Podarok											
Control	253+22	1	36+2.4	4.6	7.7	22+1.4	1.7+0.4	0.06+0.014	43.58+1.42	277.3+24.2	-
Rostovit	284+26	1	44+2.8	4.8	7.3	29+1.8	2.4+0.4	0.10+0.022	22.86+2.22	270.5+26.2	-
OMEK-7	136+18	1	43+1.8	4.0	8.7	42+2.0	1.8+0.2	0.07+0.014	69.66+1.64	269.7+18.8	-
Aminozol	284+20	1	41+2.2	4.9	9.4	30+1.8	1.2+0.6	0.06+0.008	35.37+2.82	197.4+16.4	-
Garlic F_1 Strelets											
Control	50+4	0.5	20+1.6	-	41.2	24+1.6	1.8	-	0.27+0.22	189.4+16.8	1.2+0.2
Rostovit	63+6	0.8	22+1.8	-	42.7	28+1.8	1.7	-	0.71+0.18	105.1+14.2	2.2+0.1
OMEK-7	60+4	0.6	28+1.8	-	42.5	22+1.6	2.4	-	0.65+0.24	243.3+18.8	2.3+0.1
Aminozol	50+2	0.5	25+2.0	-	40.2	22+1.4	1.5	-	0.70+0.16	156.6+17.4	1.8+0.1

nitrate accumulation (by 1.8-2.1 times) was noted in experiments with white cabbage in the 3rd option in comparison with the control and Options 2 and 4. We assume that this is caused by the slow release of nitrogenous elements after treatment with OMEK-7 and Aminozol. This showed a trend (an increase of 12-22% compared to the control), and the dry matter content in garlic was noted at the control level in all options.

In our study, foliar top dressing with Rostovit and Aminozol had no effect on the antioxidant activity (AOA) and increased the content of polyphenols in tomato fruits in all experimental options compared with the control (Table 5).

It is known from literature sources that the lack of nutrients and the water regime can negatively affect photosynthesis, thus causing oxidative stress and enhancing the production of antioxidants in plants (Ke et al., 2022; Buoso et al., 2022). Several studies have shown that a decrease in nitrogen (N) intake in plants leads to the accumulation of polyphenols in response to abiotic stress associated with N restriction. Thus, in our experiment, the level of polyphenols in the foliar treatments with Aminozol and Rostovit preparations, which contain high nitrogen content, did not significantly increase the content of polyphenols in fruits, which is consistent with the findings of Tattini et al. (2015).

Among the known biologically active compounds in vegetables, carotenoids are the most powerful singlet oxygen traps. It is known that the reduction in the risk of cardiovascular diseases under the action of carotenoids is due to the protection of low-density lipoproteins from pericardial oxidation and a decrease in the intensity of oxidative stress at the sites of atherosclerotic plaques. Cohort studies have established a protective role of beta-carotene against cardiovascular diseases in various countries worldwide (Bénard et al., 2011).

The effect of non-root treatments with Rostovit and Aminozol on the carotenoid content was ambiguous: in experiments with F_1 DRK 564 and F_1 Belido, the concentration of beta-carotene and lycopene increased slightly after treatments with Rostovit, while that of F_1 Chernysh decreased (Table 5). Lycopene has been determined by several researchers Di Mascio et al. (1989); George et al., 2004; Ali et al., 2020; Collins et al., 2022) and its values can vary widely in different tomato varieties. According to the authors, variability is associated with factors such as genotype, environmental factors (microclimate parameters) and plant nutrition, which together affect the biosynthesis of carotenoids.

It should be noted that non-root top dressing with Rostovit Aminozol did not affect the accumulation of nitrate, total sugar, and dry matter in tomato fruits. Nevertheless, the use of Rostovit increased the K (potassium) content in F_1 DRK 564 by 2 times, F_1 Belido by 1.5 times, and F_1 Chernysh by 1.7 times compared with the control (Table 6).

According to Guoxi (2007), an increased potassium content improves the activity of ascorbate peroxidase in tomato fruits, thereby contributing to an increase in ascorbic acid. A positive effect of the use of non-root treatments with organic preparations was noted on the intake of Fe in options where the maximum concentration of vitamin C was recorded (Table 6). The experimental data are consistent with the published results of Hurrell (2021),

Table 5: The effect of foliar top dressing with organic preparations on the carotenoid content and antioxidant activity of tomato, mg-eq. GA/g d.m.

Treatments	Beta-carotene	Lutein	Lycopene	Chlp a	Chlp b	AOA	Polyphenols
F_1 DRK 564							
Option I							
Control – distilled water treatment	0.4	1.09	4.39	-	-	42.4	27.6
Option II – Rostovit 1mg/1L	0.5	1.27	5.52	-	-	44.3	28.2
Option III Aminozol 1mg/1L	0.47	1.46	6.18	-	-	43.18	26.8
LSD_{05}	F act < F table	F act < F table	1.2			F act < F table	F act < F table
F_1 Belido							
Option I							
Control – distilled water treatment	0.35	1.31	4.19	-	-	47.3	27.4
Option II – Rostovit 1mg/1L	0.45	1.13	5.86	-	-	47.8	28.6
Option III Aminozol 1mg/1L	0.38	1.04	5.90	-	-	48.8	28.1
LSD_{05}	F act < F table	F act < F table	0.8			F act < F table	F act < F table
F_1 Chernysh							
Option I							
Control – distilled water treatment	1.69	1.0	4.85	0.015	0.030	39.8	29.2
Option II – Rostovit 1mg/1L	1.53	1.44	5.67	0.024	0.038	44.5	30.6
Option III Aminozol 1mg/1L	1.53	1.34	5.00	0.021	0.040	40.8	30.2
LSD_{05}	F act < F table	F act < F table	F act < F table	F act < F table	F act < F table	F act < F table	F act < F table

Table 6: Biochemical and elemental composition of vegetable crop products when applying foliar top dressing with organic preparations

Options	Nitrates, mg/kg	Protein nitrogen, %	Vitamin C, mg/100g of fresh product	Total sugar,%	Dry matter, %	mg/100g of fresh product				
						Ca	Fe	Mg	Cu	K
Tomato F_1 DRK 564										
Option I	18+1.4	2.0	18+1.6	4.49	9.6	8.15+1.0	0.3+0.1	0.68+0.12	0.7+0.14	176.8+18.2
Control – distilled water treatment										
Option II – Rostovit 1mg/1L	19+1.8	2.8	26+1.8	4.29	9.2	17.01+1.4	0.5+0.08	1.42+0.18	1.2+0.15	294.2+24.2
Option III Aminozol 1mg/1L	19+1.6	2.4	18+2.4	3.87	9.7	8.87+1.2	0.5+0.1	0.83+0.2	1.0+0.18	228.7+20.2
Tomato F_1 Belido										
Option I	16+1.4	2.0	20+1.4	3.92	9.9	8.27+1.6	0.2+0.08	1.12+0.32	1.5+0.3	234.7+18.2
Control – distilled water treatment										
Option II – Rostovit 1mg/1L	15+1.4	3.2	24+1.8	3.79	10.2	12.17+1.4	0.5+0.1	0.78+0.22	2.0+0.06	288.2+22.2
Option III Aminozol 1mg/1L	18+1.5	4.0	26+1.6	3.49	10.9	10.10+1.2	0.4+0.1	0.75+0.12	1.9+0.16	259.1+19.0
Tomato F_1 Chernysh										
Option I	18+1.5	2.0	18+1.2	4.12	9.71	8.27+1.2	0.3+0.08	1.12+0.08	1.5+0.3	268.2+20.0
Control – distilled water treatment										
Option II – Rostovit 1mg/1L	19+1.8	2.8	22+1.6	4.86	11.3	14.17+2.0	0.6+0.1	0.84+0.06	2.2+0.3	294.7+24.2
Option III Aminozol 1mg/1L	20+1.5	2.4	20+1.5	4.54	10.1	10.10+1.2	0.5+0.08	0.92+0.08	2.0+0.5	288.1+19.4

where the authors noted that ascorbic acid from vegetables and fruits activates the absorption of iron. It is generally believed that trace element iron from plant sources is difficult to digest by the human body. Nevertheless, the process of self-regulation of iron availability in the human body in conditions of a lack of consumption of trace elements from animal sources enhances the process of iron absorption from plants (Golubkina et al., 2010).

In our experiments, the calculated doses of organic preparations had a positive effect on copper content. The effect of copper on the activity of enzyme systems has been established, which enhances the process of binding atmospheric molecular nitrogen and assimilation of soil nitrogen and fertilizers, ultimately increasing yields.

Conclusion

The high efficacy of the tested preparations on white cabbage and garlic was demonstrated, but at the same time a specific reaction was observed. In garlic, the maximum yield was obtained after a triple treatment with OMEK-7 at a concentration of 1g/L, while in white cabbage the maximum yield was obtained after a triple treatment with Rostovit at a concentration of 1mL/L. As a result of the treatments, the yield of white cabbage improved.

As a result of the treatments, the product quality improved, in particular the nitrate content in garlic (OMEK-7) decreased and the ascorbic acid content in both garlic and white cabbage increased. The effect of the preparations on the trace element content was not clear.

Thus, the use of the environmentally friendly preparations Aminozol, OMEK-7 and Rostovit made it possible not only to increase the yield of products per unit area, but in some cases also to improve their quality.

A positive response of tomatoes to organic preparations containing brewer's yeast, macro- and microelements and amino acids was observed, and at the same time a species-specific response of hybrids was found. Triple foliar fertilisation with aqueous solutions of aminozole and Rostovit preparations increased the yield of the hybrid F1 Chernysh by 31 and 28% respectively compared to the control varieties. The tested preparations had a positive effect on the biochemical and elemental composition of the fruits of the tested tomato hybrids: Potassium (K), ascorbic acid (vitamin C), iron (Fe), copper (Cu).

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