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YIELD AND FRUIT QUALITY OF *Malus domestica* Borkh. AS INFLUENCED BY NOVEL ORGANOMINERAL FERTILIZERS

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Abstract

One of the most promising methods of increasing the yield and quality of agricultural products is the application of environmentally friendly compounds, such as natural biostimulants. The use of organomineral nutrient complexes contributes to a significant increase in the adaptive properties of plants and, as a result, increases productivity and improves yield quality. This paper shows for the first time the effectiveness of using new organomineral fertilizers as additional elements in cultivation of apple trees under the soil and climatic conditions of the Orel region. The aim of the work was to study the effect of new organomineral fertilizers on the yield and quality of apple fruits before and after long-term storage. Tests of the natural plant complex White Pearl (NPC WP) (OOO AgroPlus Group of Companies, Russia) were carried out at the experimental plot of Russian Research Institute of Fruit Crop Breeding in 2021-2022. Phytomodulator NPC WP Universal (WPU) Antifreeze was a suspension of a group of minerals of natural origin containing a concentrate of extracts of spruce, pine and Siberian fir needles. Phytocorrector NPC WP Drip Ca + Mg is an extract of vegetative mass of oceanic bioflora with an organomineral basis. The study was performed with a triploid apple (*Malus domestica* Borkh.) cultivar Sinap Orlovsky of late winter ripening the fruits of which are predisposed to scald and bitter pitiness. The apple trees were grafted on a medium-sized rootstock 54-118. The scheme of the tree layout in the orchard was 6×3 m. The experiment was laid on the 2013 planting site with the agro-gray forest soils, humus content of 3-4 % and humus horizon capacity of 30-35 cm. The rows were naturally overgrown with grass. Herbicides were applied into the pre-trunk strips. The agronomic practice was as generally accepted for the crop. In the early spring period, the plants were two-fold non-root treated with 1.0 % NPC WPU Antifreeze solution. Subsequent treatment was carried out in spring during the "closed inflorescence" phenophase with a tank mixture of 1.0 % of NPC WPU Antifreeze + 1.0 % NPC WP Drip Ca + Mg. In summer, the leaves were treated four times with the drugs. In the control, the plants were untreated. The fruit yield (in kg) harvested during the period of removable fruit maturity was assessed individually from each pant by weighing. The commercial qualities, chemical composition and keeping quality of the fruits under storage were evaluated. The fruits were stored in the CV114-S refrigerator (Polair, Russia) for 211 days at +2 °C. The content of calcium and magnesium was determined by the trilometric method on a flame photometer M 410 (Sherwood Scientific, Ltd., UK); potassium and phosphorus were measured after dry calcination and dissolution of ash in 20 % hydrochloric acid according to the guidelines. In the research, it was revealed that the complex application of organomineral fertilizer of the NPC WP line significantly increased the yield (by 72.5 %) and the average fruit weight (by 20.3 g) of the cultivar by optimizing the nutritional regime of plants. In addition, non-root treatments favorably affected the consumer and commodity qualities of fruits both at harvest and after long-term storage. Treatments with a tank organomineral mixture improved the taste qualities of Sinap Orlovsky fruits by increasing the amount of sucrose (by 25.6 %) and ascorbic acid (by 20.5 %) compared to control. The treatment of plants contributed to a close-to-optimal ratio (K+Mg)/Ca = 11.2. Under treatments, there was a higher yield of commercial fruits (by 14.8 %) compared to control. Moreover, the wastes were 3 times less. The use of natural plant complexes ensured a reduced incidence of bitter pitines, i.e., with prolonged storage, fruits with this disease

were 2 times fewer. The degree of fruit lesion with scald was 2.5 times less. The number of registered microbiological damages decreased. The tasting score of the treated fruits was 4.7 points for appearance and 4.9 points for taste. Our tests of new organomineral preparations of the NPC White Pearl line show the prospects of their use as an addition to common technologies for growing apples in order to increase the yield and quality of apple fruits.

Keywords: apple, Sinap Orlovsky, organomineral fertilizer, fruit quality, productivity

Modern intensive gardening aims to comprehensively address the task of creation of productive plantings for a high-quality harvest. Thereof, it becomes important to master agrotechniques that ensure crop formation regardless of weather conditions.

A high yield of agricultural crops is impossible without the use of modern chemical agents. However, chemicals pose a serious threat to the health of people, animals, plants and the entire biosphere [1] but a number of effective measures can reduce the use of pesticides and mineral fertilizers [2-4]. Environmentally friendly compounds, such as natural biostimulants, are among the most promising to increase crop yield and quality [5-7]. These preparations are based on organic and inorganic substanses and microorganisms which in small doses promote physiological and biochemical processes and thereby allow changes in metabolism in plants and in the soil [8-10]. Biostimulants improve the availability of nutrients and their absorption, which leads to higher productivity and environmental friendliness of crop yields [11-13].

Elements of biostimulant-based technology have been developed, ensuring high productivity and quality of fruits of horticultural crops [14, 15]. A 3-fold foliar application of organomineral fertilizer Evrykor Forte+7 (Agrotechnologies, Russia) at 1.5 l/ha dosage increases strawberry yield by 14-28% [16]. In addition to humic acids, this preparation includes N (8.4%), P (3.6%), K (10.4%), B (0.7%), S (0.04%), Fe (0.06%), Cu (0.01%), Zn (0.01%), Mg (0.01%), Co (0.0005%), Mo (0.0012%), Mn, Zn, Li, Cr, Ni are in chelate form.

Foliar treatments with Regalis® (BASF, Germany) (active ingredient calcium prohexadione, 100 g/kg) action of which is aimed at inhibiting the biosynthesis of gibberellins and ethylene and changing the metabolism of flavonoids [17, 18], increase the yield of apple trees due to a significant reduction in ovary abscission and improved fruit quality [19]. Treatment with prohexadione-Ca and paclobutrazol at 400 mg/l also increases pear weight and yield [18]. Complex organic fertilizer Naliv (LLC Ecoharvest, Russia) based on biohumate from horse manure and plant raw materials that contains humic and fulvic acids, amino acids, including proline, increases monosaccharides 1.8-fold and sucrose by 10 % in ripening apples [20].

In the northwestern part of Egypt, plant biostimulants improve nutrient absorption, growth, fruit yield and quality in apple trees. A 3-fold spraying with different combinations of biostimulants (4% moringa leaf extract + 0.3% seaweed extract + 0.1% fulvic acid and 6% moringa leaf extract + 0.4% seaweed extract + 0.2% fulvic acid) improved vegetative growth and physicochemical characteristics of fruits, increased the proportion of fruit set and yield in the Anna apple tree variety [21[.

Our previous experiments on apple tree foliar treatments with the organomineral mixture NPC White Pearl (AgroPlus Group of Companies LLC, Russia) revealed an acceleration of growth and fruit ripening due to regulation of protein-carbohydrate metabolism, water regime and donor-acceptor leaf-fruit relationships. This resulted in fruit harvest 1.8 times more and apple weigh was 10 g more on average [22]. Other publications confirm the effectiveness of physiologically active substances in horticulture. They accelerate the growth and ripening of fruits, improve their quality, and increase the yield of garden crops [23-25].

New biologicals require the study to improve technologies of their use for higher yields and fruit quality of horticultural crops.

This study shows for the first time the effectiveness of two developed organomineral fertilizers. The first is White Pearl Universal Antifreeze (suspension of natural minerals + a concentrate of spruce, pine, Siberian fir needles extracts; phytomodulator) and the second is White Pearl Drip Ca + Mg (extract of the vegetative mass of oceanic bioflora on organomineral basis; phytocorrector). These preparation may serve as additional elements of technology for cultivating apple trees in the soil and climatic conditions of the Oryol Province.

The purpose of the work is to study the effect of new organomineral fertilizers on the yield and quality of apple fruits before and after long-term storage.

Materials and methods. Biostimukant testing was carried out at the experimental site of the All-Russian Research Institute for Breeding Fruit Crops (RRIBFC, village of Zhilina, Oryol Province, Oryol District) in 2021-2022.

The natural plant complex White Pearl (NPC WP) (AgroPlus Group of Companies LLC, Russia) is recommended by the manufacturer to increase resistance to spring frosts, to optimize the water regime and photosynthesis, to increase crop yield and quality. Phytomodulator NPC WP Universal (WPU) Antifreeze is a suspension of natural minerals containing a concentrate of spruce, pine, and Siberian fir needles extracts. WPU is 5.6% SiO_2, 2-6% $N_{tot.}$, 5000 ppm CaO, 7000 ppm MgO, 0.2% K_2O, 130 ppm B, 150 ppm Zn, 200 ppm Mo, 1600 ppm Al_2O_3 and other trace elements; vitamins A (carotene, lutein), D (phytosterols), E, K, B_1, B_2, B_6, PP, H; essential oils, chlorophyll, flavonoids, sugars, proteins, amino acids. Phytocorrector NPC WP Drip Ca + Mg is an extract of the vegetative mass of oceanic bioflora on an organomineral basis. The phytocorrector is 3490.0 ppm Ca, 2829.0 ppm Mg, 42.9 ppm P, 38.8 ppm K, 0.3 ppm S, 68.7 ppm Fe, 3.65 ppm Mn, 3.37 ppm B, 0.85 ppm Cu, 0.05 ppm Zn, 0.1 ppm Si, 0.003 ppm Se, 2.1 ppm I, 0.01 ppm Mo (bioelements); 5.6% SiO_2, 0.4% CaO, 0.4% MgO, 0.2% K_2O, 0.4% Fe_2O_3, 0.16% Al_2O_3 (minerals); vitamins A (carotene, lutein), D (phytosterols), E, K, B1, B2, B6, PP, H; chlorophyll, sulfonic acids, humic acids, sugars, proteins, amino acids.

The triploid apple (*Malus domestica* Borkh.) variety Sinap Orlovsky of late winter ripening derives from crossing the varieties Northern Sinap and Pamyat Michurina. The advantages of the variety are early fruiting and winter hardiness, however, if calcium in the soil is deficient, the fruits can be damaged by bitter pitting during growing season and long-term storage and by tanning if the storage temperature is violated [26].

The experiment was carried out in 2023 in plantings at a site with agro-gray forest soils, the humus content is 3-4%, a humus horizon thickness is 30-35 cm. The apple variety scions were grafted onto a medium-sized rootstock 54-118. The layout of the trees in the garden is 6×3 m. In the inter-row spaces, natural grasses grew, herbicides were applied to the tree trunk strips. Agricultural technology was generally accepted for the crop. In each of the two treatment there were 3 replications, in each replication there were 5 tested trees.

In the early spring, plants were foliarly treated twice with a 1.0% solution of NPC WPU Antifreeze, the first foliar treatment in the dormant bud-silver cone phenophase, the second in the mouse ear phenophase. Next treatment was carried out in the spring during the phenophase of the closed inflorescence, using a tank mixture of 1.0% of NPC WPU Antifreeze + 1.0% NPC WP Drip Ca + Mg. In the summer, 14 days after flowering, in the fruit-hazel, fruit-walnut phases and 25 days before harvesting, the leaves were treated with 1.0% NPC WPU Antifreeze + 1.0% NPC WP Drip Sa + Mg to preserve fruits from shedding, increase yield and improve fruit quality. In the control, no treatment was carried out.

The water fractional composition in leaves was assessed by the Okuntsov-Marinchik method (a PAL-1 refractometer, Atago, Japan) [27] 5 days after each foliar treatment.

For yield recording (in kg), apples from each tree was weighed during the period of harvesting ripeness. The commercial qualities, chemical composition and storage quality of apples were assessed as described [28, 29]. The apples were stored in a ShKh CV114-S refrigerator (Polair, Russia) at +2 °C from September 13, 2021 to April 11, 2022 [29], 211 days in total. The content of calcium and magnesium was measured trilonometrically (a flame photometer M 410. Sherwood Scientific, Ltd., UK), potassium and phosphorus after dry ashing and dissolving the ash in 20% hydrochloric acid according to recommendations ([30].

The results were processed by one-way analysis of variance (ANOVA) in Microsoft Excel 2003 with Fisher's test (*F*). The critical significance level was 5%. Arithmetic means (*M*) and standard error of the arithmetic mean (±SEM) were calculated.

Results. In the spring-summer period, foliar treatments with a mixture of NPC WPU Antifreeze 1.0% + 1.0% NPC WP Drip Ca + Mg contributed to a 2.1% increase in the free water content in leaves of the Sinap Orlovsky apple tree compared to the control (Fig. 1).

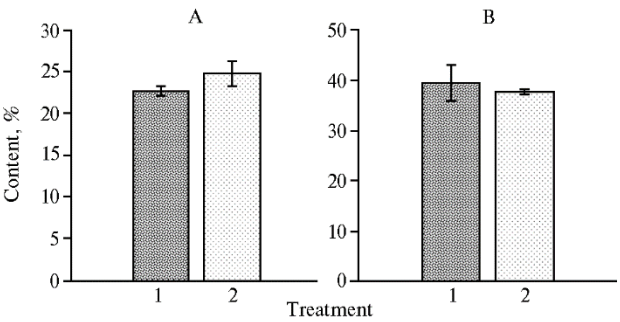

Fig. 1. The content of free (A) **and bound** (B) **water in the leaves of the apple (*Malus domestica* Borkh.) variety Sinap Orlovsky upon foliar treatment with 1.0% White Pearl Universal Antifreeze + 1.0% White Pearl Drip Ca + Mg:** 1 — control, 2 — test ($N = 3$, $n = 5$, M±SEM; village of Zhilina, Oryol Province, Oryol District, 2021-2022).

We did not find any statistically significant differences between the experimental variants.

Water is an essential component of the cytoplasm of living cells. Free water as a solvent is essential for cell metabolism, hydrolytic and synthetic processes, it promotes the interaction of molecules and the intensive outflow of organic substances accumulated in the leaves during photosynthesis to fruits. Presumably, foliar treatments with an organomineral mixture had a positive effect on the water regime of leaves, contributing to the intensive transition of bound water into a more mobile form which serves as the main transporter of organic substances and is necessary for the normal functioning of plants during fruit formation and ripening.

S.G. Denisova et al. [31] tested organomineral fertilizer Gumi-20 (an aqueous solution of at least 60% sodium humate; 0.5-2%nitrogen, 0.5-2% phosphorus, 0.1-1%potassium) (NVP BashInkom, Russia) that is recommened as an anti-stress adaptogen. The preparation did not have a significant effect on the water regime parameters (water content, water deficit, water-holding capacity) in chrysanthemum varieties. The water regime indicators of the treated chrysanthemum plants were comparable to the control.

When the fruits reached ripeness in September, we weighed the yield. There was an increase in the average yield per tree upon treatment with NPC White Pearl preparations vs. control (Fig. 2, A).

According to the publications [32, 33], complex biostimulants containing protein hydrolyzate, seaweed extract, chitosan and humic acids also increases the crop yields. For example, biostimulants containing alfalfa protein hydrolysate, B

vitamins, chitosan and silicon increased strawberry yield by 20% [34].

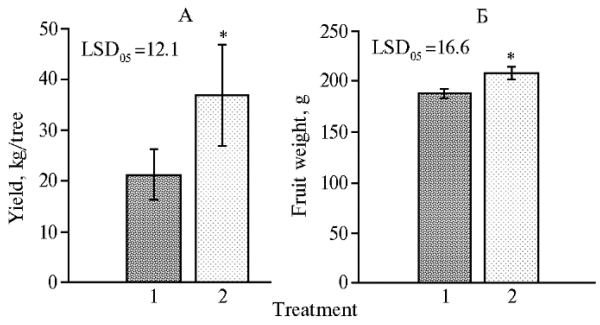

Fig. 2. Yield (А) **and fruit weigh** (Б) **in apple (*Malus domestica* Borkh.) variety Sinap Orlovsky upon foliar treatment with 1.0% White Pearl Universal Antifreeze + 1.0% White Pearl Drip Ca + Mg:** 1 — control, 2 — test ($N = 3$, $n = 5$, M±SEM; village of Zhilina, Oryol Province, Oryol District, 2021-2022).
* Differences between the treatments are statistically significant at $p < 0.05$.

Foliar spraying with organomineral fertilizer Evrikor Forte+7 (Agrotechnologies, Russia) contributed to an increase in strawberry productivity, depending on the variety, from 3.5% (Orlets) to 17.7% (Junija Smaids) [16]. It is noteworthy that under the influence of complex organomineral fertilizer Naliv (Ecoharvest LLC, Russia), apple tree yields were only 14% more [20]. Five foliar sprayings with seaweed *Ascophyllum nodosum* extract (1.5 kg/ha) had no positive effect on the yield, size of grape bunches and berries [14].

Thereof, the organomineral mixture NPC WPU Antifreeze 1.0% + 1.0% NPC WP Drip Ca + Mg we used to treat apple trees showed greater effectiveness than the preparations discussed hereinabove. The increase in yield from all trees of the treated plants of the Sinap Orlovsky variety was 72.5% ($p < 0.05$) (see Fig. 2, A).

Foliar treatments with an organomineral mixture NPC WPU Antifreeze 1.0% + 1.0% NPC WP Drip Ca + Mg provided a better fruit quality. According to our data, the average weight of an apple from treated trees increased by 10.8% (20.3 g) compared to control (see Fig. 2). A similar positive effect occurred when spraying strawberry plants with organomineral fertilizer Evrykor Forte+7 when the average berry weight increased by 8.0-18% and was in the range of 9.5-11.8 g [16].

1. Chemical composition of harvested fruits in apple (*Malus domestica* Borkh.) variety Sinap Orlovsky upon foliar treatment with 1.0% White Pearl Universal Antifreeze + 1.0% White Pearl Drip Ca + Mg ($N = 3$, $n = 5$, M±SEM; village of Zhilina, Oryol Province, Oryol District, 2021-2022)

Treatment	Soluble dry matter, % wet weight	Organic acids, % wet weight	Monosaccharides, %	Sucrose, % wet weight	Ascorbic acid, mg/100 g wet weight
Control (without treatment)	11.59±0.19	0.83±0.03	6.86±0.07	2.42±0.06	11.58±3.17
Test	11.50±0.16	0.83±0.05	6.62±0.11	3.04±0.07*	13.95±3.02

* Differences between the treatments are statistically significant at $p < 0.05$.

Biochemical analysis showed that foliar treatments with the preparations improved taste of apples because of a 25.6% increase in sucrose and 20.5% increase in ascorbic acid (Table 1). The increase in sucrose content in treated fruits is presumably due to the fact that sucrose serves as a substrate for respiration processes, and was consumed to a greater extent in the control than upon treatment with the organomineral preparations that increase stress resistance. Moreover, it cannot be ruled out that treatments with adaptogenic drugs enhanced the transformation of monosaccharides, thereof, more sucrose was accumulated in apple upon theatmtnt than in the control.

Our data on the accumulation of ascorbic acid are consistent with the results of other researchers. Thus, foliar treatment with organomineral fertilizer

Evrykor Forte+7 affected the accumulation of ascorbic acid in the berries of the strawberry varieties Anastasia (61.8 mg/100 g, a 3.5% increase compared to the control) and Orlets (60.2 mg/100 g, an increase of 6.1%) [16].

Foliar treatments with the organomineral mixture NPC WP did not significantly affect the amount of soluble solids (SS), organic acids and monosaccharides in the fruits of the Sinap Orlovsky variety. Similar results were obtained after treating strawberry plants with Evrikor Forte+7 fertilizer. The SS content and total acidity in the treated berries were comparable to the control [16]. S. Soppelsa et al. [35] also did not reveal a positive effect of macroalgae extract, B vitamins and protein hydrolyzate on the content of soluble solids and organic acids in apples. However, biostimulants based on alfalfa protein hydrolyzate, seaweed extract, chitosan and B vitamins improved the chemical composition of strawberries, increasing the amount of phenolic compounds [33]. Foliar spraying of grapes with seaweed extract *Ascophyllum nodosum* (1.5 kg/ha) accelerated ripening and increased the content of anthocyanins and phenolic compounds in berries [14].

The balance of the mineral composition of fruits plays a significant role in the apple shelf life. Bitter pitting. a physiological disorder is associated with a lack of calcium in fruits. In apple tree varieties that are sensitive to this disease, including Sinap Orlovskiy, up to 80% of the fruits can be affected during long-term storage [36], which causes significant losses for fruit producers. The risk of bitter pitting during long-term storage is related to the Ca/Mg, K/Ca, and (K+Mg)/Ca ratios [37]. The main indicator of the keeping properties of apple fruits is the ratio (K+Mg)/Ca. In healthy fruits of varieties grown in the south of Russia, it should be within 11/15 [38]. E.V. Leonicheva et al. [39)] note that the fruits of the Sinap Orlovsky, grown in the conditions of the Oryol region, have good shelf life and apple mineral composition meets the criteria recommended for apple varieties in the south of Russia.

In our research, upon foliar treatment with new NPC WP preparations the (K+Mg)/Ca value was 11.2 c.u., that is, close to optimal (Fig. 3). The control ratio was 9.9 c.u. It is important to note that it was with treatment using new White Pearl organomineral preparations that the proportion of apple fruits affected by bitter pitting after long-term storage decreased 2 times (Table 2).

We studied the most significant chemical components of apple fruits from the 2021 harvest, characterizing their nutritional value at the harvest and at economic maturity during storage. According to biochemical analysis before long-term storage, the sugars and ascorbic acid (AA) concentration were higher in the treated fruits than in control.

All fruits at the end of storage (Table 3) had medium SS content [29]. For apple fruits grown in central Russia, SS of more than 13% is considered high. In our experiment, the SS values at the end of storage remained higher than in the control, although we found no significant differences. The index of titratable acidity in fruits was low (< 0.61%) in both control and test variants (for varieties bred by RRIBFC, acidity is considered medium at 0.61-0.85% and high at > 0.86%) [29]. The AA content at the end of storage decreased to 7.03 mg/100 g in the control and to 2.33 mg/100 g in the treated fruits. Before storage, the fruits were characterized by medium sum of sugars (sucrose + monosaccha) both in control and treated trees, 9.61 and 10.58%, respeively (see Table 3).

2. Commercial qualities of apple (*Malus domestica* Borkh.) variety Sinap Orlovsky fruits upon foliar treatment with 1.0% White Pearl Universal Antifreeze + 1.0% White Pearl Drip Ca + Mg after 211-day storage at +2 °C (N = 3, n = 5, M±SEM; village of Zhilina, Oryol Province, Oryol District, harvest of 2021)

Treatment	Commercial grade fruits, %	Fruit waste, %	Scald, %	Overmaturity, %	Browning, %	Bitter pit, %	Partially rotted, %	Completely rotted, %	Other
Control (without treatment)	78.0±2.7	22.0±2.7	11.7±7.1	1.2±0.6	2.7±2.6	5.0±1.6	0.7±0.6	0.7±0.6	Visual single average fading
Test	92.8±0.9*	7.2±2.1*	4.7±2.1	–	–	2.5±1.3	–	–	Visual single minor fading

N o t e. Dashes mean no damaged fruits.
* Differences between the treatments are statistically significant at $p < 0.05$.

3. Chemical analysis of apple (*Malus domestica* Borkh.) variety Sinap Orlovsky fruits upon foliar treatment with 1.0% White Pearl Universal Antifreeze + 1.0% White Pearl Drip Ca + Mg after 211-day storage at +2 °C (N = 3, n = 5, M±SEM; village of Zhilina, Oryol Province, Oryol District, harvest of 2021)

Treatment	Timing of analysis	Soluble solids, %	Titratable acidity, %	Total sugars, %	Sugar/acid	Ascorbic acid, mg/100 g	Tasting score
Control (without treatment)	BS	12.07±0.48	0.96±0.05	9.61±0.19	10.01±0.72	19.37±6.27	
	ES	12.87±0.19	0.35±0.02	12.62±1.04	36.14±4.60	7.03±2.05	4.5/4.6
Test	BS	11.77±0.30	0.96±0.08	10.58±0.43	11.02±1.23	23.78±5.29	
	ES	13.43±0.93	0.39±0.04	12.34±0.71	31.64±5.28	2.33±0.29	4.7/4.9

N o t e. BS — befining of storage, ES — end of storage with tasting assessment.

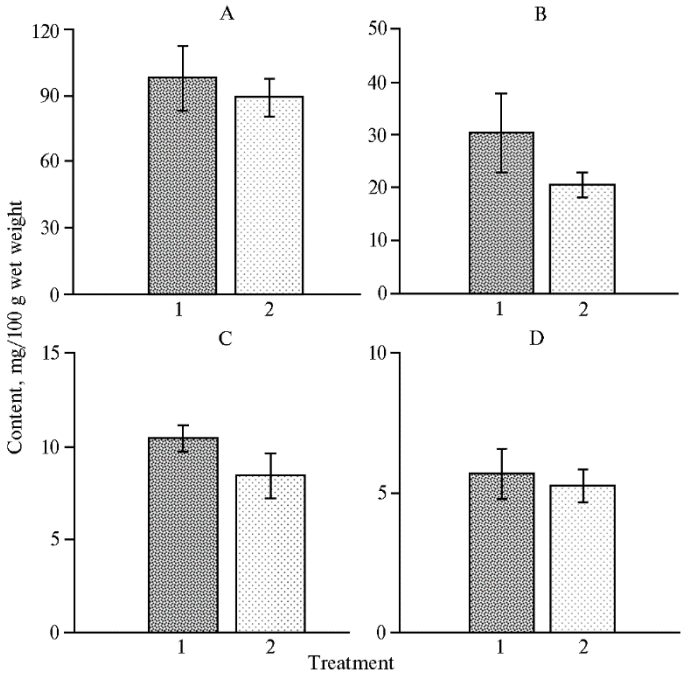

Fig. 3. Content of potassium (A)**, phosphorus** (B)**, calcium** (C) **and magnesium** (D) **in harvested fruits of apple (*Malus domestica* Borkh.) variety Sinap Orlovsky upon foliar treatment with 1.0% White Pearl Universal Antifreeze + 1.0% White Pearl Drip Ca + Mg:** 1 — control, 2 — test ($N = 3$, $n = 5$, $M \pm$SEM; village of Zhilina, Oryol Province, Oryol District, 2021-2022).

At the stage of economic maturity (after long-term storage), the studied fruits in both variants were of a fairly high nutritional value, as evidenced by the the sugar acid index (SAI is the ratio of the sum of sugars to titratable acidity). The optimal fruit SAI value which is used to determine the harmonious (sweet and sour) taste is 15-20. In our experiment, after harvesting, SAI varied from 10.01 (control) to 11.02 (foliar treatments), after storage from 31.64 (foliar treatments) to 36.14 (control). Due to a decrease in the content of titratable acids and an increase in sugars, the SAI value increased, which had a positive effect on the taste of the fruit. The tasting score was higher for the treated fruits, 4.7 points (appearance) and 4.9 points (taste), while the scores of control fruits were 4.5 and 4.6 points, respectively (see Table 3).

In terms of the yield of marketable fruits (see Table 2), the experiment revealed significant differences between the options ($p < 0.05$). When treated with organomineral fertilizers, 92.8% of fruits were marketable with a waste of 7.2% vs. 78.0 and 22.0%, respectively, in control.

Physiological diseases of the fruit that occur during storage can seriously affect the quality of apples and lead to significant economic losses (40). Treatment with new NPC WP preparations almost 3 times reduced the degree of damage to fruits by tanning (browning of the skin surface) during storage, although statistical differences between the variants were not confirmed. We obtained similar data for bitter pitting, which may indicate an imbalance in the mineral composition of the fruit. In addition, in control, there were overripe and browned fruits. Fruits treated with NPC WP preparations did not have similar damage. Of the microbiological diseases on fruits in the control variant, minor damage was recorded, mainly by fruit rot (moniliosis, pathogen *Monilia fructigena* Pers.) [29]. Small round spots of a brownish color quickly increased in size to form concentric circles at the site of infection. Upon the treatments, the fruits did not have microbiological damage

(see Table 3). Based on the data obtained, we can conclude that foliar treatment with the White Pearl organomineral mixture, due to balanced nutrition of apple plants, increases the yield of marketable fruits by reducing damage from bitter pitting and tanning during long-term storage.

Plant biostimulants were tested to reduce fruit spotting in the Jonathan variety [35, 41]. The preparations used, like organomineral fertilizers NPC WP, contained humic acids, seaweed extracts, proteins, amino acids, zinc, silicon, B vitamins. The authors [35, 41] note the effectiveness of acalcium chloride + seaweed extract + a Zn-containing product (Siliforce®, Spain) combination in reducing Jonathan fruit spotting during storage. Co-application of Ca and Zn resulted in higher concentrations of these elements in fruit skins [41], which may strengthen cell membranes [42], reducing disease incidence during long-term storage.

Thus, the natural plant complex 1.0% White Pearl Universal Antifreeze + 1.0% White Pearl Drip Ca + Mg showed high efficiency in the apple orchard. The plants of the Sinap Orlovskiy variety upon foliar treatment were 72.5% ahead of the control in yield. The average apple weight upon treatment exceeded the control by 20.3 g. The taste of the fruits improved due to an increase in the content of sucrose (by 25.6%) and ascorbic acid (by 20.5%). Upon treatment, the ratio (K+Mg)/Ca was close to the optimal, 11.2 c.u. The organomineral nutritional complex significantly (by 14.8%) increased the yield of marketable fruits and reduced the incidence of physiological diseases during long-term storage. The number of fruits with bitter pitting were 2 times less vs. control, the degree of sun damage decreased 2.5-fold. The tasting scores were higher upon treatmrnt, 4.7 points for appearance, 4.9 points for taste. Physiologically active substances significantly increase fruit yield and quality due to a balanced organomineral nutrition of the apple tree. Testing of new organomineral fertilizers of the NPC White Pearl line have shown their high efficiency when used additionally to traditional apple tree cultivation technologies. These fertilizers are recommended to increase the yield and quality of apples before and during long-term storage.

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