reaching 64.4–66.3 cm. The application of mineral fertilizers with microelements resulted in an increase in plant height from 0.9–1.9 cm to 1.0–2.7 cm compared to the control. Furthermore, a tendency of increased leaf formation in alfalfa plants was noted with the application of higher doses of potassium fertilizer and microelements at both seeding rates. The leaf formation at a seeding rate of 6.0 million/ha ranged from 50.45 % to 53.53 %, which was 2.24–2.42 % higher than at a seeding rate of 8.0 million/ha. The application of macro- and microelements promoted an increase in leaf formation of alfalfa plants by 2.21–5.29 % compared to the control. The study contributes to the understanding of alfalfa growth and development in its first year, providing valuable insights for optimizing cultivation practices. The findings highlight the importance of appropriate seeding rates and fertilization strategies in enhancing alfalfa productivity and competitiveness against weeds.

***Key words**: alfalfa, plant height, leaf formation, hydrothermal conditions, growth and development, weed infestation, seeding rate, mineral fertilizers.*

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THE YIELD AND QUALITY OF STRAWBERRY CASSETTE PLANTING MATERIAL DEPENDS ON THE COMPOSITION OF THE SUBSTRATE FOR ITS ROOTING IN THE RIGHT BANK FOREST STEPPE OF UKRAINE

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Публікація містить матеріали досліджень, спрямованих на удосконалення елементів технології вирощування касетного садивного матеріалу суниці, пов'язаних з підбором оптимального складу субстрату для окорінення розеток і підвищення виходу розсади високої якості. Експериментально підтверджено краще окорінення розеток з підвищенням ростових показників розсади за насичення субстратної торфосуміші Біогумусом і Триходерміном. При цьому, збільшується її облистненість, наростає стеблова частина і загальна довжина кореневої системи, що веде до підвищення виходу якісного садивного матеріалу суниці.

***Ключові слова:** суниця, касетна розсада, субстрат, торфосуміш, Біогумус, Триходермін, продуктивність, сорти, окорінення, якість.*

Statement of the problem. The need for a great number of strawberry seedlings per area unit and the use of intensive technologies for growing this crop is based on the establishment of plantations with high-quality planting material that gives a marketable yield already in the year of planting [1]. Refrigerated storage seedlings («frigo») which

cultivation is too complicated in the conditions of the Right-Bank Forest-Steppe with heavy soils by granulometric composition meet these requirements. An alternative to this is cultivation of cassette planting material in artificial substrate, which is related to the risks of insufficient nutrition of rooted rosettes or damage of their root system by soil diseases. In this case, strawberry cassette seedlings can meet all modern quality requirements under the condition of being completely rooted and nourished in a phytosanitary and organically enriched substrate [2]. Therefore, the development of measures to select the optimal composition of the substrate for rooting and full rosettes growth of strawberry based on its biologization with Biohumus and Trichodermin is a current issue nowadays and is gaining urgency.

Analysis of recent researches and publications. Strawberry occupies over 70 % of the world's berry sector and has been popular for over two centuries. In modern conditions, agricultural technology of this berry crop is based on a short cycle of its cultivation and, along with a high density of plantations (over 55 thousand pcs/ha), requires a large number of planting material [3]. In world practice, the most popular type of strawberry seedlings is «frigo» seedlings, which is based on refrigerated storage conditions. Technology for production of such seedlings has been developed quite effectively on the basis of agrotechnical requirements. Among the latter, it is necessary to highlight the need for light soils, which allow you to dig up seedlings already after autumn frosts onset [4].

For the conditions of the Right-Bank Forest-Steppe of Ukraine with the predominant amount of heavy soils by granulometric composition, the technology of growing strawberry seedlings with an open root system is quite complicated and loses its advantage. Instead, an alternative way is to grow cassette strawberry seedlings with a closed root system. The advantage of such planting material is intactness of the root system and high plant survival after planting for fruiting [5]. Another important factor is the sterility of soil environment under which the strawberry root system is not under the risk of root rot diseases. This type of seedlings has recently become popular not only in the closed soil conditions but also in the open ones [6]. Difficulty in receiving high-quality cassette planting material of strawberry is weakening of rosettes growth at the time of their rooting and growth retardation due to the compaction of plants and a low-nutrient substrate. At the same time, prolonging the growth period of strawberry seedlings in cassettes does not significantly improve its quality [7].

An alternative way to improve the quality of cassette planting material of strawberry is the selection of optimal substrate composition for rosettes rooting based on biologically active compounds. Among these, Biohumus as a basis for saturating the substrate with humic compounds and improving the nutrient environment for young seedlings should be singled out. Such saturation of soil mixture exposes the risk of contact of the root system of strawberry seedlings with pathogens that can enter the substrate with Biohumus [8]. There is a practice of introducing biocompounds of a fungicidal nature into the soil environment in order to partially avoid or relieve such a phenomenon. Trichodermin can be among the abovementioned compounds which is used both in the form of a solid mass and by spraying or wetting [9]. Positive properties of Biohumus and Trichodermin are mutually complementary components for

saturating the substrate with them for the purpose of strawberry rosettes rooting and require a more detailed study under experimental conditions.

The purpose of research is to increase the yield and quality of cassette planting material of strawberry by improving the substrate for rooting seedlings with substances of a biological nature in the conditions of the Right-Bank Forest-Steppe of Ukraine.

Research methodology. Control variant with a ready-made peat mixture for strawberry rosettes rooting was included in the experiment scheme in order to determine the efficiency of applied substrate compositions. Variants with two types of substrate – one with application of Biohumus, and the other – with additional treatment with Trichodermin were accepted as experimental ones. Determining the efficiency of these agricultural measures was conducted on two strawberry varieties – Dukat and Malvina. Cassette seedlings were grown in cassettes with a cell volume of 384 cm^3 (6 × 8 × 8 cm). To do this, runners on the experimental mother plant were cut after the formation of two rosettes on them, but not yet rooted. Later, these rosettes were dived into the cassette cells and rooted in the fog-forming machine. Among the records, yield of rooted seedlings and their leaves density, the number of stolons and their diameter, the length of a root system, and the marketable quality of the cassette planting material of strawberry were determined [9, 10].

Research results. When growing cassette planting material of strawberry, not all plants are rooted successfully due to many factors, one of which is the type of substrate or its filling with specific compounds. In our experiment, rooting of strawberry rosettes varied depending on the substrate composition and pomological variety (Table 1).

Table 1. Rooting and leaves density of cassette strawberry seedlings depending on the substrate composition (on average for 2023–2024)

Variants		Indicators	
Varieties	Composition of the substrate	Rooting, %	Leafiness, pcs/plant
Dukat	Peat mixture (control)	77,1	3,7
	Peat mixture + Biohumus	79,3	4,5
	Peat mixture + Biohumus + Trichodermin	85,8	5,3
Malvina	Peat mixture (control)	79,2	3,2
	Peat mixture + Biohumus	81,7	4,1
	Peat mixture + Biohumus + Trichodermin	88,2	4,9
LSD_{05}		*4,2*	*0,6*

Conducted researches indicated a significant increase in yield of rooted strawberry seedlings under the effect of adding Biohumus and Trichodermin to the peat mixture. In this variant, rosettes rooting varied averagely at 85.2–87.9 % for the experimental varieties. Comparing these data with the control variant, where only peat mixture was used, the excess amounted to 8.5–9.1 % and, according to the statistical processing of the materials, it was reliable according to LSD_{05} = 4.3.

Analyzing the filling of the peat mixture with biohumus only, increasing in rosettes rooting was not considerable and amounted to 2.2–2.3 %. This indicated the insignificant effect of biohumus on rooting processes compared to other factors. A similar pattern of strawberry rosettes rooting was noted averagely across the years of research. Significant difference between the years of research was not practically recorded.

For cassette strawberry seedlings, successful rooting and further plant productivity is based on high leaves density. In our research, this was facilitated by adding Biohumus and Trichodermin to the peat mixture. Among the variants of the experiment, the least leaves density had strawberry seedlings after their rooting in only peat mixture – 3.2–3.7 pcs/plant. Adding Biohumus to the peat mixture contributed to leaves growth on plants to the values of 4.1–4.5 pcs/plant, which reliably exceeded the control data by 22–28 %. This indicated an improvement in the nutrient regime of the substrate due to organic fertilizer.

The most significant effect on leaves density of strawberry planting material was caused by adding Biohumus in a complex with Trichodermin to the peat mixture. Such a mixture had the effect of better nutrition and phytosanitary properties, which manifested itself in a smaller number of diseased plants. In this variant, the number of leaves in the seedlings, averaged across experimental strawberry varieties, reached 4.9–5.3 pcs/plant. At the same time, the excess of indicators of the control variant was reliable and amounted to 1.6–1.7 pcs/plant, or 46 % (LSD_{05} = 0.6). A similar dependence of leaves density of strawberry seedlings depending on the composition of the substrate was obtained over the years of research. Among strawberry varieties, Dukat formed an insignificantly larger number of leaves per seedling.

Diameter of the stem part of a planting material – stolon which changed under the influence of a substrate composition to assess the quality of strawberry planting material had great importance (Table 2).

Table 2. Number of stolons and their diameter in cassette strawberry seedlings depending on the substrate composition for rooting (on average for 2023–2024)

Variants		Indicators	
Varieties	Composition of the substrate	Number of stolons, pcs/plant	Diameter of stolons, mm
Dukat	Peat mixture (control)	1,2	10,6
	Peat mixture + Biohumus	1,6	12,6
	Peat mixture + Biohumus + Trichodermin	1,8	13,7
Malvina	Peat mixture (control)	1,5	11,5
	Peat mixture + Biohumus	1,7	13,7
	Peat mixture + Biohumus + Trichodermin	1,9	14,8
LSD_{05}		*0,2*	*1,1*

Analyzing the indicators of the control variant, where the only peat mixture was used, the diameter of the stem part of strawberry seedlings depending on the variety ranged from 10.6 to 11.5 mm. Adding Biohumus to the peat mixture helped to strengthen the growth processes of seedlings, and the diameter of stolons reached 12.6–13.7 mm. Compared to the control indicators, increase was 2.0–2.2 mm, or 19 %, which, according to the calculations of the statistical analysis, was significant by $LSD_{05} = 1.1$.

A more significant effect on the increase in the thickness of the seedling stem was noted by the combined filling of the peat mixture with Biohumus and Trichodermin. In this variant, the analyzed indicator averaged over the experimental varieties at the level of 13.7–14.8 mm, significantly exceeding the indicators of the control variant by 3.1–3.3 mm, or 30 %. Such parameters of the seedling stolon could potentially ensure yield capacity at the level of 10 t/ha of berries in the year of planting. The change in the parameters of a strawberry seedling stolon depending on the experiment variants was observed on average over the years of research. According to varietal indicators, Malvina variety formed stolons with a larger diameter compared to Dukat variety.

Along with the diameter of stolons in strawberry seedlings, their number is an important indicator of its productivity. Based on the received research results, the increase in the number of stolons on strawberry seedlings was more intense when they were rooted in the peat mixture filled with Biohumus and Trichodermin. On average, over the years of research, the number of stolons on seedlings of both experimental varieties of strawberry was in the range of 1.8–1.9 pcs/plant. Comparing these indicators with the control ones, where rooting was carried out only in the peat mixture, the excess reached 0.4–0.6 pcs/plant, or 27 % and, based on statistical data processing, was quite significant ($LSD_{05} = 0.2$). This indicated more favorable conditions for rosettes rooting and development of seedlings themselves by improving the substrate environment with substances of a biological nature.

When applying Biohumus only to fill the peat mixture, the intensity of stem growth in strawberry seedlings was somewhat lower. In particular, the number of stolons per seedling averaged 1.7 pcs/plant in the experimental varieties. Comparing this indicator with the control one, the difference was 0.3 pcs/plant and was reliable, although it was inferior to the indicators of the previous experimental variant. Such indicators testified to the efficiency of Trichodermin as a biological preparation for improving phytosanitary properties of the substrate. Over the years of research, the formation of the number of stolons in strawberry seedlings was similar depending on the substrate composition. There was not recorded a significant difference between the pomological varieties, with a slight advantage of the analyzed indicator for Malvina variety. Intactness of roots during transplanting is an important characteristic feature for cassette strawberry seedlings. At the same time, formation of the root system significantly depends on the substrate for rosettes rooting (Table 3).

Washing of the root system in experimental variants proved a significant impact of the substrate composition on rooting of strawberry rosettes. The longest length of

the root system was obtained in the variant where Biohumus and Trichodermin were added to a peat mixture.

Table 3. Length of the root system and yield of quality strawberry seedlings depending on the substrate composition for their rooting (on average for 2023–2024)

Variants		Indicators	
Varieties	Composition of the substrate	Length of the root system, cm	Commodity quality, %
Dukat	Peat mixture (control)	19,3	68,5
	Peat mixture + Biohumus	25,0	76,0
	Peat mixture + Biohumus + Trichodermin	28,3	83,4
Malvina	Peat mixture (control)	21,0	71,4
	Peat mixture + Biohumus	26,4	79,5
	Peat mixture + Biohumus + Trichodermin	29,5	86,2
LSD_{05}		*2,9*	*5,9*

On average, for both experimental varieties, the indicators ranged from 28.3 to 29.5 cm. Comparing these indicators with the control ones, where rosettes rooting was carried out only in the peat mixture, the excess was 8.5–9.0 cm and according to the calculations of the statistical analysis, it was reliable (LSD_{05} = 2.9). This indicated the most optimal substrate environment for growing highly productive strawberry seedlings. Filling the peat mixture with Biohumus only also reliably increased the mass of the strawberry root system, but somewhat less than the previous variant. In general, in this variant, the length of the roots reached the indicator of 25.0–26.4 cm, which significantly exceeded the control data by 5.4–5.7 cm.

Such indicators emphasized the importance of organic nutrition of strawberry seedlings in the limited area of cassette cells. On average, over the years of research, an identical dependence of the growth of the root system depending on the composition of a peat mixture was observed. Conducted calculations and estimation of the component indicators of the commercial evaluation of strawberry seedlings proved the highest quality of planting material under its rooting in the peat mixture filled with Biohumus and Trichodermin. On the whole, the average indicators for both experimental varieties of strawberry ranged at the level of 83.4–86.2 %. For cassette strawberry seedlings, these were quite high analyzed values. Comparing them with the indicators of the control variant, where rosettes rooting occurred only in the peat mixture, the excess reached an average of 14.8 %, which, according to the calculations of the statistical analysis, had a significant impact by LSD_{05} = 5.9.

When growing strawberry seedlings in the peat mixture filled with Biohumus only, the yield of high-quality planting material was significantly lower than the previous variant. This indicated the importance of Trichodermin as a phytosanitary

component of the substrate. Compared with the control parameters, seedlings quality of the experimental varieties was significantly higher and was 76.0–79.5 %. A similar dependence of the quality of planting material on the variants of filling the peat mixture was observed on average for all years of research. There was practically no remarkable difference between the experimental strawberry varieties.

Conclusions. Adding Biohumus and Trichodermin to the peat mixture improved nutritional and phytosanitary properties of the substrate for strawberry rosettes rooting. Such biologization of the substrate increased rosettes rooting by 9 % and their leaves density by 25 %. The growth of the stem part of strawberry seedlings was more intensive when the peat mixture was filled with Biohumus and Trichodermin, which led to the increase in the diameter and the number of stolons by 30 %. Better formation of the root system occurred in biologically filled peat mixture with Biohumus and Trichodermin. Such a substrate contributed to the improvement of quality indicators of seedlings, which increased its market value by 15 %.

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Annotation

Butsyk R. M., Chaploutskyi A. M., Golovatiy P. A., Polunina O. V., Butsyk M. M.
The yield and quality of strawberry cassette planting material depends on the composition of the substrate for its rooting in the Right Bank Forest Steppe of Ukraine

The publication contains research materials aimed at improving the elements of technology for growing cassette planting material of strawberry. They are related to the selection of the optimal composition of the substrate for rosettes rooting and increasing the yield of high-quality seedlings by improving the substrate for runners rooting with substances of a biological nature in the conditions of the Right-Bank Forest-Steppe of Ukraine.

In order to establish the efficiency of the applied substrate compositions, a control variant with a ready-made peat mixture for strawberry rosettes rooting was included in the experiment scheme. Variants with two types of substrate were accepted as experimental – one with Biohumus adding, and the other one with additional treatment with Trichodermin. Establishing the efficiency of these agricultural measures was carried out on two strawberry varieties - Dukat and Malvina.

It was experimentally confirmed that better rosettes rooting with increased growth rates of seedlings was achieved by saturating the substrate peat mixture with Biohumus and Trichodermin. Nutritional and phytosanitary properties of the substrate for strawberry rosettes rooting were improved by filling the peat mixture with Biohumus and Trichodermin. Such biologization of the substrate increased rosettes rooting by 9 % and their leaves density by 25 %. The growth of stem part of strawberry seedlings was more intensive when adding Biohumus and Trichodermin to the peat mixture, which led to the increase in the diameter and the number of stolons by 30 %. Better formation of the root system occurred in the biologically filled peat mixture with Biohumus and Trichodermin. Such a substrate contributed to the improvement of quality indicators of seedlings which increased its market value by 15 %.

Key words: *strawberry, cassette planting material, substrate, peat mixture, Biohumus, Trichodermin, productivity, varieties, rooting, quality.*