The Effect of Vermicompost from Local Raw Materials on Tomato Productivity in Yakutia

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Abstract. The authors conducted an experiment on the effect of different types of biofertilizers (vermicomposts) on tomato productivity in Central Yakutia greenhouses. The experiment was replicated three times. The greenhouse soil mixture consisted of equal parts sod (turf), decomposed manure, and old wood shavings. The experimental data show the optimal specifications and timing of vermicompost addition. The dose of 100 grams of vermicompost per plant increased the tomato yield in July and August by 7.6 kg/m² and in early yields by 1.6 kg/m². The application of biofertilizer increased Vitamin C concentration by 22.8-25.6 mg% in fruits. The local vermicompost application method allowed to decrease the prime cost of tomato growing by 11%. As a result of this study, the authors developed a series of guidelines on vermicompost addition in the Yakutia environment that allowed maximizing yields while lowering prime costs.

Keywords: Crop farming · Vegetables · Fertilizer · Productivity · Quality · Efficiency

1. Introduction
The climate of Yakutia is subarctic, with significant annual variation in temperature. The summer is warm but short. The climate is extremely dependant on Arctic air infiltrations. The frost-free period lasts for 60 to 100 days, on average. The average sum of precipitation in the growth period is only 123 mm [8].

Yakutia commonly experiences fresh vegetable shortages. Growing high-value, environmentally safe vegetables is only possible in greenhouses. Greenhouse efficiency mostly depends on the physical properties of the building, the agrochemical qualities of soils, and fertilizer application.

Some scholars believe that greenhouse soils require higher dosages of mineral fertilizers [14].

Vermicomposting drastically changes the physical properties and chemical composition of manure-based and dropping-based biofertilizers [4, 15]. The moisture retention properties of biofertilizer-treated soils are increased by up to 99% because of the added coprolites. The decomposed substrates become crumbly with 0.68 g/cm³ density and more than 300% moisture-retaining capacity.

Vermicomposting removes germs and odors from the substrate and increases mineral contents in the compost. Vermicomposts have lower NO₃- concentration and higher NH₄⁺ concentration, and better physical properties than conventional composts because of the faster substrate decomposition [19, 20].
All vermicomposts have a balanced mineral composition of biogenic elements, especially nitrogen, phosphorus, and calcium. The by-products of worms’ calciferous glands raise the calcium content and pH balance of vermicomposts [1]. The organo-mineral composition of vermicomposts allows the plants to fixate nutritious and mineral elements faster. This process produces less toxic compounds, compared to the fixation of mineral salts [2, 17]. Biofertilizers contain high amounts of biogenic elements, i.e., phosphorus, calcium, potassium, and magnesium [5, 9].

Vermicomposts may contain more nitrogen than the substrate due to the activity of nitrogen-fixating microorganisms.

Vermicomposts are known to increase the amounts of vitamins, ferments, and growth stimulators [13, 16].

There are manure-recycling fertilizer producers in the United States of America, where cattle farming is highly developed. Farming enterprises that switched to environment-friendly biological fertilizers had higher yields: 60 t/ha for cereals and 10 t/ha for corn.

Vermicomposting is popular in Italy. In the 1980s, the annual average production of vermicompost in Italy was 180,000 tons [7].

The switch to biological fertilizers increased the production of eco-friendly food in several countries. The vermicompost application in open soils increased to 7 t/ha for cereals and 80 t/ha for potatoes [10].

In New Zealand and Hungary, biofertilizer application increased crop productivity up to 70% [3].

Vermicomposting, especially in greenhouse soils, was adopted in several Russian regions [12, 21]. In the Republic of Sakha (Yakutia), there were no prior comprehensive studies on the use of biofertilizers in olericulture. Therefore, the issue of increasing vegetable crop productivity is relevant to the regional technology and science.

This study aims to empirically examine the efficiency of vermicomposts application to growing tomatoes in Yakutia greenhouses. The authors examined the effects of vermicomposts on flowering and fruit-blossoming indexes, growth indexes, leaf surface area, and yield of tomatoes.

2. Materials and Methods
The experiments were conducted in the greenhouse complex “Pokrovskoye” in Khangalassky District, Central Yakutia. Tomatoes of “FI Verlioka” variety were used in this experiment. The experiment scheme contained the following groups:

- Control group – greenhouse soil;
- I group – greenhouse soil + 100 g/plant of cattle-manure-based biofertilizer;
- II group – greenhouse soil + 300 g/plant of cattle manure-based biofertilizer;
- III group – greenhouse soil + 500 g/plant of cattle-manure-based biofertilizer;
- IV group – greenhouse soil + 1 kg/m² of cattle-manure-based biofertilizer;
- V group – greenhouse soil + 3 kg/m² of cattle-manure-based biofertilizer;
- VI group – greenhouse soil + 5 kg/m² of cattle-manure-based biofertilizer;
- VII group – greenhouse soil + nitrogen fertilizer (carbamide, equivalent 1 kg of vermicompost);
- VIII group – greenhouse soil + 100 g/plant of dropping-based biofertilizer;
- IX group – greenhouse soil + 200 g/plant of dropping-based biofertilizer;
- X group – greenhouse soil + 300 g/plant of dropping-based biofertilizer.

The plants were sown in the first decade of June, in 3.3 m² boxes. The experiment was replicated three times. The greenhouse soil was four years in use. It consisted of 40% sod, 30% manure, and 30% wood shavings. All 540 grown plants were relatively uniform: 35–40 cm in height, with 9–10 leaves, 200–300 cm² of photosynthetic surface, and a developed root system.

Phenological observations and measurements were made during flowering, fruit-blossoming, and the formation of 6–7 infructescences. The height of the plants was measured every 30 days. The inflorescences were counted three times: in the beginning, the middle, and the end of fruit-blossoming.
The vitamin C contents were analyzed using the titrimetric analysis method of I. K. Murri. The nitrate concentration was determined using the ion-selective method.

Mathematical data was processed using B. A. Dospekhov’s method [6].

The economic efficiency of biofertilizer application was determined using standard expenditure rates, fixed in technological flow charts.

3. Results and Discussion

In this experiment, the authors studied the effect of vermicompost fertilizers made from locally-sourced cattle manure and bird droppings. The manure-based vermicomposts were applied in 100 g, 300 g, 500 g dosages per plant and 1 kg, 3 kg, and 5 kg per m². The dropping-based composts were applied in 100 g, 200 g, and 300 g dosages per plant. Moreover, an additional control group with mineral nitrogen fertilizer (carbamide) was used in the experiment.

According to Semenova [18], flowering and fruit-blossoming stages are crucial to tomato formation; therefore, these parameters were examined as well. Vermicompost application in different doses affected flower formation in tomatoes (see table 1).

Table 1. Vermicompost effect on flowering and fruit-blossoming of tomatoes.

| Groups | Flower amount | Number of fruits on a single plant |
|--------|---------------|-----------------------------------|
|        | 26.06 | 10.07 | 10.06 | 28.06 | 13.07–23.07 | 2.08–23.08 |
| Control group (greenhouse soil) | 19 | 19 | 6 | 20 | 17 | 98 |
| I group – greenhouse soil + 100 g/plant of cattle-manure-based biofertilizer | 20 | 16 | 9 | 16 | 19 | 130 |
| II group – greenhouse soil + 300 g/plant of cattle-manure-based biofertilizer | 20 | 10 | 5 | 13 | 20 | 126 |
| III group – greenhouse soil + 500 g/plant of cattle-manure-based biofertilizer | 27 | 7 | 5 | 13 | 21 | 157 |
| IV group – greenhouse soil + 1 kg/m² of cattle-manure-based biofertilizer | 14 | 13 | 11 | 24 | 23 | 104 |
| V group – greenhouse soil + 3 kg/m² of cattle-manure-based biofertilizer | 27 | 5 | 9 | 18 | 22 | 126 |
| VI group – greenhouse soil + 5 kg/m² of cattle-manure-based biofertilizer | 14 | 5 | 13 | 22 | 19 | 92 |
| VII group – greenhouse soil + nitrogen fertilizer (carbamide, equivalent 1 kg of vermicompost) | 20 | 6 | 10 | 15 | 20 | 93 |
| VIII group – greenhouse soil + 100 g/plant of dropping-based biofertilizer | 18 | 15 | 8 | 14 | 16 | 127 |
| IX group – greenhouse soil + 200 g/plant of dropping-based biofertilizer | 21 | 11 | 6 | 12 | 17 | 106 |
| X group – greenhouse soil + 300 g/plant of dropping-based biofertilizer | 17 | 8 | 4 | 11 | 18 | 94 |

The III and V experimental groups had the most flowers in the beginning and the end of the experiment.

The experimental data on infructescence formation in different fertilizer groups is presented in table 2.

Table 2. The effect of vermicompost on infructescence formation in tomatoes.

| Groups | 26.06 | 10.07 | 28.07 | 23.08 |
|--------|-------|-------|-------|-------|
| Control group (greenhouse soil) | 3.0 | 4.0 | 4.0 | 7.0 |
| I group – greenhouse soil + 100 g/plant of cattle-manure-based biofertilizer | 3.0 | 4.0 | 3.0 | 7.0 |
| II group – greenhouse soil + 300 g/plant of cattle manure-based | 4.0 | 3.0 | 3.0 | 7.0 |
biofertilizer

III group – greenhouse soil + 500 g/plant of cattle-manure-based biofertilizer

IV group – greenhouse soil + 1 kg/m² of cattle-manure-based biofertilizer

V group – greenhouse soil + 3 kg/m² of cattle-manure-based biofertilizer

VI group – greenhouse soil + 5 kg/m² of cattle-manure-based biofertilizer

VII group – greenhouse soil + nitrogen fertilizer (carbamide, equivalent 1 kg of vermicompost)

VIII group – greenhouse soil + 100 g/plant of dropping-based biofertilizer

IX group – greenhouse soil + 200 g/plant of dropping-based biofertilizer

X group – greenhouse soil + 300 g/plant of dropping-based biofertilizer

All plant groups had the same infructescence counts in the middle of the experiment. At the end of the investigation, the IV group had the most (8) infructescences. However, this did not affect the yield since the late fruits could not mature before the first night colds at the beginning of September. Only the fruits that appeared in July and the beginning of August developed fully. Therefore, creating the conditions for early blooming guarantees crop harvestability in Yakutia. From the end of July to the beginning of August, the number of tomato fruits increased considerably.

Regardless of the method and amounts of applied biofertilizers, the height of plants in all experimental groups was not lower than in the control group. In the IV, V, and VI groups, the plant height was the same as in the control group by the end of fruit formation (160–161 cm) (see table 3).

Table 3. The effect of vermicompost on the height of tomatoes, cm.

| Groups | Years | The beginning of flowering | The beginning of fruit formation | Fruit formation |
|--------|-------|---------------------------|---------------------------------|-----------------|
| Control group (greenhouse soil) | 1st year | 35.7 | 116.0 | 157.1 |
| | 2nd year | 37.0 | 101.5 | 164.5 |
| | 3rd year | 35.6 | 115.3 | 157.2 |
| | 3-year average | 36.1 | 110.9 | 159.6 |
| I group – greenhouse soil + 100 g/plant of cattle-manure-based biofertilizer | 1st year | 42.8 | 119.2 | 162.4 |
| | 2nd year | 45.3 | 104.5 | 165.0 |
| | 3rd year | 43.6 | 120.2 | 160.3 |
| | 3-year average | 43.9 | 114.6 | 162.6 |
| II group – greenhouse soil + 300 g/plant of cattle manure-based biofertilizer | 1st year | 42.8 | 118.0 | 160.1 |
| | 2nd year | 46.0 | 103.5 | 162.7 |
| | 3rd year | 41.5 | 118.2 | 159.3 |
| | 3-year average | 43.4 | 113.2 | 160.7 |
| III group – greenhouse soil + 500 g/plant of cattle-manure-based biofertilizer | 1st year | 38.8 | 119.5 | 159.9 |
| | 2nd year | 44.0 | 101.7 | 158.7 |
| | 3rd year | 42.2 | 119.1 | 160.9 |
| | 3-year average | 41.7 | 113.4 | 159.8 |
| IV group – greenhouse soil + 1 kg/m² of cattle-manure-based biofertilizer | 1st year | 34.6 | 115.5 | 159.2 |
| | 2nd year | 35.4 | 100.5 | 162.8 |
| | 3rd year | 35.6 | 115.3 | 158.8 |
| | 3-year average | 35.2 | 110.4 | 160.7 |
The experimental data on the effect of biofertilizers on tomato leaf surface area is presented in Table 4.

**Table 4.** The effect of vermicompost on the sum leaf surface area of tomatoes, cm².

| Groups | Years | The beginning of flowering | The beginning of fruit formation | Formation of 7–8 infructescences |
|--------|-------|----------------------------|----------------------------------|----------------------------------|
| Control group (greenhouse soil) | 1st year | 2,345.9 | 4,409.9 | 7,518.5 |
| | 2nd year | 2,592.1 | 6,637.1 | 8,679.0 |
| | 3rd year | 2,627.1 | 6,171.3 | 8,207.9 |
| | 3-year average | 2,521.7 | 5,739.4 | 8,135.1 |
| I group – greenhouse soil + 100 g/plant of cattle-manure-based biofertilizer | 1st year | 3,418.9 | 5,830.2 | 7,935.1 |
| | 2nd year | 2,834.9 | 9,174.0 | 9,996.4 |
| | 3rd year | 3,247.5 | 7,568.3 | 9,682.1 |
| | 3-year average | 3,167.1 | 7,524.1 | 9,204.5 |
| II group – greenhouse soil + 300 g/plant of cattle-manure-based biofertilizer | 1st year | 3,790.1 | 6,788.9 | 8,940.1 |
| | 2nd year | 2,899.5 | 8,073.0 | 9,493.1 |
| | 3rd year | 3,496.8 | 8,565.7 | 10,481.5 |
| | 3-year average | 3,395.4 | 7,809.2 | 9,638.2 |
| III group – greenhouse soil + 500 g/plant of cattle-manure-based biofertilizer | 1st year | 3,683.4 | 6,406.5 | 8,557.4 |
| | 2nd year | 2,493.4 | 6,442.0 | 8,336.3 |
| | 3rd year | 3,563.2 | 8,481.9 | 10,359.1 |
| | 3-year average | 3,246.6 | 7,110.1 | 9,150.9 |
The II group had the highest sum leaf surface area. In the III group, where the amount of fertilizer was increased to 500 g/plant, the surface area decreased to 9,150.9 cm$^2$. Biofertilizers made from different substrates affected the leaf surface area differently. The experimental plant groups were not affected by the disease during the whole experiment.

Biofertilizers significantly affected the early harvests.

**Table 5.** The effect of vermicompost on the first crop of tomatoes.

| Groups | Fruit amount | Total mass, kg | Mass of one fruit, g | Dry mass percentage, % |
|--------|--------------|----------------|---------------------|------------------------|
| Control group (greenhouse soil) | 11 | 1.1 | 100 | 4.9 |
| I group – greenhouse soil + 100 g/plant of cattle-manure-based biofertilizer | 14 | 1.4 | 100 | 4.9 |
| II group – greenhouse soil + 300 g/plant of cattle manure-based biofertilizer | 12 | 1.1 | 92 | 4.7 |
| III group – greenhouse soil + 500 g/plant of cattle-manure-based biofertilizer | 19 | 0.7 | 37 | 4.7 |
| IV group – greenhouse soil + 1 kg/m$^2$ of cattle-manure-based biofertilizer | 23 | 1.9 | 83 | 4.6 |
| V group – greenhouse soil + 3 kg/m$^2$ of cattle-manure-based biofertilizer | 16 | 1.3 | 81 | 5.6 |
| VI group – greenhouse soil + 5 kg/m$^2$ of cattle-manure-based biofertilizer | 15 | 1.2 | 80 | 5.2 |
| VII group – greenhouse soil + nitrogen fertilizer (carbamide, equivalent 1 kg of vermicompost) | 12 | 1.0 | 83 | 4.8 |
The I and II groups had the biggest fruits (92–100 g on average). The further increase in biofertilizer application did not increase the fruit weight.

Biofertilizer application also affected the total productivity of tomatoes (see table 6).

**Table 6.** The effect of vermicompost on the yield of tomatoes, kg/m².

| Groups                                                                 | 1st year | 2nd year | 3rd year | 3-year average | Increase kg/m² | %     |
|------------------------------------------------------------------------|----------|----------|----------|----------------|----------------|-------|
| Control group (greenhouse soil)                                        | 6.1      | 6.2      | 6.0      | 6.1            | -              | -     |
| I group – greenhouse soil + 100 g/plant of cattle-manure-based biofertilizer | 6.8      | 8.2      | 7.4      | 7.5            | 1.4            | 23.0  |
| II group – greenhouse soil + 300 g/plant of cattle manure-based biofertilizer | 7.6      | 8.4      | 8.0      | 7.9            | 1.8            | 30.0  |
| III group – greenhouse soil + 500 g/plant of cattle-manure-based biofertilizer | 7.6      | 8.0      | 7.8      | 7.9            | 1.8            | 30.0  |
| IV group – greenhouse soil + 1 kg/m² of cattle-manure-based biofertilizer | 6.7      | 7.7      | 7.3      | 7.2            | 1.1            | 18.0  |
| V group – greenhouse soil + 3 kg/m² of cattle-manure-based biofertilizer | 6.7      | 7.7      | 7.3      | 7.2            | 1.1            | 18.0  |
| VI group – greenhouse soil + 5 kg/m² of cattle-manure-based biofertilizer | 6.4      | 7.4      | 7.6      | 7.1            | 1.0            | 16.4  |
| VII group – greenhouse soil + nitrogen fertilizer (carbamide, equivalent 1 kg of vermicompost) | 6.3      | 7.3      | 6.5      | 6.7            | 0.6            | 9.8   |
| VIII group – greenhouse soil + 100 g/plant of dropping-based biofertilizer | 7.3      | 8.0      | 7.4      | 7.6            | 1.5            | 24.6  |
| IX group – greenhouse soil + 200 g/plant of dropping-based biofertilizer | 6.7      | 8.3      | 7.8      | 7.6            | 1.5            | 24.6  |
| X group – greenhouse soil + 300 g/plant of dropping-based biofertilizer | 6.4      | 7.7      | 7.6      | 7.2            | 1.4            | 24.1  |

The highest total harvest figures and early harvest figures were in II and IV groups. The highest 3-year average harvest was in II and III experimental groups. Biofertilizer application affected the early crops and the total yields in the same way. In IV and V control groups, with the application of 1 and 3 kg/m² of vermicompost, respectively, the total yield increased by 16.4–18.0%. Among the bird droppings vermicompost, the lowest dosage of 100 g/plant was the most effective one. It increased productivity by up to 7.6 kg/m², 24.6% higher than the control group.

The experimental data on the nitrate concentration in tomato fruits are presented in table 7.

**Table 7.** The effect of vermicompost on nitrate concentration in tomato fruits, mg/kg.

| Groups                                                                 | Nitrates, mg/kg |
|------------------------------------------------------------------------|-----------------|
| Control group (greenhouse soil)                                        | 133             |
| I group – greenhouse soil + 100 g/plant of cattle-manure-based biofertilizer | 175             |
| II group – greenhouse soil + 300 g/plant of cattle manure-based biofertilizer | 152             |
| III group – greenhouse soil + 500 g/plant of cattle-manure-based biofertilizer | 129             |
| IV group – greenhouse soil + 1 kg/m² of cattle-manure-based biofertilizer | 159             |
| V group – greenhouse soil + 3 kg/m² of cattle-manure-based biofertilizer | 145             |
VI group – greenhouse soil + 5 kg/m² of cattle-manure-based biofertilizer
VII group – greenhouse soil + nitrogen fertilizer (carbamide, equivalent 1 kg of vermicompost)
VIII group – greenhouse soil + 100 g/plant of dropping-based biofertilizer
IX group – greenhouse soil + 200 g/plant of dropping-based biofertilizer
X group – greenhouse soil + 300 g/plant of dropping-based biofertilizer

The lowest dosage of bird dropping vermicomposts decreased the nitrate concentration if compared to the control group. However, the concentration increased with higher dosages of said biofertilizer (142 mg/kg at 200 g and 124 mg/kg at 300 g). The nitrate concentration in all plant groups was relatively low (100–175 mg/kg), and it did not exceed the established limit of 300 mg/kg.

The Vitamin C concentration changes in tomato leaves and fruits are presented in table 8 and table 9.

Table 8. The effect of vermicompost on Vitamin C in tomato leaves, mg%.

| Groups                                                   | 1st year | 2nd year | 3rd year | 3-year average |
|----------------------------------------------------------|----------|----------|----------|----------------|
| Control group (greenhouse soil)                          | 25.1     | 40.2     | 21.7     | 29.1           |
| I group – greenhouse soil + 100 g/plant of cattle-manure-based biofertilizer | 30.2     | 40.6     | 27.4     | 32.6           |
| II group – greenhouse soil + 300 g/plant of cattle manure-based biofertilizer | 27.7     | 47.8     | 29.6     | 35.0           |
| III group – greenhouse soil + 500 g/plant of cattle-manure-based biofertilizer | 17.6     | 50.3     | 29.6     | 35.0           |
| IV group – greenhouse soil + 1 kg/m² of cattle-manure-based biofertilizer | 32.7     | 37.7     | 28.5     | 32.1           |
| V group – greenhouse soil + 3 kg/m² of cattle-manure-based biofertilizer | 27.7     | 35.2     | 27.4     | 30.1           |
| VI group – greenhouse soil + 5 kg/m² of cattle-manure-based biofertilizer | 32.7     | 42.7     | 34.2     | 36.5           |
| VII group – greenhouse soil + nitrogen fertilizer (carbamide, equivalent 1 kg of vermicompost) | 30.2     | 27.4     | 33.1     | 30.2           |
| VIII group – greenhouse soil + 100 g/plant of dropping-based biofertilizer | 32.7     | 28.5     | 26.2     | 32.9           |
| IX group – greenhouse soil + 200 g/plant of dropping-based biofertilizer | 40.2     | 26.2     | 29.7     | 32.8           |
| X group – greenhouse soil + 300 g/plant of dropping-based biofertilizer; | 32.7     | 29.6     | 21.7     | 32.6           |

Biofertilizer application increased Vitamin C concentration in leaves up to 35 mg%. The concentration in fruits was lower.

Table 9. The effect of vermicompost on Vitamin C in tomato fruits, mg%.

| Groups                                                   | 1st year | 2nd year | 3rd year | 3-year average |
|----------------------------------------------------------|----------|----------|----------|----------------|
| Control group (greenhouse soil)                          | 22.7     | 16.0     | 28.2     | 22.3           |
| I group – greenhouse soil + 100 g/plant of cattle-manure-based biofertilizer | 23.7     | 16.1     | 28.7     | 22.8           |
| II group – greenhouse soil + 300 g/plant of cattle manure-based biofertilizer | 23.6     | 21.8     | 20.3     | 21.9           |
| III group – greenhouse soil + 500 g/plant of cattle-manure-based biofertilizer | 17.1     | 16.1     | 23.1     | 18.8           |
| IV group – greenhouse soil + 1 kg/m² of cattle-manure-based biofertilizer | 19.9     | 11.4     | 19.2     | 16.8           |
| V group – greenhouse soil + 3 kg/m² of cattle-manure-based biofertilizer | 20.8     | 18.1     | 23.0     | 20.6           |
biofertilizer
VI group – greenhouse soil + 5 kg/m\(^2\) of cattle-manure-based biofertilizer  
VII group – greenhouse soil + nitrogen fertilizer (carbamide, equivalent 1 kg of vermicompost)  
VIII group – greenhouse soil + 100 g/plant of dropping-based biofertilizer  
IX group – greenhouse soil + 200 g/plant of dropping-based biofertilizer  
X group – greenhouse soil + 300 g/plant of dropping-based biofertilizer;

The application of biofertilizer guaranteed high vitamin C in the harvested plants without a considerable increase in nitrate concentration.

The data on the economic efficiency of the biofertilizer application is presented in table 10.

**Table 10.** The economic efficiency of biofertilizer use in tomato growing per 10 m\(^2\).
The biofertilizer application affected the prime cost of production, which varied between 38 and 54 rubles/kg. The per-plant application of cattle manure vermicompost was the most efficient one, as it decreased the prime cost by 11% if compared to the per-m² application.

4. Conclusion
In Yakutia, cattle graze in the summer grazing period. In winter, cattle are housed in sheltered buildings. Their manure is mechanically removed and conserved in frozen piles of up to 25 kg, but the frozen manure cannot be processed into fertilizer. The thawing manure piles pollute the surrounding soils, waters, and air. Thus, using manure as a substrate for vermicomposts has a positive effect on the environment.

The application of manure and droppings biofertilizers increased total yields by 7.1 and 7.6 kg/m², and the early yields by 1.4 and 1.6 kg/m².

The local application of vermicomposts increased vitamin C concentration to 22.8 – 25.6 mg% and decreased nitrate concentration to 102 – 170 mg/kg.

The analysis of the economic efficiency of biofertilizer application revealed that the local application method was the most effective one, as it decreased the prime cost of growing tomatoes by 11%. The most efficient dosage was 100 g/plant of dropping vermicompost with the prime cost of 38 rubles/kg.

Therefore, the local biofertilizer application achieves the tomato productivity of 6.2 – 7.6 kg/m², with the most cost-efficient dosage being 100 g/plant.

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