The effectiveness of vermigumates under the conditions of vegetation experience

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Abstract. The effectiveness of biofertilizer, which was obtained by extracting humic acids from vermicompost 0.02 n NaOH, is shown. The increase in the productivity of the test culture in the growing experiment against the background of watering with the vermigumate (dilution 1:50) was 73% in relation to the control.

1. Introduction and Background
At the present stage of development of human society, the problem of restoring and improving the fertility of cultivated soils is more acute than ever. One of the ways to solve this pressing problem is vermicomposting. This would allow to get environmentally friendly highly effective organic fertilizer based on almost any organic substrates, including food waste, in large quantities which would be generated in the course of human life. Furthermore, the latter allows us to solve another global problem of society. It is the disposal of organic waste. Vermicomposting is widely used in the USA, Western Europe, Japan. However, in our country there are no more than 5 large vermicomposts that work.

The scientific literature actively discusses issues which are related to the production technologies and the effectiveness of vermicomposts, their influence on the yield of cultivated plants and the chemical, physico–chemical and physical properties of soils. The properties of vermicomposts, which were obtained in the processing of various types of manure [1, 2] and leaf litter [3] are relatively well studied. However, the agrochemical properties of vermicomposts that are based on food waste have practically not been studied. The issues related to the technology of using liquid agents, including vermigumate that was extracted from vermicomposts, have not been sufficiently studied. It is humic acids that play a crucial role in increasing plant productivity, which is associated with such mechanisms of their influence on living organisms as the activation of protein synthesis in cells [4], the effect on the rate of electron-donor-acceptor reactions, interaction with cell membranes and effects on biochemical processes [5], penetration of humic acids into cells and interaction with intracellular components [6, 7].

The purpose of this study is to obtain an organic fertilizer that is based on vermicomposting food waste, to study its properties and to identify the effect of different doses of vermigumates on the productivity of the green mass of the test culture (arugula) under the conditions of a growing experiment.

2. Materials and Methods
The objects of study were: vermicompost which was obtained by the method of processing (within 8 months) food waste by the California worm Eisenia andrei Bouche; vermigumates that were represented by humic compounds that were extracted with 0.02 n NaOH from vermicompost; cultivated horizon of agro–gray soil (horizon material was used as a substrate in the growing experiment); test culture for the growing experience of arugula Indau Poker.

For the preparation of vermicompost, food waste of plant origin was used: bananas, carrots, beets, fruits, zucchinis, pumpkins, as well as tea and coffee. Vermigumates were prepared as follows: 200 g of vermicompost was poured with 2 liters of 2n NaOH, shaken and filtered after 24 hours. In the resulting extract, the organic carbon content was 2.5%.

To characterize the properties of agro–gray soil and vermicompost, the main agrochemical indicators (content of C, N, P2O5, absorbed bases, qualitative composition of humus, pH, particle size distribution) were determined by methods and techniques generally accepted in soil science.

The vegetation experiment was carried out in plastic ("seedling") vessels with a capacity of 250 ml, filled with soil material that were removed from the cultivated horizon by agro–gray soil. Irrigations with solutions of vermigumates with different concentrations were carried out from above until the soil was completely saturated with a frequency of 5 days, combining them with watering. Excess irrigation water flowed through the openings at the bottom of the vessels. The experiment was carried out in 4–fold repetition according to the following scheme:

- Control (watering).
- Variant 1 (watering: 2 ml of vermigumates + 200 ml of water, dilution 1: 100).
- Variant 2 (watering: 4 ml of vermigumates + 200 ml of water, 1:50 dilution).
- Variant 3 (watering: 6 ml of vermigumates + 200 ml of water, dilution 1:33).

The arugula of the early-ripening Indau Poker variety (20–25 days), which has unpretentiousness and rapid growth, was chosen as a test culture. After emergence on the 7th day, 4 plants were left in each cup, the rest were removed. The calendar terms of the experiment are from June 20 to July 17, 2019 (duration 27 days).

During the biometric observations, the following morphological indicators were recorded (at the time the experiment was completed): the number of true leaves; the maximum plant height; parameters of lamina (maximum length and width).

Productivity was estimated by the weight of the aboveground (green) part of the plants.

Mathematical processing of the results was carried out in Excel.

3. Experimental Section

The agrarian soil used in the growing experiment was characterized by medium loamy fine-arenic coarse–grained granulometric composition with a content of current–dispersed (<0.001 mm) particles of 14%, a high content of adsorbed cations (41 mEq / 100 g), close to neutral pH (6, 54). The content of organic carbon is 3.2%, total nitrogen is 0.25%, total phosphorus is 0.28%. In the composition of humus, the proportion of humic acids (HA) is about 26% of the total organic carbon (Ctotal), fulvic acids (FA) is 23%, the ratio of carbon HA to carbon FC (Cg : Cfc) is 1,11 (type of humus is fulvate-humate). The characteristics of vermicompost indicate a high content of organic carbon (23%), total forms of nitrogen (2.13%) and phosphorus (0.63%), enrichment with easily hydrolyzed forms of nutrients (nitrogen content 345 mg / 100 g, phosphorus 500 mg / 100 g), strongly alkaline reaction of the medium (pH more than 9 units). The high fertilizer value of vermicompost is indicated by the narrow ratio C: N (10,9).

The fractional group composition of the system of humic substances of vermicompost differs from that in agro–gray soil with a high proportion of HA, 2 times the proportion of FA, which makes it possible to classify humus as a humate type (Cg : Cfc = 2.29). The absolute content of humic acids is high, about 7.8% of vermicompost, which is more than 33% of total organic carbon. HAs are represented mainly by the most valuable fraction, the calcium humates (black HAs), their share reaches 28% of the total.
The results of the growing experiment showed that irrigation with a vermigumates in all of the applied concentrations led to an increase in the biometric parameters of the test culture and its productivity compared to the control one. At the time of completion of the experiment, in all of the variants of the experiments, the number of real leaves in plants that were irrigated with biofertilizer was 4–5 pcs., whereas in all of the replications of the experiment in the control there were no more than 3–4 pcs. The maximum height of the plants was also greater (by an average of 2.8 cm), as affected by vermigumates, although differences in the experimental variants were observed. The greatest effect on this indicator was noted in variant 1 with a dilution of 1:100 – 18.1 cm (in the control 14.6 cm), and the smallest (16.3 cm) was in variant 3 with a dilution of 1:33. The dimensions of the arugula leaf lamina in the variants with vermigumate irrigation were also significantly larger than in the control: length was on average 1.3 cm, width was 0.5 cm. The greatest effect was observed in variant 2 with a dilution of 1:50. There the increase of the width of the leaf lamina was 0.7 cm. In the same embodiment, the highest productivity of the test culture was revealed. The weight of the aerial part of 4 plants on average of 4 replicates was 8.78 g, while in the control it was 4.71 g. In the variants with a lower and higher concentration of the agent, the productivity was also higher than in the control, but the increase was slightly less (figure 1).

![Maximum plant height](a)
![Lamina length](b)
![Lamina width](c)
![Aboveground biomass](d)

**Figure 1.** Biometric characteristics and arugula productivity in experiment (K – control, B1-B3 – experiment variants).
Thus, it was concluded that the use of vermigumates is effective and has a positive effect on the growth and development of Indau Poker arugula. The best indicators of vegetative growth and development of the test culture were noted in variant 2 (4 ml of the drug + 200 ml of water, 1:50 dilution), where the productivity of arugula, compared with the control, was 73% higher. When the vermigumates concentration was 1.5 times higher (variant 3), a slight decrease was observed in relation to variant 2 of the main parameters characterizing the development of culture.

4. Result and Discussion
Stimulation of plant growth and development by vermicomposts and vermigumates is associated with improved water-physical properties and optimization of the soil nutritional regime, as shown by numerous studies [8], as well as with a positive effect on plant physiological processes [9]. Another reason for increasing the productivity of crops against the background of the use of vermicomposts and vermigumates, as N.N. Tereshchenko et al. [8] emphasize, lies in the biological characteristics of vermicompost products. These authors consider the calling card of earthworms, which is the presence in the substrates of their habitat of such groups of microorganisms as nitrogen bacteria and nitrifying bacteria. Along with the function of regulating the nitrogen nutrition of plants, the azotobacter also produces biologically active substances: plant growth and development stimulants and biofungicides.

The positive effect of irrigation with a vermigumates is most likely due not only to the effect on the physiological processes occurring in plants, but also to the optimization of conditions for the life of the soil biota and the development of the root system, which has contributed to an increase in the amount of root excretions and metabolites in the soil. The fact of enhancing the biological (including enzymatic) activity of the soil under the influence of root secretions of plants receiving humic substances has been shown by many researchers [9, 10, 11].

The Growth-stimulating agents, which include vermigumates, can likely, at high doses, reduce the effectiveness of the action and even have an inhibitory effect on plants. The data available in the literature show that low doses of humic preparations (0.001–0.010% solutions) are more effective, while increased doses are generally less economical and may be toxic [9, 10, 11], which requires a cautious approach to the application.

5. Conclusion
The studies expand the understanding of the properties of vermicomposts which were obtained on the basis of food waste, especially in the field of fractional group composition of the humic substances system. HAs are the dominant group, and their composition is dominated by the fraction of calcium humates, which plays a leading role in the processes of structuring soil fine earth, creating favorable water-air, physicochemical and chemical properties of the soil. Vermigumates extracted with 0.02 n NaOH from vermicomposts have growth-promoting properties and are highly effective. An analysis of the yield structure of the test culture of the Indau Poker aragula variety showed that the use of vermigumates (under the conditions of the growing season) positively affected the height of the plants, the length and width of the leaf blades, which contributed to an increase in productivity by 73%.

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