https://www.proconference.org/index.php/usc/article/view/usc23-00-033
DOI: 10.30888/2709-2267.2024-23-00-033

УДК 631.874

QUESTIONS ABOUT IMPROVING SOIL FERTILITY BY VERMICULTING

ПИТАННЯ ЩОДО ПОКРАЩЕННЯ РОДЮЧОСТІ ҐРУНТУ ВЕРМИКУЛЬТИВУВАННЯМ

Mitina N.B./Мітіна Н.Б.
cand. sci. (mech.), assoc. prof. / к.т.н., доц.
ORCID: 0000-0002-5384-7040
SHEI Ukrainian State University of Chemical Technology,
Dnipro, Naberezhna Peremohy, 40, 49005
Державний вищий навчальний заклад «Український державний хіміко-технологічний університет», вул. Набережна Перемоги, 40, м. Дніпро, 49094

Анотація. *В роботі розглядається біотехнологічний підхід покращення родючості ґрунту (відновлення біоти) на пошкоджених землях за рахунок внесення біопрепаратів, отриманих в процесі вермікультивування. Впровадження в агропромислових комплексах і на переробних підприємствах України безвідходного процесу вермікультивування дозволить отримувати високоцінні органічні добрива (біогумус, біогумат), що знизить навантаження на ґрунти, особливо після впливу бойових дій. Також біомасу вермікультури з високою біологічною ефективністю можливо використовувати, як кормову добавку в раціоні сільськогосподарських тварин.*

Ключові слова: *вермикультивування, вермикультура E. fetida, біогумус, біогумат, біомаса, родючість ґрунтів.*

Abstract. *The work considers a biotechnological approach to improving soil fertility (restoration of biota) on damaged lands due to the introduction of biological preparations obtained in the process of vermiculture. The introduction of a waste-free process of vermiculture in agro-industrial complexes and processing enterprises of Ukraine will allow obtaining high-value organic fertilizers (biohumus, biohumate), which will reduce the load on the soil, especially after the impact of hostilities. It is also possible to use vermiculture biomass with high biological efficiency as a feed additive in the diet of farm animals.*

Key words: *vermiculture, vermiculture of E. fetida, biohumus, biohumate, biomass, soil fertility.*

Introduction.

Today, issues of environmental protection are acute due to the significant accumulation of organic waste of various origins. A large amount of agricultural waste remains during the harvesting and processing of grain and fodder crops. Their impact on the environment cannot be underestimated. One of the options for an agro-ecological solution to this problem is vermitechnology. Through bioturbation [1], such as excavation, coprolite production, and mixing of organic matter with mineral particles, earthworms affect the physical and biological properties of soil [2]. Therefore, earthworms are used for biological transformation of organic waste in industrial vermiculture [3].

Main text

Earthworms are traditionally considered a useful biological indicator of soil fertility, play an important role in land reclamation [4], change the distribution of material and energy flows in the soil food chain, which leads to the creation or destruction of habitats for dependent species [5, 6]. It has long been known that typical combinations of earthworm species correspond to certain combinations of soil

properties and can be used for zoological soil diagnostics [6, 7]. Thus, several groups of species are considered indicators of biotope characteristics: *E. fetida*, *E. andrei* – organic accumulations, such as compost piles; *A. chlorotica*, *E. tetraeda* – extremely humid conditions in coastal biotopes; *L. Eiseni* – tree stumps and bark; *L. Terrestris* – deep, slightly acidic or neutral soils with a low sand content, i.e. typical indicators of mulching soils [8, 9]. In many terrestrial ecosystems, earthworms act as important ecological system engineers [10]. Foreign researchers draw attention to the fact that microorganisms contained in vermicomposts contribute to the translation of toxic forms of heavy metals into inactive compounds. This is very important, because the application of vermicomposts to the soils around large cities, industrial plants, as well as where a lot of mineral fertilizers and pesticides have been used, will contribute to the improvement of these soils and the environment as a whole.

Earthworms play an important role in ecosystems. As a result of their vital activity, the fermentation of the organic substrate in humus is accelerated, the nitrogen exchange and the structural formation of the soil are accelerated [4]. A study by scientists from many countries of the world showed that the most promising and practically waste-free biotechnology for the processing of organic waste is biotechnology using vermiculture [3, 10, 11]. Artificial cultivation of earthworms can play a key role in solving issues such as the high market value of fertilizers, animal proteins and the growing demand for these products.

Recently, vermiculture biotechnology has been actively spreading on the territory of Ukraine. Most often, in this technology, cultures of the species *Eisenia foetida, Eisenia andrei* and *Dendrobaena veneta* are used [10, 11]. *Eisenia foetida* is a vermiculture that can be represented as a difficult biocenotic society limited to the appropriate biotope. During artificial cultivation, the vermiculture of *E. foetida* can be represented as a complex biocenotic group, which is limited to a certain biotope. The nutrient substrate should contain at least 20-25% of cellulose and be well crushed, because the largest particles that the California worm can consume are up to 1 mm in size [9, 11].

The population of *Eisenia foetida* in a short period of time transforms food waste into high-value organic fertilizers (biohumus, biohumate), which do not have a sharp unpleasant smell, as in representatives of other species. So, the biotechnological process of obtaining biohumus, biohumate is based on the ability of the *Eisenia foetida* culture to use organic residues, transform them in the intestines and secrete them in the form of coprolites. The use of this technology is particularly relevant at the present time due to the fact that the content of humus in Ukrainian chernozems has decreased from 4 to 5% to 3.3% over the past ten years, and soil with a humus content of less than 2.5% is not chernozem. Biohumus is a brown-gray micro-granular substance with an earthy smell, contains almost all the necessary trace elements and biologically active substances, including enzymes, vitamins, hormones, auxins. Biohumus does not contain non-recyclable substances (polymers, stones, glass). Depending on the size of the granules, biohumus is classified into types [11, 13]:

- moder (granules 0.3-0.7 mm in size) soft fraction of biohumus. Used for fertilizing greenhouse and hothouse crops;

- mor (granules 0.7-1 mm in size) is the largest fraction of biohumus. Intended for use in crop production, horticulture, horticulture. It is applied during sowing in rows and holes;

- silt (granules up to 0.1 mm in size), the smallest fraction of biohumus (or humus flour). When applied to the soil, it immediately dissolves. It is used for the treatment of plants that have experienced a stressful state during transplantation, as well as for obtaining a quick effect when growing plants.

The scale of vermicomposting throughout the world is quite large. The very first farms for the cultivation of earthworms on organic waste were created in the late 1940s in the USA. Grown worms were used as bait for fishermen, as fodder for fish, and for animals in the zoo. Biohumus began to be used to increase soil fertility and obtain environmentally friendly products. Nowadays, there are thousands of farms and about 700 biofactories. In many countries of the world, especially in the USA and Canada, there is a real boom associated with the development of new, more effective vermicomposting technologies [13].

The American corporation Worm World has patented a method of accelerated vermicomposting of organic waste (a complete seven-day cycle) using the Worm Gin continuous action automated vermicomposter, which is capable of producing one ton of biohumus per day on an area of 20 m2. The method is patented in the USA, Canada, East Korea and Australia [13].

There are more than 40 companies and farms in 13 states in Mexico. There are 170 vermiculture enterprises in Cuba, which process animal dung of various species, sugar cane pulp, coffee grounds and various plant residues. For example, in the province of Pinardel Rio, vermiculture is carried out in fields on 4 hectares. The resulting vermicompost is used as a fertilizer for tobacco, corn, tomatoes, onions, garlic, and coffee trees. In European countries, the cultivation of earthworms on waste became the most widespread, first in Italy, and then companies producing biohumus appeared in Great Britain, the Netherlands, Germany, France, Poland, Hungary and other countries. Thus, the French company Sovadec vermicomposts 20 tons of the organic part of solid household waste every day [13].

At the current stage, the biotechnology of vermiculture requires compliance with the following sequence of actions: preparation of a nutrient medium (substrate), analysis of its suitability for use, formation of an area for settlement by California worms, feeding of oligochaetes, separation of beds, obtaining finished products - worm biomass and biohumus. Preparation of the substrate involves the fermentation of organic waste, which is carried out in tanks at different temperature regimes, which reduces the number of weed seeds, helminth eggs and pathogenic microflora. In closed rooms, worms can be cultivated year-round with the arrangement of beds on a concrete floor or on racks placed in tiers. In such premises, the yield of annual products is twice as much as with seasonal cultivation. Red California worms are one of the most popular types of worms used to make biohumus. For successful vermicomposting, it is necessary to use a certain type of substrate suitable for the development and vital activity of worms. The substrate for worms should contain: 20 - 25% fiber, no more than 10% minerals, optimal humidity 70 - 80%, temperature 19 - 20 °C, acidity 6.8 - 7.2. To neutralize acidity, add the necessary amount of lime or

chalk to the substrate, as well as mineral substances in the form of clay, feces, dolomites and zeolite. In the process of cultivation, the basic substrate is continuously moistened once for 4 days, then weekly for 30 days [10, 12].

In the process of digesting organic substances in the intestines of worms, humic substances are formed, including high-molecular organic acids. Their concentration in coprolites is several times higher than in the initial substrate [11].

Various organic wastes are used for the cultivation of *E. foetida* vermiculture: manure, chicken droppings, straw, sawdust, fallen leaves, weeds, branches of trees and bushes, processing industry waste, vegetable storage [10, 12]. Methods of preparing compost for worms: litter-free cattle manure + straw + rotten vegetables in a volume ratio of 3:1:1. The second option: chicken droppings + sawdust + weeds + soil in a ratio of 4:1:1:0.5. In both cases, the mixture was thoroughly mixed, laid in 1.5 m wide, 20-25 cm high sides, with any length. Compost contains 20-40% (from the total volume) of livestock waste (manure, droppings) or rotten remains of vegetables, fruits, etc., that is, organic waste in which microorganisms rapidly multiply [11].

Cultivation of the *E. foetida* culture on a substrate made of modified sunflower husk (SL), crushed to fractions of 200-500 microns, moistened with water in a ratio of 1:2. The substrate for fermentation is placed in special containers (plastic sides) with a height of 50-60 cm. Fermentation process is carried out for 12-14 days under the action of enzymes of microorganisms. To improve the aeration of the fermenting mass, to activate the microbiological activity of microorganisms, to equalize the humidity throughout the volume, to prevent the formation of clay zones in the depth of the sides, the substrate was mixed once a day. The humidity of the substrate is maintained at the level of 70-80%, temperature 20-250 C, pH 6.5-7.5. Top dressing with a thickness of up to 5 cm is applied 10-15 days after the basic substrate is populated with *E. foetida* culture [12].

Biohumus obtained from various substrates has the following agrochemical composition: dry organic mass - 40 - 60%, humus - 10 - 12%, pH - 6.5 - 7.5, humidity - 45 - 55%, nitrogen - 1.5 – 3%; phosphorus – 1.3 - 2.5%, potassium – 4.5 – 8%, magnesium – 0.6 – 2.3%, iron – 0.6 – 1.0%, manganese – 60 – 80 mg/kg , zinc – 28 – 35 mg/kg [11].

The product of vermiculture waste processing is the total vermiculture biomass, which contains more than 60-85% protein, which allows it to be used as a feed additive for farm animals and poultry. It is known from literary sources that the nutritional value of *Eisenia foetida* worms is due to the presence in them of both high-quality proteins and mineral components. Earthworms *Eisenia foetida* contain trace elements Fe, Cu, Mn, Zn, etc., as well as vitamins of complexes A and B, enzymes, antibiotics, etc. [14].

Conclusions.

The achievements of vermiculture need further development and improvement. This will make a contribution to biotechnology and agrotechnology, will include new knowledge of the mechanisms of interaction between the components of substrate mixtures, their influence on the process of vermiculture, transformation of enrichment with organic compounds of biohumus and soil.

References

1. Meysman F.J.R. Bioturbation: a fresh look at Darwin's last idea / F.J.R. Meysman, J.J. Middelburg, C.H.R. Heip // Trends Ecol. Evol. – 2006. – Vol. 21. – P. 688–695.

2. Lee K. E. Earthworms: their ecology and relationships with soil and Land use / K. E. Lee – London: Acad. Press, 1985. – 411 p.

3. Edwards, K. A., Arancon, N. K., Sherman, R. L. Vermiculture technology: earthworms, organic waste and environmental management. CRS Press, Taylor and Francis Group, 2010. – 623 p.

4. Rodriguez-Campos, J., Dendooven, L., Alvarez-Bernal, D., Contreras-Ramos, S. (2014). Potential of earthworms to accelerate removal of organic contaminants from soil: A review. Soil Ecology apple, 79, P. 10-25.

5. Andrusevich K. V. Ecomorphic organization of mesopedobiont communities as the basis for zoological diagnostics of anthropogenic soils / K. V. Andrusevich, A. V. Zhukov, O. N. Kunakh // Bulletin of the Kharkov National University. – 2014. – Issue. 22. – P. 86–97.

6. Bulakhov V.L., Pakhomov O.E. Biological diversity of Ukraine. Dnipropetrovsk region. Mammals (Mammalia). - D.: Publishing House of Dnipropetr. University, 2006. – 356 p.

7. Wright J.P. Patch dynamics in a landscape modified by ecosystem engineers / J.P. Wright, W.S.C. Gurney, C.G. Jones // Oikos. – 2004. – Vol. 105. – P. 336–348.

8. Rombke J. The use of earthworms in ecological soil classification and assessment concepts / J. Rombke, S.Janscha, W. Didden // Ecotoxicology and Environmental Safety. – 2005– Vol. 62 – P. 249–265.

9. Zhukov O. V. Ecological niche of earthworms (Lumbricidae) in the hygrotop and trophotope space of biogeocenoses of the Dnieper steppe / O. V. Zhukov, D. B. Shatalin // Bioresources and environmental management. – 2016. – Vol. 8, No. 3–4. – P. 53–67.

10. Zubareva I. M., Mitina N. B., Vasilkova A. V. Dependence of the biosynthetic ability of the producers of biologically active substances on quality of nutrient medium and substratum // Food and environment safety. – 2014. – Vol. 11(1). – P. 60 - 67.

11. Titov I.N., Usoev V.M. «Vermikultura kak vozobnovlyaemyj istochnik zhivotnogo belka iz organicheskih othodov» Vestnik Tomskogo gosudarstvennogo universiteta. Biologiya. 2012. № 2 (18)

12. Mitina, N. B. Study on modified sunflower husk fermentation process for vermicultivation / N. B. Mitina, I. M, Zubareva, A. D. Odina // Food and environment safety. – 2015. – Vol. 15 (2). – P. 175 –179.

13. Technological aspects of the processing of organic agricultural waste by the method of vermiculture. /V.N. Sendetskyi, N.M. Kolysnyk, I.P. Melnyk, O.M. Bunchak, V.S. Hnydyuk, O.M. Berdnikov// Foliant, Ivano-Frankivsk, 2010 , p. 53.

14. Rodriguez-Campos, J. Potential of earthworms to accelerate removal of organic contaminants from soil: A review / J. Rodriguez-Campos, L. Dendooven, D. Alvarez-Bernal, S. Contreras-Ramos // Applied Soil Ecology. – 2014. – Vol. 79. – P. 10–25.

Стаття відправлена: 25.03.2024 р.