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Efficiency of The Vermicomposting Process Using Californian Red Worms (Eisenia Fetida) And Analysis of The Agrochemical Properties of The Resulting Biohumus

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Abstract: This article investigates the efficiency of the vermicomposting process and the agrochemical properties of biohumus obtained from various organic substrates. The results demonstrated a significant increase in the content of organic matter (43.60–47.4%) and nutrient elements in comparison with the control variant during the vermicomposting process. The highest nitrogen content was identified in biohumus produced from cattle manure (2.31%), the highest potassium content in biohumus obtained from sheep manure (4.91%), and the highest phosphorus content in biohumus derived from poultry manure (2.49%).

The research findings revealed a direct relationship between the chemical composition of biohumus and soil fertility. In addition, the balanced ratio of nutrient elements was found to be an important factor in the formation of the soil chemical environment.

Keywords: Vermicomposting, biohumus, soil fertility, agrochemical analysis, organic fertilizers, Eisenia fetida, organic matter, nitrogen, phosphorus, potassium.

Introduction: Currently, more than 96 million hectares of agricultural land worldwide are managed using organic farming methods. In particular, Australia accounts for 55 million hectares, Argentina for 5 million hectares, China for 4 million hectares, India and Spain for 3 million hectares each, France for 2.5 million hectares, Germany for 2 million hectares, and the United States for 2.5 million hectares. These indicators demonstrate the global expansion of organic agriculture and the increasing demand for environmentally sustainable production systems.

Under the conditions of Uzbekistan, the development of organic farming, including the widespread use of biohumus, plays an important role in improving soil fertility, reducing degradation and salinization processes, and establishing environmentally sustainable agriculture. From this perspective, the use of biohumus produced through vermiculture is considered one of the important innovative agrotechnologies in modern agriculture.

The Resolution of the President of the Republic of Uzbekistan “On measures to create an effective system for combating land degradation” outlines important tasks aimed at improving the meliorative condition of lands, restoring soil fertility, and developing environmentally sustainable agriculture. The resolution emphasizes the necessity of implementing scientifically based agrotechnologies, ensuring efficient use of land resources, and carrying out systematic measures to prevent soil degradation.

LITERATURE REVIEW

In his scientific work, Ch.Darwin (1881) was the first to scientifically substantiate the importance of earthworms in soil formation. He reported that earthworms process 10–20 tons of soil per hectare annually through their digestive system and that their activity raises the soil surface by approximately 2–5 mm per year.

According to the studies conducted by S.Gajalakshmi and S.A.Abbasi (2008), the vermicomposting process using earthworms can reduce organic waste by up to 70%. Through this process, one ton of waste can be converted into 400–600 kg of high-quality biohumus, which significantly enriches the soil with nutrients.

J.Grimm and M.Curto (2015) analyzed the significance of vermicomposting in Germany, where the volume of organic waste was reduced by 40–60% through vermicomposting technologies.

V.P.Stadnik (1997) studied the influence of vermicompost on soil agrochemical processes. His research demonstrated that the application of vermicompost increased total nitrogen content in soil by 20–25%, available phosphorus by 15–20%, and significantly enhanced soil microbiological activity, with the number of beneficial microorganisms increasing by 1.5 times.

Studies conducted by J.Hanc (2014) investigated the effects of vermicompost on the physicochemical properties of soil. The results indicated that vermicompost application increased the organic matter content of soil by 12–20%, while improving soil structure stability and water-holding capacity by 15–18%.

A.Khalid (2017) analyzed the importance of vermicompost in sustainable agricultural systems. The author scientifically substantiated that the use of vermicompost reduces the need for mineral fertilizers by 25–30% and enhances biological activity in soils.

MATERIALS AND METHODS. During the research, the vermicomposting process was carried out under laboratory and experimental conditions. The experimental system consisted of the following variants (Table 1).

Table 1

Experimental Design

Variant	Substrate Composition
Control (Variant I)	straw + *Eisenia fetida*
Variant II	Cattle manure + straw + *Eisenia fetida*
Variant III	Sheep manure + straw + *Eisenia fetida*
Variant IV	Poultry manure + straw + sawdust + *Eisenia fetida*

During the experiment, optimal conditions were maintained to ensure the efficient progress of the vermicomposting process, with the temperature stabilized at 26 ± 1 °C and relative air humidity at 55 ± 1%. Under these conditions, the obtained biohumus samples were dried and subjected to laboratory analysis. The following agrochemical parameters were determined: organic matter content, total nitrogen (N), total potassium (K_2O), and total phosphorus (P_2O_5).

All observations, soil sampling procedures, and calculations were carried out in accordance with the guidelines "Methods of Conducting Field Experiments" and "Field experiment methodology" adopted by research institute of Cotton breeding, seed production and agrotechnologies . The determination of humus content and the total and available forms of NPK in soil samples was conducted based on the manuals "Methods of Agrochemical, Agrophysical, and Microbiological Research in Irrigated Cotton-Growing Regions" and "Methods of Agrochemical Analysis of Soils and Plants in Central Asia".

RESULTS AND DISCUSSION

Vermicomposting is considered one of the most promising methods for the environmentally safe recycling of organic waste. This process is carried out with the participation of specialized compost worms, particularly Eisenia fetida, resulting in the production of biologically active biohumus. The efficiency of vermicomposting largely depends on environmental factors, especially temperature and humidity. When optimal living conditions for earthworms are provided, their feeding activity, reproduction, and the rate of organic matter bioconversion increase significantly.

From this perspective, the main objective of the present study was to determine the agrochemical properties of biohumus obtained from different organic substrates and to evaluate their effects on soil fertility. The research results demonstrated that the composition of biohumus varied considerably depending on the type of substrate used.

Laboratory analyses of the biohumus obtained during the experiment revealed that the control variant

(Variant I) contained low levels of nutrients in the soil, specifically 2.23% organic matter, 0.35% nitrogen (N), 1.7% potassium (K_2O), and 0.13% phosphorus (P_2O_5). Under such conditions, the concentration of the soil solution was low, and ion exchange processes occurred slowly. In particular, due to the insufficient amounts of phosphorus and nitrogen, the soil nutrient regime remained limited. This indicates that the soil represented an agrochemically low-active environment (Table 2).

Table 2

Agrochemical Properties of Biohumus Produced During the Vermicomposting Process with the Participation of Californian Red Worms (Eisenia fetida)

№	Experimental Variant	Name of indicators%			
		Organic Matter Content	Total Nitrogen (N)	Total Potassium (K_2O)	Total Phosphates (P_2O_5)
1	Control (ordinary soil + straw)	2,23	0,35	1,7	0,13
2	Biohumus produced from cattle manure + straw with the participation of *Eisenia fetida*	43,60	2,31	3,80	0,62
3	Biohumus produced from sheep manure + straw with the participation of *Eisenia fetida*	47,4	2,23	4,91	0,26
4	Biohumus produced from poultry manure + straw + sawdust with the participation of *Eisenia fetida*	44,78	1,20	1,52	2,49

In Variant II (43.60% organic matter; 2.31% N; 3.80% K_2O; 0.62% P_2O_5), the sharp increase in nutrient elements led to an increase in the chemical capacity of the soil solution. Due to the high content of nitrogen and potassium, exchange processes in the soil intensified, while the moderate level of phosphorus stabilized the overall nutritional background. As a result, the soil chemical environment was formed as a complex and balanced system.

In Variant III (47.4% organic matter; 2.23% N; 4.91% K_2O; 0.26% P_2O_5), a significant difference in the ratio of elements was observed. The highest potassium content ensured the dominance of K^+ ions in the soil solution. However, due to the low phosphorus content, a relative imbalance occurred in the nutrient system. Chemically, this indicates the formation of a selective dominance of a specific element in the soil environment.

Variant IV (44.78% organic matter; 1.20% N; 1.52% K_2O; 2.49% P_2O_5) differed sharply from the other variants. In this case, the high phosphorus concentration resulted in the predominance of phosphate ions in the soil solution. At the same time, due to the relatively low amounts of nitrogen and potassium, the chemical balance shifted toward phosphorus dominance. Consequently, the soil chemical environment transformed into a system characterized by the predominance of a single element (phosphorus).

The overall analyses demonstrated that, together with the increase in organic matter content (from 2.23% to 47.4%), the total concentration of nutrient elements also increased significantly, leading to a substantial rise in soil chemical activity. At the same time, the different N:P:K ratios formed in each variant altered the ionic composition and chemical balance of the soil solution in different ways.

CONCLUSION

According to the obtained analytical results, the studied indicators demonstrated that the chemical properties of soil depend not only on the quantity of elements but also on their mutual ratios. As a result, depending on the amount and proportion of nutrient elements, balanced, potassium-dominant, or phosphorus-enriched chemical environments were formed in the soil. This condition directly influenced the ionic composition of the soil solution, the bioavailability of elements, and the nutritional regime of plants.

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