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THE INFLUENCE OF WORM COMPOST ON QUALITY AND HARVEST OF SOME FORRAGE CROPS

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Abstract

This article synthesizes own experience in the bioconversion of organic waste through worm cultivation. The main objective of the research was to assess the development of organic agriculture, using the technology of worm cultivation in the bioconversion of biodegradable waste in order to obtain the organic fertilizer (the worm compost) and ecological agricultural production. The relevant elements of the research consisted in estimating the role of hybrid species of earthworms Red California (Eisenia foetida andrei) in the bioconversion of biodegradable organic waste and obtaining the organic fertilizer (the worm compost), main element for the development of organic agriculture. As a result of researches it was found, that the values of quality indicators of the worm compost exceeded the essentially those of the nutritive substrate, and the incorporation of the worm compost in the soil, at a dose of 4 t/ha, has diminished the period of germination and ripening of forage crops, increasing harvest from 64.92 up to 110.14% and improved their quality, through diminishing nitrosocompounds content.

Key words*: bioconversion, biodegradable organic waste, worm compost, forage crops, quality.*

INTRODUCTION

Obtaining organic agricultural products in recent years occupies a special place in the development of modern organic agriculture. The development of organic agriculture implies a return to the values of traditional agriculture, but not to its methods. The process and procedures for obtaining organic products are regulated by strict production rules and principles, which start from the quality, that the soil must possess and until the actual obtaining of the final product. Organic farming is carried out directly by using organic fertilizers, controlling diseases and pests through integrated ecological methods, total exclusion from agricultural technologies of industrially obtained chemicals (fertilizers, pesticides, growth stimulants) and completely giving up genetic engineering applications.

The ecological situation in the Republic of Moldova, for the last 4-5 decades of the XX century, has worsened as a result of the capitalization, practically total, of the territory and under the influence of decreasing the amount of humus in the soil. From this point of view, the territory of the republic can be considered an area with ecological balance disorders. The ecological status is largely marked by the result of the socio-economic policy promoted in the post-war period in the USSR. The territory of the Republic of Moldova often served as an experimental base for: testing various chemicals (pesticides, herbicides and mineral fertilizers); implementation of intensive irrigation and the formation of gigantic zootechnical complexes (Băbălău et al., 1991), which had serious consequences for the environment.

At present, in order to solve the ecological problems of the environment, worldwide, modern methods and technologies are developed, of perspective for the technology of bioconversion of organic waste. In order to avoid the pollution of the asbestos environment and to obtain profit from the use of organic waste in many states (USA, Japan, Italy, Hungary, France, Ukraine, etc.) is practiced the processing by worm cultivation of biodegradable organic waste (Boclaci & Cremeneac, 2011; Cremeneac et al., 2012; Gorodnyi et al., 1996).

The objectives of the carried out researches consisted in the use of bioconversion technology for organic waste by worm cultivation for solving important ecological

problems: complete bioconversion of organic waste; improving and reviving soil fertility; obtaining long-acting ecological organic fertilizers; increasing the harvest of agricultural crops; environmental protection.

The technology of processing organic waste by this method is based on the biological capacity of the earthworms to use the solid fraction of organic waste as a substrate and source of nutrients. In a relatively short period of time, the valuable organic fertilizer (worm compost) can be obtained. The obtained warm compost has a high biological activity, in which are concentrated significant amounts of macro- and microelements, growth stimulants, antibiotics, vitamins and others. Its use at a dose of 3-10 t / ha contributes to increasing productivity and improving the quality of agricultural crops (Boclaci & Cremeneac, 2013; Cremeneac & Boclaci, 2015; Kosolapova et al., 1996).

The technology of bioconversion of organic waste through worm cultivation is a perspective method, which can be practiced in all types of households (public, peasant and private). It provides for the use of organic animal, household and vegetable waste, which has been partially subjected to the fermentation process, as a nutrient substrate and living environment for worm culture (Povkhan et al., 2004).

The research results demonstrate the importance of warm compost as an organic fertilizer, for the physiological development of plants, increasing the harvest and improving the quality of the obtained products, thus favoring the development of organic agriculture.

MATERIALS AND METHODS

The experiment was organized in the Technological-Experimental Station "Maximovca", where in five sectors for worm cultivation, with a width of 1m and a length of 50 m was placed the nutrient substrate prepared for bioconversion through worm cultivation.

The period of the experiment depended on the physiological development of the plants.

In order to obtain forage crops it was organized experiment in field conditions in which were included three types of forage crops: alfalfa varieties ‘Tuna’, fodder beet variety ‘Ekkendorfskaya’ and maize varieties ‘M-450’. Surface lots amounted to 2 acres. For each fodder crop were used three lots: one control and two experimental. For lot I was kept natural background, lot II was fertilized with worm compost (from considerations 4 t/ha), and the third lot - ammonium nitrate (285 kg/ha), according to the scheme of the experiment (Table 1).

Before the incorporation of fertilizers in the soil, was performed the soil preparation (autumn - tilling to a depth of 30 cm- 40 cm and spring – loosening (by harrowing). Fertilization was carried out in early spring, immediately after snow melting on the autumn plowing. After harvesting of the forage crops, was carried out the determination of some quality indicators in accordance with the usual methods (Popov A. et al., 1973; Razumov V. et al., 1986).

Table 1. The experimental scheme

The lots	The conditions of the experiment	Investigations carried out
I - control	Natural background	Will be determined: a) observations on the physiological development of fodder crops b) the quality of worm compost and fodder crops; c) harvest for each fodder crops
II - experimental	With worm compost background (4 t / ha)	
III - experimental	With ammonium nitrate background (250 kg/ha)	

Materials for research were used the manure of cattle, subjected to the fermentation process for 6-7 months, subsequently used as a nutrient substrate, obtained worm compost, corn, alfalfa and fodder beet, and the object of research - earthworm California Red Hybrid, biotransformer of organic waste.

The nutrient substrate, placed in the sectors for worm cultivation, was subjected to biochemical analysis and to the determination of its nutritional value. The quality of the nutrient substrate (initially and during the experiment) and of the obtained fertilizer as a result of the bioconversion of organic waste (worm compost) was determined according to the following indicators: active acidity (pH), amount of ammonia, total nitrogen, organic matter, potassium, calcium, magnesium, phosphorus and non-pathogenic bacterial flora.

The biochemical analysis of the quality of the nutrient substrate, of the obtained fertilizer and the fodder crops was performed according to the usual methods, set out below: active acidity,

using the pH meter; total nitrogen - according to the Kjeldahl method (Popov, et al., 1973).; the ammonia content - according to methodological guidelines (Poloz et al., 1987), and the calcium, phosphorus, and potassium content - according to the methods from the handbook of Razumov et al. (1986).

RESULTS AND DISCUSSIONS

In the sectors for worm cultivation, 25 tons of organic waste were placed, which were subjected to bioconversion by worm culture in order to obtain the organic fertilizer – worm-compost.

Previously, the organic waste was subjected to the fermentation process for 6 months. After fermentation it was placed the nutrient substrate with a thickness of 25-35 cm - in summer and 35-45 cm - in winter in the sectors for worm cultivation. Each sector for worm cultivation was divided into sections with dimensions of 1 m × 2 m.

During a month, in order to reduce the ammonia content and regulate the active acidity, the nutrient substrate in the sectors was sprayed for a week - daily, and then once a week with drinking water. Subsequently, the substrate prepared for worm cultivation was subjected to chemical analyzes in order to determine its quality. As a result of the analyzes, it was found that the nutrient substrate according to its chemical composition can be used as a nutrient substrate and living environment for worm culture, in the process of bioconversion of organic waste by worm cultivation (Table 2).

Table 2. Quality indicators of the nutrient substrate

Quality indicators	Indicator values, M ± m
Active acidity (pH), conventional units	7.57 ± 0.08
Ammonia, mg/kg	5.56 ± 0.57
Total nitrogen, %	0.83 ± 0.63
Organic matter, %	30.35 ± 0.60
Magnesium, %	1.17 ± 0.52
Phosphorus (P_2O_5), %	0.65 ± 0.32
Potassium (K_2O), %	0.68 ± 0.01
Calcium, %	0.55 ± 0.35

Worm culture (earthworms) was placed in the prepared nutrient substrate, from consideration 30-100 thousand individuals of all ages at two square meters. The duration of complete processing of the nutrient substrate in a section, in this case was 6 months. During the experimental period the nutrient substrate was sprayed with water (as needed). Sectors for worm cultivation were covered with straw in order to reduce evaporation - summer and protection from cold - winter.

During the experimental period, were respected the requirements of the technology of bioconversion of organic waste by worm-culture (humidity - 70-80%, ammonia content 1.0-20 mg/kg, active acidity (pH) - 6.8-7.6 conventional units and cellulose content - 30%).

After 30 days from the beginning of the experiment, it was found that the worm-culture processed a substantial part of the nutrient substrate; therefore, the addition of the additional nutritive substrate was started. This process took place every 10-14 days. At the end of the experimental period, the worm-culture was separated from the substrate and placed in other sectors, prepared in advance for the development of the bioconversion technology of organic waste. As a result of the processing of organic waste, the valuable organic fertilizer –worm compost was obtained (Figure 1).

Figure 1. Worm compost - organic fertilizer obtained from cattle manure

Worm compost is one of the final products of the bioconversion of biodegradable waste obtained as a result of the vital activity of worm culture. It is made up of small dark brown granules, with the smell of soil after rain, is hydroscopic and can be stored in dry rooms for many years, without losing its qualities. The amount of obtained worm compost depends on

the type of biodegradable waste used as a nutrient substrate. From a ton of organic waste as a result of bioconversion, 700 kg of worm compost were obtained during six months.
In Table 3 are shown the quality indicators of two fractions of worm compost obtained as a result of the bioconversion of organic waste by worm culture

Table 3. Quality indicators of worm-compost

Quality indicators	Worm compost fractions and indicator values, M ± m	
	fraction 0.25 mm	fraction 1.00 mm
Active acidity (pH-ul), units	7.81 ± 0.03	8.08 ± 0.02
The organic substance, %	24.39 ± 0.45	27.41 ± 0.41
Total nitrogen, %	1.09 ± 0.01	3.00 ± 0.04
Potassium (K2O), %	1.92 ± 0.02	2.50 ± 0.03
Magnesium, %	1.18 ± 0.03	2.50 ± 0.04
Phosphorus (P2O5), %	1.37 ± 0.08	2.50 ± 0.06
Calcium, %	0.62 ± 0.02	3.80 ± 0.05
Humus, %	29.66 ± 1.40	35.91 ± 1.90
Non-pathogenic bacterial flora, colonies	2×10^{12}	2×10^{12}

Comparing the values of the quality indicators of the worm compost in the two fractions, with those of the initial nutritive substrate, it was found that the active acidity, the content of total nitrogen, calcium, magnesium, potassium and phosphorus in the 0.25 mm fraction of the obtained worm compost, exceed that, from the nutrient substrate, respectively by 3.17%, 31.33%, 12.70%, 3.82 times, 2.11 times, and in the fraction of 1.00 mm, these indicators exceeded them, respectively by 6.74%, 3.61 times, 6.90 times, 2.14 times, 3.67 times and 3.84 times. The organic matter content decreased in the investigated fractions, respectively by 19.64% and 9.69%. As a result of the research, it was found that the worm compost contains 100 times more non-pathogenic microflora (2×10^{12} colonies) than ordinary compost.
According to the obtained results, it was found that the worm compost is superior to the nutrient substrate. The organic substance during the bioconversion was transformed into humus. When incorporating worm compost into the soil, considerable savings are made, taking into account that 3-6 tons of worm compost are used per hectare compared to 40-70 t/ha of traditional compost.
According to the researches, it was found that one ton of worm compost contains 270-300 kg of humus. This allows to an essential reduce of the filling period of the amount of humus in the soil, thus restoring soil fertility and soil resistance to wind and alluvial erosion. Worm compost can be used to cultivate all species of agricultural plants, influencing beneficially on their physiological development and the yield obtained per unit area.
The period for obtaining worm compost from cattle manure lasted 8 months.
At the initial stage of the field experiment it was found that all crops in the experiment cultivated with worm-compost background, emerged 2 - 3 days earlier than those cultivated with mineral fertilizer and 5 - 7 days earlier than those in the control lots. This demonstrates that the worm compost beneficially influences the process of seed germination and emergence of agricultural crops.
Comparing the process of development of plants from all variants, it was found that in the lots with a background of worm compost, agricultural crops developed more intensely, the early flowering of alfalfa, the intense development of the rhizocarps in fodder beet and the formation of corn cobs took place with 5-6 days earlier than in the control lots and with 3-4 - earlier than in the groups with ammonium nitrate. Therefore, as a result of the performed studies, it was found that the incorporation of the worm compost in the soil, in a dose of 4 t/ha, led to the early physiological development of the crops, diminishing the flowering and ripening period of the cultivated plants.
To evaluate the quality of fodder crops, at the end of the experiment was determined the amount of nitrates in alfalfa, fodder beet and maize. The results of the investigations are set out in Table 4.
Analyzing the obtained results, it was found that in forage samples the amount of nitrates the nitrate content was varied, in some cases, exceeding the maximum permissible concentration (MPC), which for roughage is 500 mg/kg and for fodder beet - 800mg/kg. The amount of nitrates depended on half collection phase of vegetation and type of fertilizer used in the cultivation of forage crops.

Table 4. The content of nitrates in the forage crops

Types of forage crops	Variants of the experiment and the quantity of nitrates (mg/kg)		
	Control	Worm compost (4t / ha)	Ammonium nitrate (250 kg/ha
Alfalfa Fîn din lucernă	129.00 ± 1.10-178.00 ± 0.97	200.50 ± 0.86-207.00± 0.09	457.00 ± 1.74-550.00 ± 1.15
Fodder beet	283.50 ± 0.66-583.50 ± 6.19	376.00 ± 7.07-631.00 ± 1.11	719.00 ± 2.11-919.0 ± 5.31
Maize (stalks and the leaves)	157.80 ± 0.53-257.80 ± 0.42	250.70 ± 0.46-302.00 ± 0.81	926.4 ± 0. 46-1113.00 ± 5.11

In all phases of vegetation of forage crops grown with fertilizer of ammonium nitrate was found a high content of nitrates. In samples of forage crops (in the last phase of vegetation), the amount of nitrates ascertained in alfalfa, fodder beet, and stems and leaves dry maize, it collected on lots with ammonium nitrate fund, surpassed that of control lot, respectively from 3.09 times, 1.58 times and 4.33 times.

At the end of the experiment, the concentration of nitrates in samples of alfalfa, fodder beet and maize, collected from the lots with ammonium nitrate exceeding the maximum permissible concentration (MPC), respectively by 175.00%, 14.88% and 39.13%

In the plants collected from the lots with worm compost, the nitrate content exceeded by 3.50% the value MPA, only in the alfalfa sample. In the samples fodder beet and the maize, the nitrate content was within the permitted limit (respectively 800mg/kg and 500 mg/kg).

In fodder collected on lot with fund of worm compost this indicator exceeds for 1.16-1.55 times (hay), 1.08-1.33 times (fodder beet) and 1.17-1.59 times (maize) that from plants of control lot, but did not exceed the maximum permissible concentration.

At the end of the experiment, an essential difference in forage crops harvest was found, depending on the background on which they were grown and the type of crop (Table 5).

Table 5. Influence of worm compost and mineral fertilizers on harvest of forage crops

Types of forage crops	Lots and quantity of obtained harvest				
	Control	With worm compost background (4 t/ha)		With ammonium nitrate background (250 kg/ha)	
	kg	kg	The increase production, %	kg	The increase production, %
Alfalfa	650	1072	164.92	865	133.08
Fodder beet	690	1450	210.14	1173	170.00
Maize	420	693	165.00	567	135.00

It is necessary to mention that the harvest of alfalfa, fodder beet and corn obtained on the lots with worm-compost background was higher than on those with ammonium nitrate background. According to the results, the difference between the harvests of these two lots was 23.93% for alfalfa, 23.61% for fodder beet and 22.22% for maize.

Analyzing the results of the harvest of fodder crops, obtained from the experimental lots, it was found that the harvest of alfalfa, fodder beet and maize collected from the lots with worm compost background exceeded it by 64.92%, 110.14% and 65.00%, respectively, and the harvest collected from the lots with ammonium nitrate background exceeded, respectively by 33.08%, 70.00% and 35.00% that of the harvest of fodder crops from the control lots

Therefore, the worm compost influenced the early development of agricultural crops and the increase of the crop per unit area.

In the fodder crops cultivated on the lots with worm compost background, exceeding the content of nitrates was nonessential, remaining within the limits of the allowed value, and in those of the lots with ammonium nitrate background the concentration of nitrate was higher than the permissible.

Thus, the bioconversion of biodegradable organic waste through worm culture is a component part of organic agriculture and can be used in households with various forms of ownership.

CONCLUSIONS

Bioconversion of organic waste through worm culture solves the important problems of organic agriculture: improving and reviving soil fertility; obtaining long-acting ecological organic fertilizers; increasing the harvest of agricultural crops; environmental protection.

The values of the qualitative indices of the worm compost essentially exceeded those of the nutrient substrate (partially fermented biodegradable waste).

The incorporation of worm compost in the soil, in the dose of 4 t/ha, influenced the early development of fodder crops, reducing the duration of the phenological phases.

In the crops cultivated with worm compost background, the content of nitrocomposites decreased, thus improving the quality of the obtained production.

The concentration of nitrates in samples of alfalfa, fodder beet and maize, collected from the lots with ammonium nitrate exceeding the maximum permissible concentration (MPC), respectively by 175.00%, 14.88% and 39.13%

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Worm cultivation technology is an effective method for the development of organic agriculture.

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