Acta Biol. Univ. Daugavp. 15 (1) 2015
ISSN 1407 - 8953

EFFECT OF THE PEAT ELIXIR AND VERMIKOMPOST EXTRACT ON THE SOIL MICROFLORA IN THE POTATO PLANTATION

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Vojevoda L., Šteinberga V., Gaile Z. 2015. Effect of the peat elixir and vermikompost extract on the soil microflora in the potato plantation. *Acta Biol. Univ. Daugavp., 15 (1): 221 – 226.*

The testing was carried out in State Stende Cereals Breeding Institute from 2011 to 2012. The aim of the study was to identify the biological activity of soil in the potato plantation by using extracts from the organic products in two cultivation systems: conventional and organic. The following extracts from the organic products were used: peat elixir and vermicompost extract obtained at +45° C. The study was carried out in the potato plantation with the variety 'Borodjanskij Rozovij'. Application of extracts from the organic products – peat elixir and vermicompost extract tended to have a positive impact on the number of microorganisms in the soil both in organic and conventional cultivation systems in the potato plantation. However, a tendency was observed that the number of microorganisms in conventional cultivation system was higher than in the organic cultivation system. It was observed in nearly all extract application options that the number of microorganisms was higher at the end of the summer and when the tubers were treated before planting.

Key words: microbial activity in the soil, vermicompost extract, peat elixir, potatoes.

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INTRODUCTION

Organic farming is rapidly developing world-wide now prohibiting the use of both chemical plant protection means and mineral fertilizers. Mineral and organic fertilizers applied in agriculture are estimated, mainly, by their effect on plant growth, crop yield and soil textural properties. However, the effect of the applied fertilizer on microbiological processes, which influence soil fertility and dynamics of plant-available nutrients, is estimated infrequently (Nannipieri et al. 2003). Topsoil, which is the root region of plants, is environment for different soil inhabitant activities. From these organisms soil fertility and mineral nutrition of plants are dependent. Each small organism has a special definite task and is capable of action only under definite conditions (heat, moisture, air, nutrients) (Miške et al. 2007).

Soil biological activity assessment allows clarification of the organic and mineral fertilizer effect on the biological processes and their intensity. Significant indicator for sustainable soil fertility assessment is the change of the proportion of different groups of micro-organisms in soil (Trasar – Cepeda et al. 2008). Soil micro-

flora is involved in all the processes, which are decisive for the soil fertility. Micro-organisms form the most significant part of the soil micro-flora, therefore term microbiological activity is frequently used. Some authors are of the opinion (Praveen – Kumar &Tarafdar 2003) that enzyme effectiveness is mainly dependent on bacteria and actinomycetes. Mineral fertilizer effect is usually short because micro-organisms, which utilize more easy available nutrients, are activated at first. Changes in count and activity of micro-organisms, which decompose organic materials and humic substances, are usually slower (Ходжаева et al. 2010).

Different organic fertilizers, including vermicompost, are mainly incorporated into the soil. The use of vermicompost and peat extract preparations, spraying them on plant leaves, is rather infrequent. Information about the impact of organic fertilizers, incorporated into the soil, on plants and micro-organisms is prevailing in the scientific literature (Arancon et al. 2006), less data are available about the use of extracts of organic origin (Zaller 2006). Studies (Grantina-Ievina et al. 2013) on the use of different kind of organic preparations are also conducted in Latvia to increase the productivity of plants, incorporating these preparations into the soil. However, there are few studies on the use of organic preparations spraying them on the above-ground parts of plants (Vojevoda & Gaile 2012). Fungi, bacteria, including actinomyces, occurring in the soil were recorded depending on the applied extracts from the organic products. Microscopic fungi are spread not only in the soil but also in the environment with organic matter occurrence. In the soil, mycelium concentration is reaching 700-1000 m g^{-1}. Fungi are synthesizing different hydrolytic enzymes and secreting them in the external environment. These hydrolytic enzymes are decompopsing all organic substrate up to lignin. During day/night fungi are decomposing 2-7 times more organic material than consume them. Soil fungi are taking part in metabolic processes and are extracting organic acids, which help plants in uptake of immobile phosphate and other nutrients as well as participate in nitrification processes (Ходжаева et al. 2010). Bacteria, including actinomycetes, play a very important role in decomposition of the soil organic substances under aerobic and anaerobic conditions. Actinomycetes have been studied in detail, particularly genus *Streptomyces*, which is included in one of the groups which decompose soil organic matter. Almost all actinomycetes are forming mycelium in soil micro-zones with high in organic matter content (Praveen – Kumar & Tarafdar 2003).

The aim of the study was to identify micro-biological activity of the soil in the potato plantation by using extracts from the organic products (peat elixir and vermicompost extract) employing different methods of spraying in conventional and organic cultivation systems.

MATERIAL AND METHODS

The study was carried out in State Stende Cereals Breeding Institute from 2011 to 2012 in two cultivation systems: conventional and organic. The study was established in three replications with randomized treatment design. Early maturing potato variety 'Borodjanskij Rozovij' (the Ukraine) was chosen for the study. The study in conventional cultivation system was established on sod podzolic gleysolic soil with pH KCl 5.3, 2.6% organic matter, P – 414 mg L^{-1} and K – 255 mg L^{-1} in 2011 and pH KCl – 5.6, 2.7% organic matter, P – 447 mg L^{-1} and K – 195 mg L^{-1} in 2012. In organic cultivation system, the study was established on sod podzolic gleysolic soil with pH KCl – 6.5, 3.8% organic matter, P – 167 mg L^{-1} un K – 125 mg L^{-1} in 2012. Prior to trial in spring, the soil in the field was levelled and loosened using chisel cultivator KR – 4. Potatoes were hand-planted in the 3rd decade of May. Spacing between tubers was 0.3 m, row spacing – 0.80 m in the conventional field and 0.70 m in the organic field. In the conventional field, in each variant complex mineral fertilizer NPK 11:9:21, application rate – 550 kg ha^{-1} (a.i. N – 61 kg ha^{-1}, P – 49 kg ha^{-1}, K – 115 kg ha^{-1}) was incorporated into the soil prior to planting. In the organic field mineral fertilizer was not applied.

Table 1. Meteorological indices (Stende HMS data) 2011 – 2012

Month	Mean air temperature, °C			Sum of precipitation, mm		
	2011.	2012.	Norm	2011	2012	Norm
May	10.2	11.0	10.2	54.7	58.9	45
June	14.2	13.2	14.2	59.6	78.7	57
July	16.3	17.5	16.3	165.3	91.7	87
August	15.5	15.5	15.5	155	115.1	87

In both cultivation systems, treatment with extracts from the organic products were applied corresponding to methods in the following variant groups:

1. control – untreated with organic product extracts;
2. tuber treatment with organic product extracts before planting;
3. plant treatment with organic product extracts three times in season: after germination, at plant height of 10 cm, before and after flowering;
4. tuber treatment with organic product extracts before planting and plant treatment with these products three times in season in the above mentioned terms.

Extracts from the organic products included: peat elixir and vermicompost extract obtained at +45° C. Preparations before application were chemically analyzed for nutrients. Results suggest that extracts contain humic substances, macro- and microelements (N, P, K, Mg, Ca, B, Mn, etc.) and microorganisms. Aerobic and anaerobic organisms were detected both in peat elixir and vermicompost extract. In extracts, bacteria counts ranged from 16.5 to 21.7 million per 1 mL. However, anaerobic bacteria count in preparations was considerably lower compare to aerobic bacteria count. Most of aerobic bacteria were spore-forming bacteria – 90%, including such genera as *Pseudomonas* – 6% and *Artrobacter* – 4%. Genus *Clostridium* and 0.5% of other anaerobic bacilli were dominant in anaerobic microflora. Extracts from the organic products contained microscopic fungi the count of which was higher in peat elixir, but were not detected in vermicompost extract. Microscopic fungi were represented by the species of fungal genera such as *Penicillium, Pythium* and *Chetonium* in approximately equal amounts. For extracts, medium pH was determined, which show differences in the composition of solutions. These differences are small because all the preparations have a slightly alkaline reaction (peat elixir – 8.6; vermicompost extract – 8.0).

Tuber treatment with elixirs was performed in the day of planting using knapsack sprayer JACTO HD 300, spraying dose 2.5 L t^{-1}. Plant treatment with organic product extracts was performed after germination, before and after flowering phases, spraying dose – 1.5 L ha^{-1}. Plants were sprayed with organic product extracts using specific bicycle-type sprayer Birchmeier Spray-Matic 10 S. This sprayer is equiped with flat-jet nozzles, pressure – 250 kPa, consumption of working solution – 250 L ha^{-1}.

The soil was sampled for microbiological analyses at a depth of 0.20 m both in organic and conventional fields: in 11 July and 26 August in 2011 and in 9 July and 3 August in 2012, respectively.

Counts of aerobic microorganisms were detrmined by sowing on selective microbiological culture medium in three replications. Bacteria were cultivated in *Nutrient agar* culture medium, actinomycetes in special selective culture medium but microscopic fungi – in *Sabourad Chloramphenicol agar* culture medium. From the collected soil samples soil dilutions were made and sown in Petri dishes with the corresponding culture medium. Bacteria and microscopic fungi were incubated in thermostat at +28°C, but actinomyces at +24°C. Anaerobic bacteria counts were determined using specific BD GasPakTMEZ PouchSystem equipment.

Table 2. Effect of the organic product extracts on soil microorganisms counts in the potato plantation in organic cultivation system, on average in 2 years

Variants	Bacteria million cfu g^{-1} *		Actinomycetes million cfu g^{-1} *		Microscopic fungi thou. cfu g^{-1} *of dry soil	
	July	August	July	August	July	August
1. Control	5.50	5.60	0.54	1.20	15.05	19.57
2. Potato tuber treatment with peat elixir	4.60	11.30	0.81	2.40	17.45	17.24
3. Plant treatment with peat elixir	4.70	10.10	1.40	1.60	13.83	47.31
4. Potato tuber and plant treatment with peat elixir	5.50	11.0	1.80	1.20	18.28	21.25
5. Potato tuber treatment with vermicompost extract	6.90	12.20	2.20	2.00	13.33	24.73
6. Plant treatment with vermicompost extract	7.40	13.80	1.50	1.20	9.79	19.44
7. Potato tuber and plant treatment with vermicompost extract	6.70	7.90	1.00	2.30	11.70	41.22

*cfu g^{-1} – number of colonies forming units per 1 g^{-1} of soil

Microorganisms biomass in the samples of soil (mg C microorg. kg^{-1} of dry soil) was calculated by the substrate induced respiration (SIR) results (LVS ISO 14240 – 1:1997; Microbiological Methods for Assessing Soil Quality, 2005). On the basis of the soil microbiological analysis, amounts of different groups of microorganisms were compared.

Meteorological conditions in 2011 and 2012 characterized with frequent precipitation and moderately warm summers.

RESULTS AND DISCUSSION

The count of soil microorganisms in the potato plantation in organic cultivation system

Analysis of the soil samples collected in July and August allows conclusion that soil treatment with extracts from the organic products, compare to control, have affected the counts of microorganisms (bacteria and actinomycetes counts – million cfu g^{-1} of dry soil; microscopic fungi count – thou. cfu g^{-1} of dry soil) (Table 2). The highest values of the soil bacteria counts, compare to control, were obtained at the end of summer in all the treatments receiving peat elixir. There were no significant differences in actinomycetes counts between months, however it was comparatively higher in variant with tuber treatment. The highest soil microscopic fungi count was stated in August in variant 3, when plants were treated 3 times in season.

Vermicompost extract affected the count of soil microorganisms in all treatments, which differed depending on the date of application. Microscopic fungi were most affected, besides, this effect was higher in August, in case when tubers were treated before planting, and in case when both tubers were treated before planting and plants were treated three times in season. Species of fungal genera such as *Penicillium, Trichoderma, Mucor* occurred in the soil samples most frequently, but *Aspergillus* and *Fusarium* were identified infrequently.

Table 3. Effect of the organic product extracts on soil microorganisms counts in the potato plantation in conventional cultivation system

Variants	Bacteria million cfu g^{-1} *		Actinomycetes million cfu g^{-1} *		Microscopic fungi thou. cfu g^{-1}* of dry soil	
	July	August	July	August	July	August
1. Control	2.80	4.80	0.70	1.80	12.77	14.36
2. Potato tuber treatment with peat elixir	3.80	7.10	1.10	2.70	13.16	12.11
3. Plant treatment with peat elixir	6.70	5.80	1.80	2.00	12.64	16.67
4. Potato tuber and plant treatment with peat elixir	3.50	5.90	1.30	2.30	15.26	18.95
5. Potato tuber treatment with vermicompost extract	11.10	12.00	1.90	1.60	18.95	28.95
6. Plant treatment with vermicompost extract	9.7	9.0	1.6	2.80	12.64	28.42
7. Potato tuber and plant treatment with vermicompost extract	3.20	5.60	1.60	2.10	16.84	19.68

*cfu g^{-1} – number of colonies forming units per 1 g^{-1} of soil

Comparison between the influence of peat elixir and vermicompost extract leads to conclusion that the count of soil microorganisms was greater under the influence of peat elixir than with vermicompost extract applied. The count of soil microorganisms in the potato plantation increased during the last month of summer – August. Peat elixir treatments showed a positive effect on the count of soil microscopic fungi in August, in the 3rd variant, when plants were treated three times in vegetational season: after germination, before flowering and a week after flowering.

The soil microorganisms count in the potato plantation in conventional cultivation system

Peat elixir application in conventional cultivation system showed a tendency of positive effect in several treatment variants compare to control (Table 3).The increase of bacteria counts was higher in August in all treatment variants, however the highest increase was observed in variant when tubers were treated before planting. Actinomycetes counts in the soil were higher in July after plant treatment with peat elixir, but in August it was higher in the 2nd variant of the tuber treatment.

Soil microscopic fungi counts after treatment with peat elixir were highest in the 4th variant when both tubers and plants were treated. Treatment with vermicompost extract increased the soil bacteria counts in variant when tubers were treated before planting and when plants were treated three times in season. Actionomycetes counts were increased in almost all variants compare to control. Microscopic fungi counts increased both in July and August compare to control. A tendency towards increase was observed in variants with tuber treatment before planting as well as treating plants three times in season. The increase of the soil microorganism counts was more pronounced at the end of summer. In the potato fields in conventional cultivation system, the count of soil microorganisms was higher than in organic fields. Literature findings support information that these differences

are associated with the speed of nitrification processes and increased CO_2 (Ходжаева и др. 2010). The counts of soil microorganisms are affected both by the soil agrochemical properties, soil moisture and soil temperature. Considering, that aerobic and anaerobic microorganisms (genus *Pseudomonas*, genus *Artrobacter* and *Clostridium*),which were identified both in peat elixir and vermicompost extract, coming into contact with tubers, plants and soil, affected, possibly, the soil microorganisms counts. The results of studies on organic extracts confirm their positive effect on soil microflora (Zaller 2006).

CONCLUSIONS

Vermicompost extract used in the potato plantation in organic cultivation system has affected the soil microscopic fungi counts most of all, besides, the observed effect was higher in August in variants when tubers were treated before planting, and when tubers were treated before planting and plants were treated three times in growing season. With peat elixir, the count of soil microoranisms was higher than with vermicompost extract applied.

Also in conventional cultivation system in the potato plantation in all treatments the increase of the soil microorganisms counts was higher in August. The potato tuber treatment both with peat elixir and vermicompost extract resulted in highest bacteria and microscopic fungi counts, but plant treatment with vermicompost extract resulted in highest actinomycetes counts in the soil (2.80).

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Received: 09.04.2015.
Accepted: 08.06.2015.