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INFLUENCE OF COMPOSTING ON THE MICROBIOLOGICAL ACTIVITY OF THE SOIL

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Abstract

The aim of the experiment was to study the influence of composting on the microbiological activity of the soil. The experiment was carried out in 2017 in the experimental field on University of Forestry of Sofia. Three types of compost (prepared in 2016) were used: two spring composts with plant residues (grape vine canes, fruit twigs and grass windrow) and in the second one was added and rabbit manure. And autumn compost only with plant residues from vegetable field (frostbitten tomato and pepper stems and fresh leek residues). The composts were applied to the soil at a rate of 5 t/ha by incorporating and mulching in the cultivation of tomatoes. Agrochemical and microbiological soil analyses were carried out. The main groups of heterotrophic microflorae - ammonifying bacteria (non-spore and bacilli), actinomycetes and micromycetes are defined. Data showed that spring composts increased the amount and activity of microorganisms. Autumn compost did not increase the amount but their activity was higher.

Key words: *actinomycetes, ammonifying bacteria, C/N ratio, compost, micromycetes.*

INTRODUCTION

Application of organic fertilizer improves soil fertility irrespective of the method of use - the use of compost in agriculture can be both for plowing and for covering the soil (mulching) with a layer of organic material. The addition of compost increases the amount of organic matter and improves soil porosity, structural stability, moisture and nutrient availability as well as biological activity of the soil (Francis et al., 2010, Wang et al., 2011).

Lee et al., (2004) found that the populations of fungi and bacteria, soil biomass and soil enzyme activities in the rhizosphere greatly increased using a compost of food waste in comparison to control samples, commercial compost and mineral fertilizer of the 2nd, 4th and 6th week of study. Some studies have reported that soils in organic farming have a wider variety of microbial functionalities than conventional farming systems (Mäder et al., 2002). According to other researchers, bacterial diversity has always been higher in arable soils, regardless of fertilization patterns or land use seasons (Ge et al., 2008).

According to Dong's research, et al., (2017) mulch has a positive impact on the physicochemical properties of the soil, namely: higher soil temperature, higher moisture content and more nutrients. Studies of these and other authors confirm that mulching reduces the loss of evaporation water (Kasirajan and Ngouajio, 2012), increases soil temperature (Wang et al., 2015) and improves soil nutrient composition (Wang et al., 2016).

Mulching also leads to a significant increase in the species diversity of bacteria and fungi, which plays an important role in the composition of microbial communities. Soil fungi and bacteria show different dynamics in microbiocenosis by mulching (Baldrian et al., 2012; Prewitt et al., 2014).

The impact of mulching reflects both on individual groups of microorganisms that change their ability to adapt to different environmental conditions as well as their composition and activity (Muñozet al., 2015). Li et al. (2004) found that multiplication of mulch increases the microbial activity of the soil in spring wheat field, but the extent of this effect depends on the duration of maintenance of the mulching during the growing period. In a study conducted in a system for the cultivation of corn, application of the mulch shows that increasing the amount of the microbial biomass and activity of enzymes involved in the cycle of C, N and P, relative to samples without mulching (Wang, 2014).

Mulching is widely used to increase crop yields, but little is known about the effect of different mulching systems on microbial soil properties, which play an important role in agroecosystem functioning and nutrient circulation. The results of Shen et al., (2016) show that mulching with inorganic and organic nitrogen fertilizer results in increased carbon and nitrogen content, microbial biomass, dehydrogenase activity, microbial activity and the Shannon diversity index.

Although in many studies the effects of organic fertilization on microbial communities have been analyzed (Dinesh et al., 2010, Qiu et al., 2012, Zhen et al., 2014), for a fuller study of the dynamic models of bacteria, fungi and actinomycetes in different types of fertilization, it is necessary to conduct ongoing studies in this field. In addition, the microbial biomass in the soil, activity and the structure of soil microbial communities are reliable indicators of soil quality and health as they are sensitive to changes in arable land management practices (Bending et al., 2002). Adaptation of soil microflora to the environment is considered to be an essential indicator of sustainable agricultural production (Wardle et al., 1999).

The aim of the present study is to investigate the effect of the application of different composts by different methods - plowing and mulching, on quantitative and qualitative composition of microorganisms.

MATERIALS AND METHODS

In 2017 was carried out an experiment with different application of compost from agricultural wastes, during cultivation of tomatoes.

Three different composts (prepared in 2016) were tested: V1, spring compost prepared by composting of plant residues (grape vine canes, fruit twigs and grass windrow), with a C/N ratio of matured compost 12:1; V2 spring compost prepared by composting of plant residues wit manure (grape vine canes, fruit twigs, grass windrow and rabbit manure), with a C/N ratio of the matured compost of 13:1; V3, autumn compost only with plant residues from vegetable field (frostbitten tomato and pepper stems and fresh leek residues)q with C/N ratio of matured compost 4.5:1.

The three composts selected for the experiment were applied by two methods - once using the compost as an organic fertilizer - i.e. by ploughing, and the second is the use of compost as mulch - i.e. by covering the soil surface.

Seven variants had been developed: variant 1 (V1.Inc) - the first compost applied by incorporation into the soil; variant 2 (V1.M) - the first compost applied by mulching; variant 3 (V2.Inc) - the second compost applied by incorporation into the soil; variant 4 (V2.M) - second compost applied by mulching; Variant 5 (V3.Inc) - the third compost applied by incorporation into the soil; variant 6 (V3.M) - third compost applied by mulching and variant 7 (V0) - control, no composts were used.

The composts were applied with an average rate of use of plant compost of 5t / ha. Mulching is done with the same amount of compost to make comparisons between the two methods of applying. The thickness of the mulching layer was about 3 cm.

Soil samples were taken for agrochemical and microbiological analysis at the beginning of experimentation and at the end of vegetation, at a depth of 0-20 cm. Agrochemical analysis included: pH level of soil (H_2O), humus content (%), total nitrogen (N) content (%) phosphorus (P) and potassium (K) content (mg/100 g).

Microbiological analysis included the determination of non-sprouting bacteria, bacilli, micromycetes and bacteria digesting mineral nitrogen by method of selective plating and direct viable counts. They were used two solid nutrient media (meat-peptone agar for determination of non-sprouting bacteria and bacilli, and medium of Chapek-Dox for determination of micromycetes and bacteria digesting mineral nitrogen), and counting of colony forming units (CFU), recalculated to 1 g of absolute dry substrate/soil.

The statistical analysis of microbiological data includes the calculation of an average of three iterations and a coefficient of variation.

RESULTS AND DISCUSSIONS

Regardless of the method of application of the compost (by incorporation or mulching), it increased the humus content of the soil. By comparing the influence of different types of compost on the humus content of the soil, the strongest influences were when using the second compost which was prepared with rabbit manure (Table 1).

Table 1 Agrochemical analysis of soil in field experiment with tomatoes, by variants

Variants	pH (H_2O)	Hummus (%)	Macro elements content		
			N (%)	P (mg/ 100g)	K (mg/ 100g)
V0 start	7.2	1,04	0,198	111.98	9.5
V0 end	7.4	2.15	0.234	84.32	9.3
V1.Inc	7.5	2.71	0.261	84.40	10.3
V1.M	7.6	2.90	0.261	89.42	15.6
V2. Inc	7.4	3.17	0.281	102.20	17.0
V2.M	7.5	2.61	0.269	104.86	13.7
V3. Inc	7.6	2.32	0.253	81.84	9.4
V3.M	7.6	2.42	0.226	86.95	12.7

Of the three macro elements - N, P, and K, the most pronounced was the influence of the composts on the K content in the soils, compared to the control. By comparing the influence of different types of compost on the K content of the soil, again the strongest influence was when using the second compost. This compost also affected soil phosphorus content, unlike other composts and controls (Table 1).

Soils in which was used the same compost (V2), irrespective of the method of application, showed increased phosphorus content even at the end of the experiment, while in the soils in which was used the other two composts, the phosphorus content at the end of the experiment, was approximately the same as in the control. These differences, although minimal, showed that composts prepared from seemingly identical materials, with little difference (manure supplement) can affect the soil in a different way.

The third compost V3, although was prepared mainly from vegetable wastes, had a lesser impact on soil macro elements content, as most of the plant wastes were frostbitten before composting and matured compost had a low C/N ratio – 4.5:1. This showed that not only the types of materials but also their quality affected the final product – mature compost.

The method of applying compost (incorporation or mulching) showed uniformity only on the nitrogen content of the soil. For all three composts, the total nitrogen content was higher when the composts were incorporated than they were used for mulching (Table 1).

The results of the amount of total microflora gave an idea of the degree of development, respectively germination of soil with microbes after incorporating or mulching with compost variants. This indicator is important for assessing the degree of destruction of compostable substrates and other organic matter contained in the soils tested, as long as the microorganisms carry out the mineralization of the organic compounds. Data on soil biogenicity are presented in Fig. 1.

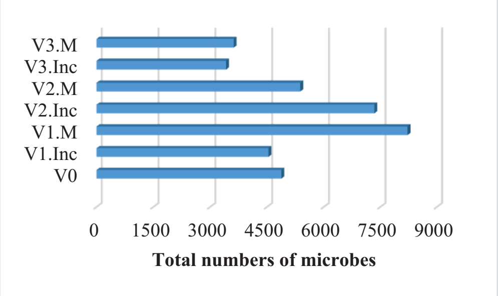

Figure 1. Total microflora (x 10^4 CFU/g abs. dry soil)

There is no clear tendency for increased biogenicity due to the use of the compost variants by incorporating or mulching. Mulching with spring compost prepared only from plants waste (V1) resulted in an almost double increase in the amount of total microflora, whereas during mulching with autumn vegetable waste compost (V3) this increase was 1 time. The second compost with rabbit manure (V2), the incorporating showed a better result - the biogenicity at was 1.4 times higher than the mulch with this variant.

It increased by 1.5 times when incorporating compost with rabbit manure (V2) and 1.7 times when mulching with compost from plant waste (V1) relative to the control. Biogenicity was lowest in autumn compost with low C/N ratio of matured compost (V3 – 4.5:1). It was lower by 1.4 times when incorporate and 1.3 times when mulching compared to the control.

Data showed that the application of all compost variants increased the activity of microorganisms – the rate of degradation of organic materials was higher in all variants compared to the control most clearly expressed in V3 (Table 2)

Table 2. Quantity and qualitative composition of microorganisms in soils with compost (number x 10^4 CFU/g;) ± C.V.*, and percentage of total microflora in brackets

Variants	Non-sprouting bacteria	Bacilli	Micromycetes	Bacteria, digesting min. nitrogen	Coefficient of mineralization
V0	3840 ± 0.260* (78.7%)	640± 0.625* (13.1%)	400± 0.500* (8.2%)	4800± 0.208*	1.07/1.25
V1.Inc	3200± 0.250* (70.5%)	1280± 0.469* (28.2%)	60± 0.667* (1.3%)	5280± 0.189*	1.18
V1.M	6400± 0.109* (77.9%)	1420± 0.282* (17.3%)	400± 0.750* (4.9%)	9440± 0.106*	1,21
\\V2. Inc	5760± 0.159* (78.5%)	1420± 0.244* (19.3%)	160± 0.625* (2.2%)	8320± 0.144*	1.16
V2. M	4000± 0.250* (74.3%)	1020± 0.294* (19.0%)	360± 0.735* (6.7%)	8000± 0.164*	1.59
V3. Inc	2440± 0.246* (71.3%)	860± 0.233* (25.1%)	120± 0.667* (3.5%)	8960± 0.112*	2.72
V3. M	2000± 0.265* (55.2%)	1540± 0.130* (42.5%)	80± 0.500* (2.2%)	9280± 0.216*	2.62

Note: The mineralization coefficient is calculated using the formula: Bacteria, digesting min. nitrogen / (Non-sprouting bacteria + Bacilli)

The highest percentage in the composition of total microflora was occupied by ammonifying bacteria (non-sprouting bacteria - 55.2-78.7% and bacilli - 13.1-42.5%). These groups of microbes, such as highly plastic, are the most active disruptors of organic compounds. Their quantity was higher in soils with applied spring composts: 1.7 times at V1 after mulching, 1.5 times and 1.1 times when applying V2, respectively, by incorporating and mulching.

The amount of ammonia actors at V1, when was incorporated, remained the same as in control variant, and V3 showed less development of non-sprouting bacteria but increased presence of the bacilli. This can be due to the quality of the material - the vegetable waste from tomatoes and pepper, had been frostbitten and the matured compost had a very low C/N ratio of 4.5:1.

Under-represented in the composition of total microflora are micromycetes. Their quantity is lower in all variants (1.3 - 6.7%) compared to the control sample (8.2%), except for the use of V1 after mulching, where the development of molds is as in the control variant. This group of microorganisms is predominantly developed at higher humidity - higher was the amount of fungi after mulching at V1 and V2, 6.7 times (V1) and 2.3 times (V2) respectively compared to using the same variants by incorporating.

The amount of bacteria digesting mineral nitrogen was increased by using all compost variants versus the control - 1.1 times in the soil with compost V1 (incorporated), 2 times with the sample with compost V1 (mulch), 1.7 times with compost V2 (incorporated) and 2 times in the soils with compost V2 (mulch), 1.9 times with compost V3 (incorporated and mulched).

Regardless of the lower amount of total microflora in samples with autumn compost (V3), the rate of degradation of the materials is highest (the mineralization coefficient is about 2 times higher than the control and the other variants) because of the higher quantity of bacteria absorbing mineral nitrogen and the lower amount of ammonifiers. This is due again to the quality of the compost and more precisely to the low C/N ratio of 4.5:1.

The activity of microorganisms by mulching with V2 compost was 1.4 times higher than by incorporating. Mulching increases the amount and/or activity of microorganisms to a greater degree. Moreover, not always the lower amount of microorganisms is a prerequisite for lower mineralization activity – influenced by humidity, temperature, pH of the soil, the type of compost and other factors.

CONCLUSIONS

The application of the analyzed composts increases the biogenicity of the soil for two of the compost variants - V1 and V2, which had an optimal C/N ratio (12.1-13.1) - the amount of microorganisms in them, was higher than in the control. A similar trend was not found in the use of variant V3 (autumn) with a C/N ratio of 4.5:1. Autumn compost, however, activated the decomposition of organic matter to a greater extent.

For all variants, ammonifiers (non-sprouting bacteria and bacilli) occupy the highest percentage of the total microflora composition. Under-represented in the composition of total microflora are micromycetes. The amount of bacteria, digesting mineral nitrogen, increased due to the use of all compost variants relative to the control, which affected the rate of mineralization of organic matter - about twice as high in autumn compost as compared to spring.

In general, mulching increases to a greater extent both the amount and the activity of the microorganisms.

When manure was included as one of the composting materials, it increased the nutritional value of the final product - compost. This compost influenced more clearly the content of food macro elements in the soil when it is applied. Composts obtained from seemingly the same materials, with little difference (manure supplement), can affect soil differently. Composts that have a low C/N ratio at the end of the process, have a lesser influence on the nutrients in the soil.

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