THE EFFECT OF FARMING SYSTEM ON SOIL MICROBIAL HYDROLYTICAL ACTIVITY

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Abstract. *The aim of this study was to investigate the influence of conventional and organic farming on soil hydrolytic activity (FDA). The experiment consisted of five-field crop rotation with three organic systems: Org 0 without winter cover crops (as control), Org I with winter cover crops and Org II with winter cover crops plus composted manure; and two conventional farming systems: Conv I as control (no fertiliser use) and Conv II (with mineral N). The results show increase of FDA in all systems in 2013. Within the average of 2012-2014 the FDA is the lowest in Conv. I and the highest in Org II system.*

Key words: *microbial activity, organic and conventional farming, soil quality, organic manure.*

INTRODUCTION

Soil quality may be described as the ability of a soil to support biological activity, preserve environmental quality, and favour the health of all soil biota (Oldare et al 2008). The biological characteristics of the soil, such as microbial activity parameters, are much more sensitive to changes than physical or chemical parameters (Oldare et al 2008; Oldare et al 2011; Tejada et al 2008), therefore it is believed to be a reliable indicator of changes in soil quality (Oldare et al 2008).

Many studies have shown a negative impact of nitrogen-based fertilisers on soil biological parameters (Geisseler et al 2014, Liu & Greaver 2010). It has also been found that organic waste when added into the soil, can increase nutrient content, improve soil composition (Joshua et al., 1998) and increase microbial biomass, thus reducing the need for chemical weed control (Oldare et al 2008). Winter cover crops, as a type of organic waste, have nitrogen-binding features, which have effect on the succeeding crops (Sanches de Cima et al 2015).

Although weeds are not a desirable feature within a field, they nonetheless are the biggest contributors to plant diversity thus providing essential resources for other organisms in the field (Plaza et al 2015). The aim of the study was to investigate the influence of conventional and organic farming on the soil hydrolytic activity (FDA).

MATERIALS AND METHODS

The field experiment was situated at the experimental station of the Estonian University of Life Sciences in Eerika, Tartu, Estonia (58°22'N, 26°40'E). The soil type of the experiment area was sandy loam *Stagnic Luvisol* according to the World Reference Base classification (FAO 2014). In a five-field crop rotation, barley undersown with red clover, red clover, winter wheat, peas and potato were grown in succession. There were two conventional farming systems without winter cover crops: Conv I as control (no fertiliser use) and Conv II (winter wheat and potato 150 kg ha^{-1} N, barley undersown with red clover 120 kg ha^{-1} N and pea 20 kg ha^{-1} N) and three organic farming systems: Org 0 without winter cover crops (as control), Org I with winter cover crop and Org II with winter cover crops plus composted manure (40 t ha^{-1}). Conventional systems were treated with herbicides and fungicides.

For the fluorescein diacetate hydrolysis activity (FDA) analysis, 500 g samples were taken at 5–10 cm depth. More accurate description of the FDA measurement is presented in the article by Sánchez de Cima et al (2015).

Statistical method used was ANOVA (Tukey test) with statistical significance level of $P < 0.05$.

RESULTS AND DISCUSSION

The microbial activity in the soil can be indicated by hydrolytic activity and the soil microbial respiration, which is measured through CO_2 production (Tejada et al 2008).

There have been a tendency of increase in the hydrolytic activity in 2013, but in 2014-2015 yearly differences were not found ($p< 0.05$) (Table 1). Higher microbial activity was found in organically amended soils. The average results during 2012-2015 show, that the highest hydrolytic activity was in Org II system ($p<0.05$) (Fig 1), where green manures with combination of composted manure were used. Due to the addition of easily degradable organic manure, the soil microbial processes and thus the enzyme activity increased (Sanches de Cima et al 2015). Also, the organic cropping systems produced higher biomass and species number of weeds than conventional treatment. Added biomass of different weeds may also stimulate microbial activity in the soil. Tejada et al (2008) found that diverse sources of organic matter had a positive effect on the activity of microbial activity.

Table 1

FDA hydrolytic activity, µg fluorescein g $^{-1}$ soil h $^{-1}$ (oven dry) in spring of 2012, 2013, 2014 and 2015 in five cropping systems

Treatment	2012	2013	2014	2015
Org. 0	49.8Ba ± 0.5	55.4BCb ± 0.5	53.9Bb ± 0.8	54.2Bb ± 0.9
Org. I	51.6BCa ± 0.6	56.9Cb ± 0.5	55.3BCb ± 1.0	58.6CDb ± 1.3
Org. II	52.7Ca ± 0.5	59.8Db ± 0.5	58.4Cb ± 1.2	59.3Db ± 1.2
Conv. I	43.1Aa ± 0.7	48.8Ab ± 0.6	48.1Ab ± 1.2	46.7Aab ± 1.2
Conv. II	49.5Ba ± 0.6	54.5Bb ± 0.5	52.6Bb ± 1.	54.9BCb ± 0.8

Note. [1] – Means followed by different capital letters within each column indicate significant influence ($P < 0.05$) of farming systems TUKEY HSD; [2] – Means followed by different small letters within each row indicate significant influence ($P < 0.05$) of year TUKEY HSD; [3] – Data represents mean ±95% standard error.

Org 0 – without cover crops (CC), Org I – with CC; Org II – with CC and composted cattle manure, Conv I – no fertiliser use; Conv II – with mineral N.

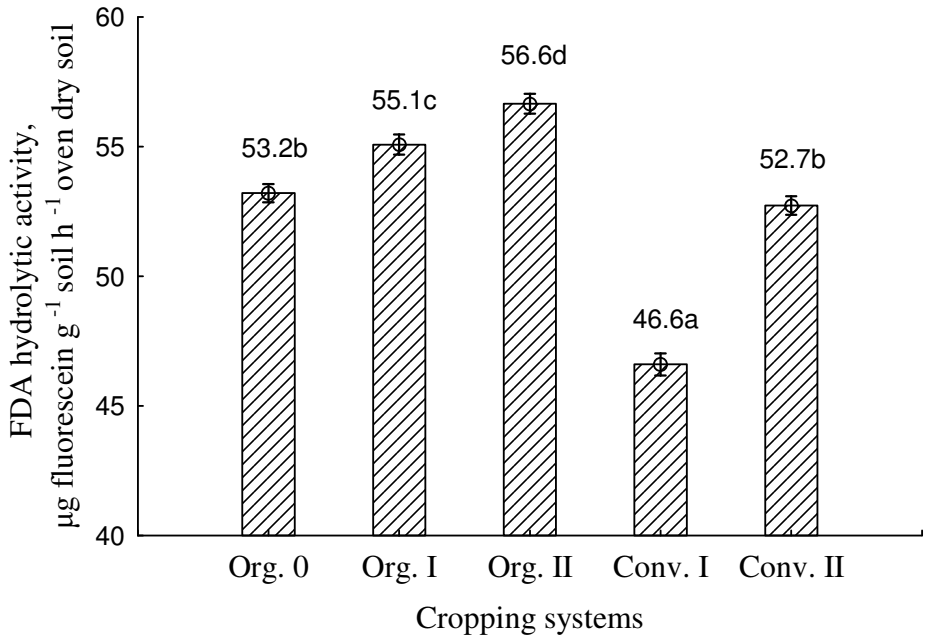

Figure 1. FDA hydrolytic activity (2012–2015 average), µg fluorescein g $^{-1}$ soil h $^{-1}$ (oven dry soil) in spring TUKEY HSD, ($P < 0.05$). – Data represents mean ± standard error, ($P < 0.05$). Org 0 – without cover crops (CC), Org I – with CC; Org II – with CC and composted cattle manure, Conv I – no fertiliser use; Conv II – with mineral N.

The hydrolytic activity on average during 2012-2015 was the lowest in Conv I system (Fig. 1). Although there was a significant increase in 2013 (Table 1), the FDA increase in 2014-2015 was not significant. In Conv II system herbicides were also used, but the FDA showed an increasing tendency through the years.

This can be explained by the fact, that most of the microbial populations in the soil use organic carbon, carbohydrates and starch for their energy source. Thus, adding organic matter raises the soil ability to support a larger biomass, thereby affecting the respiration parameters (Oldare et al 2008, Oldare et al 2011, Tejada et al 2008). Also, larger biomass means that more nutrients are released into the soil. In system Conv I there was no organic matter added and herbicide was used to control weediness. Bajwa (2014) have pointed out, that most herbicides have considerable stability in the soil that causes a remarkable reduction of microorganisms in rhizosphere. According to the research made by Sanches de Cima et al (2015) the pH was lower in system Conv I compared to other systems. Due to all of the above mentioned factors the FDA in system Conv I is lower than Conv II system.

CONCLUSIONS

Adding organic manure to field contribute largely in improving soil quality by increasing the microbial activity. The results show a tendency of increase of the hydrolytic activity in all systems. The FDA was higher in all organic systems due to higher amount of incorporated biomass from organic winter crops, cattle manure and weed biomass. The highest FDA was measured in system Org II due to added organic matter. The lowest FDA occured in Conv I system because of very low input of the organic matter, usage of pesticides and low soil pH.

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REFERENCES

Bajwa, A.A. 2014. Sustainable weed management in conservation agriculture. Crop Protection, 65: 105-113.

FAO, 2014. World reference base for soil resources 2014. International soil classification system for naming soils and creating legends for soil maps World Soil Resources Report 106. Food and agriculture organization of the United Nations. Rome, pp. 181.

Geisseler, D. and Scow, K.M. 2014. Long-term effects of mineral fertilizers on soil microorganisms – A review. Soil Biology and Biochemistry, 75: 54–63.

Hernández Plaza, E., Navarrete, L. and González-Andújar, J.L. 2015. Intensity of soil disturbance shapes response trait diversity of weed communities: The long-term effects of different tillage systems. Agriculture, Ecosystems and Environment, 207: 101–108.

Liu, L. and Greaver, T.L. 2010. A global perspective on belowground carbon dynamics under nitrogen enrichment. Ecology Letters, 13: 819–828.

Odlare, M., Arthurson, V., Pell, M., Svensson, K., Nehrenheim, E. and Abubaker, J. 2011. Land application of organic waste – Effects on the soil ecosystem. Applied Energy, 88: 2210–2218.

Odlare, M., Pell, M. and Svensson, K. 2008. Changes in soil chemical and microbiological properties during 4 years of application of various organic residues. Waste Management, 28: 1246–1253.

Sánchez de Cima, D., Tein, B., Eremeev, V., Luik, A., Kauer, K., Reintam, E. and Kahu, G. 2015: Winter cover crop effects on soil structural stability and microbiological activity in organic farming, Biological Agriculture & Horticulture, DOI: 10.1080/01448765.2015.1130646

Sánchez de Cima, D., Reintam, E., Tein, B., Eremeev, V. and Luik, A. 2015. Soil Nutrient Evolution during the First Rotation in Organic and Conventional Farming Systems. Communication in Soil Sciences and Plant Analysis, 46 (21): 2675-2687.

Tejada, M., Gonzalez, J.L., Garcia-Martinez, A.M. and Parrado, J. 2008. Effects of different green manures on soil biological properties and maize yield. Bioresource Technology, 99: 1758–1767.