Winter cover crops improve soil properties in organic cropping systems

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**Implications**

An introduction of winter cover crops (wcc) into the crop rotation had a positive impact on soil quality in organic cropping systems. Wcc alone and in combination with composted manure enriched soil with organic matter, activated soil life (increased number of earthworms and soil microbial activity - FDA), increased soil pH value, and supported nutrient cycling and soil formation.

**Background and objectives**

To achieve a more sustainable production it is important to establish growing systems with appropriate crop rotations to ensure fertile and biologically active soils that are providing good crop yields in the long-run. One way to improve soil is to grow winter cover crops as green manure in crop rotations. The interest among farmers for using wcc in the crop rotation is high, especially in organic farming. Therefore, the long-term effects of wcc management need to be evaluated. The aim of the present research was to investigate the impact of winter cover crops on different soil properties in organic cropping systems in comparison with supply of mineral fertilizers in a conventional system.

**Results and discussion**

Winter cover crops (Org I) and wcc in combination with composted cattle manure (Org II) had significantly positive impact on soil properties. Soil organic carbon (Corg) content increased due to use of cover crops and composted manure. In the organic systems Corg content was on average 11 percent higher (p< 0.05) than in conventional system, where mineral fertilizers instead of cover crops were used (Conv II). Earthworms play an important role in the humification of organic matter in arable soils (Scullion et al. 2007). Higher content of Corg is achieved by higher input of organic matter from wcc and manure and by greater number of earthworms. On average, the highest number and biomass of earthworms were in the Org II. This could be explained by the higher amount of added organic matter in the system (food supply for earthworms). The number of earthworms was lower in both conventional systems, however, the non-fertilized (Conv I) and fertilized system (Conv II) did not differ. Pesticides could also contribute to long term negative influence on soil life (Pelosi et al. 2014).

Soil organic matter is the energy source for microbial processes. Microbial activity was higher in organic systems than in conventional ones (Table 1). The lowest microbial activity occurred in Conv I and Conv II, evidently because of low input of organic matter, usage of pesticides and soil low pH.

Different fertilization practices resulted in significant differences in pH among the systems. In the organic systems soil pH value increased during the experimental period with use of winter cover crops as green manures (p<0.05). This can be explained by a positive effect of added organic matter (wcc and composted manure) on the soil buffer capacity (Sánchez de Cima et al., 2015). In conventional systems repeated application of mineral fertilizers decreased the soil pH. Plant available P, K, Ca, Mg, contents decreased with time in the ploughing layer of the conventional systems, even in Conv II with addition of mineral fertilizers (Table 1). The changes in soil chemical and biological properties were correlated by changes in soil physical parameters. The highest bulk density, lower percentage of water permeability and lower air filled pores fraction was found in Conv I compared with the other systems (Sánchez de Cima et al., 2015).

Table 1. Average soil properties of different cropping systems in 2012–2015

|  |  |
| --- | --- |
|  | Cropping systems |
|  | Org 0 | Org I | Org II | Conv I | Conc II |
| pH | 5.92c | 6.02cd | 6.05d | 5.77a | 5.65b |
| FDA\*(μg fluorescein g-1 soil h-1 oven dry soil) | 53.1b | 54.7c | 56.4d | 46.6a | 52.5b |
| P (mg kg-1) | 113.5b | 112.5b | 113.5b | 80.4a | 85.7a |
| K (mg kg-1) | 123.6c | 125.4c | 133.9c | 88.3a | 104.4b |
| Mg (mg kg-1) | 179.9b | 190.2b | 211.6c | 75.1a | 83.2a |

Means followed by a different letters indicate significant influence (P < 0.05) of cropping systems (Tukey test). \* Average of 2012–2014.

It is possible to conclude that winter cover crops in crop rotation, especially in combination with manure, have significantly positive impact on soil biological, chemical and physical properties in organic systems in comparison with mineral fertilizing in conventional systems.

**How work was carried out?**

The effects of different crop managements on soil properties were studied in Estonian University of Life Sciences in 2012–2015. The soil type of the experiment area is sandy loam Stagnic Luvisol according to the World Reference Base classification (FAO 2014). In a crop rotation experiment, barley undersown with red clover, red clover, winter wheat, pea 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 (with mineral fertilizer - winter wheat and potato 150, barley undersown with red clover 120 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 (on average, the dry matter of composted cattle manure contained 138 g C kg−1, 9.7 g N kg−1, 4.6 g P kg−1, 8.6 g K kg−1, average dry matter content 44.8%). In Org I and Org II the wcc were used as follows: mixture of winter oilseed-rape and winter rye before pea; winter oilseed rape before potato and winter rye before barley. Since 2014 winter oilseed rape was replaced with winter turnip rape. Conventional systems were treated with pesticides (herbicides, fungicides, insecticides).

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