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THE INFLUENCE OF CATCH CROPS AND MANURE ON SOIL BIOACTIVITY IN SUSTAINABLE AND ORGANIC FARMING

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Abstract

Field experiments were conducted in 2000 and 2001 under the conditions of sustainable farming at the Experimental Station of the Lithuanian University of Agriculture and under the conditions of organic farming in the territory of Kazliskiai organic farm. The objective was to study the influence of different catch crops (*Trifolium pratense* L.*, Lolium multiflorum* Lam., *Sinapis alba* L., *Brassica napus* L.) for green manure and of cattle manure on soil hydrolases (urease and saccharase) activity. The results show that manure 40 Mg ha^{-1} significantly stimulated the activity of soil urease in the arable layer of 0-25 cm. The influence of catch crops for green manure was lower than that of manure (in sustainable farming: 6.9-60.6 %, in organic farming: 6.7-41.4 %). In sustainable agriulture the activity of urease was stronger in uncultivated soil that had been sprayed with roundup in spring, while in organic farming – in shallowly ploughed in spring soil than in deeply ploughed in autumn soil. Neither catch crops for green manure nor manure had influence on the activity of saccharase. Humus determined the activity of soil urease ($r = 0.59$ and $r = 0.69$, $P < 0.01$) and saccharase ($r = 0.58$ and $r = 0.65$, $P < 0.01$) in sustainable and organic farming.

Key words: catch crops, manure, hydrolases, sustainable farming, organic farming.

Introduction

The base of alternative farming is soil fertility, which is closely associated with biological processes of the soil, their nature and intensity. The intensity of those processes is indicated by biomass of micro organisms, prevalence and the variety of physiologic groups of micro organisms, CO_2 emission, formation of amino acids, soil enzyme activity and etc. /Šiuliauskienė, 1995; Arlauskienė, 1997; TrasarCepeda et al., 1998/. Soil enzyme activity is one of the main indicators of biological activity and soil fertility. Enzyme activity is closely related to other important indicators of biological activity: respiration intensity, nitrification ability, total amount of micro organisms and even more associated with soil humus content, amounts of mobile P_2O_5 and K_2O, soil acidity and crop yield /Gostowska et al., 1993; Schimner, Sonnleitner, 1996; Svirskienė et al., 1997; Bandick, Dick, 1999; Svirskienė, 1999/.

According to Lacko-Bartašova et al. (1999), Grigaliūnienė (2005) the effect of organic and especially organic-mineral fertilizers on soil enzyme activity is usually higher than the effect of mineral fertilizers.

The scientists of many countries investigated positive effect of incorporation of catch crops for green manure on soil enzyme activity /Martens et al., 1992; Abdallahi, N'Dayegamiye, 2000; Kara, Penezoglu, 2000/.

Nawrath (1998) found higher effect of green manure with straw incorporation. Soil enzymal activity also depends on the method of green manure incorporation.

According to the data of Kahnt and Eusterschulte (1998), soil biological activity was most improved by shallow green manure incorporation, compared to other treatments.

The objective of this investigation was to determine the influence of catch crops (red clover, Italian ryegrass, white mustard, winter rape) for green manure and of animal manure (40 Mg ha^{-1}) on soil hydrolases (urease and saccharase) activity in sustainable and organic farming.

Materials and methods

The investigations were carried out over the period of 2000 - 2001 under the conditions of sustainable farming (trial I) in the Experimental Station of the Lithuanian University of Agriculture and under the conditions of organic farming (trial II) on Kazliskiai organic farm, Kaunas distr. In the trial I the soil was carbonate deeper gleyic eluviated medium loam on light sandy loam (*Calc(ar)i-Endohypogleyic Luvisol*). In the trial II the soil was deeper gleyic saturated planosoil medium loam on light sandy loam (*Endohypogleyic-Eutric Planosol*).

Treatments of the experiments are presented in Table. Catch crop species for green manure were sown into wheat or after their harvesting (factor B). Red clover (*Trifolium pretense* L.) 'Liepsna' (8 kg ha^{-1}) and Italian ryegrass (*Lolium multiflorum* Lam.) 'Rapid' (14 kg ha^{-1}) were undersown into wheat in early spring. White mustard (*Sinapis alba* L.) 'Karla' (35 kg ha^{-1}) and winter rape (*Brassica napus* L.) (in 1998 – 'Apex', in 1999 – 'Accord', in 2000 – 'Valesca' 20 kg ha^{-1}) after wheat harvesting were direct drilled into stubble. After wheat harvesting in the plots without catch crop the stubble was no-tilled until the main soil tillage. The plots planned for fertilization with animal manure after wheat harvesting were shallowly ploughed at the depth of 10-12 cm.

Catch crops for green manure and manure were incorporated by soil tillage in autumn, or in spring (factor A). In one part catch crops for green manure and manure were deeply ploughed (at the depth of 23-25 cm) in late autumn. In the other part they were left not incorporated during winter until the following spring. In organic farming catch crops for green manure were shallowly ploughed at the depth of 10-12 cm. In sustainable farming – only manure was shallowly ploughed in, while the no-tilled soil with catch crops and plant residue was sprayed with roundup (glyphosate) in spring (4 l ha^{-1}).

To evaluate the influence of catch crops and manure on soil bioactivity barley 'Ūla' (180 kg ha^{-1}) was grown every year. In sustainable farming barley was sown with no-till drill John Deere 750 A, in organic farming – with 'Saxonia' anchor ploughshares. In sustainable farming barley was fertilized with complex fertilizers ($N_{60}P_{60}K_{60}$) and sprayed with herbicides MCPA (l ha^{-1}).

Experiments in sustainable and organic farming were carried out in three replicates, split-plot design. The activity of soil urease was determined in dry samples according to Hofmann and Schmidt (1953), that of saccharase – according to Hofmann and Seegerer (1950) methods, modified by Ciunderova (1979). Analyses of variance

($P < 0.05$) based on 2-factorial split-plot design model, were performed using the SAS GLM procedure /SAS Institute Inc., 1999; Bogužas, Marcinkevičienė, 2005/. The Fisher LSD test was used to determine significant treatment effects.

Results and Discussion

The activity of soil hydrolases: urease and saccharase and the relations of their activity with soil humus content were evaluated under sustainable and organic agricultural systems. The obtained data showed that activity of hydrolases in 0-25 cm soil layer depended on different crops incorporated for green manure, fertilization with manure and on the time of their incorporation.

The activity of urease in continuously grown barley under sustainable farming was low (0.10-0.33 mg NH_3 1 g soil in 24 h) (Fig. 1). The highest activity of urease in spring of 2000 and 2001 was in fertilized with manure soil. Similar urease activity in 2000 was found only when white mustard for green manure was incorporated in autumn and in no tilled soil, where rape had been sprayed with roundup in spring. The effect of green manure of other catch crops on soil urease activity was lower than that of manure. The activity of urease increased with increasing amount of humus in the soil (Table). Similar results were also obtained by Svirskienė and Magyla (1997).

The incorporation of manure and catch crops for green manure had no significant influence on the activity of saccharase. According to the data of Loshakov et al. (1985) catch crops of *Brassicaceae* family had higher influence on the activity of urease than saccharase.

The time of catch crop green manure incorporation had no influence on the activity of saccharase and urease in 2000, except rape, also a tendency of increased urease activity was noticed in roundup sprayed no-tilled soil. The activity of urease in sprayed with roundup no-tilled soil with volunteer rape catch crop, compared to deep incorporation in autumn, was significantly (42.1 %) higher, while the activity of saccharase significantly (16.2 %) decreased. Significantly stronger activity of urease (from 23.1 to 65.0 %) in 2001 was found in the soil, which was in spring fertilized with manure and in no-tilled soil with volunteer catch crops or their residue, which was sprayed with roundup in spring. The influence of catch crop green manure and cattle manure on saccharase activity was diverse. Significantly higher activity of saccharase (from 42.8 to 43.9 %) was found in no-tilled soil after spraying with roundup in spring, compared to deeply in autumn incorporated clover and ryegrass. Shallowly incorporated manure, compared to deeply incorporated in autumn, also improved saccharase activity.

Significant positive correlations between urease activity and humus content ($y = -0.23+0.14x$, $r = 0.59$, $P < 0.01$) and between saccharase activity and humus content ($y = -3.34+7.75x$, $r = 0.58$, $P < 0.01$) were found. According to the data of Svirskienė (1999) the activity of urease and saccharase also positively correlated with soil humus content.

Under organic agricultural system the activity of hydrolases was very dynamic and incoherent therefore it was difficult to evaluate the influence of agrotechnical measures on their activity.

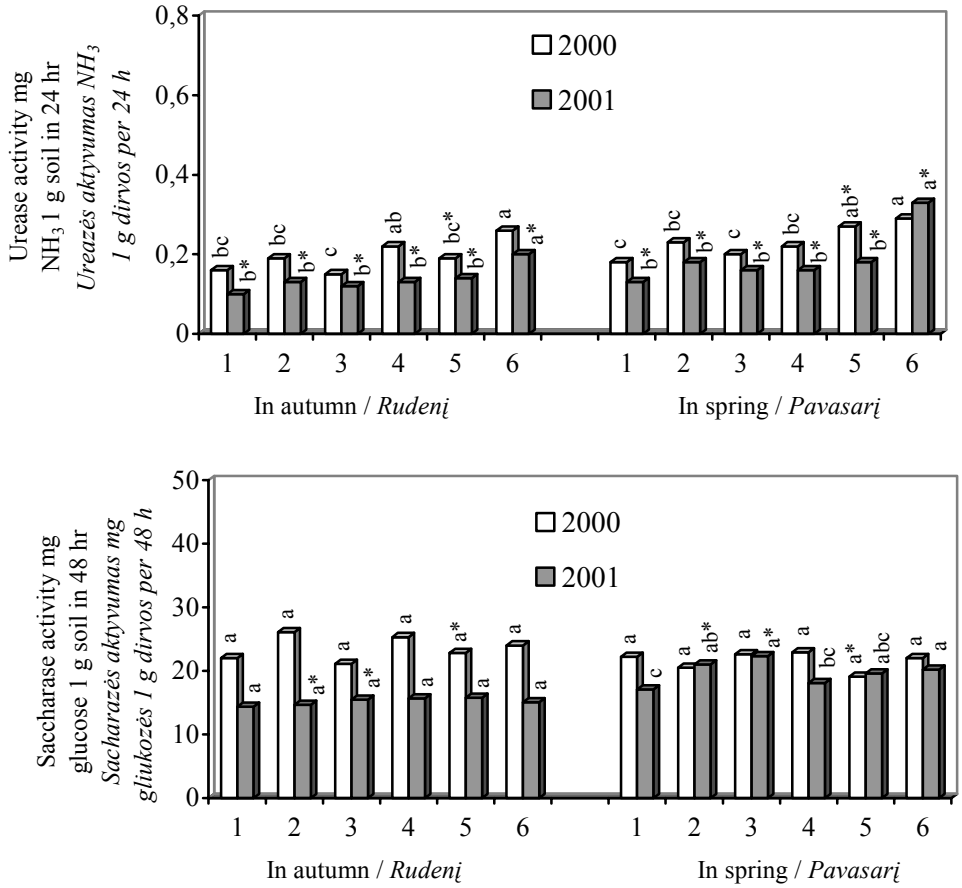

Figure 1. The influence of catch crops and manure on the activity of soil hydrolases in sustainable farming: 1 – without catch crop; 2 – red clover; 3 – Italian ryegrass; 4 – white mustard; 5 – winter rape; 6 – manure 40 Mg ha^{-1}. Asterisks (for factor A) and different letters (for factor B) indicate significant differences between treatments ($P < 0.05$)

1 paveikslas. *Tarpinių pasėlių ir tręšimo mėšlu įtaka dirvožemio hidrolazių aktyvumui, taikant tausojančiąją žemdirbystę: 1 – be tarpinio pasėlio; 2 – raudonieji dobilai; 3 – gausiažiedės svidrės; 4 – baltosios garstyčios; 5 – žieminiai rapsai; 6 – tręšta mėšlu 40 Mg ha^{-1}. Žvaigždutės (faktoriui A) ir skirtingos raidės (faktoriui B) rodo esminius skirtumus trap variantų ($P < 0,05$)*

The influence of catch crops and manure on humus content in sustainable and organic farming. Asterisks (for factor A) and different letters (for factor B) indicate significant differences between treatments ($P < 0.05$)

Tarpinių pasėlių ir tręšimo mėšlu įtaka humuso kiekiui taikant tausojančiąją ir ekologinę žemdirbystės sistemas. Žvaigždutės (faktoriui A) ir skirtingos raidės (faktoriui B) rodo esminius skirtumus tarp variantų ($P < 0,05$)

Catch crops for green manure and manure (Factor B) / *Tarpiniai pasėliai žaliajai trąšai ir tręšimas mėšlu (Faktorius B)*	Humus content % / *Humuso kiekis %*			
	Time of soil tillage (Factor A) / *Dirvos dirbimo laikas (Faktorius A)*			
	In autumn / *Rudenį*		In spring / *Pavasarį*	
	2000	2001	2000	2001
Sustainable farming / *Tausojančioji žemdirbystė*				
1. Without catch crop / *Be tarpinio pasėlio*	2.98b	2.55d*	3.26b	2.94ab*
2. Red clover / *Raudonieji dobilai*	2.97b	2.57d*	3.28b	3.00a*
3. Italian ryegrass / *Gausiažiedės svidrės*	2.98b*	2.74b*	3.59a*	3.00a*
4. White mustard / *Baltosios garstyčios*	3.21ab	2.69bc*	3.27b	2.87b*
5. Winter rape / *Žieminiai rapsai*	3.15ab	2.60cd*	3.17b	3.00a*
6. Manure 40 Mg ha^{-1} / *Tręšta mėšlu 40 Mg ha^{-1}*	3.35a	2.92a	3.18b	3.04a
Organic farming / *Ekologinė žemdirbystė*				
1. Without catch crop / *Be tarpinio pasėlio*	3.53ab	2.87a	3.59a	2.85abc
2. Red clover / *Raudonieji dobilai*	3.33bc	3.02a	3.53a	3.03ab
3. Italian ryegrass / *Gausiažiedės svidrės*	3.30c*	2.94a	3.57a*	3.01ab
4. White mustard / *Baltosios garstyčios*	3.36bc*	2.94a	3.66a*	3.08a
5. Winter rape / *Žieminiai rapsai*	3.26c*	2.78a	3.58a*	2.79bc
6. Manure 40 Mg ha^{-1} / *Tręšta mėšlu 40 Mg ha^{-1}*	3.59a	2.94a	3.65a	2.71c

The activity of urease in 2000 was stronger in the soil with higher humus content (Table, Fig. 2). The strongest activity of urease was found in deeply autumn ploughed soil without catch crop for green manure – 0.64 mg NH_3 1 g soil in 24 h. Similar urease activity was found after deep incorporation of clover and ryegrass catch crop for green manure and manure in autumn. Meanwhile deep autumn incorporation of mustard and rape green manure, compared to the soil without catch crops, reduced urease activity significantly, by 26.6 and 32.8%, respectively. There was no significant effect of green manure and manure on saccharase activity in 2000.

The activity of hydrolases in less humous soil was lower in 2001 than in 2002. Deep incorporation of manure in autumn and shallow incorporation in spring improved urease activity in 2001 significantly – from 16.0 to 70.6 % and from 18.2 to 34.5 %, respectively.

There was no significant effect of green manure of catch crops and manure on saccharase activity. Stronger effect of different catch crops and manure on saccharase activity was found when they had been shallowly incorporated in spring. Shallow spring incorporation of clover catch crop, compared to other treatments, increased the activity of saccharase significantly, from 23.1 to 86.8 %.

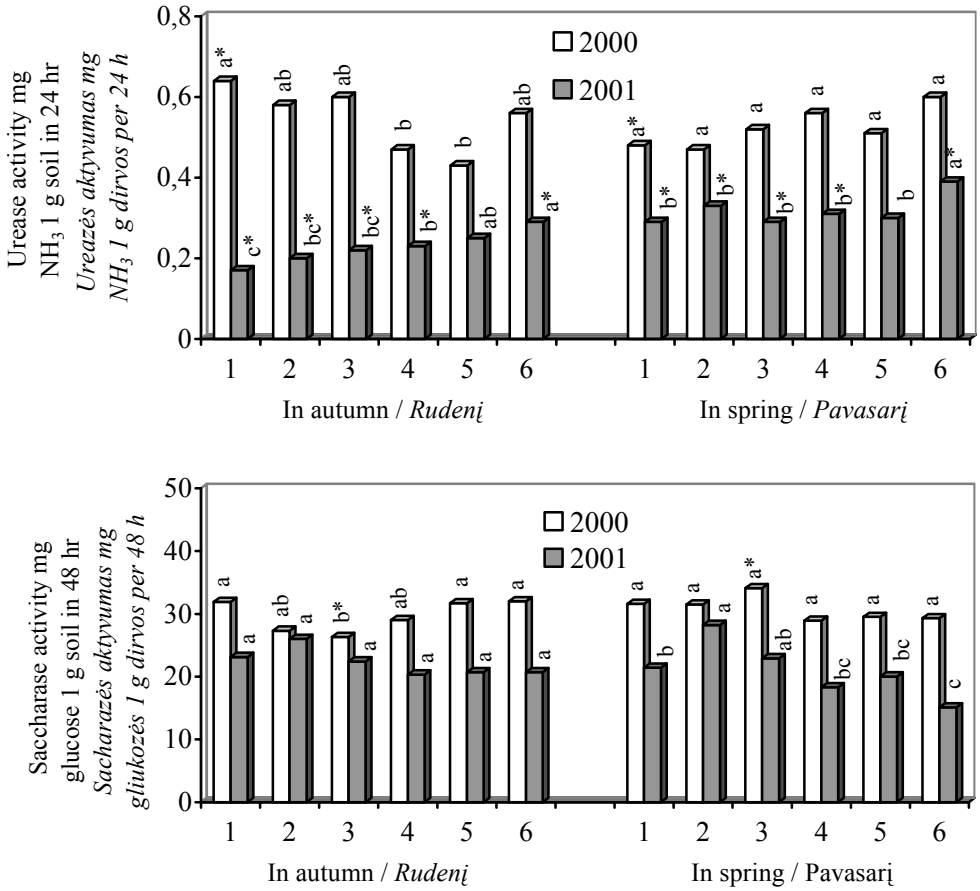

Figure 2. The influence of catch crops and manure on the activity of soil hydrolases in organic farming: 1 – without catch crop; 2 – red clover; 3 – Italian ryegrass; 4 – white mustard; 5 – winter rape; 6 – manure 40 Mg ha^{-1}. Asterisks (for factor A) and different letters (for factor B) indicate significant differences between treatments ($P < 0.05$)
2 paveikslas. *Tarpinių pasėlių ir tręšimo mėšlu įtaka dirvožemio hidrolazių aktyvumui taikant ekologinę žemdirbystę: 1 – be tarpinio pasėlio; 2 – raudonieji dobilai; 3 – gausiažiedės svidrės; 4 – baltosios garstyčios; 5 – žieminiai rapsai; 6 – tręšta mėšlu 40 Mg ha^{-1}. Žvaigždutės (faktoriui A) ir skirtingos raidės (faktoriui B) rodo esminius skirtumus tarp variantų (P < 0,05)*

There was no significant effect of shallow spring incorporation of catch crop green mass and manure on urease activity, compared to deep incorporation in autumn in 2000, while in 2001 it increased the activity significantly, from 20.0 to 65.0 %. This was a response to higher amount of catch crop green manure incorporated in 2001, than in 2000.

There was no significant effect of catch crop green mass and manure incorporation time in 2000 and 2001. Shallowly incorporated catch crop for the green manure, compared to deep incorporation in autumn, improved saccharase activity significantly, by 29.6 %. Significant positive correlations where identified between urease activity and humus content ($y = -0.87+0.39x$, $r = 0.69$, $P < 0.01$) and between saccharase activity and humus content ($y = -17.10+13.43x$, $r = 0.65$, $P < 0.01$).

Conclusions

1. Manure 40 Mg ha^{-1} significantly stimulated the activity of soil urease in the arable layer of 0-25 cm. The influence of catch crops for green manure was lower than that of manure (in sustainable farming: 6.9-60.6 %, in organic farming: 6.7-41.4 %).

2. In sustainable farming the activity of urease was stronger in uncultivated soil that had been sprayed with roundup in spring, while in organic farming – in shallowly ploughed in spring soil than in deeply ploughed in autumn soil. Neither catch crops for green manure nor manure had influence on the activity of saccharase.

3. Humus determined the activity of soil urease ($r = 0.59$ and $r = 0.69$, $P < 0.01$) and saccharase ($r = 0.58$ and $r = 0.65$, $P < 0.01$) in sustainable and organic farming.

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TARPINIŲ PASĖLIŲ IR MĖŠLO ĮTAKA DIRVOŽEMIO BIOLOGINIAM AKTYVUMUI TAIKANT TAUSOJANČIĄJĄ IR EKOLOGINĘ ŽEMDIRBYSTĖS SISTEMAS

A. Marcinkevičienė, V. Bogužas

Santrauka

2000-2001 m. tirta įvairių tarpinių pasėlių (*Trifolium pratense* L.*, Lolium multiflorum* Lam., *Sinapis alba* L., *Brassica napus* L.) žaliosios trąšos ir mėšlo bei jų įterpimo laiko įtaka dirvožemio hidrolazių (ureazės ir sacharazės) aktyvumui. Atskiri lauko bandymai pagal tą pačią schemą daryti tausojančiosios žemdirbystės sąlygomis LŽŪU Bandymų stotyje ir ekologinės žemdirbystės sąlygomis LŽŪU Kazliškių ekologiniame ūkyje. Tyrimų rezultatai rodo, kad tręšiant mėšlu iš esmės – 40 Mg ha^{-1} padidėjo ureazės aktyvumas 0-25 cm armens sluoksnyje. Tarpinių pasėlių žaliųjų trąšų poveikis buvo mažesnis, nei tręšiant mėšlu (taikant tausojančiąją žemdirbystę – 6,9-60,6 %, ekologinę – 6,7-41,4 %). Ureazės aktyvumas, taikant tausojančią žemdirbystę, palyginus su giliai rudenį arta dirva, didesnis buvo neįdirbtoje pavasarį raundapu purkštoje dirvoje su tarpiniais pasėliais, o taikant ekologinę – sekliai pavasarį artoje. Sacharazės aktyvumui neturėjo įtakos nei tarpinių pasėlių žalioji trąša, nei tręšimas mėšlu. Humuso kiekis, taikant tausojančiąją ir ekologinę žemdirbystės sistemas, lėmė dirvožemio ureazės (r = 0,59 ir r = 0,69, P < 0,01) bei sacharazės (r = 0,58 ir r = 0,65, P < 0,01) aktyvumą.

Reikšminiai žodžiai: tarpiniai pasėliai, mėšlas, hidrolazės, tausojančioji žemdirbystė, ekologinė žemdirbystė.

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