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THE INFLUENCE OF CROP ROTATION, CATCH CROP AND MANURE ON SOIL ENZYME ACTIVITIES IN ORGANIC FARMING

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Abstract

A field experiment was carried out in an organic certified field of the Experimental Station of the Lithuanian University of Agriculture during 2003–2008 on a *Calc(ar)i Epihypogleyic Luvisol* (*LVg-p-w-cc*). Factor A of the experiment – crop rotations with a different ratio of nitrogen fixing crops: I – 43% (grass-clover→grass-clover→winter wheat→spring barley→peas→winter wheat→spring barley), II – 43% (grass-clover→winter wheat→peas→ spring barley→grass-clover→winter wheat→spring barley), III – 29% (grass-clover→ potato→oat→spring barley→peas→winter wheat→spring barley), IV – 14% (grass-clover→ winter wheat→potato→spring barley→winter rape→winter wheat→spring barley). Factor B – catch crop: 1) without catch crop, 2) with catch crop. Factor C – farmyard manure: 1) without farmyard manure, 2) with farmyard manure. The objective of this investigation was to determine the influence of crop rotation, catch crop for green manure and farmyard manure on soil enzyme (urease and saccharase) activities in organic farming.

The highest activity of urease and saccharase in 2007 was in the soil in the crop rotation, where perennial grasses and peas had been grown. The activity of urease increased from 14.3 to 60.0% and that of saccharase from 14.8 to 28.3%, compared to the other crop rotations. In the crop rotation with 14% of nitrogen fixing crops, the catch crop increased the activity of urease by 100% and the activity of saccharase by 43.6% in the soil, compared to the treatments without catch crop.

Farmyard manure 30 Mg ha^{-1} significantly stimulated the activity of soil urease in 2008, while the activity of saccharase was not significantly influenced. Crop rotation and catch crop for green manure had no significant effect on soil hydrolase activity.

The activity of soil urease directly depended on total nitrogen (r = 0.50, P < 0.05), mineral nitrogen (r = 0.50, P < 0.05), organic carbon (r = 0.56, P < 0.05), and content of potassium (r = 0.59, P < 0.05).

Key words: enzyme activities, crop rotation, catch crop, manure, organic farming.

Introduction

Soil is an ecosystem with complex biochemical reactions going on continuously. Several enzymes in soil catalyse these biochemical reactions, which are responsible for nutrient cycling in soils /Krishnakumar et al., 2005/. Soil enzyme activity is one of the main indicators of soil biological activity and fertility /Mikhailovskaya, Tarasyuk, 2008/. I. Mijangos et al. (2006) maintain that soil biological activity has great value as early and

sensitive indicator of changes in soil properties induced by different management strategies in the short-term. 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 /Schimner, Sonnleitner, 1996; Svirskienė et al., 1997; TrasarCepeda et al., 1998; Bandick, Dick, 1999; Svirskienė, 1999/. A significant and positive relationship of enzyme activity with organic carbon and total nitrogen suggested that the addition of organic manure to soils increased carbon turnover, nitrogen availability and microbial activity which in turn led to greater enzyme synthesis and accumulation in the soil matrix /Dinesh et al., 1998/.

According to A. K. Bandick and R. P. Dick (1999) enzyme activities were generally higher in continuous grass fields than in cultivated fields. In cultivated systems, activity was higher where cover crops or organic residues were added as compared to treatments without organic amendments. D. Zakarauskaitė et al. (2005) found higher urease activity in the soil where cereals were grown and higher saccharase and dehydrogenase activity where perennial grasses were grown.

The scientists of many countries investigated positive effect of incorporation of catch crops for green manure on soil enzyme activity /Bandick, Dick, 1999; Abdallahi, N'Dayegamiye, 2000; Kara, Penezoglu, 2000/.

According to M. Lacko-Bartašova et al. (1999), K. Grigaliūnienė (2005) the effect of organic and especially organic-mineral fertilisers on soil enzyme activity is usually higher than that of mineral fertilisers. M. Nawrath (1998) found higher effect of green manure with straw incorporation. Combined use of organic manures improved the enzyme activity of the soil rather than single organic manure application /Krishnakumar et al., 2005/. Enzyme activities were greater in long-term manured soils compared to unmanured soils /Goyal et al., 1993/.

The objective of this investigation was to determine the influence of crop rotation, catch crop for green manure and farmyard manure on soil enzyme (urease and saccharase) activities in organic farming.

Materials and methods

Field experiment was carried out in organic certified field of the Experimental Station of the Lithuanian University of Agriculture during 2003–2008 on a *Calc(ar)i Epihypogleyic Luvisol* (*LVg-p-w-cc*). The experiment involved the following factors: A – crop rotations with a different ratio of nitrogen fixing crops, B – catch crop (without and with catch crop), C – farmyard manure (without and with farmyard manure). Four 7-year crop rotations with a different ratio of nitrogen fixing crops were compared: I – 43% (grass-clover→grass-clover→winter wheat→spring barley→peas→winter wheat→ spring barley), II – 43% (grass-clover→winter wheat→peas→spring barley→grass-clover→winter wheat→spring barley), III – 29% (grass-clover→potato→oat→spring barley→peas→winter wheat→spring barley), IV – 14% (grass-clover→winter wheat→ potato→spring barley→winter rape→winter wheat→spring barley) (Table 1). Soil urease and saccharase activities were evaluated in the 4th and 5th year of the experiment.

Initial plot size was 126 m^2, with each plot replicated 3 times.

The catch crop in all crop rotations was white mustard *Sinapis alba* L., sown after the main crop. Straw of cereals and yield of catch crop were chopped and ploughed down during autumn. Farmyard manure (30 Mg ha^{-1}) was incorporated by soil tillage in the autumn of 2003 and 2007.

To estimate the activity of soil enzymes soil samples were taken in 2007 and 2008 from the soil layer of 0–25 cm in May (intensive crop growing). The activity of soil urease was determined in dry samples according to Hofmann and Schmidt, that of saccharase according to Hofmann and Seegerer methods, modified by A. I. Cunderova /Чундерова, 1973/.

The means were compared using the least significant difference test at $P_{(level)} < 0.05$ with *Systat 10*. The relationships between the activity of soil enzymes and content of total nitrogen, mineral nitrogen, organic carbon and potassium in the soil were estimated using *Systat 10* /SPSS Inc., 2000/.

Table 1. The structure of four different seven-course crop rotations with and without catch crops

1 lentelė. *Keturių skirtingų septynių narių sėjomainų rotacijų su tarpiniais pasėliais ir be tarpinių pasėlių struktūra*

Catch crop *Tarpiniai pasėliai*	Year *Metai*	Crop rotation I *I sėjomainos rotacija*	Crop rotation II *II sėjomainos rotacija*	Crop rotation III *III sėjomainos rotacija*	Crop rotation IV *IV sėjomainos rotacija*
1	2	3	4	5	6
Without *Be*	2003	Grass-clover *Daugiametės žolės*	Grass-clover *Daugiametės žolės*	Grass-clover *Daugiametės žolės*	Grass-clover *Daugiametės žolės*
	2004	Grass-clover *Daugiametės žolės*	Winter wheat *Žieminiai kviečiai*	Potato *Bulvės*	Winter wheat *Žieminiai kviečiai*
	2005	Winter wheat *Žieminiai kviečiai*	Peas *Žirniai*	Hulless oat *Belukštės avižos*	Potato *Bulvės*
	2006	Spring barley *Vasariniai miežiai*	Spring barley *Vasariniai miežiai*	Spring barley *Vasariniai miežiai*	Spring barley *Vasariniai miežiai*
	2007	Peas *Žirniai*	Grass-clover *Daugiametės žolės*	Peas *Žirniai*	Winter rape *Žieminiai rapsai*
	2008	Winter wheat *Žieminiai kviečiai*	Winter wheat *Žieminiai kviečiai*	Winter wheat *Žieminiai kviečiai*	Winter wheat *Žieminiai kviečiai*
	2009	Spring barley *Vasariniai miežiai*	Spring barley *Vasariniai miežiai*	Spring barley *Vasariniai miežiai*	Spring barley *Vasariniai miežiai*

Table 1 continued
1 lentelės tęsinys

1	2	3	4	5	6
	2003	Grass-clover *Daugiametės žolės*	Grass-clover / aftercrop for green manure *Daugiametės žolės / tarpinis pasėlis žaliajai trąšai*	Grass-clover / aftercrop for green manure *Daugiametės žolės / tarpinis pasėlis žaliajai trąšai*	Grass-clover / aftercrop for green manure *Daugiametės žolės / tarpinis pasėlis žaliajai trąšai*
	2004	Grass-clover / aftercrop for green manure *Daugiametės žolės / tarpinis pasėlis žaliajai trąšai*	Winter wheat / aftercrop for green manure *Žieminiai kviečiai / tarpinis pasėlis žaliajai trąšai*	Potato *Bulvės*	Winter wheat / aftercrop for green manure *Žieminiai kviečiai / tarpinis pasėlis žaliajai trąšai*
	2005	Winter wheat / aftercrop for green manure *Žieminiai kviečiai / tarpinis pasėlis žaliajai trąšai*	Peas / aftercrop for green manure *Žirniai / tarpinis pasėlis žaliajai trąšai*	Hulless oat / aftercrop for green manure *Belukštės avižos / tarpinis pasėlis žaliajai trąšai*	Potato *Bulvės*
With Su	2006	Spring barley / aftercrop for green manure *Vasariniai miežiai / tarpinis pasėlis žaliajai trąšai*	Spring barley *Vasariniai miežiai*	Spring barley / aftercrop for green manure *Vasariniai miežiai / tarpinis pasėlis žaliajai trąšai*	Spring barley *Vasariniai miežiai*
	2007	Peas *Žirniai*	Grass-clover *Daugiametės žolės*	Peas *Žirniai*	Winter rape *Žieminiai rapsai*
	2008	Winter wheat / aftercrop for green manure *Žieminiai kviečiai / tarpinis pasėlis žaliajai trąšai*	Winter wheat / aftercrop for green manure *Žieminiai kviečiai / tarpinis pasėlis žaliajai trąšai*	Winter wheat / aftercrop for green manure *Žieminiai kviečiai / tarpinis pasėlis žaliajai trąšai*	Winter wheat / aftercrop for green manure *Žieminiai kviečiai / tarpinis pasėlis žaliajai trąšai*
	2009	Spring barley *Vasariniai miežiai*	Spring barley *Vasariniai miežiai*	Spring barley *Vasariniai miežiai*	Spring barley *Vasariniai miežiai*

Note. The solidus sign (/) indicates catch crop after a main crop.
Pastaba. Pasvirasis brūkšnys (/) žymi tarpinį pasėlį po pagrindinio pasėlio.

Results and discussion

In organic farming, the activity of urease in the soil was low (0.03–0.11 mg NH_3 g^{-1} soil 24 h^{-1}) in 2007 (Table 2). Although the soil was fertilised with farmyard manure (30 Mg ha^{-1}) only in 2003, in the manured soil, compared to the unmanured soil, the tendency of urease activity increase was observed. There was no significant effect of farmyard manure on urease activity. Crop rotation and catch crop for green manure had significant effect on the activity of urease. Significantly higher activity of urease (from 40 to 60%) was found in the soil in crop rotations II and IV, where grass-clover and winter rape were grown, compared to III crop rotation, where peas were grown.

In the soil of crop rotation IV (14% of nitrogen fixing crops) grown with legume, catch crop increased the activity of urease by 100%, compared to the soil without catch crop.

Table 2. The influence of crop rotation, catch crop and manure on soil urease activity in organic farming

2 lentelė. *Sėjomainos rotacijų, tarpinių pasėlių ir mėšlo įtaka dirvos ureazės aktyvumui taikant ekologinę žemdirbystę*

2007

Crop rotation (factor A) *Sėjomainos rotacija (A veiksnys)*	Crop *Pasėlis*	Farmyard manure (factor B) *Kraikinis mėšlas (B veiksnys)*	Urease activity, mg NH_3 g^{-1} soil 24 h^{-1} *Ureazės aktyvumas mg NH_3 1 g dirvos per 24 h*		Average *Vidurkis*
			Catch crop for green manure (factor C) *Tarpinis pasėlis žaliajai trąšai (C veiksnys)*		
			without catch crop *be tarpinio pasėlio*	with catch crop *su tarpiniu pasėliu*	
1	2	3	4	5	6
I	Peas *Žirniai*	without manure *be mėšlo*	0.06	0.04	0.07ab
		with manure *su mėšlu*	0.07	0.09	
		average *vidurkis*	0.07ab	0.07b	
II	Grass-clover *Daugiametės žolės*	without manure *be mėšlo*	0.07	0.09	0.08a
		with manure *su mėšlu*	0.10	0.06	
		average *vidurkis*	0.09a	0.08ab	

Table 2 continued
2 lentelės tęsinys

1	2	3	4	5	6
III	Peas *Žirniai*	without manure *be mėšlo*	0.03	0.06	0.05b
		with manure *su mėšlu*	0.06	0.03	
		average *vidurkis*	0.05b	0.05b	
IV	Winter rape *Žieminiai rapsai*	without manure *be mėšlo*	0.03	0.09	0.07a
		with manure *su mėšlu*	0.06	0.11	
		average *vidurkis*	0.05b*	0.10a*	
Average *Vidurkis*	without manure *be mėšlo*	0.06a	0.06a	0.07a	
	with manure *su mėšlu*	0.07a			

Note. Means not sharing a common letter (a, b) and asterisks are significantly different ($P < 0.05$). Crop rotations: I – 43% (grass-clover→grass-clover→winter wheat→spring barley→ peas→winter wheat→spring barley), II – 43% (grass-clover→winter wheat→peas→spring barley→grass-clover→winter wheat→spring barley), III – 29% (grass-clover→potato→ oat→spring barley→peas→winter wheat→spring barley), IV – 14% (grass-clover→winter wheat→potato→spring barley→winter rape→winter wheat→ spring barley).

Pastaba. Vidurkiai, pažymėti ne ta pačia raide (a, b) ir žvaigždute, yra esminiai (P < 0,05). Sėjomainos rotacijos: I – 43 % (daugiametės žolės→daugiametės žolės→žieminiai kviečiai→ vasariniai miežiai→ žirniai→žieminiai kviečiai→vasariniai miežiai), II – 43 % (daugiametės žolės→žieminiai kviečiai→ žirniai→vasariniai miežiai→daugiametės žolės→žieminiai kviečiai→ vasariniai miežiai), III – 29 % (daugiametės žolės→bulvės→avižos→vasariniai miežiai→ žirniai→žieminiai kviečiai→vasariniai miežiai), IV – 14 % (daugiametės žolės→žieminiai kviečiai→bulvės→vasariniai miežiai→žieminiai rapsai→ žieminiai kviečiai→vasariniai miežiai).

In the soil without catch crop, significantly higher activity of urease (0.09 mg NH_3 g^{-1} soil 24 h^{-1}) was found in crop rotation II, where grass-clover was grown. Significantly lower activity of urease (44.4%) was evaluated in the soil in crop rotations III and IV, where peas and winter rape were grown, compared to crop rotation II. In the soil with catch crop for green manure significantly higher activity of urease (0.10 mg NH_3 g^{-1} soil 24 h^{-1}) was found in crop rotation IV, where winter rape was grown. Significantly lower activity of urease (from 30.0 to 50.0%) was evaluated in the soil in crop rotations I and III, where peas were grown, compared to crop rotation IV. The activity of urease in the soil in crop rotation II, where grass-clover were grown, was the same as in the soil in crop rotation IV.

Crop rotation and catch crop for green manure significantly influenced the activity of saccharase (Table 3). But according to the data of V. I. Loshakov et al. (1986) catch crop of *Brassicaceae* family had higher influence on the activity of urease than saccharase. Significantly higher activity of saccharase (18.6 mg glucose g^{-1} soil 48 h^{-1}) was found in the soil in crop rotation II, where perennial grasses were grown.

Significantly lower activity of saccharase (from 18.8 to 22.0%) was evaluated in the soil in crop rotations I and III, where peas were grown, compared to crop rotation II. The activity of saccharase in the soil in crop rotation IV, where winter rape was grown, was the same as in the soil in crop rotation II.

Table 3. The influence of crop rotation, catch crop and manure on soil saccharase activity in organic farming

3 lentelė. *Sėjomainos rotacijų, tarpinių pasėlių ir mėšlo įtaka dirvos sacharazės aktyvumui taikant ekologinę žemdirbystę*

2007

Crop rotation (factor A) *Sėjomainos rotacija (A veiksnys)*	Crop *Pasėlis*	Farmyard manure (factor B) *Kraikinis mėšlas (B veiksnys)*	Saccharase activity, mg glucose g^{-1} soil 48 h^{-1} *Sacharazės aktyvumas mg gliukozės 1 g dirvos per 48 h*		Average *Vidurkis*
			Catch crop for green manure (factor C) *Tarpinis pasėlis žaliajai trąšai (C veiksnys)*		
			without catch crop *be tarpinio pasėlio*	with catch crop *su tarpiniu pasėliu*	
1	2	3	4	5	6
I	Peas *Žirniai*	without manure *be mėšlo*	16.5	12.3	15.1b
		with manure *su mėšlu*	14.6	16.9	
		average *vidurkis*	15.6b	14.6b	
II	Grass-clover *Daugiametės žolės*	without manure *be mėšlo*	18.7	18.0	18.6a
		with manure *su mėšlu*	21.7	15.8	
		average *vidurkis*	20.2a	16.9ab	
III	Peas *Žirniai*	without manure *be mėšlo*	14.4	13.3	14.5b
		with manure *su mėšlu*	14.9	15.3	
		average *vidurkis*	14.7b	14.3b	

Table 3 continued
3 lentelės tęsinys

1	2	3	4	5	6
IV	Winter rape *Žieminiai rapsai*	without manure *be mėšlo*	13.4	18.2	16.2ab
		with manure *su mėšlu*	13.2	19.9	
		average *vidurkis*	13.3b*	19.1a*	
Average *Vidurkis*	without manure *be mėšlo*	15.6a	15.9a	16.2a	
	with manure *su mėšlu*	16.5a			

Explanations under Table 2 / *Paaiškinimai po 2 lentele.*

In the soil of crop rotation IV (14% of nitrogen fixing crops) where legume was grown, catch crop increased the activity of saccharase by 43.6%, compared to the soil without catch crop.

In the soil without catch crop, significantly higher activity of saccharase (20.2 mg glucose g^{-1} soil 48 h^{-1}) was found in crop rotation II, where grass-clover were grown. Significantly lower activity of saccharase (from 22.8 to 34.2%) was evaluated in the soil in crop rotations I, III and IV (where peas and winter rape were grown), compared to II crop rotation. In the soil with catch crop for green manure significantly higher activity of saccharase (19.1 mg NH_3 g^{-1} soil 48 h^{-1}) was found in crop rotation IV, where winter rape was grown. Significantly lower activity of saccharase (from 23.6 to 25.1%) was evaluated in the soil in crop rotations I and III, where peas were grown, compared to crop rotation IV. The activity of saccharase in the soil in crop rotation II, where grass-clover were grown, was the same as in the soil of crop rotation IV.

The activity of urease directly depended on agrochemical soil properties. Significant positive correlations between urease activity and total nitrogen (Fig. 1) and between urease activity and organic carbon (Fig. 2) were established. According to the data of A. Svirskienė and A. Magyla (1997) the activity of urease and saccharase positively correlated with soil humus content. H. Kheyrodin and H. Antoun (2008) suggested that enzyme activities were closely correlated to the nitrogen mineralization potential, nitrogen and carbon mineralization rates, total amounts of carbon or nitrogen, soil pH, ammonification rates and soil structural stability. On the contrary, the data of Ch. Stark (2005) showed that using green manures and crop rotations improved soil biology in both production systems, that no relationships existed between enzyme activities and nitrogen mineralization, and that enzyme activities are more closely associated with inherent soil and environmental factors, which makes them less useful as early indicators of changes in soil quality.

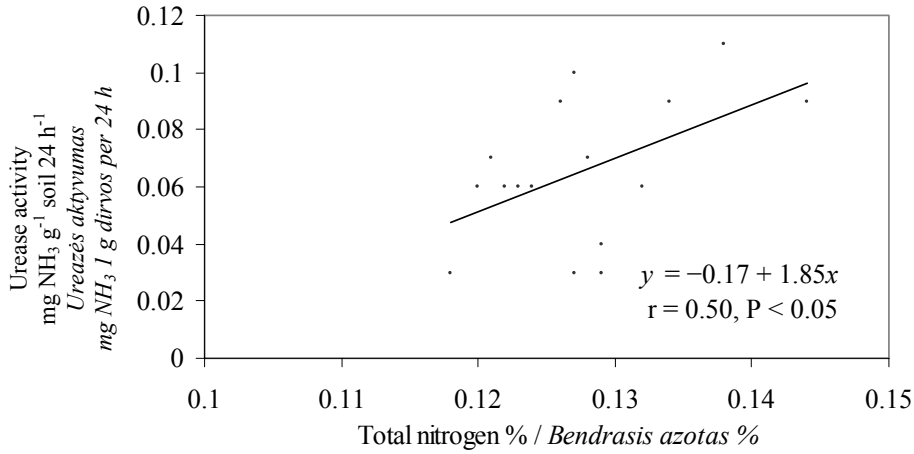

Figure 1. Soil urease activity as affected by the content of total nitrogen
1 paveikslas. *Dirvos ureazės aktyvumo priklausomumas nuo bendrojo azoto kiekio*
2007

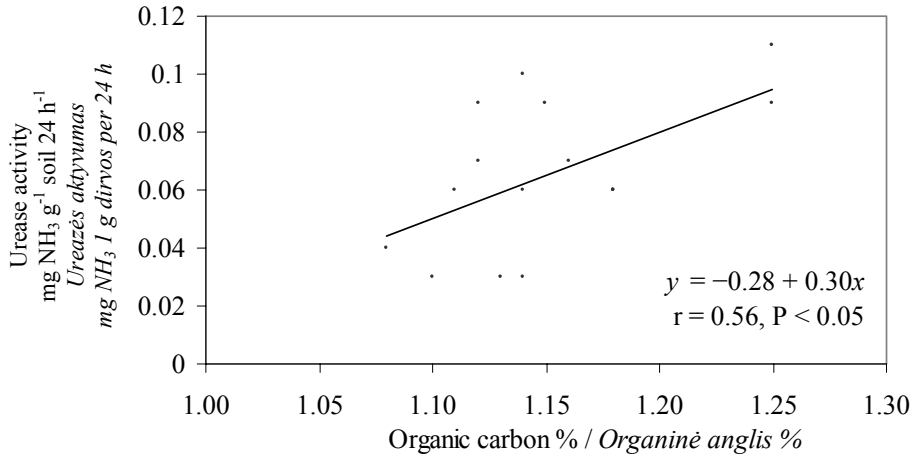

Figure 2. Soil urease activity as affected by the content of organic carbon
2 paveikslas. *Dirvos ureazės aktyvumo priklausomumas nuo organinės anglies kiekio*
2007

In organic farming, the activity of urease in the soil in 2008 was low (0.09–0.17 mg NH_3 g^{-1} soil 24 h^{-1}) (Table 4). Farmyard manure had significant effect on the activity of urease. Significantly stronger activity of urease (27.3%) was found in the manured soil, compared to unmanured soil. Crop rotation and catch crop for green manure had low effect on the activity of urease. The highest activity of urease was in the soil in crop rotation II, where grass-clover was grown. The results of our investigation did not show any significant effect of crop rotation on urease activity. Catch crop for green manure had no significant influence on the activity of urease.

Table 4. The influence of crop rotation, catch crop and manure on soil urease activity in organic farming

4 lentelė. *Sėjomainos rotacijų, tarpinių pasėlių ir mėšlo įtaka dirvos ureazės aktyvumui taikant ekologinę žemdirbystę*

2008

Crop rotation (factor A) *Sėjomainos rotacija (A veiksnys)*	Pre-crop of winter wheat *Žieminių kviečių priešsėlis*	Farmyard manure (factor B) *Kraikinis mėšlas (B veiksnys)*	Urease activity, mg NH_3 g^{-1} soil 24 h^{-1} *Ureazės aktyvumas mg NH_3 1 g dirvos per 24 h*		Average *Vidurkis*
			Catch crop for green manure (factor C) *Tarpinis pasėlis žaliajai trąšai (C veiksnys)*		
			without catch crop *be tarpinio pasėlio*	with catch crop *su tarpiniu pasėliu*	
I	Peas *Žirniai*	without manure *be mėšlo*	0.10	0.11	0.13a
		with manure *su mėšlu*	0.15	0.17	
		average *vidurkis*	0.12a	0.14a	
II	Grass-clover *Daugiametės žolės*	without manure *be mėšlo*	0.13	0.13	0.14a
		with manure *su mėšlu*	0.16	0.15	
		average *vidurkis*	0.14a	0.14a	
III	Peas *Žirniai*	without manure *be mėšlo*	0.10	0.09	0.11 a
		with manure *su mėšlu*	0.14	0.10	
		average *vidurkis*	0.12a	0.10a	
IV	Winter rape *Žieminiai rapsai*	without manure *be mėšlo*	0.10	0.14	0.13a
		with manure *su mėšlu*	0.10	0.16	
		average *vidurkis*	0.12a	0.13a	
Average *Vidurkis*	without manure *be mėšlo*	0.11b	0.12a	0.13a	
	with manure *su mėšlu*	0.14a			

Explanations under Table 2 / *Paaiškinimai po 2 lentele.*

Crop rotation, catch crop for green manure and farmyard manure had low effect on the activity of saccharase (Table 5). The highest activity of saccharase (24.7 mg glucose g^{-1} soil 48 h^{-1}) was in the soil in crop rotation I (with 43% of nitrogen fixing crops; perennial grasses and peas). The results obtained did not show any significant effect of crop rotation II (with 43% of nitrogen fixing crops; also perennial grasses and peas) on saccharase activity, compared to other crop rotations. In the soil with catch crop for green manure and farmyard manure, compared to unmanured soil, the tendency of saccharase activity increase was observed.

Table 5. The influence of crop rotation, catch crop and manure on soil saccharase activity in organic farming

5 lentelė. *Sėjomainos rotacijų, tarpinių pasėlių ir mėšlo įtaka dirvos sacharazės aktyvumui taikant ekologinę žemdirbystę*

2008

Crop rotation (factor A) *Sėjomainos rotacija (A veiksnys)*	Pre-crop of winter wheat *Žieminių kviečių priešsėlis*	Farmyard manure (factor B) *Kraikinis mėšlas (B veiksnys)*	Saccharase activity, mg glucose g^{-1} soil 48 h^{-1} *Sacharazės aktyvumas mg gliukozės 1 g dirvos per 48 h* — Catch crop for green manure (factor C) *Tarpinis pasėlis žaliajai trąšai (C veiksnys)*		Average *Vidurkis*
			without catch crop *be tarpinio pasėlio*	with catch crop *su tarpiniu pasėliu*	
1	2	3	4	5	6
I	Peas *Žirniai*	without manure *be mėšlo*	27.4	28.9	24.7a
		with manure *su mėšlu*	20.5	22.0	
		average *vidurkis*	24.0a	25.5a	
II	Grass-clover *Daugiametės žolės*	without manure *be mėšlo*	20.3	25.1	22.4a
		with manure *su mėšlu*	25.8	18.3	
		average *vidurkis*	23.1a	21.7a	
III	Peas *Žirniai*	without manure *be mėšlo*	19.7	23.3	23.1a
		with manure *su mėšlu*	23.6	25.8	
		average *vidurkis*	21.7a	24.6a	

Table 5 continued
5 lentelės tęsinys

1	2	3	4	5	6
IV	Winter rape *Žieminiai rapsai*	without manure *be mėšlo*	13.0	19.7	19.1a
		with manure *su mėšlu*	21.2	22.5	
		average *vidurkis*	17.1a	21.1a	
Average *Vidurkis*	without manure *be mėšlo*	22.2a	21.5a	23.2a	
	with manure *su mėšlu*	22.5a			

Explanations under Table 2 / *Paaiškinimai po 2 lentele.*

Significant positive correlations were identified between urease activity and mineral nitrogen content (Fig. 3) and between urease activity and potassium content (Fig. 4).

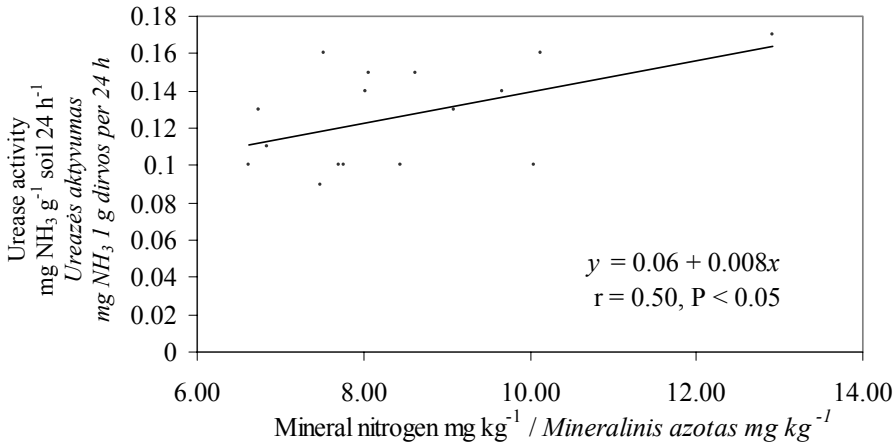

Figure 3. Soil urease activity as affected by the content of mineral nitrogen
3 paveikslas. *Dirvos ureazės aktyvumo priklausomumas nuo mineralinio azoto kiekio*
2008

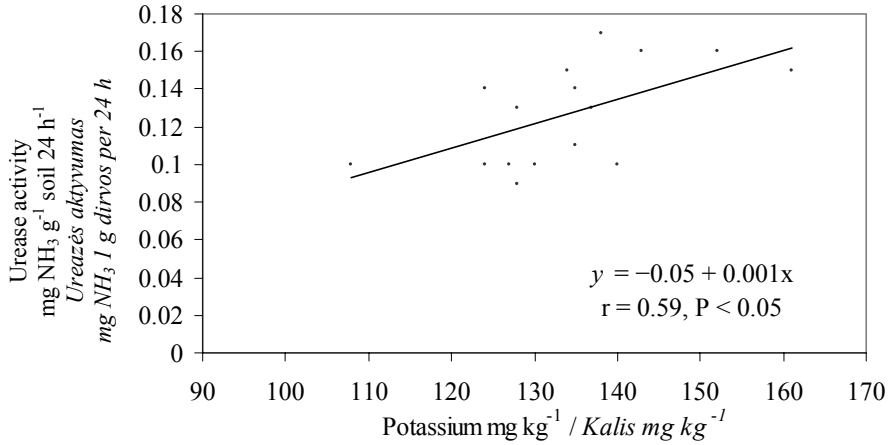

Figure 4. Soil urease activity as affected by the content of potassium
4 paveikslas. *Dirvos ureazės aktyvumo priklausomumas nuo kalio kiekio*
2008

Conclusions

1. The highest activity of urease and saccharase in 2007 was observed in the crop rotation soil with perennial grasses and peas. The activity of urease increased from 14.3 to 60.0% and that of saccharase from 14.8 to 28.3%, compared to the other crop rotations. In the soil of the crop rotation with 14% of nitrogen fixing crops, catch crop increased the activity of urease by 100 % and that of saccharase by 43.6% compared to the soil without catch crop.

2. Farmyard manure applied at 30 Mg ha^{-1} significantly stimulated 27.3% the activity of soil urease in 2008, while the activity of saccharase was not significantly influenced. Crop rotation and catch crop for green manure had no significant effect on soil hydrolase activity.

3. The activity of soil urease directly depended on the content of total nitrogen (r = 0.50, P < 0.05), mineral nitrogen (r = 0.50, P < 0.05), organic carbon (r = 0.56, P < 0.05), and potassium (r = 0.59, P < 0.05).

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REFERENCES

1. Abdallahi M. M., N'Dayegamiye A. Effects of green manures on soil physical and biological properties and on wheat yields and N uptake // Canadian Journal of Soil Science. – 2000, vol. 80, No. 1, p. 81–89

2. Bandick A. K., Dick R. P. Field management effects on soil enzyme activities // Soil Biology and Biochemistry. – 1999, vol. 31, No. 11, p. 1471–1479

3. Dinesh R., Dubey R. P., Shyam Prasad G. Soil microbial biomass and enzyme activities as influenced by organic manure incorporation into soils of a rice-rice system // Journal of Agronomy and Crop Science. – 1998, vol. 181, No. 3, p. 173–178

4. Goyal S., Mishra M. M., Dhankar S. S. et al. Microbial biomass turnover and enzyme activities following the application of farmyard manure to fields soils with and without previous long-term applications // Biology and Fertility of Soils. – 1993, vol. 15, No. 1, p. 60–64

5. Grigaliūnienė K. Ilgalaikio tręšimo poveikis skirtingos kilmės dirvožemių biologiniam aktyvumui: daktaro disertacijos santrauka. – Akademija (Kauno r.), 2005. – 24 p.

6. Kara E. E., Penezoglu M. The effect of green manuring on soil organic content and soil biological activity // Anadolu. – 2000, vol. 10, No. 1, p. 73–86

7. Kheyrodin H., Antoun H. Tillage and manure effect on soil microbial biomass and respiration and on enzyme activities // 5th international symposium ISMOM: session 4. – Pucón, Chile, 2008, p. 16

8. Krishnakumar S., Saravanan A., Natarajan S. K. et al. Microbial population and enzymatic activity as influenced by organic farming // Research Journal of Agriculture and Biological Sciences. – 2005, vol. 1, No. 1, p. 85–88

9. Lacko-Bartašova M., Zaujec A., Števlikova T. Effect of ecological and integrated arable farming systems on crop productivity and soil fertility // Designing and testing crop rotations for organic farming. – Denmark, 1999, p. 297–304

10. Mijangos I., Perez R., Albizu I., Garbisu C. Effects of fertilization and tillage on soil biological parameters // Enzyme and Microbial Technology. – 2006, vol. 40, p. 100–106

11. Mikhailovskaya N., Tarasyuk E. Polyphenoloxidase and peroxidase activity in *Luvisol* loamy sand soil // Dirvožemis tvarioje aplinkoje: tarptautinės mokslinės konferencijos pranešimų santraukos. – Akademija (Kauno r.), 2008, p. 47

12. Nawrath M. Einfluß von organischer Düngung (Stroh- und Gründüngung, Stallmist) auf Humusgehalt, Humusqualität und Pflanzenertrag: Dissertation Agrarwissenschaft Fachbereich. – Gießen, 1998. – 139 S.

13. Schimner F., Sonnleitner R. Bodenökologie: Mikrobiologie und Bodenenzymatik // Bodenbewirtschaftung, Düngung und Rekultivierung. – Berlin, 1996. – 359 S.

14. SPSS Incorporated. *Systat 10*. Statistics I. – USA, 2000. – 663 p.

15. Stark Ch. Effects of long- and short-term crop management on soil biological properties and nitrogen dynamics / Australasian digital theses program. – 2005. Internete: <http://search.arrow.edu.au>

16. Svirskienė A. Antropogeniniam poveikiui jautrių dirvožemio mikrobiologinio aktyvumo ir jo derlingumo indikatorių įvertinimas // Ekologija. – V., 1999, No. 3, p. 90–94

17. Svirskienė A., Magyla A. Įvairios specializacijos sėjomainų bei monokultūrų įtaka dirvožemio biologiniam aktyvumui // Žemdirbystė-Agriculture. – 1997, t. 59, p. 3–15

18. Svirskienė A., Šlepetienė A., Bučienė A. Microbiological processes and humus quality while applying organic and mineral fertilizers // Ecological effects of microorganism action: material of international conference. – Vilnius, 1997, p. 213–217

19. TrasarCepeda C., Leiras C., GilSotres F., Seone S. Towards a biochemical quality indexes for soils. An expressions relating several biological and biochemical properties // Biology and Fertility of Soils. – 1998, No. 26, p. 100–106

20. Zakarauskaitė D., Grigaliūnienė K., Kučinskas J. ir kt. Ilgalaikio tręšimo organinėmis ir mineralinėmis trąšomis poveikis dirvožemio biologiniam aktyvumui // Vagos: mokslo darbai / LŽŪU. – 2005, Nr. 68 (21), p. 44

21. Лошаков В. И., Емцев В. Т., Ницэ Л. К. и др. Биологическая активность почвы в специализированном зерновом севообороте при использовании поживного сидерата и соломы в качестве удобрения // Известия ТСХА. – 1986, вып. 4, с. 10–17

22. Чундерова А. И. Ферментативная активность дерново-подзолистых почв Северо Западной зоны: автореферат диссертации кандидата сельскохозяйственных наух. – Таллин, 1973. – 47 с.

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SĖJOMAINŲ, TARPINIŲ PASĖLIŲ IR TRĘŠIMO MĖŠLU ĮTAKA DIRVOS FERMENTŲ AKTYVUMUI EKOLOGINĖJE ŽEMDIRBYSTĖJE

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Santrauka

Tyrimai atlikti 2003–2008 m. Lietuvos žemės ūkio universiteto bandymų stotyje. Tyrimų lauko dirvožemis – karbonatingas sekliai glėjiškas išplautžemis (*IDg8-k*), *Calc(ar)i-Epihypogleyic Luvisol* (*LVg-p-w-cc*). Tyrimo A veiksnys – 4 septynių narių sėjomainų rotacijos su nevienoda azotą fiksuojančių augalų dalimi: I – 43 % (daugiametės žolės→daugiametės žolės→žieminiai kviečiai→vasariniai miežiai→žirniai→žieminiai kviečiai→miežiai), II – 43 % (daugiametės žolės→žieminiai kviečiai→žirniai→vasariniai miežiai→daugiametės žolės→ žieminiai kviečiai→miežiai), III – 29 % (daugiametės žolės→bulvės→belukštės avižos→ vasariniai miežiai→žirniai→žieminiai kviečiai→miežiai), IV – 14 % (daugiametės žolės→ žieminiai kviečiai→bulvės→vasariniai miežiai→žieminiai rapsai→žieminiai kviečiai→miežiai). B veiksnys – tarpinis pasėlis: 1) be tarpinio pasėlio, 2) su tarpiniu pasėliu. C veiksnys – tręšimas mėšlu: 1) netręšta, 2) tręšta mėšlu. Tyrimų tikslas – įvertinti sėjomainų rotacijų su nevienoda azotą fiksuojančių augalų dalimi, tarpinių pasėlių žaliajai trąšai ir tręšimo mėšlu įtaką dirvos fermentų (ureazės bei sacharazės) aktyvumui taikant ekologinę žemdirbystę.

Didžiausias ureazės ir sacharazės aktyvumas 2007 m. nustatytas sėjomainos, kurioje du kartus augintos I n. m. daugiametės žolės ir pupiniai augalai (žirniai), dirvoje. Palyginti su kitomis sėjomainomis, ureazės aktyvumas padidėjo nuo 14,3 iki 60,0 %, sacharazės – nuo 14,8 iki 28,3 %. Žaliajai trąšai augintas tarpinis pasėlis, palyginti su jo nenaudojimu, iš esmės (100 ir 43,6 %) padidino ureazės ir sacharazės aktyvumą sėjomainos dirvoje, kurioje auginta tik 17 % pupinių augalų.

Dirvos ureazės aktyvumą 2008 m. iš esmės padidino tręšimas mėšlu, o sacharazės aktyvumui esminės įtakos neturėjo. Sėjomainos ir tarpiniai pasėliai žaliajai trąšai esminės įtakos dirvos fermentų aktyvumui neturėjo.

Dirvos ureazės aktyvumui padarė įtaką dirvoje esantis visas azoto kiekis (r = 0,50, P < 0,05), mineralinio azoto kiekis (r = 0,50, P < 0,05), organinės anglies kiekis (r = 0,56, P < 0,05) ir kalio kiekis (r = 0,59, P < 0,05).

Reikšminiai žodžiai: fermentų aktyvumas, sėjomainos, tarpiniai pasėliai, mėšlas, ekologinė žemdirbystė.

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