ISSN 1392-3196
Zemdirbyste-Agriculture, vol. 96, No. 1 (2009), p. 113–126
UDK 631.461:631.879:631.826

THE EFFECT OF CELLULOSE-DEGRADING MICRO-ORGANISMS ON THE BIODESTRUCTION OF CROP RESIDUES IN THE SOIL

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Abstract

Research on crop residue decomposition was carried out during the period of 2004–2006 in a model field trial set up at the Experimental Station of the Lithuanian University of Agriculture. The soil of the experimental site is *Endocalcari-Epihypogleyic Cambisol* (*sicco*) (*CMg-p-w-can*). Samples of residues of the aboveground parts and roots of winter and spring rape, winter wheat and red clover incorporated in the soil for different duration (7.5, 14.5, 19.5 and 26.0 months) were explored. The study was aimed to determine the incidence of micro-organisms, capable of assimilating cellulosic substrate, on those residues as well as the variability of species composition of micromycete communities, and the impact on the decomposition rate of crop residues and lignin accumulated in them.

The occurrence of cellulose-degrading micro-organisms depended on the type of crop residue. After 26 months of crop residue incubation in the soil the highest amount of lignin from its maximum concentration was degraded in red clover stubble (42.1%), in spring and winter rape threshing remains (35.0 and 28.5%, respectively). Accordingly, those residues were decomposed most. Moreover, the amount of colony forming units of cellulose-degrading micro-organisms identified on them was higher than that on other crop aboveground residues. The roots of red clover and lignin in it were decomposed (accordingly 84.4 and 34.5%), and the content of cellulose-degrading micro-organisms was higher than that on other plant roots. The roots of winter rape and lignin in it on the contrary were decomposed the least (accordingly 57.1 and 17.3 %).

With increasing the duration of crop aboveground residue and red clover root decomposition, the amount of micro-organisms capable of assimilating cellulosic substrate, increased. Statistically significant negative correlation was established between the number of colony forming units of micro-organisms capable of assimilating cellulose and crop residue decomposition rate.

During the warm period of the year, there were isolated cellulose-degrading micromycetes belonging to 46 genera, during the cold period of the year, the species diversity of those micromycetes tended to decrease, and there were identified micro-organisms belonging only to 18 genera.

Key words: crop aboveground and root residues, decomposition, micro-organisms, lignin, correlation.

Introduction

Biological plant residue biodestruction depends on the peculiarities of plants as well as composition and abundance of the micro-organisms involved and functioning in the plant ecosystem, also on their catalytic activity /Тейт, 1991/. The quality of crop residues is considered to be of primary importance for the development of the microbial populations /Blair, Parmelee, 1990, Georgieva et al., 2005/. After plant residue is ploughed in, soil biota starts its mineralization and humification /Eitminavičiūtė, 1994; Tripolskaja, 2005/. Diversity of soil biota and its biotic activity is an indicator of plant residue decomposition /Лугаускас, 1988/.

Phytomass decomposition involves two stages. In the first stage, representatives of the zoocenosis and micro-organisms decompose readily decomposable cytoplasmic compounds by using them for energy and building of their own cells and at the same time leaving plant available nutrients in the soil /Александрова, 1980; Eitminavičiūtė, 1994/. This stage is short and, depending on the environmental conditions, lasts from several weeks to several months /Kögel-Knabner, 2002; Varnaitė, 2004; Jenkinson, Rayner, 2006/. During the second stage of plant residue decomposition, different kinds of micro-organisms – bacteria, micromycetes, actinomycetes, basidiomycetes break down complex organic compounds: cellulose, hemicellulose, lignin and their metabolites up to intermediate products of humic acids. This process is lengthy and, depending on the environmental conditions, lasts from several months to 3–10 years, and in some cases it can last for indefinite time /Myrayama, 1984; Тейт, 1991; Blanchette, 2000/. This process is determined mostly by cellulose, hemicellulose and lignin, a compound characterised by a complex polymer origin and structure, whose breakdown is determined by a complex of micro-organism communities and ligninolytic enzymes /Тейт, 1991; Sjöberg, 2003; Varnaitė et al., 2008/.

The objective of the present study was to identify the abundance of cellulose-degrading micro-organisms and their effect on the decomposition rate of soil-incorporated crop residues (oilseed rape, wheat and clover) and lignin accumulated in them.

Materials and methods

The experiments of crop residue decomposition were carried out at the Experimental Station of the Lithuanian University of Agriculture (54°53'N, 23°50'E) in a model field experiment during the period of 2004–2006. The soil of the experimental site according to the soil classification of the year 1999 (LTDK-99) is drained moraine loamy *Endocalcari-Epihypogleyic Cambisol* (*sicco*) (*CMg-p-w-can*). Soil pH 6.7, humus content in the arable layer 2.1%, total N 1.47 g kg^{-1}, base saturation >90%, available phosphorus (P_2O_5) 119 mg kg^{-1}, available potassium (K_2O) 100 mg kg^{-1}, available sulphur (SO_4^{-2}) 15.4 mg kg^{-1}. Soil texture in the arable layer (0–25 cm) was dominated by silt (0.05–0.002 mm) – 55.3% and sand (2.00–0.05 mm) – 33.8%, while clay particles (< 0.002 mm) amounted only to 10.9%. C_{org} : N was 9.2.

The experiment had two factors design. It was performed in four replications. *Factor A* – crop residues: aboveground residues: 1) stubble of winter oilseed rape (30 cm from root collar), 2) threshing remains of winter oilseed rape (stems with branches and siliques), 3) stubble of spring oilseed rape (30 cm from root collar), 4) threshing remains

of spring oilseed rape (stems with branches and siliques), 5) stubble of winter wheat (20 cm height), 6) stubble of red clover (20 cm height); roots: 1) winter oilseed rape, 2) spring oilseed rape, 3) winter wheat, 4) red clover. *Factor B* – decomposition duration: 1) 7.5, 2) 14.5, 3) 19.5 and 4) 26 months.

The experiment started on the 1st of September 2004. End-datum point of different duration decomposition periods was set up when average temperature in 20 cm soil depth for three successive days in spring was ≥ +5 °C and in autumn ≤ +5 °C. Samples of rape and wheat residues were prepared after harvesting. Sampling of residues of the second year red clover was done after the first cut. Collected crop residues were cleaned and chopped in 2–3 cm size chaffs. Content of their dry matter (DM) was estimated. Samples of natural humidity and 20 g weight were taken and put into the 9 x 12 cm size net polychlorvinyl bags with 0.05 mm mesh diameter. Bags with crop residues were incorporated in ploughed up furrow of black fallow at the 20 cm depth, at 20 cm distances. At the end of research period bags with crop residues were dug out and analysed. Investigations of micro-organisms were performed at the Laboratory of Biodeterioration Research of the Institute of Botany. The ablution method was used for micro-organism isolation /Билай, 1982/. For the micro-organisms capable of assimilating cellulosic substrate evolution the cellulose agar medium was used /Билай, 1982/. Cultures were cultivated at +26 °C temperature. The number of micro-organisms (colony forming units, cfu) was calculated in 1 g of dry substrate /Мирчинк, 1988/. The species of micromycetes were identified according to cultural and morphological features using descriptors: Ellis (1976), Domsch et al. (1980), Ramirez (1982), Bissett (1991), Larone (1993), Samuels et al. (2002), Chaverri, Samuels (2003), Samson, Frisvad (2004) and Aleksandrova (2003).

Table 1. Duration of investigation periods and their meteorological conditions
1 lenetelė. *Tyrimų laikotarpių trukmė ir meteorologinės sąlygos*
LUA Experimental Station / *LŽŪU bandymų stotis, 2004–2006 m.*

No. *Nr.*	Duration of investigation period, month[x] *Tyrimo laikotarpio trukmė mėn.*	Date *Data*	Conditions during period *Laikotarpio sąlygos*			Average conditions for successive 3 days[xxx] *Vidutinės 3 d. sąlygos*		
			average temperature ºC *vidutinė temperatūra °C*		precipitation mm *krituliai mm*	temperature ºC *temperatūra °C*		soil moisture % *dirvos drėgnis %*
			air *oro*	soil[xx] *dirvos*		air *oro*	soil[xx] *dirvos*	
1.	7.5	11 11 2004–11 04 2005	−1.1	1.4	216.0	6.7	6.5	26.8
2.	14.5	11 04 2005–02 11 2005	13.4	15.0	399.0	2.3	3.2	21.6
3.	19.5	02 11 2005–24 04 2006	−2.0	0.5	157.0	8.1	7.5	21.7
4.	26.0	24 04 2006–02 11 2006	15.1	16.1	476.4	3.5	4.7	17.0

[x] – from initiation / *nuo bandymo įrengimo*, [xx] – at a depth of 20 cm / *20 cm gylyje*, [xxx] – before samples digging out / *prieš bandinių iškasimą.*

Chemical composition of crop residues was established at the Experimental Station and "Tempus" laboratory of the Lithuanian University of Agriculture.

Content in the bag was dried out until air dry weight, ground, sieved through 1 mm separator. The following chemical analyses of samples were performed: DM content was determined by drying in a thermostat at +105 °C temperature, the content of total nitrogen by the Kjeldahl, lignin by Klason methods.

Data statistical analysis was performed using *MS Excel 98*, *Anova* for two-factor experiment and *Stat* for correlation analysis from package *Selekcija* /Tarakanovas, 2001/.

Investigations were carried out during cold and warm periods (Table 1). Warm periods were characterised by a sharp shift of prolonged drought, high air temperatures and rainfall.

Results and discussion

During the process of crop residue decomposition in soil, initially it is enriched by nutrients from readily metabolisable organic compounds to which the following simple polymers of cell cytoplasm are attributed: protein, mono and polysaccharides, amino acids and their monomers. These readily degradable compounds are the main energy source of soil micro-organisms. Many micromycetes metabolise lignin into intermediate compounds that are degraded by other species of fungi into carbon dioxide, other volatile products and water. This destruction of organic compounds is inhibited by physical relationship between polymers and monomers both in plant and soil. Decomposition rate of crop residues depends on nitrogen and lignin content, their ratio and lignin composition. Destruction of complex lignin polymers is possible after intensive decomposition of metabolisable substrates /Тейт, 1991; Jenkinson, Rayner, 2006/.

While investigating the total incidence of micro-organisms on crop residues, the highest number of their colony forming units and the highest species diversity of micromycetes (especially of *Penicillium* genus) were identified on clover residues and winter and spring rape threshing remains /Kriaučiūnienė, 2008/. The diversity and incidence of micro-organisms, capable of assimilating cellulosic substrate, on these residues were also found to be the highest (Table 2). It is likely that this is one of the reasons for intensive biodestruction of these crops' residues.

With increasing the duration of incubation of crop aboveground residues and roots of red clover in soil, the incidence and abundance of the micro-organisms, capable of assimilating cellulosic substrate, increased. On crop root residues, except for clover, the number of colony forming units of micro-organisms of this group was increasing during decomposition, but after 19.5 months of incubation in soil it started to decrease. The incidence of micro-organisms capable of assimilating cellulosic substrate was strongly dependent on the weather conditions: after the warm periods of the year (14.5 and 26.0 months of crop residue decomposition) the number of micro-organisms colony forming units isolated on aboveground residues and red clover roots was higher than that after the cold periods (7.5 and 19.5 months).

Table 2. The occurrence of cellulose-degrading micro-organisms on crop residues decomposing in soil (cfu × 10^3 g^{-1} DM)
2 lentelė. *Celiuliozę skaidančių mikroorganizmų paplitimas ant dirvoje skaidomų augalų liekanų (kfv × 10^3 g^{-1} SM)*

LUA Experimental Station / *LŽŪU bandymų stotis, 2004–2006 m.*

Crop residue *Augalų liekanos*	Duration of crop residue decomposition in soil, months *Augalų liekanų skaidymosi trukmė mėn.*			
	7.5	14.5	19.5	26.0
Aboveground part / *Antžeminė dalis*				
Stubble of winter rape *Žieminių rapsų ražienojai*	41.8 ± 1.04	174.4 ± 6.8	328.7 ± 21.9	446.2 ± 29.8
Threshing remains of winter rape *Žieminių rapsų kūlenos*	524.2 ± 27.3	980.3 ± 48.3	3045.9 ± 270.6	4872.6 ± 432.8
Stubble of spring rape *Vasarinių rapsų ražienojai*	116.7 ± 4.3	380.8 ± 17.5	279.3 ± 23.1	427.4 ± 35.3
Threshing remains of spring rape *Vasarinių rapsų kūlenos*	299.7 ± 13.9	717.7 ± 35.9	1282.0 ± 80.6	2334.5 ± 146.7
Stubble of winter wheat *Žieminių kviečių ražienojai*	116.6 ± 4.4	179.6 ± 7.7	399.6 ± 31.5	541.9 ± 42.7
Stubble of red clover *Raudonųjų dobilų ražienojai*	169.6 ± 5.1	364.6 ± 17.7	835.8 ± 57.3	1279.1 ± 87.8
Roots / *Šaknys*				
Winter rape *Žieminių rapsų*	42.8 ± 1.3	128.6 ± 6.3	3966.1 ± 30.1	851.8 ± 22.0
Spring rape *Vasarinių rapsų*	136.4 ± 5.4	148.9 ± 6.5	4239.5 ± 48.5	1190.5 ± 125.1
Winter wheat *Žieminių kviečių*	103.8 ± 4.1	240.5 ± 9.9	6845.0 ± 35.9	1189.2 ± 62.4
Red clover *Raudonųjų dobilų*	72.0 ± 3.3	340.7 ± 15.0	2448.1 ± 11.7	4008.6 ± 190.9

Biodestruction of different crop residues depended on the abundance of micro-organisms capable of assimilating cellulose. At the end of the study (after 26 months), of the crop aboveground part residues, the winter and spring rape threshing remains and clover stubble were decomposed most, and that of the underground crop parts – clover roots (Figures 1, 2). The highest amount of cellulose-degrading micro-organisms respectively 4 872.6, 2 334.5, 1 279.1 and 4 008.6 thous. cfu g^{-1} DM was found on the residues of these crops. The correlation-regression analysis of experimental data revealed a statistically significant linear correlation between the number of colony forming units of the micro-organisms capable of assimilating cellulose and percent of DM of threshing remains of winter and spring oilseed rape, also stubble and roots of red clover, respectively $r = -0.79$, $P \leq 0.05$ and $r = -0.85$, $P \leq 0.05$, also $r = -0.63$, $P \leq 0.05$ and $r = -0.53$, $P \leq 0.05$.

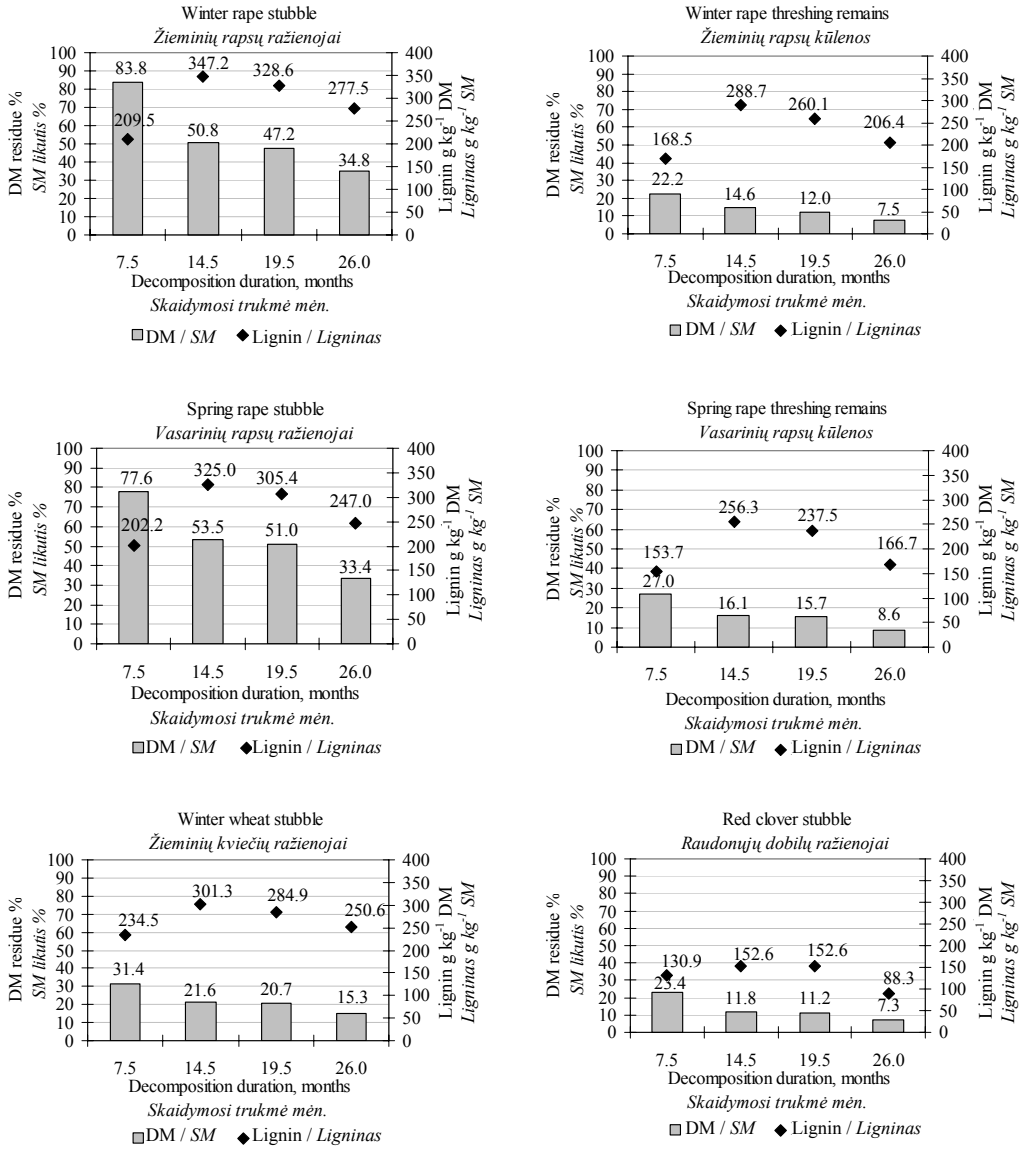

Figure 1. Biodestruction rate of aboveground part of plant residues (DM LSD_{05} = 2.95) in soil and lignin concentration (LSD_{05} = 16.21)

1 paveikslas. *Augalų antžeminių dalių liekanų biodestrukcijos intensyvumas (SM R_{05} = 2,95) dirvožemyje ir lignino koncentracija (R_{05} = 16,21)*

LUA Experimental Station / *LŽŪU bandymų stotis, 2004–2006 m.*

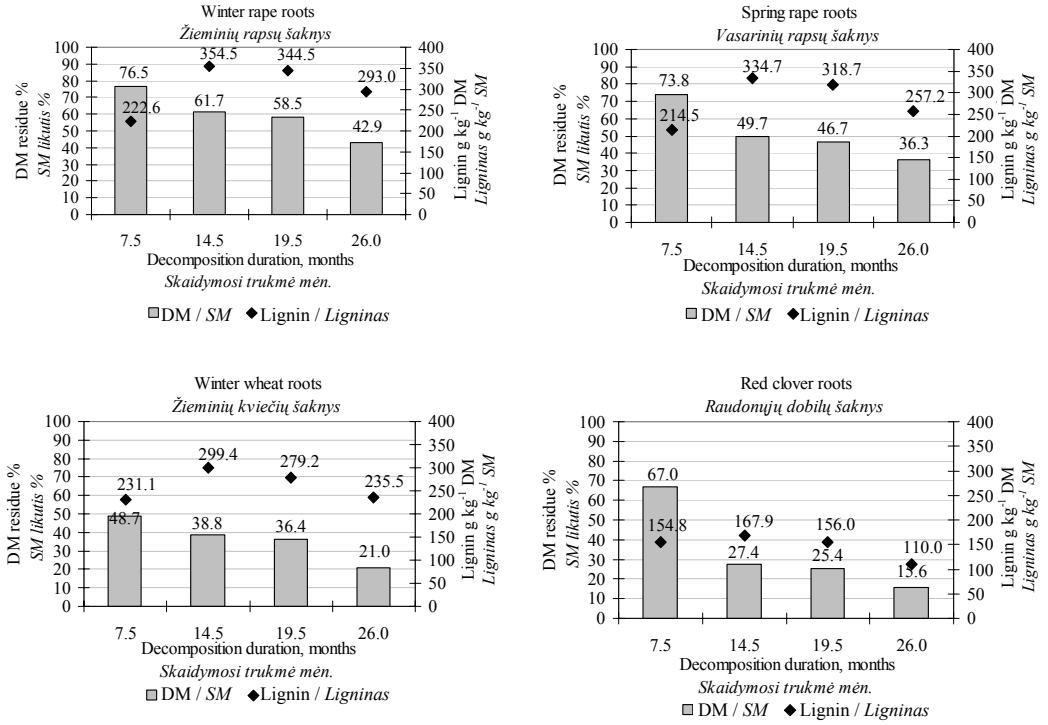

Figure 2. Biodestruction rate of crop root residues (LSD_{05} = 2.42) in soil and lignin concentration (LSD_{05} = 16.15)

2 paveikslas. *Augalų šaknų liekanų biodestrukcijos intensyvumas (R_{05} = 2,42) dirvožemyje ir lignino koncentracija (R_{05} = 16,15)*

LUA Experimental Station / *LŽŪU bandymų stotis, 2004–2006 m.*

During 14.5 months of crop residue decomposition, the concentration of lignin in it was relatively increasing, because of intensive decomposition of readily degradable components of crop residues immediately after incorporation into soil. More intensive biodestruction of lignin in crop residues started after 14.5 months and its concentration started to decrease; after 26 months in all crop residues lignin concentration significantly decreased from its highest value (Figures 1, 2). The highest amount of lignin was degraded in red clover residues: in stubble 42.1%, in roots 34.5% and in spring and winter rape threshing remains 35.0 and 28.5%, respectively. At the end of the study (after 26 months), the highest amount of colony forming units of cellulose-degrading micromycetes was isolated from the residues of these crops as well. The lowest decomposition rate of lignin was identified in the roots of winter rape – after 26 months its concentration declined by 17.4% from the maximal value. It is noteworthy that fewer cellulose-degrading micro-organisms (851.8 thous. g^{-1} DM) were identified on these residues than on the roots of other crops.

Table 3. The spread of cellulose-degrading micro-organisms and micromycete species on crop residues decomposing in soil during cold period of the year

3 lentelė. *Celiuliozinį substratą gebantys pasisavinti mikroorganizmai ir mikromicetų rūšys ant dirvoje skaidomų augalų liekanų šaltuoju metų laikotarpiu*

LUA Experimental Station / *LŽŪU bandymų stotis, 2004–2006 m.*

Micro-organisms and micromycete genera *Mikroorganizmai ir mikromicetų gentys*	Duration of crop residue decomposition in soil, months *Augalų liekanų skaidymosi trukmė mėn.*																			
	after 7.5 months *po 7,5 mėn.*										after 19.5 months *po 19,5 mėn.*									
	Aboveground part *Antžeminė dalis*							Roots *Šaknys*			Aboveground part *Antžeminė dalis*						Roots *Šaknys*			
	WRS[xxx]	WRTR	SRS	SRTR	WWS	RCS	WR	SR	WW	RC	WRS	WRTR	SRS	SRTR	WWS	RCS	WR	SR	WW	RC
	Number of species *Rūšių skaičius*																			
Acremonium			2						1										1	2
Aspergillus					1	1		1						1						
Fusarium				1		1											1			1
Mycelia sterilia					1				1		1	1	1	1	1	1	1	1	1	1
Myceliophthora												1								1
Mortierella	1					1				2	1	1	1	1		1				2
Mucor												1								3
Oidiodendron	1									1		1	1	1	1				1	
Pythium															1		1			
Penicillium	3	4	5	1	5	4	4	4	3	4	1	2			1	1			1	1
Rhizopus	1									1										
Trichoderma				1									2		1		1		1	
Other[x] *Kitos*	2	1	1		1			1			1	2				2	1			2
All genera *Iš viso genčių*	6	2	3	3	4	4	1	3	3	4	5	9	4	4	5	5	5	1	5	9
All species *Iš viso rūšių*	8	5	8	3	8	7	4	6	5	8	5	10	5	4	5	5	5	1	5	13
Actinomyces[xx]	0	2	1	1	1	1	0	1	1	0	1	2	2	2	2	2	1	2	2	2
Bacterium[xx]	1	1	1	1	1	1	1	1	1	0	2	2	2	2	2	2	1	2	2	1
Yeast *(Rhodotorula* etc)[xx] *Mielės*	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0

[x] – occasional micromycete genera (once isolated) / *atsitiktinės (vienkartinio pasireiškimo) mikromicetų gentys*: *Arthroderma*, *Botryotrichum*, *Chrysosporium*, *Cladosporium, Gonatobotrys*, *Phoma*

[xx] – 0 – not isolated / *neaptikta*, 1 – isolated in one replicate / *aptikta 1 pakartojime*, 2 – isolated in two replicates / *aptikta 2 pakartojimuose.*

[xxx] – WRS – winter rape stubble / *žieminių rapsų ražienojai*, WRTR – winter rape threshing remains / *žieminių rapsų kūlenos*, SRS – spring rape stubble / *vasarinių rapsų ražienojai*, SRTR – spring rape threshing remains / *vasarinių rapsų kūlenos*, WWS – winter wheat stubble / *žieminių kviečių ražienojai*, RCS – red clover stubble / *raudonųjų dobilų ražienojai*, WR – winter rape / *žieminiai rapsai*, SR – spring rape / *vasariniai rapsai*, WW – winter wheat / *žieminiai kviečiai*, RC – red clover / *raudonieji dobilai.*

In our study we also identified species and seasonal variation of micromycetes capable of assimilating cellulosic substrate (Tables 3, 4). In both experimental years, species composition of cellulose-degrading micromycete communities was found to be much more diverse during the warm periods compared with that during the cold ones. During the warm period of the year there were identified cellulose-degrading micromycete species belonging to 46 genera. Isolates of 23 genera were identified only once and were attributed to occasional. During the cold period of the year, micromycetes belonging to 18 genera were identified on the crop residues decomposing in soil, of which 6 genera were attributed to occasional. During the warm period of the year, the highest number of micromycete species was identified from *Penicillium*, *Acremonium*, *Chrysosporium*, *Trichoderma* genera, while during the cold period, the most numerous were only *Penicillium* fungi. *Mycelia sterilia* can be attributed to the constant components of micromycete communities tested. Its incidence was identified on almost all crop residues tested, irrespective of the season of the year.

Table 4. The spread of cellulose-degrading micro-organisms and micromycete species on crop residues decomposing in soil during warm period of the year
4 lentelė. *Celiuliozinį substratą gebantys pasisavinti mikroorganizmai ir mikromicetų rūšys ant dirvoje skaidomų augalų liekanų šiltuoju metų laikotarpiu*
LUA Experimental Station / *LŽŪU bandymų stotis, 2004–2006 m.*

Micro-organisms and micromycete genera *Mikroorganizmai ir mikromicetų gentys*	Duration of crop residue decomposition in soil, months *Augalų liekanų skaidymosi trukmė mėn.*																			
	after 14.5 months *po 14,5 mėn.*										after 26.0 months *po 26,0 mėn.*									
	Aboveground part *Antžeminė dalis*						Roots *Šaknys*				Aboveground part *Antžeminė dalis*						Roots *Šaknys*			
	WRS[xxx]	WRTR	SRS	SRTR	WWS	RCS	WR	SR	WW	RC	WRS	WRTR	SRS	SRTR	WWS	RCS	WR	SR	WW	RC
	Number of species *Rūšių skaičius*																			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Acremonium	1	1			1			1	1	3	1	3			1	1			1	2
Aspergillus					1	1				1										
Chaetomium															2					
Chrysosporium	1					1			1											
Cladosporium		2	1	1	2	2					1	1	1		1					
Exophiala		1	1			1														
Fusarium					2				2			1								
Geomyces											1	1	1							
Geotrichum									1							1				
Gliocladium												1				1				1
Hormiscium												1							1	
Mycelia sterilia	1	1	1	1	1	1	1	1		1		1	1	1	1	1		1	1	1
Myceliophthora							1		1	1		1	1							

Table 4 continued
4 lentelės tęsinys

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Mortierella							1	1	1		1			1	1	1	2	1		2
Mucor									1			1			1	2				
Paecilomyces		1	1										1						2	1
Penicillium	4	4	6	3	1	3	1	1		3		2		1		1	1			2
Pythium					1		1	1												
Sepedonium						1				1										
Torula						1					1				1					
Trichoderma	1			2			1				1	3	1	2	2	3	4			1
Verticillium											1									3
Other[x] *Kitos*	1	1	2	1	1	3	2		1	4				1	2	3	3			2
All genera *Iš viso genčių*	6	7	7	5	8	11	8	5	8	10	8	12	6	5	10	11	6	2	4	10
All species *Iš viso rūšių*	9	11	12	7	10	14	8	5	9	14	8	17	6	6	12	14	10	2	5	15
Actinomyces[xx]	1	1	1	2	1	2	1	2	2	1	2	2	2	2	2	2	2	2	2	1
Bacterium[xx]	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2
Yeast *(Rhodotorula* etc)[xx] / *Mielės*	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0

[x] – occasional micromycete genera (once isolated) / a*tsitiktinės (vienkartinio pasireiškimo) mikromicetų gentys*): *Absidia*, *Alternaria*, *Arthrinium*, *Aureobasidium*, *Botrytis*, *Colletotrichum*, *Coremiella*, *Dispira*, *Emmonsia*, *Gonytrichum*, *Masoniella*, *Metarhizium*, *Myrothecium*, *Oidiodendron*, *Periconia*, *Phialophora*, *Plectosphaerella*, *Rhizopus*, *Septoria*, *Synnematium*, *Sporothrix*, *Tilachlidium.*
[xx], [xxx] – explanations under Table 3 / *paaiškinimai po 3 lentele.*

Among the micromycetes isolated on cellulosic medium the most prevalent were isolates of *Acremonium strictum* W. Gams, *Cladosporium cladosporioides* (Fresen.) G. A. de Vries, *Geomyces pannorum* (Link) Sigler et J. W. Carmich., *Trichoderma hamatum* (Bonord.) Bainier, *Mortierella polycephala* Coem*,* species. During the warm period of the study, the number of micromycetes belonging to *Torula*, *Geomyces*, *Geotrichum*, *Verticillium* genera, characterised by ligninolytic activity /Bridžiuvienė et al., 1997/, increased. Bacteria and actinomycetes were isolated on cellulosic medium from all crop residues tested, while yeast only in exceptional cases.

During all experimental periods, the highest species diversity of cellulose-degrading micromycetes was identified on clover stubble and roots also on winter and spring rape threshing remains, while the lowest diversity was found on winter and spring rape roots.

During crop residue biodestruction the population composition of cellulose-degrading micromycetes varied – the species identified during the first experimental periods disappeared and the new ones emerged. This is especially characteristic of micromycetes of *Penicillium* genus. After 19.5 months of residue decomposition, the high incidence of the micromycetes of this genus decreased.

The physiological activity of micromycetes is determined by many factors of which nitrogen concentration and substrate pH are of special importance and whose optimum is up to 24 mM and 4.0–4.5, respectively. With increasing values of these indicators the energy of micromycetes is inhibited /Kirk et al., 1978/. The close to neutral soil reaction (pH 6.7) was not favourable for the development of fungi, therefore the incidence of some micromycete species decreased at the end of the experiment.

One of white rot causal agents – *Fusarium solani* Mart. Appel et Wollenw. was isolated from clover and wheat residues already at the beginning of biodestruction. It was found that for these fungi lignin degraded by them is the only source of carbon /Norris, 1980/. It has been reported that the incidence of some species of *Fusarium* genus is inhibited by the secondary metabolites released by certain fungi species of *Trichoderma* genus /Salina, Lugauskas, 2002/. In our study, at the end of the experiment a high incidence of fungi of *Trichoderma hamatum* and *T. spirale* Bissett species was identified on crop residues, which was one of the reasons why the number of micromycetes of *Fusarium* species declined and *F. solani* fungi disappeared. The variation of micromycete species was found to be strongly dependent on their nutrient substrate (crop residue), since for some micro-organisms lignin is a source of energy, while others need a substrate of readily degradable organic compounds for lignin degradation. Some organisms partly metabolise lignin, while others use lignin carbon for their cell structure building.

Conclusions

1. While applying different technologies in agriculture and choosing crops for crop rotations, one should take into account the peculiarities of crop residue biodestruction in soil and effects on the formation of the structure of micro-organism communities.

2. The highest amount of micro-organism colony forming units, diversity and incidence of micro-organisms capable of assimilating cellulosic substrate were identified on red clover stubble and root residues decomposing in soil, as well as on winter and spring rape threshing remains. After 26 months of crop residue incubation in soil, the highest amount of lignin from its maximum concentration was degraded in red clover stubble (42.1%), in spring and winter rape threshing remains (35.0 and 28.5%, respectively). Accordingly, those residues were decomposed most. The roots of red clover and lignin present in them were decomposed (accordingly 84.4 and 34.5%) more than those of other plants. The roots of winter rape and lignin in it on the contrary were decomposed the least (accordingly 57.1 and 17.3%).

3. With increasing the period of crop aboveground part and red clover root residue decomposition, the amount of micro-organisms capable of assimilating cellulosic substrate increased. Statistically significant negative correlation was established between the number of colony forming units of those micro-organisms and crop residue decomposition rate.

4. During the warm period of the year, there were isolated cellulose-degrading micromycetes belonging to 46 genera. During the cold period of the year, their species diversity tended to decrease, and there were identified micro-organisms belonging only to 18 genera. The highest number of micromycete species was identified from *Peni-*

cillium, *Acremonium*, *Chrysosporium*, *Trichoderma* genera. *Mycelia sterilia* can be attributed to the constant components of micromycete communities tested. The population composition of cellulose-degrading micromycetes varied – the species identified during the first experimental periods disappeared and the new ones emerged.

Received 09 12 2008
Accepted 13 02 2009

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ISSN 1392-3196
Žemdirbystė-Agriculture, t. 96, Nr. 1 (2009), p. 113–126
UDK 631.461:631.879:631.826

CELIULIOZĘ SKAIDANČIŲ MIKROORGANIZMŲ POVEIKIS AUGALŲ LIEKANŲ IR LIGNINO BIODESTRUKCIJAI DIRVOŽEMYJE

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Santrauka

Augalų liekanų skaidymosi tyrimai atlikti 2004–2006 m. modelinių lauko bandymų metu LŽŪU bandymų stotyje, drenuotame giliau karbonatingame sekliai glėjiškame rudžemyje (RDg8-k2). Tirtos žieminių ir vasarinių rapsų, žieminių kviečių ir raudonųjų dobilų antžeminių dalių bei šaknų liekanos, dirvoje laikytos įvairios trukmės laikotarpius (7,5, 14,5, 19,5 ir 26,0 mėn.). Tyrimų tikslas – nustatyti mikroorganizmų, gebančių pasisavinti celiuliozinį substratą, paplitimą ant šių liekanų, taip pat mikromicetų bendrijų rūšinės sudėties kintamumą bei poveikį augalų liekanų ir jose sukaupto lignino skaidymo intensyvumui.

Mikroorganizmų paplitimas priklausė nuo augalų liekanų rūšies. Po 26 mėn. augalų liekanų inkubacijos dirvoje daugiausia lignino nuo maksimalios lignino koncentracijos suiro raudonųjų dobilų ražienojuose (42,1 %) ir vasarinių bei žieminių rapsų kūlenose (atitinkamai 35,0 bei 28,5 %). Taip pat šios liekanos buvo labiausiai suirusios ir ant jų nustatyta daugiau celiuliozę skaidančių mikroorganizmų pradų nei ant kitų antžeminių liekanų. Raudonųjų dobilų šaknys ir ligninas jose buvo suiręs (atitinkamai 84,4 bei 34,5 %), o celiuliozę skaidančių mikroorganizmų buvo daugiau nei ant kitų augalų šaknų. Žieminių rapsų šaknys ir ligninas, atvirkščiai, buvo suskaidytas mažiausiai – atitinkamai 57,1 bei 17,3 %.

Ilgėjant augalų antžeminių liekanų ir raudonųjų dobilų šaknų skaidymosi dirvožemyje trukmei, didėjo mikroorganizmų, gebančių pasisavinti celiuliozinį substratą, gausa. Nustatyta esminė neigiama koreliacija tarp celiuliozę gebančių pasisavinti mikroorganizmų pradų kiekio ir augalų liekanų susiskaidymo procento.

Šiltuoju metų laiku celiuliozę pasisavinantys mikromicetai išskirti iš 46 genčių. Šaltuoju metu laiku šių mikromicetų rūšių įvairovė mažėjo – rūšys identifikuotos tik iš 18 genčių.

Reikšminiai žodžiai: augalų antžeminių dalių ir šaknų liekanos, skaidymasis, mikroorganizmai, ligninas, koreliacija.