THE EFFECT OF SWARD MANAGEMENT ON CELLULOSE DECOMPOSITION AT FLOODPLAIN MEADOW*

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The effect of mowing and mulching frequency on microbiological soil activity of floodplain meadow was studied during the years 2004 to 2006. The experiment was carried out on a permanent meadow of *Alopecuretum* community type near the village of Černíkovice (363 m a.s.l.). Following five treatments were evaluated: mowing once and twice a year, mulching once and twice a year; fallow. Cellulose decomposition during a vegetation season (April to October) and the whole year was evaluated. Results show that the highest microbial celulose occurred on the once mulched plots ($P = 0.012$) while the lowest on fallow. Once mulched plots recorded 54% higher decomposition compared to fallow and 6% higher decomposition in comparison to once cut plots. The decomposition of cellulose was also significantly dependent on the year. The highest microbial cellulose decomposition was observed in the warm year 2006 ($P = 0.015$). The relatively high decomposition rates took place even in the winter period probably due to soil washing by precipitation and melting water, not only due to microflora activity.

meadow; fallow; cutting; mulching; soil; cellulose decomposition

INTRODUCTION

Grasslands have a high soil organic matter content that supplies (after mineralization) plant with nutrients, increases soil aggregation, limits soil erosion and also increases the soil microbial activity (Miller, Donahue, 1990). From 60 to 90% of the net primary production and about 90% of the secondary production of the grassland take part in the soil: as the roots or microorganisms (Stanton, 1988). The soil organisms may act as one of the limiting factors to grasslands productivity (Rychnovská et al., 1993). Previous studies of meadow grasslands have suggested that management-caused shift in the composition of the soil microbial community led to improvements in the efficiency of nutrient cycling and decomposition processes in the grasslands (Bardgett, McAlister, 1999).

Complex carbohydrates as cellulose – $(C_6H_{10}O_5)_n$ formed of microfibrils of glucose molecules – is fundamental part of the plant tissue. Cellulose is a prominent carbonaceous constituent of higher plants and probably the most abundant organic compound in nature. Different substrates were often used as the model material for measuring the decomposition activity in soils in previous research studies (Velich et al., 1968; Rychnovská, 1987). Rychnovská et al. (1985) mentioned the results of Úlehlová et al. (1976) and Hundt, Unger (1968), who used a cellulose substrate in the form of filter paper to measure the cellulose decomposition intensity in different types of plant associations. They found the cellulose decomposition activity increased with higher vegetation productivity as well as depended on moisture, temperature and type of soil (Stanton, 1988).

Šimek et al. (2001) found in an experiment focused on the rate of cellulose decomposition in the soil that in mulched and abandoned plots the cellulose decomposition was lower than in mowed treatments. They therefore concluded that the change of grassland management from mowing to mulching or abandonment could cause changes in soil microbial community and in nutrient cycling in a relatively short time-period. In the contrary, the cellulose decomposition and mineralization rates were significantly higher in the mulched and abandoned plots in comparison to the mowed plot on the oligotrophic plant community of the grassland (Uhlířová et al., 2005).

Defoliation was reported to increase rhizodeposition, which positively influenced the size and activity of the soil biotic community (Rice et al., 1996) and consequently the cellulose decomposition rate in mowed meadows (Holland, 1996; Hamilton, Frank, 2001). Bargett et al. (1998) reported a positive effect of plant defoliation on microbial biomass and improved nutrient cycling. Also increase in C-use efficiency was observed (Guitian, Bargett, 2000).

In aquatic environment the intensity of cellulose decomposition can be very high reaching up to 30 $mg.g^{-1}.day^{-1}$ (Úlehlová et al., 1976). Meneses (2005) concluded that the decomposition rate on mesohygrophytic meadow was about 20% higher during vegetation season compared to winter.

In this study we evaluated the effect of different frequencies of mowing and mulching in meadow stand on the activity of cellulose decomposition microflora in years 2004, 2005 and 2006 after 4 or 6 years, respectively.

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MATERIAL AND METHODS

The study was carried out on a meadow near the village of Černíkovice, district of Benešov (363 m a.s.l., 49° 47′ N, 14° 45′ E). The experiment was established in spring 2001. Mean annual precipitation of the locality is 617 mm and mean annual temperature is 7.8 °C. The vegetation belongs to the foxtail stand type. The water regime of the stand is mesohygrophytic with fluctuating underground water level.

Following treatments were evaluated: mowing once a year, mowing twice a year, mulching once a year, mulching twice a year and fallow. The whole stand was not fertilized. There were four replications per treatment with the plot size of 5 x 4.5 m. Two cellulose tests from each plot were taken out of the soil after 6 months of vegetation season (from April to October) another two tests were withdrawn after 12 months in April in years 2004, 2005 and 2006. The dates of maintenance and samplings are presented in Table 1. The rest of the cellulose was separated from soil particles by washing. Then it was dried at 65 °C for 24 hours and weighed. Based on the difference between initial and final weight (g) the decomposition rate (%) was computed for vegetation season and whole year.

The statistical evaluation using the ANOVA model and Tukey HSD multiple comparison procedure was done to research the effect of management type (mowing, mulching and fallow) and defoliation frequency on the activity of soil at a depth of 150 mm.

RESULTS AND DISCUSSION

The decomposition of cellulose was significantly dependent on the management type. A significant difference was found between managed and abandoned treatments (Table 2). The highest microbiological intensity and decomposition was found on the once mulched plots (P = 0.012), on the other hand, the lowest decomposition occurred on fallow. Once mulched plots recorded 54% higher decomposition compared to fallow and 6% higher decomposition in comparison to once cut plots. The lowest microbiological intensity on the parcels without defoliation is in accordance with many other studies (Rice, Smith, 1983; Rychnovská, 1993). Higher decomposition intensity on mulched and mowed meadows could be explained due to enhanced physical and microbiological soil characteristics. On the contrary very high cellulose decomposition under black fallow was documented in some works (Tempest, Neijssel, 1978). This may be explained by to lack of native easily degradable carbon supply in non-harvested plots and a rapid and intense activity of cellulose decomposing microorganisms when cellulose substrate was available. Nutrient addition on mulched plots was also reported to have significant effect on cellulose decomposition activity (Uhlířová et al., 2005).

Twice mulched plots recorded 10% higher decomposition compared to once mulched plots and twice cut plots recorded 19% higher decomposition compared to once cut plots.

Average cellulose decomposition intensity ranged from 28 to 52% for vegetation season depending on management type (Table 3). These values did not differ from results of Meneses (2005) gained on the same study site three years ago. Bardgett et al. (1998) reported a positive effect of plant defoliation on microbial biomass with improved nutrient cycling and increased C-use efficiency. The decomposition of cellulose did not differ significantly on the mowing and mulching treatments. A similar pattern of cellulose decomposition observed under mowing and

Table 1. Terms of exposition of the cellulose samples tester insertion and withdrawal in 2004 to 2006

Test exposition for vegetation season	Test exposition for year	Time of harvest (cut or mulch)
14. 4. 2004 – 15. 10. 2004	14. 4. 2004 – 17. 4. 2005	1st harvest 18th April 2nd harvest 20th October
17. 4. 2005 – 15. 10. 2005	17. 4. 2005 – 10. 4. 2006	1st harvest 19th April 2nd harvest 16th October
10. 4. 2006 – 16. 10. 2006	10. 4. 2006 – 15. 4. 2007	1st harvest 19 April 2nd harvest 16th October

Table 2. The effect of year, period and management type on cellulose decomposition, ANOVA results

	Df	F	P	Multiplate comparison
Year	2	4.32	0.015	2004, 2005 < 2006
Season	1	319.1	0	vegetation < year
Management	4	3.32	0.012	fallow < 1x mulch, 2x mow
Year x season x management	8	2.01	0.049	
Year x season	2	30.14	0	
Season x management	4	7.56	0	
Year x managemant	8	1.93	0.06	

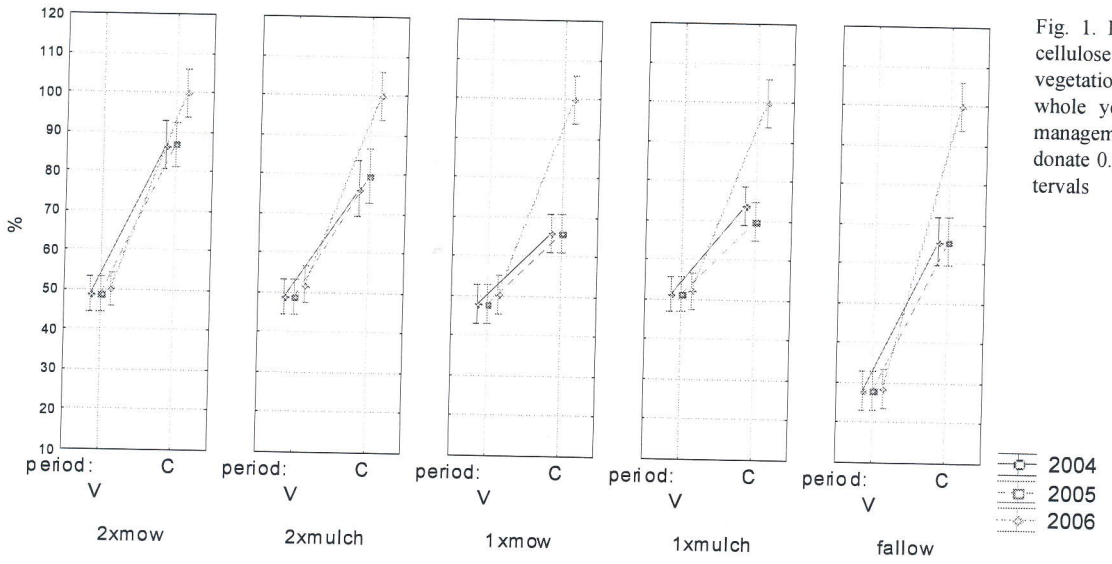

Fig. 1. Decomposition of cellulose (%) during: V – vegetation season, C – the whole year; for different management. Vertical bars donate 0.95 confidence intervals

Table 3. Average decomposition of cellulose (%) for the seasons of 2004 to 2006

Treatment	Frequency	Share decomposition of cellulose during:		
		Year (%)	Vegetation season (%)	Vegetation season/Year (%)
Mow	1x	74.4	48.8	65.6
Mow	2x	90.8	49.4	54.4
Mulch	1x	78.7	51.7	65.6
Mulch	2x	86.8	50.0	57.6
Fallow	–	77.1	28.3	36.4

mulching treatments acknowledged Saroa and Lal (2003). Neither the frequency of management caused significant difference in decomposition rate (Table 2).

The microbial intensity depends also on climatic condition (temperature and precipitation) and soil characteristics (Bardgett, McAlister, 1999). Microbial intensity is supported by higher precipitation and higher temperature. More intense microbial activity was discovered in sandy soil and loamy soil compared to fen soil (Duffková, 2002). The decomposition of cellulose was also significantly dependent on the year (Table 2). The higher microbiological intensity and defoliation was observed during 2006 ($P = 0.015$). That could be explained by different (warmer) climate conditions of 2006 vegetation season and winter 2006/2007 with higher soil moisture content. It was previously reported that, taking into account the variability of soil moisture content and water reserve, the differences resulting from different systems of grassland management are statistically insignificant (Kvítek et al., 1998).

The decomposition of cellulose was significantly different ($P < 0$) for the period of vegetation season and the whole year (Table 2). Observed cellulose decomposition values are summarized in Table 3 and Fig. 1. The relatively high decomposition rate of cellulose during the winter season was probably caused by water regime during that period of year. Locality is situated in the low elevation where rainfall occurs frequently and several melting episodes usually took place during the winter (Daňhelka, Honsová, 2006). Therefore the decomposition rate increased due to frequent washing of soil by precipitation and melting water not only due to high microflora activity.

CONCLUSION

The microbiological activity of the soil was observed and evaluated on the mesohygrophytic permanent meadow for different management types using cellulose decomposition test. Results proved the increase of cellulose decomposition in managed treatments comparing to the abandoned treatment and interannual differences in decomposition rate. Relatively high decomposition takes place even in winter period due to specific water regime. The activity of cellulose decomposing as well as soil-forming process increased in the response to sward management. From that perspective mulching could be recommend as a suitable technique of management.

REFERENCES

BARDGETT, R. D. – McALISTER, E.: The measurement of soil fungal: bacterial biomass rations as an indicator of ecosystem self-regulation in temperate meadow grasslands. Biol. Fert. Soils, *29*, 1999: 282–290.

BARDGETT, R. – WARDLE, D. – YEATES, G.: Linking aboveground and belowground interactions: some plant responses to foliar herbivore influence soil organisms. Soil Biol. Biochem., *30*, 1998: 1867–1878.

DAŇHELKA, J. – HONSOVÁ, D.: Climate impact on yields of permanent grassland. In: Sbor. VI. Roč. mezin. vědecké konf. Agroregion 2006: 20–23.
DUFFKOVÁ, R.: The effect of rainfall and extensive use of grasslands on water regime. Rostl. Výr., *48*, 2002: 89–95.
HAMILTON, E. – FRANK, D.: Can plants stimulate soil microbes and their own nutrient supply? Evidence from grazing tolerant grass. Ecology, *82*, 2001: 2397–2402.
HOLLAND, J. N.: Effect of aboveground herbivory on soil microbial biomass in conventional and no-tillaged agroecosystems. Appl. Soil Ecol., *2*, 1996: 257–279.
HUNDT, R. – UNGER, H.: Untersuchungen über die zellulolytische Aktivität unter Grunlandgesellschaften. Tag. Ber. der DALW, Berlin, *98*, 1968: 142–144.
GUITIAN, R. – BARDGETT, R. D.: Plant and soil microbial responses to defoliation in temperate semi-natural grasslands. Plant Soil, *14*, 2000: 271–277.
KVÍTEK, T. – KLÍMOVÁ, P. – ŠONKA, J.: The effect of mulching on botanical composition and species representation in grassland, evapotranspiration and soil moisture content. Rostl. Výr., *44*, 1998: 553–560.
MENESSES, L. F.: Effect of meadow management on species diversity, aboveground phytomass yield and sodding process. [Thesis.] Praha, 2005. 88 pp.
MILLER, R. W. – DONAHUE, R. L.: Soils. Engelwood Cliffs, New Jersey, USA, Prentice Hall 1990. 248 pp.
RICE, R. W. – SMITH, M. S.: Nitrification of fertilizer and mineralized amonium in no-till and plowed soil. Soil Sci. Soc. Am. J., *47*, 1983: 1125–1129.
RICE, C. W. – MOORMAN, T. B. – BEARE, M.: Role of microbial biomass carbon and nitrogen in soil quality. In: DORAN, J. W. – JONES, A. J.: Methods for Assesing Soil Quality. SSSA Special Publication No. 49. Soil Science Society of America, Madison, Wisconsin, 1996: 203–215.
RYCHNOVSKÁ, M.: Methods of study of grassland ecosystems. Praha, Academia 1987: 104–108.
RYCHNOVSKÁ, M. et al.: Ecology of grassland. Praha, Academia 1985. 291 pp.
RYCHNOVSKÁ, M. et al.: Structure and functioning of semi-natural meadows. Praha, Academia 1993: 133–136.
SAROA, G. S. – LAL, R.: Soil restorative effect of mulching on aggregation and carbon sequestration in miamian soil in central Ohio. Land Degradation Dev., *14*, 2003: 481–493.
STANTON, N. L.: The underground in grasslands. Ann. Rev. Ecol. Syst., *19*, 1988: 573–589.
ŠIMEK, M. – ŠANTRŮČKOVÁ, H. – UHLÍŘOVÁ, E. – ZÁHORA, J. – PICEK, T. – BRYCHTOVÁ, L. – ŠETLÍK, J.: The effect of management practice of montane meadows in the Bohemian Forest on selected soil biological and chemical properties. Silva Gabreta, *7*, 2001: 69–78.
TEMPEST, D. – NEIJSSEL O.: Eco-physiological aspects of microbial growth in aerobic nutrient-limited environments. Adv. Mikrob. Ecol., *2*, 1978: 105–153.
UHLÍŘOVÁ, E. – ŠIMEK, M. – ŠANTRŮČKOVÁ, H.: Microbial transformation of organic matter in soils of montane grasslands under different management. Appl. Soil Ecol., *28*, 2005: 225–235.
ÚLEHLOVÁ, B. – KLIMO, E. – JAKLOVÁ, J.: Mineral cycling in alluvial forest and meadow ecosystems in southern Moravia, Czechoslovakia. Int. J. Ecol. Environ. Sci., *2*, 1976: 15–25.
VELICH, J. – ŠTRÁFELDA, J. – PRAJZLER, J. – BĚLOHOUBEK, A.: The effect of fertilization on biological activity of grassland soils and yielding of different types of grasslands. Rostl. Výr., *14*, 1968: 233–241.

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Vliv obhospodařování na rozklad celulózy lučního porostu.

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V letech 2004 až 2006 byl zkoumán vliv rozdílného obhospodařování trvalé louky psárkového porostového typu na aktivitu půdních mikroorganismů prostřednictvím rychlosti a míry dekompozice celulózy. Pozorovány byly varianty: 1x seč, 2x seč, 1x mulč, 2x mulč a úhor (neobhospodařovaná varianta). Celulolytické testy byly do půdy vkládány na jaře (duben), polovina z nich byla vyjmuta na konci vegetačního období (říjen), ostatní byly v půdě ponechány po celý rok. Výsledky ukazují na vyšší mikrobiální aktivitu v půdě na obhospodařovaných variantách oproti úhoru. Nejvyšší rozklad nastal na jednou ročně mulčované variantě, naopak nejnižší byl zaznamenán na úhorové variantě ($P = 0.012$). Na jednou ročně mulčované variantě byla míra rozkladu celulózy o 54 % vyšší než na úhoru a o 6 % vyšší než na jednou ročně sečené variantě. Vliv frekvence mulčování a sečení na intenzitu rozkladu celulózy průkazný nebyl. Naopak průkazný byl vliv ročníku, kdy v teplém roce 2006 byla zjištěna vyšší intenzita rozkladu než v předešlých letech ($P = 0.015$). Značná část celoroční dekompozice byla realizována v mimo vegetačním období, což lze vysvětlit intenzivním promýváním půdy srážkami a odtávajících sněhem.

louka; úhor; sečení; mulčování; půda; rozklad celulózy

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