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SOIL MICROBIAL ACTIVITY UNDER DIFFERENT MANAGEMENT

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Summary

The effects of integrated (IS) and ecological (ES) management of soil on the biomass of microorganisms (C_{mic}) and dehydrogenase activity (DHA) were investigated in the period 1999-2000. The soils used were collected from a stationary experiment established in 1990 on gley brown soil at the Experimental Station of the Slovak Agricultural University, Nitra. For each field with a different structure of crops two fertilization treatments were used : (a) no fertilization and (b) use of manure for silage maize and, within IS, also mineral fertilizers for balancing. A higher amount of microbial biomass (C_{mic}) in terms of absolute values was noted for ES but without statistical significance. Cultivated crops and the timing of soil sampling were found to have the greatest effect on the parameters observed in individual experimental years and within the two systems of soil management.

Key words: soil microbial biomass, enzymatic activity of soil, dehydrogenase, integrated management of soil, ecological management of soil

Introduction

In the recent years many works have been published in which alternative and conventional systems are compared and evaluated from different aspects (Beyer et al., 1993; Kandeler et al., 1999). The most often used parameters which are used to assess the soil biological activity is an amount of microbial biomass (Šatrůčková, 1993), which is usually supplemented with determination of the enzyme activity (Šíša, 1993; Beyer et al., 1993). A choice of sensitive indicators of the soil quality reflecting the effects of soil management should also help those who cultivate soil and take an active part in sustainability of agro-ecosystems.

Material and methods

Within the stationary experiment established on gley brown soil, the effects of two systems of soil management, namely the integrated system (IS) and the ecological system (ES), on soil biological activity were observed in the above mentioned type of soil during the growing period of 1999 - 2000. The fields chosen from the experiment to study soil biological activity are given in Table 1. For each of these fields two treatments of fertilizing were used: (a) no fertlization and (b) organic fertilization using manure for silage maize and within IS, it was also supplemented with mineral fertilizers for the purposes of balancing. Soil samples were collected 5 - 6 times in a depth of 0 - 0.2 m during the vegetation period. After being passed through a 2 mm sieve, they were analysed for:
- basic soil characteristics: oxidizable organic carbon (C_{ox}), total nitrogen (N_t), pH active and exchangeable;
- biomass carbon of soil microorganisms (C_{mic}) (Vance et al., 1987);
- dehydrogenase activity (DHA) (Casida et al., 1964);

For the statistical evaluation of results, the χ^2 test of good conformity was used, then analysis of variance was used for comparing means of the basic set and Scheffe test for testing the differences in means (Stehlíková, work being at the printers).

Table 1 Crop rotation in chosen fields of integrated and ecological systems

Year	Integrated system			Ecological system		
	Field I	Field V	Field VII	Field II	Field V	Field VII
1999	bean + alfalfa	spring barley	winter wheat	bean + alfalfa	pea	winter wheat
2000	Alfalfa	winter wheat	silage maize	Alfalfa	silage maize	pea

Results and discusssion

One of the parameters which is most often studied for the purposes of evaluating the biological status of soil is an amount of microbial biomass

Table 2 Basic soil characteristics within the integrated and ecological system soil management (average values)

Soil Management	Year	C_{ox} [%]	N_t [%]	$pH_{(H2O)}$	$pH_{(KCl)}$	C_{mic}	DHA
IS+ fert.a	1999	1.21	0.138	6.62	5.32	168.17	5.00
	2000	1.20	0.163	6.98	5.19	169.67	5.53
IS+fert.b	1999	1.31	0.144	6.66	5.40	172.59	5.04
	2000	1.36	0.170	6.46	5.37	157.30	6.19
ES+fert.a	1999	1.25	0.146	6.58	5.30	164.41	5.42
	2000	1.27	0.167	6.40	5.43	213.37	6.13
ES+fert.b	1999	1.29	0.151	6.62	5.39	167.61	5.70
	2000	1.28	0.166	6.47	5.41	184.56	5.59

C_{mic} in mg per kg dry soil
DHA in μg TPF per g dry soil per hour
IS = integrated system of soil management
ES = ecological system of soil management
fert. = fertilization

(Šantrůčková, 1993). According to our results, the differences in an amount of biomass between IS and ES only occured in the second experimental year (Table 2). The absolute values within ES were 35.48 mg C.kg $^{-1}$ higher on average, but without statistical significance, in the fields where alfalfa, silage maize and pea (*Pisum sativum*) were grown. An influence of the quality and amount of plant residues ploughed in soil has been confirmed for both of the systems (Table 3). Within IS, the crops with statistical significance affected the quantity of biomass in either of the experimental years, the greatest values being determined for the soil under alfalfa in the year 2000 (199.28 mg C.kg $^{-1}$ dry soil) and under bean with undersown alfalfa in 1999 (187.3 mg C.kg $^{-1}$ dry soil). As far as ES is concerned, the significant effect of crops was observed in 1999, with the highest value for the soil under wheat 184.38 mg C.kg^{-1} dry soil). The dynamics of biomass within individual experimental years as well the systems of soil management was affected by the time factor, i.e. the timing of soil sampling. There was no statistical significance of differences between fertilization treatments (a, b).

Many authors consider the determination of soil microbial biomass together with enzyme activities to be a sensitive and suitable indicator of changes in the influence of anthropogenic interventions. However, the views on suitability of the use of individual parameters are different.

Based on our measurements, in spite of non-significant differences between the two systems of soil management for 2 years of observations (Table 3), we can indicate that DHA is a good indicator of general physiological processes of soil microflora. It sensitively reacts to changes in a supply of organic substances to soil in the form of after-harvest residues and root secretions. Also, changes in an amount of DHA by soil microflora have supported this fact. Within ES, the effect of crop was highly significant in both of the experimental years, with the highest values for the soil under wheat in 1999 (9.84 μg TPF per g dry soil per hour) and under alfalfa in 2000 (12.09 μg TPF per g dry soil per hour). As to IS, the significance was only confirmed in the year 2000 when higher values were determined for the soil under alfalfa and wheat in comparison with maize. The biological soil activity expressed by DHA was affected by the time factor (statistically significant at α = 0.01) in both years and within both the systems of soil management, the highest values being observed for the soil samples taken in September.

Table 3 Analysis of variance according to ANOVA for soil microbial biomass and soil dehydrogenase activity

Source of variability	Count	F	Test statistic	Significant level
Year 1999				
Soil microbial biomass				
Fertilization IS	18	1	0.31	0.59
Fertilization ES	18	1	0.21	0.66
Sampling IS	6	5	4.96	0.00++
Sampling ES	6	5	2.39	0.07
Crop IS	12	2	4.56	0.02+
Crop ES	12	2	9.85	0.00++
Soil dehydrogenase activity				
Fertilization IS	18	1	0.03	0.88
Fertilization ES	18	1	1.64	0.21
Sampling IS	6	5	42.04	0.00++
Sampling ES	6	5	29.78	0.00++
Crop IS	12	2	1.68	0.21
Crop ES	12	2	16.95	0.00++
Year 2000				
Soil microbial biomass				
Fertilization IS	15	1	1.01	0.33
Fertilization ES	15	1	3.24	0.09
Sampling IS	6	4	3.37	0.03+
Sampling ES	6	4	3.31	0.03+
Crop IS	10	2	11.10	0.00++
Crop ES	10	2	3.23	0.06
Soil dehydrogenase activity				
Fertilization IS	15	1	4.88	0.04+
Fertilization ES	15	1	5.83	0.03+
Sampling IS	6	4	37.15	0.00++
Sampling ES	6	4	116.02	0.00++
Crop IS	10	2	20.24	0.00++
Crop ES	10	2	45.92	0.00++

f-degree of freedom

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