INFLUENCE OF IRRIGATION AND CROP ROTATION COMBINATION ON THE ENZYMATIC ACTIVITIES IN A BROWN LUVIC SOIL

INFLUENȚA IRIGAȚIEI ȘI ROTAȚIEI CULTURILOR ASUPRA ACTIVITĂȚII ENZIMATICE DINTR-UN SOL BRUN LUVIC

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Abstract. *Soil enzyme activities (actual and potential dehydrogenase, acid and alkaline phosphatase) were determined in the 0-10-, 10-20- and 20-30-cm layers of a brown luvic soil submitted to a complex irrigation and crop rotation (2- and 3-crop rotations) experiment. Non-irrigation - in comparison with irrigation - resulted in significantly higher soil phosphatase activities in the 0-10-, 10-20- and 20-30-cm layers, whereas dehydrogenase activities were significantly higher in irrigated soil. The soil under wheat or maize was more enzyme-active in the 3- than in the 2- crop rotation and in the monoculture. Each activity in both non-irrigated and irrigated soil under wheat and maize crops was higher in the intermediate layer than in the upper, respectively deeper layers.*

Rezumat. *S-au urmărit efectele irigației şi rotației culturilor asupra activității microbiene globale reflectată prin activitatea dehidrogenazică şi asupra activității enzimatice: fosfataza acidă şi alcalină, la trei adâncimi în solul brun luvic:0-10-, 10-20- şi 20-30-cm. Activitatea dehidrogenazică este semnificativ mai mare în solul irigat, atât sub cultura de grâu cât şi sub cultura de porumb, în timp ce activitatea fosfatazică acidă şi alcalină prezintă valori mai ridicate în solul neirigat. Toate activitățile enzimatice studiate sunt mai ridicate sub culturile de grâu şi porumb din rotația de 3 culturi, în toate straturile analizate. Activitățile dehidrogenazică actuală şi potențială şi fosfatazică acidă şi alcalină prezintă valorile cele mai mari în stratul intermediar (10-20-cm) atât în solul irigat cât şi în solul neirigat.*

INTRODUCTION

Soil enzymes are important for catalyzing innumerable reactions necessary for life processes of microorganisms in soils (Pulford and Tabatabai, 1988) decomposition of organic residues, cycling of nutrients and formation of organic matter and soil structure (Dick, 1992). Although enzymes are primarily of microbial origin it can also be originate from plants and animals (Zelles et al., 1997). These enzymes are constantly being synthesized, could be accumulated, inactivated and/or decomposed in the soil, assuming like this, great importance for the agriculture for their role in the recycling of the nutrients (Balota et al.,2004; Bandick and Dick, 1999).

Soil enzymes activities have successfully discriminated between a wide range of soil management practices (Lovell et al., 1995; Samuel et al., 2005).

In order to obtain new data on the soil enzymological effects of management practices we have determined some enzymatic activities in a brown luvic soil submitted to a complex irrigation and crop rotation experiment at the Agricultural Research and Development Station in Oradea (Bihor county).

MATERIAL AND METHODS

The ploughed layer of the studied soil is of mellow loam texture, it has a pH value of 5.5, medium humus (2.32%) and P (22 ppm) contents, but it is rich in K (83 ppm).

The experimental field was divided into plots and subplots for comparative study of irrigation and non-irrigation and rotations of 2- and 3-crops. Each plot consisted of two subplots representing the irrigation and non-irrigation variants. The plots (and subplots) were installed in three repetitions.

In October 2006, soil was sampled from 0-10-, 10-20- and 20-30- cm depths of the subplots under wheat and maize crops. The soil samples were allowed to air-dry, then ground and passed through a 2-mm sieve and, finally, used for enzymological analyses.

Actual and potential dehydrogenase activities were determined according to the methods described in Drăgan-Bularda (1983). Dehydrogenase activities are expressed in mg of triphenylformazan (TPF) produced from 2,3,5-triphenyltetrazolium chloride (TTC) by 10 g of soil in 24 hours.

For determination of phosphatase activities, disodium phenylphosphate served as enzyme substrate (Drăgan-Bularda, 1983; Öhlinger, 1996). Phosphatase activities are expressed in mg phenol/g soil/2 hours.

The activity values were submitted to statistical evaluation by the two *t*-test (Sachs, 1968).

RESULTS AND DISCUSSIONS

Results of the enzymological analyses are presented in Table 1, and those of statistical evaluation are summarized in Table 2.

The effect of irrigation on the enzymatic activities in soil. Actual and potential dehydrogenase activities were significantly higher (at least at $p<0.05$) in the three soil layers analysed of the non-irrigated soil, excepting potential dehydrogenase activity in the deeper layer which was unsignificantly higher ($p>0.05$). These findings are valid under each crop.

The effect of crop rotation on the enzymatic activities in soil. For evaluation of this effect, the results obtained in the three soil layers analysed in the two subplots of each plot were considered together.

The soil enzymological effect of the same crop in the two rotations. As wheat and maize were crops in monoculture and both rotations, it was possible to compare the soil enzymological effect of the monoculture and of the 2- and 3-crop rotations. In the soil under wheat, the enzymatic activities were significantly higher in the 3-crop rotation than in the 2-crop rotation and monoculture. In the soil under maize, each activity was significantly higher (at least at $p<0.05$) in the 3-crop rotation.

The soil enzymological effect of different crop in the same rotation.

The monoculture. Potential dehydrogenase activity measured in the wheat soil exceeded significantly ($p<0.02$) the corresponding activities recorded in the maize soil, whereas actual dehydrogenase activity was unsignificantly higher ($p>0.05$) in the wheat soil. Acid and alkaline phosphatase activities were higher under maize.

Table 1

The effects of soil management practices on enzymatic activities in a brown luvic soil

Soil enzymatic activity *	Soil depth (cm)	Monoculture**		Rotation of 2 crops		Rotation of 3 crops	
		Wheat	Maize	Wheat	Maize	Wheat	Maize
		N I	N I	N I	N I	N I	N I
ADA	0-10	7.84	7.28	8.96	7.84	9.00	8.00
	10-20	8.40	8.14	11.08	8.84	11.26	8.96
	20-30	8.54	8.68	9.03	9.12	10.08	11.20
		11.40	9.52	12.40	11.20	12.80	11.40
		8.22	8.68	9.00	8.94	9.96	11.72
		11.20	8.24	11.20	9.80	11.52	9.96
PDA	0-10	23.52	24.08	25.64	29.80	29.28	30.36
	10-20	31.60	29.60	32.40	31.20	35.20	32.96
	20-30	33.60	29.04	35.48	33.44	38.28	37.04
		34.00	35.12	37.40	36.09	38.96	38.68
		28.00	25.16	35.20	32.79	38.04	36.43
		33.88	31.08	36.88	32.17	37.88	37.07
AcPA	0-10	0.159	0.163	0.167	0.176	0.173	0.189
	10-20	0.120	0.129	0.135	0.144	0.143	0.179
	20-30	0.179	0.180	0.191	0.187	0.190	0.195
		0.140	0.155	0.168	0.185	0.161	0.188
		0.165	0.174	0.189	0.180	0.189	0.190
		0.125	0.144	0.141	0.173	0.152	0.185
AlkPA	0-10	0.061	0.065	0.073	0.071	0.076	0.083
	10-20	0.050	0.053	0.067	0.062	0.070	0.068
	20-30	0.084	0.082	0.089	0.083	0.091	0.095
		0.079	0.071	0.082	0.077	0.085	0.080
		0.067	0.071	0.078	0.077	0.083	0.087
		0.055	0.066	0.070	0.070	0.075	0.076

* ADA - Actual dehydrogenase activity.
PDA - Potential dehydrogenase activity.
AcPA - Acid phosphatase activity.
AlkPA - Alkaline phosphatase activity.

**N - non-irrigation.
I – irrigation.

The 2-crop rotation. Each enzymatic activity measured in the wheat soil exceeded significantly (at least at $p<0.05$) the corresponding activity recorded in the maize soil, excepting acid phosphatase activity which was higher under maize.

The 3-crop rotation. Significant ($p<0.005$ to $p<0.001$) and unsignificant ($p>0.05$ to $p>0.1$) differences were registered in the soil enzymatic activities, depending on the kind of enzymatic activities and the nature of crop.

Dehydrogenase activities are considered as indicators of the global and respiratory activity of soil, whereas phosphatase activities are related to the P cycling in soil. Dehydrogenase activities were significantly higher (at least at $p<0.01$) in the wheat soil, while phosphatase activities were higher in the maize soil.

Table 2

Significance of the differences between enzymatic activities in a brown luvic soil submitted to different management practices

Management practices	Soil enzymatic activity*	Soil depth (cm)	Mean activity values in management practices a a - b	b	Significance of the differences
1	2	3	4 6	5	7
Irrigation (a) versus non-irrigation (b)	ADA	0-10 10-20 20-30	8.15 -1.30 9.44 -2.01 9.42 -0.90	9.45 11.45 10.32	0.01>p>0.002 0.02>p>0.01 0.01>p>0.002
	PDA	0-10 10-20 20-30	27.11 -5.05 34.48 -2.23 32.60 -2.23	32.16 36.16 34.83	0.01>p>0.002 0.05>p>0.02 0.10>p>0.05
	AcPA	0-10 10-20 20-30	0.171 0.030 0.187 0.021 0.181 0.028	0.141 0.166 0.153	0.001>p>0.0001 0.02>p>0.01 0.02>p>0.01
	AlkPA	0-10 10-20 20-30	0.071 0.010 0.087 0.008 0.077 0.020	0.061 0.079 0.057	0.001>p>0.0001 0.01>p>0.002 0.001>p>0.0001
The same crop in the two rotation Wheat in monoculture (a) versus wheat in 2-crop rotation (b)	ADA	0-40	9.27 -1.01	10.28	0.05>p>0.02
	PDA		30.77 -3.06	33.83	0.05>p>0.02
	AcPA		0.148 -0.017	0.165	0.01>p>0.002
	AlkPA		0.066 -0.01	0.076	0.01>p>0.002
Wheat in monoculture (a) versus wheat in 3-crop rotation (b)	ADA	0-40	9.27 -1.50	10.77	0.01>p>0.002
	PDA		30.77 -5.50	36.27	0.05>p>0.02
	AcPA		0.148 -0.02	0.168	0.001>p>0.0001
	AlkPA		0.066 -0.014	0.080	0.002>p>0.001
	ADA	0-40	10.28 -0.49	10.77	0.05>p>0.02

Wheat in 2-crop rotation (a) versus wheat in 3-crop rotation (b)	PDA		33.83 -2.44	36.27	0.002>p>0.001
	AcPA		0.165 -0.003	0.168	0.05>p>0.02
	AlkPA		0.076 -0.004	0.080	0.02>p>0.01
Maize in monoculture (a) versus maize in 2-crop rotation (b)	ADA	0-40	8.42 -0.87	9.29	0.02>p>0.01
	PDA		29.01 -3.57	32.58	0.05>p>0.02
	AcPA		0.157 -0.017	0.174	0.01>p>0.002
	AlkPA		0.068 -0.005	0.073	0.01>p>0.002
Maize in monoculture (a) versus maize in 3-crop rotation (b)	ADA	0-40	8.42 -1.79	10.21	0.01>p>0.002
	PDA		29.01 -6.41	35.42	0.01>p>0.002
	AcPA		0.157 -0.03	0.187	0.002>p>0.001
	AlkPA		0.068 -0.013	0.081	0.002>p>0.001
Maize in 2-crop rotation (a) versus maize in 3-crop rotation (b)	ADA	0-40	9.29 -0.92	10.21	0.50>p>0.10
	PDA		32.58 -2.84	35.42	0.05>p>0.02
1	2	3	4 6	5	7
Maize in 2-crop rotation (a) versus maize in 3-crop rotation (b)	AcPA	0-40	0.174 -0.013	0.187	0.05>p>0.02
	AlkPA		0.073 -0.008	0.081	0.01>p>0.002
Different crops in the same rotation *Monoculture* Wheat (a) versus maize (b)	ADA	0-40	9.26 0.84	8.42	0.10>p>0.05
	PDA		30.76 1.75	29.01	0.02>p>0.01
	AcPA		0.148 -0.009	0.157	0.01>p>0.002
	AlkPA		0.066 -0.002	0.068	0.02>p>0.01
2-crop rotation Wheat (a) versus maize (b)	ADA	0-40	10.28 0.99	9.29	0.05>p>0.02
	PDA		33.83 1.25	32.58	0.01>p>0.002
	AcPA		0.165 -0.009	0.174	0.05>p>0.02
	AlkPA		0.076 0.003	0.073	0.05>p>0.02
3-crop rotation Wheat (a) versus	ADA	0-40	10.77 0.56	10.21	0.001>p>0.0001
	PDA		36.27 0.85	35.21	0.01>p>0.002

maize (b)	AcPA		0.168 -0.019	0.187	0.05>p>0.02
	AlkPA		0.080 -0.002	0.082	0.02>p>0.01

* ADA - Actual dehydrogenase activity.
PDA - Potential dehydrogenase activity.
AcPA - Acid phosphatase activity.
AlkPA - Alkaline phosphatase activity.

CONCLUSIONS

1. Non-irrigation - in comparison with irrigation - resulted in higher phosphatase activities, whereas dehidrogenase activities were higher in irrigated soil.

2. The 3-crop rotation - as compared to the 2-crop rotation and monoculture - led to higher enzymatic activities in the soil layers under maize or wheat.

3. The soil enzymatic activities under wheat and maize crops in both non-irrigated and irrigated soil were higher in the intermediate layer than in the upper, respectively deeper layers.

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