DEHYDROGENASE AND CATALASE ACTIVITIES IN A BROWN LUVIC SOIL UNDER WHEAT AND MAIZE CROPS

Alina-Dora SAMUEL[1], Simona VICAŞ[2] & Monica ŞIPOŞ[1]

[1]University of Oradea, Department of Plant Biology, Str. Armatei Romane, 5, 410087 Oradea,
e-mail: samuelalina@rdslink.ro
[2]University of Oradea, Faculty of Environmental Protection, Str. Gen Magheru, 26, 410048 Oradea,
e-mail: simona.vicas@rdslink.ro

Abstract. Actual and potential dehydrogenase and catalase were determined in the 0-20-, 20-40- and 40-60-cm layers of a brown luvic soil submitted to a complex tillage, crop rotation and fertilisation experiment. It was found that no-till – in comparison with conventional tillage – resulted in significantly higher soil enzymatic activities in the 0-20-cm layer and in significantly lower activities in the deeper layers. The soil under maize or wheat was more enzyme-active in the 3- than in the 2 crop rotation . In the 2- crop rotation, higher enzymatic activities were registered under wheat than under maize. It should be emphasised that farmyard.manuring of maize – in comparison with its mineral (NP) fertilisation – led to a significant increase in each of the three enzymatic activities determined. Each activity in both non-tilled and conventionally tilled soil under wheat and maize crops of both rotations decreased with increasing sampling depth.

INTRODUCTION

It is well know (see the reviews [1,4,6,7] that the dehydrogenase activity of a soil is thus the results of the activity of different dehydrogenases, which are an important component of the enzyme system of all microorganisms. Dehydrogenase activity is thus an indicator of biological redox-systems, and can be taken as a measure for the intensity of microbial metabolism in soil.

The catalase of aerobic organism splits the toxic H_2O_2 produced from the mitochondrial electron transport and from various hydroxylation and oxygenation reactions into water and oxygen. Since aerobic organism predominate in non-compacted and non-waterlogged soils, catalase activity was used to characterize soil microbial activities.

MATERIALS AND METHODS

The ploughed layer of the studied brown luvic 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 experiment started in 1992. The experimental field occupying 3.84 ha was divided into plots and subplots for comparative study of no-till and conventional tillage, rotations of 2 and 3 crops, and mineral (NP) fertilisation and farmyard-manuring.

The crops of the 2- and 3- crop rotations are specified in Table 1.

Table 1 Crops of the two rotations

Year	Rotation of 2 crops		Rotation of 3 crops		
	plots		Plots		
	1	2	1	2	3
2005	Maize	Wheat	Maize	Maize (FYM)*	Wheat

*(FYM) - (farmyard-manured).

Each plot consisted of two subplots representing the no-till and conventional tillage variants. The plots were annualy NP fertilised at rates of 120 Kg of N/ha and 90 Kg of P/ha, excepting, in each year, a maize plot (in the 3-crop rotation) which received farmyard manure (50t/ha) instead of mineral fertilisers. The plots (and subplots) were installed in three repetitions.

In April 2005, soil was sampled from the 0-20-, 20-40- and 40-60- cm depths of the subplots. The soil samples were allowed to air-dry, then ground and passed through a 2-mm sieve and, finally, used for enzymological analyses.Three enzymatic activities (actual and potential dehydrogenase and catalase) were determined according to the methods described in[2,5]. Dehydrogenase activities are expressed in mg of triphenylformazan (TPF) produced from 2,3,5-triphenyltetrazolium chloride (TTC) by 10g of soil in 24 hours, whereas catalase activity is recorded as mg of H_2O_2 decomposed by 1 g of soil in 1 hour. The enzymatic activity values were submitted to statistical evaluation by the two-way t-test [3].

RESULTS AND DISCUSSION

Results of the enzymological analyses are presented in Table 2, and those of the statistical evaluation are summarised in Table 3.

The effect of tillage practices on the enzymatic activities in soil. Each of the three enzymatic activities determined was significantly higher (at least at $p < 0.0001$) in the upper (0-20 cm) layer of the non-tilled subplots than in the same layer of the conventionally tilled subplots. The reverse was true (at least at $p < 0.01$) in the deeper (20-40 and 40-60 cm) layers. These findings are valid for subplots under each crop of both rotations.

Table 2 The effects of soil management practices on enzymatic activities in a brown luvic soil

Soil enzymatic activity	Soil depth (cm)	Rotation of 2 crops*				Rotation of 3 crops*					
		Maize		Wheat		Maize		Maize (FYM)**		Wheat	
		N.t.	C.t.	N.t	C.t.	N.t	C.t.	N.t	C.t.	N.t	C.t.
Actual dehydrogenase (mgTPF/10g soil/24 hours)	0-20	5.86	5.33	7.31	6.04	6.75	6.12	7.74	7.08	7.65	7.29
	20-40	2.87	2.98	4.31	4.44	3.06	3.57	5.08	5.31	4.95	5.18
	40-60	1.12	1.71	1.57	1.87	1.81	2.02	2.04	2.14	2.23	2.43
Potential dehidrogenase (mgTPF/10g soil/24 hours)	0-20	22.73	22.35	23.05	22.87	22.95	22.55	27.45	26.66	24.62	24.28
	20-40	15.16	16.52	15.26	16.39	15.54	16.61	17.17	17.28	17.14	17.65
	40-60	4.18	4.72	5.20	5.42	4.64	5.31	6.62	6.72	5.97	5.99
Catalase (mg H_2O_2/g soil/hour)	0-20	1.75	1.58	1.83	1.76	1.85	1.75	2.00	1.94	1.91	1.87
	20-40	1.23	1.43	1.32	1.38	1.41	1.51	1.55	1.58	1.50	1.56
	40-60	0.67	0.75	0.76	0.82	0.68	0.71	0.83	0.85	0.76	0.79

*N.t. – No-till. C.t. – Conventional tillage.
**(FYM) – (farmyard –manured).

The effect of crop rotations 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 maize and wheat were crops in both rotations, it was possible to compare the soil enzymological effect of the 2 - and 3 - crop rotations. The soil under both plants was more enzyme-active in the 3-than in the 2-crop rotation.

But in the soil under maize, each activity was significantly higher (at least at $p < 0.01$) in the 3-than in the 2-crop rotation, whereas in the soil under wheat each activity was significantly higher ($p < 0.05$) in the 3-than in the 2-crop rotation.

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

The 2-crop rotation. Dehydrogenase and catalase activities were significantly higher ($p < 0.02$ and $p < 0.01$, respectively) in the wheat soil than in the soil under maize.

The 3-crop rotation. Significant ($p < 0.05$ to $p < 0.001$) and unsignificant ($p>0.05$ to $p > 0.10$) differences were registered in the soil enzymatic activities depending on the kind of enzymatic activity and the nature of crop. Based on these differences the following decreasing orders of the enzymatic activities could be established in the soil of the three plots:

actual dehydrogenase activity: maize (FYM) > wheat > maize;
potential dehydrogenase activity: maize (FYM) > wheat > maize;
catalase activity: maize (FYM) > wheat > maize.

The effect of fertilisation on the enzymatic activities in soil. The two maize plots in the 3-crop rotation could serve for comparing the soil enzymological effect of mineral (NP) fertilisation and farmyard-manuring. One can see from Table 2 that the enzymatic activities were always higher in the 0-20 cm layer

and were generally higher in the 20-40 and 40-60 cm layers of the farmyard-manured subplots in comparison with the subplots that had received mineral (NP) fertilisers. When the three soil layers were considered together (Table 3), each of the three enzymatic activities was found to be significantly higher (at least at $p < 0.05$) in the farmyard-manured plot than in the minerally fertilised plot.

Table 3 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			Significance of the differences
			a	b	a-b	
1.	2.	3.	4.	5.	6.	7.
No-till(a) versus conventional tillage(b)	ADA	0-20	7.02	6.07	0.95	0.001>p>0.0001
		20-40	4.04	4.48	-0.44	0.01>p>0.002
		40-60	1.77	2.14	-0.37	0.002>p>0.001
	PDA	0-20	24.49	23.94	0.55	0.001>p>0.0001
		20-40	15.99	16.72	-0.73	0.01>p>0.002
		40-60	5.33	5.67	-0.34	0.01>p>0.002
	CA	0-20	1.88	1.80	0.08	0.001>p>0.0001
		20-40	1.41	1.50	-0.09	0.01>p>0.002
		40-60	0.73	0.78	-0.05	0.001>p>0.0001
The same crop in the two rotations						
Maize in 2-crop rotation (a)versus maize in 6-crop rotation (b)	ADA	0-60	3.31	3.89	-0.58	0.01>p>0.002
	PDA		14.28	14.60	-0.32	0.01>p>0.002
	CA		1.24	1.32	-0.08	0.02>p>0.01
Wheat in 2-crop rotation(a) versus wheat in 6-crop rotation (b)	ADA	0-60	4.26	4.79	-0.53	0.02>p>0.01
	PDA		14.70	15.95	-1.25	0.02>p>0.01
	CA		1.31	1.40	-0.09	0.05>p>0.02
Different crops in the same rotation 2-crop rotation						
Maize (a) versus wheat (b)	ADA	0-60	3.31	4.26	-0.95	0.05>p>0.02
	PDA		14.28	14.70	-0.42	0.01>p>0.002
	CA		1.24	1.31	-0.07	0.01>p>0.002
3-crop rotation						
Maize (a) versus maize (FYM)** (b)	ADA	0-60	3.89	4.90	-1.01	0.05>p>0.02
	PDA		14.60	16.98	-2.38	0.02>p0.01
	CA		1.32	1.46	-0.14	0.001>p>0.0001
Maize (a) versus wheat (b)	ADA	0-60	3.89	4.79	-0.90	0.05>p>0.02
	PDA		14.60	15.95	-1.35	0.001>p>0.0001
	CA		1.32	1.40	-0.08	0.001>p>0.0001
Wheat (a) versus maize (FYM)** (b)	ADA	0-60	4.90	4.79	0.11	0.10>p>0.05
	PDA		16.98	15.95	1.03	0.10>p>0.05
	CA		1.46	1.40	0.06	0.002>p>0.001

*ADA-Actual dehydrogenase activity.
PDA- Potential dehydrogenase activity.
CA – Catalase activity.
** (FYM) – (farmyard-manured).

Variation of soil enzymatic activities in dependence of sampling depth. Each activity in both non-tilled and conventionally tilled subplots under all crops of both rotations decreased with increasing sampling depths.

CONCLUSIONS

No-till - in comparison with conventional tillage – resulted in higher enzymatic activities in the 0-20- cm soil layer and in lower activities in the 20-40- and 40-60- cm soil layers under each crop of both rotations.

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

In the 2- crop rotation, the soil layers under wheat were more enzyme- active than those under maize.

Farmyard-manuring – in comparison with mineral (NP) fertilisation – proved to be more efficient in increasing enzymatic activities in soil layers under maize in the 3-crop rotation.

The soil enzymatic activities decreased with increasing sampling depth.

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