Assay of Biological Activity in Forest Soils by Incubation Tests

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In 1987 a research project was initiated to monitor the health status of forest ecosystems by investigating their nutrient and water flow. The compilation of a methodics by adapting methods for use in investigating the organic matter in the litter and biologically active layers of forest soils was an integral part of this project. Using the results accumulated during the adaptation work we can compare the ecosystems monitored from the viewpoint of soil biology. This paper presents the results obtained from the middle of 1987 up to the end of 1988 for invertase and urease activities determined by laboratory incubation tests.

Materials and methods

The six study sites are located in various regions of Hungary. Two oak stands /Mátrafüred, Sopron/, a beech stand /Farkasgyepü/ and three Scotch pine stands /Gödöllő, Kerekegyháza, Farkasfa/ were chosen for investigation.

The site factors of the stands /soil type, climate and the age of the stands/ are tabulated for the deciduous stands in Table 1 and for the Scotch pine stands in Table 2.

The climate categories have been determined in compliance with the Hungarian site-type classification system as described by KOVÁCS /1990/.

Sampling began in 1987 when samples were collected in May and in early November. In 1988 the samples were taken 3 times during the vegetation period in May, in August and in early November. The sampling procedure is described in this Volume by KOVÁCS /1990/.

Invertase activity was examined as prescribed by the relevant Hungarian Standard /MSZ-08-1721/2-86/ based on the method of FRANKENBERGER and JOHANSON /1983/. Urease activity was measured by GALSTJAN's method /1965/.

Organic matter in the A_{oo}-layer was measured as ignition loss. In the soil layers /both 0-8 cm and 8-16 cm/ it was determined by wet combustion. For all the incubation tests air-dried samples, stored uniformly for 90 days at ambient temperature, were used.

Table 1

The site factors of the deciduous stands

Sampling Site	Soil type	Climate category	Sampling period		H %			I. A.			U. A.		
					A_{oo}	0-8	8-16	A_{oo}	0-8	8-16	A_{oo}	0-8	8-16
Sopron	Non-podzolic brown forest soil	Horn-beam oak	1987	Summer	42	9.5	5.0	174	n.d.	n.d.	<1	<1	<1
				Autumn	40.8	10.9	6.9	201	12	10	<1	<1	<1
			1988	Spring	62.2	4.5	3.5	335	12	10	5	3	2
				Summer	51.4	6.2	5.5	210	15	25	3	2	2
				Autumn	46.1	6.7	4.3	185	12	10	<1	1	1
Mátra-füred	Lessivated brown forest soil	Horn-beam oak	1987	Summer	53.5	8.1	3.7	144	26	29	4	<1	2
				Autumn	41.0	8.2	5.2	139	21	19	5	2	1
			1988	Spring	41.9	4.5	2.8	175	43	46	1	1	1
				Summer	48.4	5.1	2.2	255	53	43	4	1	1
				Autumn	56.5	4.8	2.2	160	16		7	1	1
Farkas-gyepü	Lessivated brown forest soil	Beech	1987	Summer	20.5	5.7	4.0	51	8	8	2	<1	<1
				Autumn	34.0	5.5	3.1	138	8	8	3	<1	2
			1988	Spring	43.2	3.5	2.5	200	8	8	2	1	2
				Summer	43.2	3.0	1.3	55	8	8	<1	1	2
				Autumn	51.2	3.5	0.8	125	8	8	4	<1	<1

H = humus content; I.A. = invertase activity, mg glucose/g soil/24 h; U.A. = urease activity, mg NH_4-N/g soil/24 h; n.d. = no data

Table 2
The site factors of the comferous stands

Sampling site	Soil type	Climate category	Sampling period		H %			I. A.			U. A.		
					A_{oo}	0-8	8-16	A_{oo}	0-8	8-16	A_{oo}	0-8	8-16
Farkasfa	Pseudo-gley brown forest soil	Hornbeam oak	1987	Summer	36.9	2.4	1.3	216	<8	<8	2	<1	<1
				Autumn	51.4	3.5	2.0	126	<8	<8	3	1	<1
			1988	Spring	50.5	1.5	1.5	270	<8	<8	3	2	1
				Summer	36.4	1.2	1.1	90	<8	<8	1	<1	<1
				Autumn	39.3	2.0	1.3	115	<8	<8	1	<1	<1
Gödöllõ	Rusty brown forest soil	Oak-Turkey oak	1987	Summer	45.0	2.0	1.8	90	<8	<8	<1	<1	<1
				Autumn	46.3	2.2	1.8	105	<8	<8	2	2	<1
			1988	Spring	38.5	0.8	0.8	180	<8	<8	<1	1	1
				Summer	32.8	1.3	0.5	140	<8	<8	<1	1	<1
				Autumn	66.4	0.8	0.5	350	<8	<8	<1	<1	<1
Kerek-egyháza	Humic sand	Forest steppe	1987	Summer	55.1	1.0	0.5	n.d.	<8	<8	4	3	2
				Autumn	48.4	0.9	0.5	147	<8	<8	2	<1	<1
			1988	Spring	60.5	0.8	0.8	210	<8	<8	2	1	1
				Summer	38.6	1.3	0.4	130	<8	<8	2	3	1
				Autumn	48.3	0.4	0.2	160	<8	<8	2	<1	<1

H = humus content; I.A. = invertase activity, mg glucose/g soil/24 h; U.A. = urease activity, mg NH_4-N/g soil/24 h; n.d. = no data

Results and discussion

Invertase activity

A wide variety of invertase activity was found under the forest stands investigated. A major characteristic of the data obtained on all the sites is the considerably high level of invertase activity in the A_{oo}-layer compared with the top 8 cm and 8-16 cm of the soil. This layer contained the highest proportion of organic matter. The decrease of invertase activity with soil depth was another feature of the enzyme assay data. On all the sites examined there was a sharp fall in the level of invertase activity below the A_{oo}-layer. The two lower soil layers sampled had almost the same amount of invertase.

The values obtained by incubation tests for invertase activity indicated that various patterns of such activities existed in the samples and there were differences between and within the two groups of forest stands.

In the samples from under the pine stands the level of invertase activity decreased with the sampling depth so much that it could not be measured in the soil layers by the method applied /Table 2/. Samples from these soil layers contained rather small amounts of organic matter.

In the soil under the deciduous stands the patterns of invertase activity were various. Its levels in the A_{oo}-layer of the individual oak stands did not differ appreciably from each other. However, despite the similar organic matter content of the soil samples from under these oak stands there was a difference between the stands in the invertase level. These stands were of same age and climate category but on different types of soil. The highest invertase level was measured in the soil samples from the oak stand on lessivated brown forest soil /Mátrafüred/. At the same time in the soil samples of the beech stand there was no measurable invertase activity in any of the examined soil layers. These soil samples had some organic matter content but it was significantly lower than that of the soil samples from under the oak stands. The lowest invertase activity was measured in the A_{oo} layer of this beech stand. It must be noted, however, that this stand differed from the oak stands not only in age but also in respect of site factors /soil type and/or climate category/.

The absence of invertase activity in the presence of organic matter suggests either a lack of microbe population to hydrolize carbonhydrates or the rapid destruction, or perhaps inhibition, of invertase. Although the soil organic matter is the primary factor influencing soil biological activities there are some other factors /soil properties: reaction, soil texture, CEC, gleying etc./ which can influence the activity level of the soil enzymes. These properties may influence the life circumstances of soil microbes and the stability of the soil enzymes of different origin. It must be taken into consideration that the storage of the samples to be investigated also has an effect on the invertase activity level.

We chose a relatively long storage period /90 days/ as we had to carry out a great number of examinations.

Urease activity

The values for urease activity going on in the samples fell in a range narrower than those of invertase activity. This range of activity and its level varied to a lesser or greater extent between and within the groups of the forest stands examined. Under all the stands the highest activity level was measured in the A_{oo}-layer with high organic matter content. The activity level of urease decreased with the sampling depth in a similar way as in

case of invertase but the fall below the A_{co}-layer was not so sharp. The relationship between urease activity and organic matter content did not seem to be so close as in the case of invertase. It agrees with the findings of MCGARITY and MEYERS /1967, 1968/. While organic matter is obviously a general factor affecting the overall level of enzymatic activity in the soil, there may be environmental and nutrition factors which alter the expression of this relationship.

Comparions between groups in the samples from under the deciduous stands showed an urease activity higher than in those from under the pine stands. Within each group of forest stands there were differerences depending on the soil type and/or the tree species as well as climate category.

Among the deciduous stands the samples from under the oak stand on lessivated brown forest soil /Mátrafüred/ exhibited the highest level of urease activity. This type of soil is rich in colloids. The urease activity measured in the presence of toluene is largely derived from the extracellular enzyme adsorbed in the clay colloids and humified organic matters in the soil.

Colloids, both organic and inorganic, apparently act as stabilizing agents on urease released into the soil. It appeared that the textural properties of this soil type and other site factors /climate and vegetation/ were favourable for the accumulation and preservation of extracellular urease.

From the pine stands the one on rusty brown forest soil /at Gödöllő/ deviates from the other two Scotch pine stands in the pattern of urease activity. Despite containing a high amount of organic matter samples of the A_{oo}-layer under this pine stand showed no urease activity. At the same time samples from the upper soil layer /0-8 cm/ contained measurable amounts of urease. The poorness in mineral colloids of this type of soil is partly balanced by a thick humous layer. It appeared, however, that under the conditions of this site some other factors occur which may influence the rapid destruction of urease or the production of inhibitory substances. The absence of urease activity may suggest a lack of ureolytic microorganisms as well.

Conclusions

Invertase activity was concentrated in the A_{co}-layer and decreased with the depth of the soil under the deciduous stands.

On all the sites investigated there was a sharp fall in the level of invertase activity below the A_{oo}-layer.

The soil layer samples from under the pine stands showed no invertase activity.

In most cases the level of urease activity in the samples from under the deciduous stands exceeded the level measured in their counterparts from under the pine stands.

Of the soil of every stand it was the A_{co}-layer which exhibited the highest urease activity.

Under the pine stands of the same age both invertase and urease activites varied with the site factors.

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