ECOLOGICAL CHEMISTRY AND ENGINEERING A

Vol. 18, No. 8 2011

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BIODIVERSITY OF SOIL FAUNA DEPENDING ON VEGETAL COVER AND FERTILIZATION

BIORÓŻNORODNOŚĆ FAUNY GLEBOWEJ W ZALEŻNOŚCI OD OKRYWY ROŚLINNEJ I NAWOŻENIA

Abstract: The investigations were conducted in the years 2006–2007 in Czarny Potok village at the foot of Jaworzyna Krynicka Mt. Three experimental areas were established on the investigated terrain (differing in the soil vegetal cover): grassland, arable land and forest. The soil samples were collected three times: in autumn 2006, in spring 2007 and in summer 2007. The numbers of soil fauna differed depending on the vegetal cover and the land use. The soil fauna was most numerously trapped in the mountain meadow soil used for hay production and fertilized with farmyard manure. Less numerous meso- and macrofauna was observed on the arable land.

Keywords: mesofauna, macrofauna, vegetal cover, fertilization

Soil organisms play a crucial role in processes of organic matter decomposition. Microorganisms such as fungi, Actinomycetales and bacteria participate in this process, whereas organisms classified as mesofauna and macrofauna also play an important role. Soil animals also affect the soil structure [1]. Mesofauna significantly participates in the restoration of the proper structure in compacted soils [2]. Species composition and numbers of these organisms depend on many environmental factors, such as soil physico-chemical properties or environment pollution with heavy metals [3]. Also the way and methods of soil cultivation affect the living environment of soil organisms [4, 5]. Mesofauna is often used for the environment monitoring.

The investigations aimed at identification of the impact of various vegetal cover types and land use on the occurrence of soil fauna.

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Material and methods

The research was conducted in the years 2006–2007 in Czarny Potok village at the foot of the Jaworzyna Krynicka Mt. (650 m a.s.l., 20°55′34″ E, 49°24′35″ N). Brown soil with granulometric structure of loamy sand cover the experimental field. The soil is acid, medium abundant in potassium and greatly phosphorus-deficient, its chemical composition was shown in Table 1.

Table 1

Chemical composition of soil (collected 20.09.2006)

Vegetal cover	Variant	pH_{H_2O}	pH_{KCl} [1 mol · dm^3]	Organic matter [%]	N_{total} [%]	Available [mg · kg^{-1} d.m.]		
						P	K	Mg
Grassland	0 – control	5.37	4.29	4.87	0.27	10.5	34.9	133
	fallow	5.16	4.18	4.52	0.22	11.0	47.2	123.2
	$P_{18}K_{50}$	5.42	4.53	4.7	0.25	12.6	47.3	137
	$P_{18}K_{50}N_{100}$	5.53	4.84	4.18	0.26	13.1	39.0	150.6
	manure 10 Mg · ha^{-1}	5.46	4.51	5.47	0.27	14.0	55.6	149
	manure 10 Mg + P_4N_{31}	5.26	4.2	4.77	0.17	8.7	34.9	11.2
	sheep pen	4.95	4	4.98	0.24	13.5	97.1	58
Arable land	cereals	4.95	4.17	4.44	0.15	12.0	64.2	112.7
Forest	mixed forest	3.89	2.95	11.22	0.29	7.3	31.5	46.8

The length of the vegetation period in the presented region fluctuates from 150 to 180 days and the snow cover usually remains for about 150 days.

Three parts (differing with their vegetal cover) were identified in the experimental area: grassland, arable land and forest.

The following variants were applied on the grassland:

– non-fertilized and uncut meadow (fallow),
– unfertilized but cut meadow (0 – control),
– fertilized and cut meadow ($P_{25}K_{50}N_{100}$),
– fertilized and cut meadow ($P_{25}K_{50}$),
– meadow fertilized with sheep manure and cut (manure 10 Mg · ha^{-1}),
– meadow fertilized with sheep manure plus mineral fertilizers and cut (manure 10 Mg + P_4N_{31}),
– meadow fertilized by penning and cut (sheep pen).

The following crop succession with $P_{25}K_{50}N_{100}$ fertilization is applied on the arable land:

1) Root crops, cereals, cereals with undersowing, legumes:
   – a rye mixture with vetch was sown in 2006,
   – oat was sown in 2007.
2) In the forest area:
   – mixed forest (beech and spruce).

Unfertilized and uncut meadow is an object where no cultivational measure are applied. The unfertilized and cut meadow was considered as the control site. On the fertilized and cut meadow mineral fertilization was applied each year: phosphorus – once in spring as a 46 % triple superphosphate, potassium as 56 % potassium salt in equal part under the I and II regrowth; nitrogen as 34 % ammonium nitrate was divided into two parts applied under the I and II regrowth, respectively 60 % and 40 %, sheep manure was used early in spring. The manure chemical composition was as follows: total N – 0.69; P – 0.14; K – 0.60; Ca – 0.25; Mg – 0.08; Na – 0.06 % in the fresh mass. On the manure-mineral treatment phosphorus and nitrogen doses were supplemented with mineral fertilizers to the amounts used on the treatment receiving mineral fertilizers ($P_{25}K_{50}N_{100}$). The sheep pen was established in the early spring 2005. There was one sheep per 1 m^2 of the meadow. The sheep spent two nights (2 × 7 hrs) in the pen. During 7 hours spent in the pen a single sheep produced 479 g of excrement and 371g of urea. The sheep staying in the pen left: 184 kg total N, 27.8 kg P and 294.2 kg K · ha^{-1}. The sward was cut twice a year, the first regrowth was harvested at the turn of the second and third decade of June and the second in the third decade of August. The following doses of fertilizers were applied pre-sowing on the arable land: 25 kg ha^{-1} phosphorus as 45 % triple superphosphate, 50 kg ha^{-1} potassium as 56 % potassium salt and 120 kg ha^{-1}nitrogen as 34 % ammonium nitrate. Nitrogen was divided into two doses, proportionately 60 and 40 % of which the first was applied pre-sowing and the second as a topdressing.

The soil was sampled three times: in the autumn 2006, in the spring 2007 and in the summer 2007. Three spoil samples were collected from each experimental area using a 15 cm long cylinder with 10 cm diameter. The soil samples were taken to a laboratory to isolate and determine the soil fauna in them. The soil samples were first sifted through sieves to isolate the macrofauna and subsequently the sifted soil was placed in the Tullgren apparatus to extract smaller organisms into the vials containing 75 % alcohol. The collected material was counted and labelled [6, 7].

The results were analysed statistically using the Statistica programme and ANOVA was conducted. The Newman-Keuls critical intervals were computed and the value of the final step was used for differentiating means at the significance level $p < 0.05$.

Results and discussion

Depending on the vegetal cover and meadow use the number of nematodes isolated from the soil of the analysed object differed considerably (Table 2). Nematodes were most numerous in the soil of the meadow fertilized with sheep manure. A smaller number of nematodes in comparison with the control was noted in the soil of the minerally fertilized meadow, whereas the least was found in the forest ground and from the arable land. Soil mites are an important group of soil organisms since they play a crucial role in matter transformation processes in the soil environment [8]. In the analyzed soil environment, soil mites were the most numerous in the meadow fertilized through penning. Much fewer mites were observed in the arable soil and on minerally fertilized meadow. The greatest number of captured soil mesofauna specimens belonged

to the *Collembola*. The *Collembola* were particularly numerous in the mountain meadow soil fertilized with sheep manure and in the pen soil. In the arable soil on average 30 % less *Collembola* were trapped than in the mountain meadow soil. Numerous cultivational measures, such as ploughing, negatively affect *Collembola* numbers in soil [7], which may be the cause of a smaller number of this organism group in the arable soil under analysis.

Table 2

Occurrence of soil mesofauna – average number of specimens captured on three dates: autumn, spring and summer

Vegetal cover	Variant	Number of specimens [pcs.]		
		Nematoda nematodes	*Acari* mites	*Collembola* springtails
Grassland	0 – control	11.1	5.1	59.3
	fallow	8.6	5.4	52.3
	$P_{18}K_{50}$	8.4	3.6	50.2
	$P_{18}K_{50}N_{100}$	7.8	3.7	46.2
	manure 10 Mg · ha^{-1}	15.7	4.1	66.8
	manure 10 Mg + P_4N_{31}	10.8	5.6	60.3
	sheep pen	11.8	6.1	66.3
Arable land	cereals	9.7	3.1	42.6
Forest	mixed forest	7.1	5.6	50.4
$LSD_{< 0.05}$		4.24	1.19	8.56

In the observed macrofauna the greatest number of insects belonging to the beetle order were captured (Table 3). On the other hand, representatives of beetles were scarce in the soil samples collected from the fallow, whereas in the samples taken from the meadow fertilized with manure, beetles were particularly numerously captured. In this soil also representatives of myriapods and earthworms occurred in a great number. Earthworms were not spotted in the soil samples collected from the minerally fertilized meadow, there were also only few of them in the forest soil.

Soil mesofauna is often used as an indicator in ecological research, among others due to the sensitivity to environmental factors and common occurrence [9]. The present research shows that mineral fertilization may lead to a decrease in the numbers of this organism group. On the other hand, organic fertilization favours a more numerous occurrence of nematodes and *Collembola*. Also fertilization through penning caused an increase in the mesofauna numbers in the mountain meadow soil. While comparing the effect of vegetal cover on soil fauna one may notice its more numerous presence in meadow soils in comparison with arable lands. Permanent vegetal cover on a meadow favours greater soil biodiversity. Lesser numbers of nematodes in the forest soil might have been due to its stronger acidification as compared with the meadow and the arable soil.

Table 3

Occurrence of soil macrofauna – average number of specimens captured on three dates: autumn, spring and summer

Vegetal cover	Variant	Number of specimens [pcs]						
		Araneae	*Myriapoda*	*Coleoptera*	*Diptera*	*Hymenoptera*	*Lepidoptera*	*Lumbricidae*
Grassland	0 – control	0.9	1.3	5.7	0.3	0.8	0.3	0.3
	fallow	1.3	0.9	2.9	1.3	1.1	1.6	0.4
	$P_{18}K_{50}$	1.0	0.4	4.1	0.8	1.1	0.3	0.0
	$P_{18}K_{50}N_{100}$	0.7	0.6	4.4	0.7	1.8	0.3	0.0
	manure 10 Mg · ha^{-1}	1.2	2.2	4.9	1.0	1.0	0.4	2.1
	manure 10 Mg + P_4N_{31}	1.2	1.6	4.1	0.7	0.8	0.4	1.0
	sheep pen	1.6	1.9	4.3	1.4	1.0	0.2	0.9
Arable land	cereals	1.4	1.0	4.1	0.9	0.7	0.2	0.4
Forest	mixed forest	1.7	2.4	4.4	0.2	0.3	0.1	0.1
$LSD_{< 0.05}$		n.s.	1.60	1.47	0.97	1.09	0.78	0.69

n.s. – non-significant differences.

Conclusions

1. Manure fertilization benefits more numerous occurrence of nematodes in a mountain meadow soil.

2. Mineral fertilization caused a decrease in the numbers of nematodes and soil mites.

3. The meadow soil environment was settled by a more numerous mesofauna in comparison with the arable land.

4. Manure fertilization favours earthworm presence.

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Abstrakt: Badania przeprowadzone zostały w latach 2006–2007 w Czarnym Potoku u podnóża Jaworzyny Krynickiej. Na terenie doświadczalnym wydzielono trzy obszary doświadczalne (różniące się okrywą roślinną gleby): użytek zielony, grunt orny i las. Próbki gleby pobrano trzykrotnie: jesienią 2006 r., wiosną 2007 r. i w lecie 2007 r. Liczebność fauny glebowej różniła się w zależności od okrywy roślinnej i sposobu użytkowania. Fauna glebowa najliczniej była odławiana w glebie łąki górskiej użytkowanej kośnie i nawożonej obornikiem. Mniej liczną mezo- i makrofaunę glebową zaobserwowano na gruncie ornym.

Słowa kluczowe: mezofauna, makrofauna, okrywa roślinna, nawożenie