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HUMIFICATION OF GRASS LITTER ON AGE-DIFFERENTIATED MEADOWS IN THE SUWAŁKI LANDSCAPE PARK (NORTH-EASTERN POLAND)

ABSTRACT: The field experiment was conducted to measure accumulation of carbon during 11 months in the newly established, 8-years old and permanent meadows. The decomposition of grass litter placed on the sand surface in mecosoms was investigated. It

was found that the older the meadow, the greater the rate of litter humification while the mineralization was accelerated in the newly established meadow.

KEY WORDS: humification, mineralization, humic acids, fulvic acids, grass litter

1. INTRODUCTION

The processes of organic matter decomposition are of fundamental significance for ecosystem functioning. The decomposition rate of organic residues is dependent on the structure and chemical composition of decomposing material, fertility of habitat and such factors as moisture and temperature (Myśków 1961, 1963, 1968, 1969, Borowska 1966, Kononowa 1968, Luzin 1968, Kononowa and Aleksandrowa 1973, Gołąb 1978, Dziadowiec 1979, 1990, Badura and Pacha 1983).

The earlier studies, conducted on the meadows in the Suwałki Landscape Park during the years 1984–1985 (Kajak

et al. 1991), showed that the rate of mineralization and humification of the same organic matter was dependent on the composition and number of soil animals. The greatest accumulation of humus in the soil habitat with more abundant invertebrate community was found. The fauna species richness is strictly connected with the species diversity of plant communities. The poorest in respect of the species number is the sward of the youngest, newly established meadows.

The declining species richness of many ecosystems, as being stated at present with a concern, was the reason for undertaking the investigations on the de-

composition of grass litter in three meadows, varying in the degree of species uniformity of the sward and in the successional age. A special attention was

paid to the quantity of humus compounds, produced during the humification of litter in these three meadow communities.

2. STUDY AREA AND METHODS

The studies were carried out in the Suwałki Landscape Park, the post-glacial area of north-eastern Poland with a greatly varied relief, in three meadows varying in the stage of succession (see Kajak 1997). Meadows were situated on fluvio-glacial plain. They included the newly established, one-year-old ley, eight years old and permanent meadows on the brown soils derived from median sand. Under quite shallow horizon of humus deposit, the loamy, strongly skeletal sands (up to 50 % of soil skeleton), are found. The pH of the was close to neutral and differed in respect of humus content. The younger meadows contained 1.2 % of total carbon in the horizon of humus accumulation while the permanent meadow had 1.9 % (Kusińska and Łakomic 1997).

The experiment was conducted in mesocosms (experimental design presented in Kajak 1997), filled with sand and inserted into the upper layer of the soil profile. The mesocosms were made of the nylon net of 1 mm mesh size. Two treatments, each with twenty replicats were conducted:

1. sand surface in mesocosms was covered by litter bags, each containing

10 g of dry matter of the aboveground parts of *Dactylis glomerata* (S + L)

2. mesocosms, filled with sand, without litter bags (S)

The amount of the exposed grass litter corresponded to the production of grass in this region. The samples of the sand from the mesocosms were taken from the layers of 0–10 cm and 10–20 cm. The content of carbon and of humus fractions at the beginning of the experiment and after 6 and 11 months was determined. The total carbon content of the litter at the beginning and at the end of the experiment was determined twice. In the last term, the composition of humus fractions in litter was also analysed. The carbon content was determined by Kalembsa's method (Kalembsa and Niklewski 1979) and humus fractions were isolated, using sodium pyrophosphate and sodium hydroxide solution (Kononowa 1968). The degree of humification of litter is given as a share of carbon of humic and fulvic acids in the total organic carbon. The humification means the amount of humus carbon produced during the decomposition, in relation to the initial amount of carbon in the litter at the beginning of the experiment.

3. RESULTS AND DISCUSSION

In Table 1, the fractional composition of humus found in the sand of mesocosms without and with the litter is given. The increase in the total carbon and hu-

mus fractions content was observed after 6 months of the experiment's duration in both treatments. The differences between treatments were not high, especially in

Table 1. Content of humus components extracted from sand of mesocosms without the litter (S) and with the litter (S + L).

Meadow age in years	Term of sampling*	mg C · 100 g ⁻¹ of sand							
		Sand (S)				Sand + litter (S + L)			
		total C	HA	FA	R	total C	HA	FA	R
1	I	27.4	1.3	3.9	22.2	27.4	1.3	3.9	22.2
	II	32.3	6.0	15.3	10.9	37.0	4.6	12.5	20.0
	III	68.0	9.1	20.3	38.7	91.1	13.2	23.3	54.6
8	I	27.4	1.3	3.9	22.2	27.4	1.3	3.9	22.2
	II	35.9	5.2	8.0	22.6	35.1	6.5	10.9	17.7
	III	70.9	10.0	20.3	40.5	151.2	15.2	33.8	102.3
Permanent	I	27.4	1.3	3.9	22.2	27.4	1.3	3.9	22.2
	II	36.0	8.0	12.6	15.5	58.4	9.8	17.0	31.6
	III	96.2	13.5	27.7	55.0	190.5	24.0	40.2	126.3

* I – beginning of the experiment, all the mesocosms filled with the same sand, II – after 6 months, III – after 11 months; HA – humic acids, FA – fulvic acids, R – residue after extraction.

case of one year and 8 years old meadow. On one year old meadow, the presence of the litter in the mesocosms caused a small increase of the total carbon content and of carbon in unhumified residues and humins (fraction R). On eight years old meadow although total carbon content was similar in both treatments, the amount of carbon of humic and fulvic acids was slightly increased in (S+L) treatment. The greatest difference in the content of total carbon and humus fraction between treatment was found in the mesocosms in the permanent meadow. The smaller increase in humus substances in the sand after 6 months than later, is a result of intensive mineralization of grass litter during the first stage of decomposition. In this period, the loss of litter matter amounted to 50 % and this loss was somewhat higher on one-year old meadow than on the remaining ones (Bogdanowicz and Szanser 1997). The simple organic compounds, being formed in this stage of decomposition are,

first of all, the substrate for microorganisms, no earlier than in the next stage the synthesis of humus acids takes place (Kononowa 1968, Trojanowski 1973, Zigunov and Tereszenkova 1977).

During the next stage of the experiment, lasting for 5 months, the intensive increase in the content of total carbon and humus fractions was found in the substrate of the mesocosms (Table 1). It should be noted that this increase was related to the age of the meadows. By the end of the experiment, on the one year old meadow, the quantity of carbon in mesocosms with the litter, was equal to 91 mg in 100 g of sand, on the eight years old meadow – 151 mg and, on the permanent meadow the amount of C was 190 mg. In the mesocosms containing only sand, the increase of carbon and humus fraction was also observed. At the end of the experiment, on the one year old meadow, the level of carbon amounted to 68 mg in 100 g of sand, on the 8 years old

meadow – 70.9 mg of C and on the permanent meadow – 96.2 mg of C (Table 1). The possible reasons for such increase may be: wind-blown bringing of organic matter, deposition by percolating water, bringing of the residues by the soil fauna, and also, the influence of root system from the meadow soil, surrounding the mesocosms (Szanser 1997). In all the meadows, the similar type of organic matter transformation proceeded in the mesocosms; it may be concluded from the ratio of humic to fulvic acids. This ratio is rather low (0.39–0.78) and there is an evidence of domination of fulvic acids in humus (Table 1). This fraction is translocated from the litter and it may be easily leached from the sandy substrate of mesocosms. It may be supposed that fulvic acids and other water-soluble organic compounds penetrate the sand of mesocosms from the surrounding soil. These quantities, being difficult to be estimated, do not allow to make a budget of carbon in the substrate and products of decomposition.

The increase of total carbon and humus fraction was compared in the sand of mesocosms without and with the litter (Table 2). Differences between both treatments after 11 months of the experiment were increased along the time gradient. In the one-year-old meadow, carbon

content reached to 20 mg in 100 g of the sand, on the 8-year-old meadow – 80.3 mg and in the permanent meadow – 94.3 mg. The amount of carbon in humus fractions was also increasing gradually with the age of meadows. On the one-year-old meadow, the net gain in the mesocosms with the litter was equal to 7.1 mg of C in humus acids; in the 8-year-old meadow – 18.6 mg of C and in the permanent meadow – 23.9 mg of C (Table 2).

The carbon content in the litter decreased during 11 months of the experiment (Table 3). The estimated decrease is not an effect of litter mineralization but also the effect of litter contamination with mineral particles which could not be easily separated mechanically from fine organic dust. The lowest carbon content was found in the litter from the one-year old meadow and the highest in the permanent meadow. Ratio $C_{HA}:C_{FA}$ in the litter after 11 months was also higher in two older meadows; it is a result of more advanced humification processes there. The degree of litter humification is quite high. The sum of carbon in fulvic and humic acids constitutes 45.3 % of total carbon in the litter on the one-year-old meadow, 40.4% on the 8-year-old meadow and 35.0% on the permanent meadow. During the period of the litter decomposition, the greatest amount of

Table 2. Humus components content in sand of mesocosms after 11 months of litter decomposition (mg C · 100 g⁻¹ of sand)

Meadow age in years	Sand (S)*				Sand + litter (S + L)				(S + L) – S			
	C total	HA	FA	R	C total	HA	FA	R	C total	HA	FA	R
1	40.6	7.8	16.4	16.5	63.6	11.9	19.4	32.3	23.0	4.1	3.0	15.9
8	43.4	8.7	16.4	18.2	123.8	13.9	29.9	80.0	80.3	5.2	13.5	61.8
Permanent	68.8	12.2	23.8	32.8	163.0	22.7	36.2	104.1	94.3	10.5	13.4	71.4

* difference between carbon content at the third and first sampling date, see Table 1
HA – humic acids, FA – fulvic acids, R – residue after extraction

Table 3. Content of humus components in the litter after 11 months of decomposition

Meadow age in years	mg C · 100 g ⁻¹ in dry matter of litter				C _{HA} : C _{FA}	Degree of humification %
	Total C	HA	FA	R		
1	2260	400	624	1237	0.64	45.3
8	2765	574	543	1652	1.06	40.4
Permanent	2896	465	550	1880	0.85	35.0

Degree of humification – proportion of humus acids carbon in total content of carbon in litter (%); HA – humic acids, FA – fulvic acids, R – residue after extraction.

Table 4. Approximate evaluation of mineralization and humification of grass litter in mesocosms on age-differentiated meadows after 11 months of decomposition

Meadows age in years	1		8		Permanent	
	mg	%	mg	%	mg	%
Carbon in 10 g of dry matter of litter at the beginning of experiment	3947	100	3947	100	3947	100
Humus carbon in litter after 11 – months	444.3	11	565.2	14	547.3	14
Humus carbon transported from litter to sand of mesocosms	319.9	8	824.4	21	1077.3	27
Non-humified carbon in litter residues	536.5	14	833.9	21	1016.5	26
Coefficient of humification of litter		19		35		41
Coefficient of mineralization of litter		67		44		33

humus compounds was released on permanent meadow (Table 4). After 11 months, 74.2 – 86.4% of carbon of the initial material was subjected to transformation. The intensity of mineralization was highest on the one-year-old meadow and it was decreasing gradually with the age of the meadow. The intensity of humification proceeded in the reverse direction. Carbon of humus acids, being found in mesocosms after the completion of the experiment, amounted to 8.1% on the one-year old meadow, 20.9 % on the 8-year-old meadow and 27.3% of carbon introduced to mesocosms in a form of litter on the permanent meadow.

The calculated approximate coefficient of litter humification during 11 months of its decomposition amounted to 19% on one year old meadow, 35% on 8 years old meadow and 41% on the permanent meadow (Table 4).

Summing up the obtained results, it may be stated as follows:

– In the age-varying meadows, differing 11 months of grass litter decomposition, 74.2–86.4% of carbon of the initial substance were subjected to transformation;

– Intensity of mineralization of grass litter was the greatest in one-year-old meadow and was decreasing gradually with the ageing of the meadows;

– Intensity of humification of the grass litter was accelerated with the age of the meadows.

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4. SUMMARY

The field experiment was conducted at the territory of the Suwałki Landscape Park north-eastern Poland, on the new, 8-years old and permanent meadows. The aim of the studies was to analyze the decomposition of grass litter in the mentioned above meadows, differing in age and in the degree of species unification in the sward. The experiment was conducted in the mesocosms filled with the sand and digged into the upper layer of the soil of the examined meadows. On the sand surface litter bags containing above-ground parts of *Dactylis glomerata* were placed. In the litter as well as in the substrate of mesocosms (sand), the content of carbon and humus fractions after 6 and 11 months of the experiment duration was determined (Table 1). By the end of the experiment, the increase in the

content of total carbon in the sandy substratum of mesocosms and the increase of humus carbon, were found (Table 2 and 3). Carbon of humus acids constituted 8.1% of carbon, introduced to the mesocosms in a form of litter on the one-year-old meadow, 20.9% on eight-year-old meadow and 27.3% on the permanent meadow (Table 4).

It was stated that mineralization of grass litter was the greatest in the one-year-old meadow and was decreasing together with ageing of the meadows. On the other hand, the intensity of litter humification was increased on older meadows. During the experiment, 60–75% of carbon of the initial material were subjected to mineralization and humification (Table 4).

5. POLISH SUMMARY

Przeprowadzono eksperyment na terenie Suwalskiego Parku Krajobrazowego na łące nowo założonej, 8 letniej i wieloletniej. Celem badań było prześledzenie rozkładu ściółki trawiastej na wyżejwymienionych łąkach, różniących się stopniem ujednoczenia gatunkowego runi. Eksperyment prowadzono w izolatorach wypełnionych piaskiem i wkopanych w wierzchnią warstwę gleby badanych łąk. Na powierzchni izolatorów wyłożono ściółkę trawiastą (*Dactylis glomerata*). Zarówno w ściółce, jak i w podłożu izolatorów oznaczono węgiel ogólny i frakcje próchnicy po 6-ciu i 11-tu miesiącach trwania eksperymentu (tab. 1). Pod koniec eksperymentu stwierdzono wzrost

zawartości węgla ogólnego w podłożu piaszczystym izolatorów, a także wzrost węgla humusowego (tab. 2 i 3). Obydwie wartości zwiększały się wraz z wiekiem łąk. Węgiel kwasów próchnicznych stanowił w piasku izolatorów na łące jednorocznej 8,1% węgla wprowadzonego do izolatorów w ściółce, na łące 8 letniej 20,9%, a na wieloletniej 27,3% (tab.4).

Stwierdzono, że mineralizacja ściółki trawiastej była najszybsza na łące jednorocznej i malała wraz ze starzeniem się łąk. Intensywność humifikacji ściółki zwiększała się zaś na łąkach starszych. W czasie eksperymentu od 60–75% węgla materiału wyjściowego uległo mineralizacji i humifikacji (tab. 4).

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