Role of Microorganisms and Invertebrates in the Release of Nutrients from Decomposing Plant Residues in Grasslands

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The role of litter as a pool of plant nutrients has been recognized a long time ago. Decomposition of plant remnants and, simultaneously, the release of nutrients has to be considered as a synergetic relationship between the invertebrate fauna and microorganisms. At present it is more and more often discussed how these interactions may influence the way and rate of nutrient release during the decomposition of plant remnants.

This study deals with three aspects of plant litter decomposition in managed grasslands: /1/ with the effect of the fauna on the rate of decomposition of above- and underground plant litter; /2/ with the quantification of nutrients released by the activities of various groups of decomposers, and /3/ with counting the microorganisms that take part in decomposition processes.

Materials and methods

The objects of study were natural and renovated grasslands treated with various doses of mineral fertilizers, and situated in the Bohemian-Moravian Uplands /annual mean temperature 6.3 ^{o}C, annual precipitation 786 mm/.

Litter bags, from which various groups of fauna were excluded by reducing the mesh size, were buried in the soil for 22 months. The size of bags was 12 x 18 cm, the mesh size 0.05 mm, 1.5 mm, and 7-8 mm. Each bag contained 5 g fresh litter from above- or underground plant organs. During the experiment the litter was analyzed three to four times for weight decrease and N, P, K, Na, Ca and Mg contents. For direct counting of bacteria, the fluorescent-staining technique, with acridin-orange as dye, was used.

Results and discussion

The elimination of fauna substantially decreased the loss rate of both leaves and root litter. The decomposition of roots was retarded more than that of leaves by the elimination of various faunal groups. Roots, being tougher than leaves, apparently by required fragmentation by animals before effective decomposition by microorganisms could take place /Table 1/.

The course of decomposition of leaves and roots during the 22-month exposure were approximately identical. In the first phase, lasting about 12 months, approximately 55% of the leaf litter decomposed in comparison with the original weight. The corresponding value for root litter was 38%. In the second phase /i.e. from 12 to 22 months of exposure/, decomposition decreased conspicuously, only 21% of the original weight of leaves and roots

Table 1
Decomposition of leaf and root litter
$/\bar{x} \pm s_x/$ n = 4-6/

Experiment variant	After 4 months	After 8 months	After 12 months	After 22 months
I. In per cent of remaining weight				
Leaves	72.8 ± 11.6	55.8 ± 10.6	45.7 ± 16.2	23.8 ± 11.0
Roots	89.6 ± 23.3	74.8 ± 25.8	62.9 ± 11.4	41.7 ± 14.7
II. Contribution of individual groups of soil biota to the decomposition /in %/				
Leaves				
A	30.1	40.7	57.5	56.4
B	67.4	75.6	78.9	81.2
C	100.0	100.0	100.0	100.0
Roots				
A	11.6	24.7	41.2	43.7
B	62.0	61.6	81.3	80.4
C	100.0	100.0	100.0	100.0

A: Microorganisms, microfauna; B: microorganisms, microfauna + mesofauna; C: all decomposers

was decomposed. At the end of the 22 months' exposure, 77% and 59% of the original weight of leaf and root litters was left, respectively.

The share of microorganisms and microfauna in the total amount of decomposed leaf litter reached 46% on the average, while that of microorganisms, microfauna and mesofauna 77%. The corresponding values for root litter were 30% and 71% /Table 1/. It follows from the data presented in the table that the importance of microbial activity gradually increased during the decomposition of plant remnants, while that of the mesofauna decreased.

Table 2 shows the changes in the amount of N, P, K, Ca, Na and Mg /in % of original contents/ at the end of the experiment. K was released most rapidly of all; after 22 months of exposure under field conditions, only 14% of the original content was recovered. The rate of nutrient content decrease in decomposing litter was almost identical in all experimental variants: K>Na>Mg>Ca>N>P. Nutrients from the above-ground plant litter were released more rapidly than from the underground one.

The release of nutrients from the litter was retarded by the exclusion of part of the soil biota. According to the analysis of litter at the end of the experiment, the original nutrient content decreased to 14-29% on the average in variants C, where all groups of decomposers were active. The corresponding values for the variants, from which the macro- and mesofauna were excluded, were 17-32% and 30 to 44%, respectively.

Table 2

The nutrient content of plant litter after 22 months of exposure under field conditions /remaining %/

Experiment variant	N	P	K	Na	Ca	Mg
Leaves						
A	36	48	14	18	36	25
B	22	20	11	16	18	16
C	16	20	11	14	10	11
Roots						
A	71	66	17	41	45	26
B	55	43	15	25	32	20
C	41	44	15	20	31	20

For A, B and C: See Table 1

Table 3

The nutrient content of plant litter /leaves/ before /I/ and after 8 months of exposure under field conditions with the exclusion of various groups of decomposers /II/
/n = 4-6/

Experiment variant		N	P	K	Na*	Ca	Mg
				mg/100 g			
I	$\bar{x}$	1428	127	138	89	65	55
	V %	15.0	25.0	11.5	21.3	8.0	13.5
II	Exper. var.						
A	$\bar{x}$	1604	137	69	75	65	59
	V %	11.6	17.2	10.3	18.6	10.1	16.6
B	$\bar{x}$	2002	152	66	72	63	43
	V %	14.6	11.2	10.4	16.8	10.1	11.6
C	$\bar{x}$	2127	155	67	72	62	40
	V %	18.7	15.6	14.7	15.2	11.8	13.6

For A, B and C: See Table 1

Table 4

Direct counts of bacteria /10^9 per g of dry matter/ in plant litter decomposed by various groups of decomposers
/n = 4-5/

Duration of experiment /months/		Experiment variants		
		A	B	C
4	$\bar{x}$	13.6	21.6	27.4
	V %	22.6	18.4	24.4
8	$\bar{x}$	16.9	23.6	31.6
	V %	21.0	23.8	19.4

For A, B and C: see Table 1

During the first phase of decomposition, N and P showed periods of net immobilization, which is illustrated by the data in Table 3. However the extent of N and P immobilization differed in the individual experimental variants markedly. N and P showed the most intensive immobilization in the presence of all decomposers, while in the presence of microorganisms and microfauna alone immobilization was low. This apparently was associated with the increased number of microorganisms growing on the litter decomposed by a complete community of decomposers /Table 4/. On the contrary, the exclusion of macro- and mesofauna from the community of decomposers brought about a significant decrease in the number of microorganisms. Obviously, the presence of soil fauna supports the growth and activity of microorganisms and hence alters the decomposition rate of plant remnants and the transformation of nutrients /COLE et al., 1978, ANDERSON et al., 1981, COLEMAN, 1985/.

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