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NITROGEN ACCUMULATION BY SELECTED SPECIES OF GRASSLAND LEGUMES AND HERBS

GROMADZENIE AZOTU PRZEZ WYBRANE GATUNKI ROŚLIN MOTYLKOWATYCH I ZIÓŁ ŁĄKOWYCH

Abstract: The study was conducted in 1998–2000 (June – first ten days of July) in the Olsztyn Lakeland. A total of 444 plant samples were analyzed, including 123 collected in organic soils. The analysis covered *Trifolium pratense*, *Trifolium repens*, *Lotus corniculatus*, *Lathyrus pratensis*, *Lotus uliginosus*, *Vicia cracca*, *Taraxacum officinale*, *Achillea millefolium*, *Plantago lanceolata*, *Alchemilla vulgaris*, *Heracleum sibiricum* and *Cirsium oleraceum*.

The average total nitrogen content of mineral and organic soils ranged from 1.35 to 3.40 g · kg⁻¹ and from 9.78 to 14.1 g · kg⁻¹, respectively. Significant differences were found in the nitrogen content of biomass of the analyzed plant species. The average nitrogen content of plants varied from 17.0 to 34.4 g · kg⁻¹ d.m.. The highest nitrogen accumulation levels were observed in *Vicia cracca* grown in organic soils, and the lowest in *Alchemilla vulgaris* grown in mineral soils. The coefficient of variation in the above parameter did not exceed 20 %, thus suggesting that the noted values may be considered typical of the studied species.

Keywords: grasslands, legumes, herbs, nitrogen, soil.

The quality of animal feedstuffs is largely dependent on the species composition of grasslands. Legumes are a valuable component of grassland swards. According to Novoselova and Frame [1], legumes have a beneficial influence on grassland productivity as they contribute to a high yield of total and digestible protein, a reduction in nitrogen mineral fertilization, an increase in the nitrogen content of soil, a decrease in groundwater nitrate contamination and an improvement in the quality of feedstuffs and animal products.

The most important legume species grown in grasslands in northern Europe are *Trifolium repens*, *Trifolium pratense*, *Trifolium hybridum*, *Medicago sativa* and *Lotus corniculatus*. In Western Europe, the most common species is *Trifolium repens*, accompanied by *Lotus corniculatus* and *Lotus uliginosus* which – in contrast to other legumes – can be grown under extreme conditions [1, 2].

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Herbs are also valuable components of grassland communities. They are a rich source of essential nutrients with therapeutic and medicinal properties as well as other compounds that affect feed up take and utilization by animals [3]. In comparison with grasses, herbaceous plants contain larger amounts of nutrients, particularly mineral compounds and total protein. Although the share of herbs in grassland sward should not exceed 10 %, their economic importance remains high. The most common herb species are, among others, *Taraxacum officinale*, *Achillea millefolium*, *Plantago lanceolata* and *Alchemilla vulgaris*. In view of the above, the objective of this study was to determine the levels of nitrogen accumulation by common species of grassland legumes and herbs.

Materials and methods

The study was conducted in 1998–2000 (June – first ten days of July) in the Olsztyn Lakeland, in permanent grassland communities with at least 5 % share of the following legume and herb species: *Trifolium pratense*, *Trifolium repens*, *Lotus corniculatus*, *Lathyrus pratensis*, *Lotus uliginosus*, *Vicia cracca*, *Taraxacum officinale*, *Achillea millefolium*, *Plantago lanceolata*, *Alchemilla vulgaris*, *Heracleum sibiricum* and *Cirsium oleraceum*. A total of 444 plant samples were analyzed, including 123 collected in organic soils (Table 1). The total nitrogen content of soil and plants was determined by the Kjeldahl method [4].

Table 1

Number of plant samples

Species	Site	
	Mineral soil	Organic soil
<i>Lathyrus pratensis</i>	29	13
<i>Lotus corniculatus</i>	23	—
<i>Lotus uliginosus</i>	22	29
<i>Trifolium pratense</i>	25	—
<i>Trifolium repens</i>	26	—
<i>Vicia cracca</i>	20	14
<i>Achillea millefolium</i>	33	19
<i>Alchemilla vulgaris</i>	31	17
<i>Cirsium oleraceum</i>	18	31
<i>Heracleum sibiricum</i>	29	—
<i>Plantago lanceolata</i>	32	—
<i>Taraxacum officinale</i>	33	—
Total	321	123

Results and discussion

The nitrogen content of plants grown in mineral soils varied over a wide range of 12.0 to 39.4 g · kg⁻¹ (Table 2). Legumes accumulated larger quantities of nitrogen. The highest average nitrogen content was noted in *Lotus corniculatus*, *Lathyrus pratensis*,

Lotus uliginosus and *Trifolium pratense*, while the lowest in *Plantago lanceolata*, *Achillea millefolium*, *Alchemilla vulgaris* and *Taraxacum officinale*. The coefficient of variation in the above parameter was relatively low (from 10.4 % to 17.8 %), thus suggesting that the noted values may be considered typical of the studied species. The average nitrogen content of mineral soils ranged from 1.35 to 3.40 g · kg⁻¹ (Table 3). *Cirsium oleraceum* and *Lotus uliginosus* were found in nitrogen-abundant soils, whereas *Trifolium repens* and *Taraxacum officinale* were reported from nitrogen-poor soils.

Table 2

Average nitrogen content of plants grown in mineral soils

Species	N content [g · kg ⁻¹ d.m.]			Coefficient of variation [%]
	Minimum	Maximum	Average	
<i>Lotus corniculatus</i>	22.4	39.4	31.8	16.7
<i>Lathyrus pratensis</i>	18.7	38.2	30.6	16.3
<i>Lotus uliginosus</i>	25.6	39.0	30.1	13.3
<i>Trifolium pratense</i>	19.4	38.1	29.0	15.2
<i>Trifolium repens</i>	22.4	32.2	28.3	13.6
<i>Vicia cracca</i>	21.6	33.3	28.3	10.4
<i>Heracleum sibiricum</i>	19.5	30.7	24.5	11.5
<i>Cirsium oleraceum</i>	17.4	27.4	22.1	11.7
<i>Achillea millefolium</i>	12.0	25.1	18.6	15.1
<i>Taraxacum officinale</i>	14.7	23.8	18.1	11.0
<i>Alchemilla vulgaris</i>	13.1	23.2	17.9	12.8
<i>Plantago lanceolata</i>	13.4	25.0	17.0	17.8

Table 3

Average nitrogen content of mineral soils

Species	N content [g · kg ⁻¹]			Coefficient of variation [%]
	Minimum	Maximum	Average	
<i>Cirsium oleraceum</i>	1.70	7.70	3.40	44.3
<i>Lotus uliginosus</i>	0.91	7.70	2.95	57.3
<i>Alchemilla vulgaris</i>	1.00	4.90	2.50	46.6
<i>Lathyrus pratensis</i>	0.95	4.92	2.33	44.2
<i>Heracleum sibiricum</i>	0.50	3.90	2.00	43.1
<i>Achillea millefolium</i>	0.70	7.70	1.90	73.6
<i>Vicia cracca</i>	0.88	3.96	1.87	52.0
<i>Plantago lanceolata</i>	0.50	7.70	1.60	80.4
<i>Lotus corniculatus</i>	0.46	3.70	1.50	52.6
<i>Trifolium pratense</i>	0.67	3.70	1.49	54.0
<i>Taraxacum officinale</i>	0.50	3.70	1.40	54.2
<i>Trifolium repens</i>	0.46	3.30	1.35	54.6

The nitrogen content of plants grown in organic soils also varied widely, from 13.3 to 47.4 g · kg⁻¹ (Table 4). Again, legumes were characterized by substantially higher nitrogen concentrations. The highest nitrogen content was determined in *Vicia cracca*, and the lowest in *Alchemilla vulgaris*. Similarly as in plants grown in mineral soils, the coefficient of variation in the above parameter was relatively low (from 11.7 % to 18.2 %), therefore the noted values may be considered characteristic of the analyzed species. The average nitrogen content of organic soils ranged from 9.8 to 14.1 g · kg⁻¹ (Table 5). *Achillea millefolium* was reported from soils most abundant in nitrogen, while *Lathyrus pratensis* preferred soils least abundant in this nutrient.

Table 4

Average nitrogen content of plants grown in organic soils

Species	N content [g · kg ⁻¹ d.m.]			Coefficient of variation [%]
	Minimum	Maximum	Average	
<i>Vicia cracca</i>	31.2	47.4	34.4	12.1
<i>Lotus uliginosus</i>	24.0	37.1	30.7	11.7
<i>Lathyrus pratensis</i>	20.2	33.0	30.1	12.3
<i>Cirsium oleraceum</i>	15.5	31.0	23.5	18.2
<i>Achillea millefolium</i>	16.2	28.5	22.4	14.5
<i>Alchemilla vulgaris</i>	13.3	27.7	18.6	18.0

Table 5

Average nitrogen content of organic soils

Species	N content [g · kg ⁻¹ d.m.]			Coefficient of variation [%]
	Minimum	Maximum	Average	
<i>Achillea millefolium</i>	5.60	27.8	14.1	47.9
<i>Lotus uliginosus</i>	3.84	27.8	12.9	61.0
<i>Cirsium oleraceum</i>	3.80	27.8	12.2	59.2
<i>Vicia cracca</i>	2.65	25.9	11.3	61.6
<i>Alchemilla vulgaris</i>	2.70	27.8	10.0	59.7
<i>Lathyrus pratensis</i>	4.66	20.0	9.8	49.6

Based on a statistical analysis of the obtained results, the studied plant species were divided into four groups differing with respect to total nitrogen content (Table 6). *Vicia cracca* grown in organic soils, characterized by the highest nitrogen content, constituted the first group. The second group comprised the other legume species, *Lotus corniculatus*, *Lotus uliginosus*, *Lathyrus pratensis*, *Trifolium repens* and *Trifolium pratense*. The third group was formed by *Heracleum sibiricum*, *Cirsium oleraceum* and *Achillea millefolium* grown in organic soils. The fourth group included plants with the lowest total nitrogen content: *Alchemilla vulgaris* as well as *Plantago lanceolata*, *Achillea millefolium* and *Taraxacum officinale* grown in mineral soils.

Table 6

Significance of differences in the nitrogen content of plants

Species	Soil	N [g · kg ⁻¹]	Homogeneous groups							
<i>Vicia cracca</i>	O*	34.4	■							
<i>Lotus corniculatus</i>	M	31.8		■						
<i>Lotus uliginosus</i>	O	30.7		■	■					
<i>Lathyrus pratensis</i>	M	30.6		■	■	■				
<i>Lotus uliginosus</i>	M	30.1		■	■	■				
<i>Lathyrus pratensis</i>	O	30.1		■	■	■				
<i>Trifolium pratense</i>	M	29.0			■	■				
<i>Trifolium repens</i>	M	28.3				■				
<i>Vicia cracca</i>	M	28.3				■				
<i>Heracleum sibiricum</i>	M	24.5					■			
<i>Cirsium oleraceum</i>	O	23.5					■	■		
<i>Achillea millefolium</i>	O	22.4					■	■		
<i>Cirsium oleraceum</i>	M	22.1						■		
<i>Alchemilla vulgaris</i>	O	18.6								■
<i>Taraxacum officinale</i>	M	18.1								■
<i>Alchemilla vulgaris</i>	M	17.9								■
<i>Achillea millefolium</i>	M	17.7								■
<i>Plantago lanceolata</i>	M	17.0								■

* O – organic soil, M – mineral soil.

In a study by Kacorzyk and Szewczyk [5], legumes contained the largest quantities of nitrogen, whereas protein content was 16–20 % higher in herbs than in grasses. Tsialtas et al [6] demonstrated that *Taraxacum officinale* accumulated more nitrogen than grasses. Differences in the nitrogen content of legumes and other grassland species were also reported by Bandeff et al [7], Eisenhauer and Scheu [8]. Goh and Bruce [9], Grzegorzczak and Alberski [10], and Gylfadottir [11].

Conclusions

1. Among the analyzed plant species, legumes – in particular *Vicia cracca* grown in organic soils – accumulated significantly more nitrogen. *Plantago lanceolata*, *Achillea millefolium*, *Alchemilla vulgaris* and *Taraxacum officinale* grown in mineral soils had the lowest nitrogen content.

2. The tested plant species were collected from soils with a different total nitrogen content (in most cases, the coefficient of variation did not exceed 50 %).

3. Despite considerable differences in the nitrogen content of plants, in the majority of cases the recorded average nitrogen concentrations may be considered typical of the studied species, as confirmed by low coefficients of variation.

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GROMADZENIE AZOTU PRZEZ WYBRANE GATUNKI ROŚLIN MOTYLKOWATYCH I ZIÓŁ ŁĄKOWYCH

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Abstrakt: Badania prowadzono w latach 1998–2000 (czerwiec – pierwsza dekada lipca) na terenie Pojezierza Olsztyńskiego. Łącznie przebadano 444 próbek roślinnych, w tym 123 pochodzące z gleb organicznych. Badaniem objęto *Trifolium pratense*, *Trifolium repens*, *Lotus corniculatus*, *Lathyrus pratensis*, *Lotus uliginosus*, *Vicia cracca*, *Taraxacum officinale*, *Achillea millefolium*, *Plantago lanceolata*, *Alchemilla vulgaris*, *Heracleum sibiricum* i *Cirsium oleraceum*.

Średnia zawartość azotu ogólnego w glebie mineralnej wahała się w granicach 1,35–3,40 g · kg⁻¹, a w glebie organicznej 9,78–14,1 g · kg⁻¹. Stwierdzono statystycznie istotne różnice w zawartości azotu w biomacie poszczególnych gatunków. Średnia zawartość azotu w roślinach wahała się od 17,0 do 34,4 g · kg⁻¹ sm. Najwięcej azotu gromadziła *Vicia cracca* występująca na glebach organicznych, najmniej zaś *Alchemilla vulgaris* występujący na glebach mineralnych. Można to uznać za charakterystyczną właściwość tych gatunków, bowiem współczynnik zmienności tej cechy u poszczególnych gatunków nie przekraczał 20 %.

Słowa kluczowe: użytki zielone, motylkowate, zioła, azot, gleba