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# ACCUMULATION OF POTASSIUM, CALCIUM AND MAGNESIUM BY SELECTED SPECIES OF GRASSLAND LEGUMES AND HERBS

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Abstract

The study was conducted in 1998-2000, in the Olsztyn Lakeland, on permanent grassland communities with at least 5% share of the following leguminous and herbaceous species. *Trifolium pratense*, *Trifolium repens*, *Lotus corniculatus*, *Lathyrus pratensis*, *Lotus uliginosus*, *Vicia cracca*, *Taraxacum officnale*, *Achillea millefolium*, *Plantago lanceolata*, *Alchemilla vulgaris*, *Heracleum sibiricum* and *Cirsium oleraceum*. In total, 444 plant samples were analyzed, including 123 collected on organic soils. The objective of this study was to determine the accumulation of potassium, calcium and magnesium by selected species of grassland legumes and herbs, in view of the abundance of the above elements in soil.

The analyzed organic soils were characterized by low abundance of potassium and moderate abundance of magnesium, whereas the mineral soils had a very low or low potassium content and a very high or high magnesium content. The habitats varied widely with respect to the calcium abundance. The biomass of the analyzed plant species contained high concentrations of potassium, magnesium and calcium. Plants collected from mineral soils contained more potassium and less magnesium than those growing on organic soils. *Taraxacum officinale* and *Achillea millefolium* were rich in potassium, *Achillea millefolium*, *Lotus uliginosus*, *Heracleum sibiricum*, *Vicia cracca*, *Taraxacum officinale* and *Cirsium oleraceum* had a high magnesium content, whereas *Cirsium oleraceum*, *Heracleum sibiricum* and *Alchemilla vulgaris* accumulated the largest amounts of calcium. The ability of dicotyledonous plants to accumulate high concentrations of calcium and magnesium resulted in a low K:(Ca+Mg) ratio.

Key words: grasslands, legumes, herbs, potassium, magnesium, calcium, soil.

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**GROMADZENIE POTASU, WAPNIA I MAGNEZU PRZEZ WYBRANE GATUNKI ROŚLIN MOTYLKOWATYCH I ZIÓŁ ŁĄKOWYCH**

Abstrakt

Badania przeprowadzono w latach 1998-2000 na terenie Pojezierza Olsztyńskiego. Badaniami objęto zbiorowiska roślinne trwałych użytków zielonych z co najmniej 5% udziałem wybranych gatunków roślin motylkowatych i ziół: *Trifolium pratense*, *Trifolium repens*, *Lotus corniculatus*, *Lathyrus pratensis*, *Lotus uliginosus*, *Vicia cracca*, *Taraxacum officinale*, *Achillea millefolium*, *Plantago lanceolata*, *Alchemilla vulgaris*, *Heracleum sibiricum*, *Cirsium oleraceum*. Łącznie przebadano 444 próby roślinne, w tym 123 pochodzące z gleb organicznych. Celem pracy było określenie zawartości potasu, wapnia i magnezu w wybranych roślinach motylkowatych i ziołach na tle zasobności tych pierwiastków w glebie.

W badanych siedliskach gleb organicznych stwierdzono niską zasobność w potas, średnią w magnez, zaś w glebch mineralnych – bardzo małą i małą zawartość potasu oraz dużą i bardzo dużą magnezu. Stwierdzono również duże zróżnicowanie siedlisk pod względem zasobności w wapń. Roślinność zawierała dużo potasu, magnezu i wapnia, przy czym rośliny pochodzące z siedlisk gleb mineralnych zawierały więcej potasu, a mniej magnezu niż pochodzące z gleb organicznych. Spośród badanych gatunków bogate w potas były *Taraxacum officinale* i *Achillea millefolium*, dużą zawartość magnezu stwierdzono u *Achillea millefolium*, *Lotus uliginosus*, *Heracleum sibiricum*, *Vicia cracca*, *Taraxacum officinale* i *Cirsium oleraceum*, zaś najwięcej wapnia gromadziły *Cirsium oleraceum*, *Heracleum sibiricum* i *Alchemilla vulgaris*. Zdolność roślin dwuliściennych do gromadzenia dużych ilości Ca i Mg wpłynęła na niską wartość stosunku K:Ca+Mg).

Słowa kluczowe: użytki zielone, motylkowate, zioła, potas, magnez, wapń, gleba.

# INTRODUCTION

Habitat conditions have a significant effect on the quantitative and qualitative composition of grassland communities comprising numerous species of grasses, legumes, sedges (Cyperaceae), herbs and weeds. The characteristics of grassland habitats are an important consideration since they affect the chemical composition of green forage (TRĄBA, WYŁUPEK 1998, TRZASKOŚ et al. 1998, TRĄBA, WOLAŃSKI 2003, GRZEGORCZYK et al. 2004, 2011). According to TRĄBA (1997), forage obtained from grasslands with a high share of dicotyledonous plant species is a rich source of phosphorus, magnesium, calcium and sodium, but it has a low potassium content. Herbs present in the phytomass used as livestock feed contribute to preventing microelement deficiencies, thus increasing the biological value of feed to adequately meet the nutritional requirements of animals (BENEDYCKI et al. 1999).

The objective of this study was to determine the accumulation of potassium, calcium and magnesium by selected species of grassland legumes and herbs, in view of the abundance of the above elements in soil.

## MATERIAL AND METHODS

The study was conducted in 1998-2000, in the Olsztyn Lakeland, on permanent grassland communities with at least 5% share of the following leguminous and herbaceous species. *Trifolium pratense*, *Trifolium repens*, *Lotus corniculatus*, *Lathyrus pratensis*, *Lotus uliginosus*, *Vicia cracca*, *Taraxacum officnale*, *Achillea millefolium*, *Plantago lanceolata*, *Alchemilla vulgaris*, *Heracleum sibiricum* and *Cirsium oleraceum*. In total, 444 plant samples were analyzed, including 123 collected on organic soils (Table 1). The chemical analyses of soil samples were performed by standard methods: potassium - by Egner-Riehm method, magnesium – by Schachtschabel method, calcium – by a universal method proposed by Nowosielski. Plant samples were assayed for potassium and calcium content by flame photometry, and for magnesium content – by atomic absorption spectrometry (AAS).

Table 1

Number of analyzed plant samples

| Species | Habitat | |
|---|---|---|
| | mineral soil | organic soil |
| *Lathyrus pratensis* | 29 | 13 |
| *Lotus corniculatus* | 23 | - |
| *Lotus uliginosus* | 22 | 29 |
| *Trifolium pratense* | 25 | - |
| *Trifolium repens* | 26 | - |
| *Vicia cracca* | 20 | 14 |
| *Achillea millefolium* | 33 | 19 |
| *Alchemilla vulgaris* | 31 | 17 |
| *Cirsium oleraceum* | 18 | 31 |
| *Heracleum sibiricum* | 29 | - |
| *Plantago lanceolata* | 32 | - |
| *Taraxacum officinale* | 33 | - |
| Total | 321 | 123 |

## RESULTS AND DISCUSSION

The chemical analyses of samples collected in grassland habitats showed that the average available potassium content of organic and mineral soils was very low or low, at 139.1-300.2 mg $kg^{-1}$ (Figure 1) and 49.7-110.2 mg $kg^{-1}$,

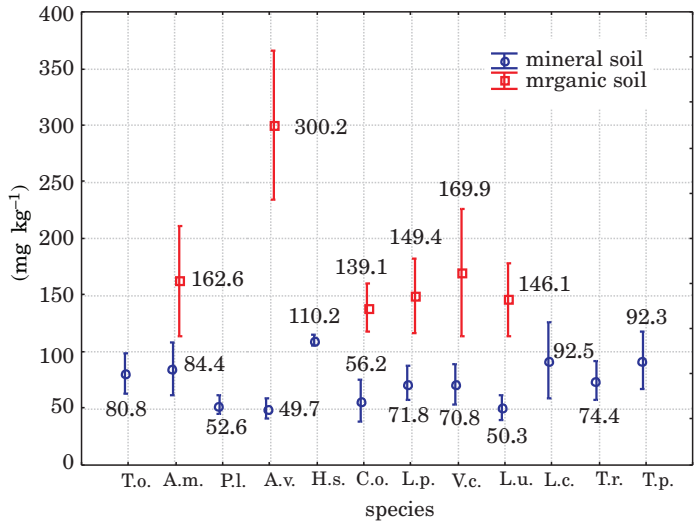


Fig. 1. Potassium content of soil (means and 95.00% confidence interval)

respectively. The communities with *Alchemilla vulgaris* on organic soils and the communities with *Heracleum sibiricum* on mineral soils were most abundant in potassium. Low potassium concentrations noted at many sampling sites corroborate the findings of MICHNA (1997), who reported potassium deficiency in 85.5% of grassland soils in north-eastern Poland.

The analyzed plant species were characterized by a high potassium content of phytomass, except for *Lotus uliginosus* growing on organic soils, whose potassium content reached 14.3 g $kg^{-1}$. Plant species collected from organic soils, more abundant in potassium, contained less potassium than those collected from mineral soils (Figure 2). Particularly high potassium concentrations were noted in *Taraxacum officinale* on mineral soils, which accumulated significantly more potassium than the other analyzed species. The biomass of *Achillea millefolium* was also characterized by a high potassium content. In general, herbs accumulated greater amounts of potassium than legumes, which is why the presence of the former in grassland sward increased the potassium content of forage. The potassium content of grassland vegetation varied over a wide range, from 6.0 to 80.0 g $kg^{-1}$ d.m., depending on species. Herbaceous plants accumulated high amounts of potassium, in excess of 80.0 g $kg^{-1}$ d.m. Forage from permanent grasslands usually provides more potassium than needed by animals. The optimum potassium content of grassland feeds is 17.0 g $kg^{-1}$ d.m., and potassium concentrations above 30.0 g $kg^{-1}$ d.m. are considered undesirable in grassland-based feeding regimes (JANKOWSKA-HUFLEJT et al. 2009).

Organic soils contained significantly more magnesium than mineral soils, and average magnesium abundance at sampling sites ranged between 572.1

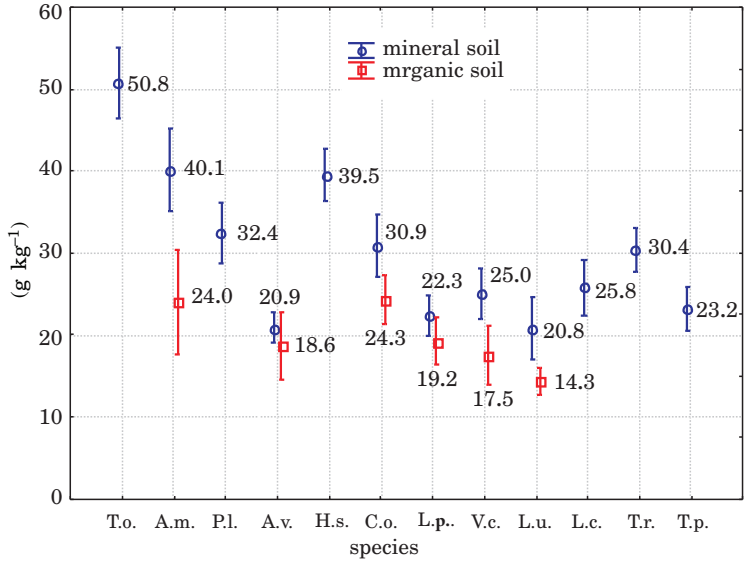


Fig. 2. Potassium content of plants (means and 95.00% confidence interval)

and 711.5 mg kg$^{-1}$ (Figure 3). The average available magnesium content of mineral soils was very high or high, reaching 68.0 to 149.3 mg kg$^{-1}$. In organic soils, the highest magnesium levels were noted in grasslands communities with *Alchemilla vulgaris* and *Cirsium oleraceum*. The communities with *Achillea millefolium, Lathyrus pratensis, Vicia cracca* and *Lotus uliginosus* were less abundant in magnesium. The differences in magnesium concentrations between organic soil habitats were statistically non-significant, while considerable differences were observed within habitats. In mineral soils, smaller differences in magnesium abundance were noted between plant communities, and higher magnesium levels were reported from the habitats of *Lathyrus pratensis, Vicia cracca, Lotus uliginosus* and *Cirsium oleraceum*. The habitats of *Plantago lanceolata* were characterized by the lowest magnesium content. The above relationships were also described by Trąba and Wolański (2003), and Kitczak (2000).

The magnesium abundance of soil was reflected in the magnesium content of plant dry matter. Plant species collected from organic soils contained significantly more magnesium than those obtained from mineral soils (Figure 4). In general, all analyzed species had a high magnesium content. In the majority of cases, magnesium concentrations in plant dry matter were higher than the optimum magnesium content determined by Falkowski et al. (2000). In organic soils, the largest amounts of magnesium were accumulated by *Achillea millefolium*, *Lotus uliginosus*, *Heracleum sibiricum* and *Vicia cracca.* No significant differences in magnesium abundance were found between those species, while there were considerable differences between

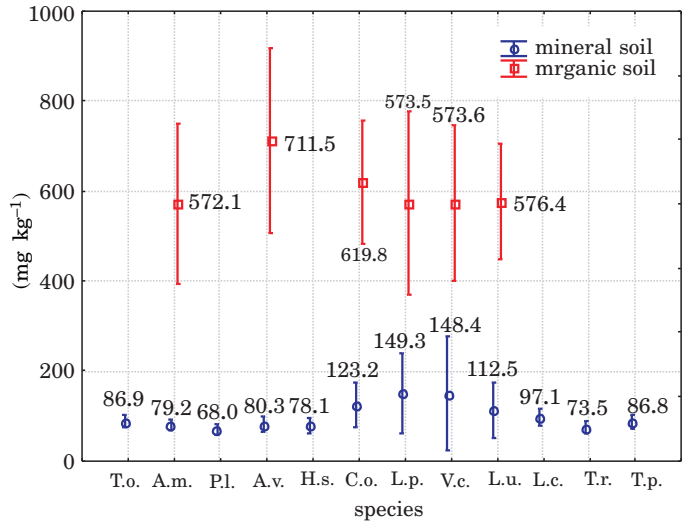


Fig. 3. Magnesium content of soil (means and 95.00% confidence interval)

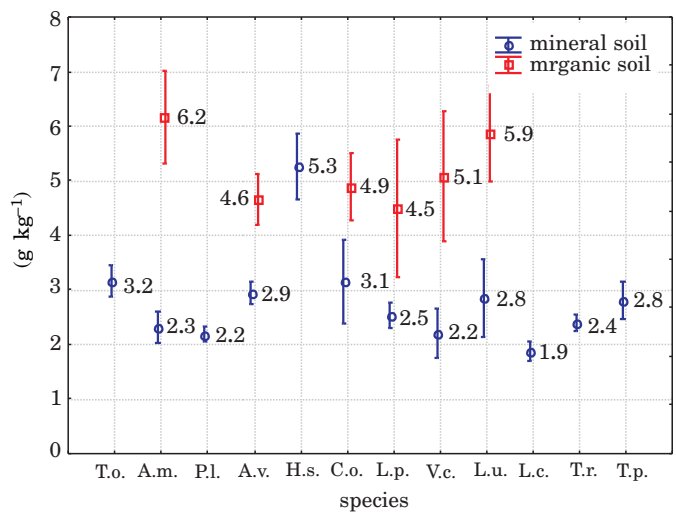


Fig. 4. Magnesium content of plants (means and 95.00% confidence interval)

sampling sites. Smaller differences in the magnesium content of plants were observed on mineral soils. No significant fluctuations in magnesium levels were noted, except for *Cirsium oleraceum* and *Lotus uliginosus*. *Taraxacum officinale* and *Cirsium oleraceum* from mineral soil habitats had a high magnesium content, whereas *Lotus corniculatus* was characterized by the lowest magnesium concentrations. High magnesium levels in the biomass

of common dandelions and cabbage thistles were also reported by ALBERSKI (2004), and KOZŁOWSKI and SWĘDRZYŃSKI (1996).

Substantial differences in the calcium abundance of soil in grassland habitats were noted in the present study (Figure 5). The calcium content of organic and mineral soils varied from 1404.6 to 1895.3 mg kg $^{-1}$, and from 662.5 to 1089.1 mg kg $^{-1}$, respectively. In organic soils, the habitats of *Achillea millefolium* were most abundant in calcium, while the communities with *Lathyrus pratensis* were poorest in calcium. In mineral soils, the highest calcium abundance was noted in the habitats of *Lotus corniculatus* and *Lathyrus pratensis,* whereas the communities with *Plantago lanceolata* and *Alchemilla vulgaris* were less abundant in calcium.

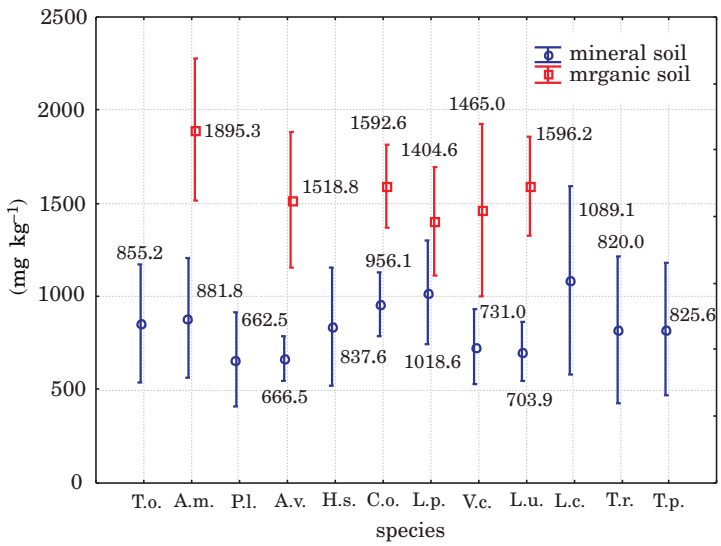


Fig. 5. Calcium content of soil (means and 95.00% confidence interval)

Fodder plants should contain 7 g kg$^{-1}$ calcium. In our study, the average calcium content of plant dry matter was higher than the levels considered optimal for high-quality feeds. The cabbage thistle was characterized by a particularly high calcium content (40.6-42.0 g kg $^{-1}$ d.m.). Regardless of the soil type, this species accumulated significantly higher amounts of calcium than the other studied species (Figure 6). ALBERSKI (2004) also reported high calcium concentrations in *Cirsium oleraceum*. A high calcium content of biomass was noted in *Heracleum sibiricum* (33.6 g kg$^{-1}$) from mineral soil habitats, and in *Alchemilla vulgaris* (24.0 g kg$^{-1}$) from organic soil habitats. The remaining species were marked by similar calcium levels, ranging from 14.1 to 20.6 g kg $^{-1}$ d.m. Our results are partially consistent with the findings of TRĄBA (1997). According to the cited author, forage from grasslands

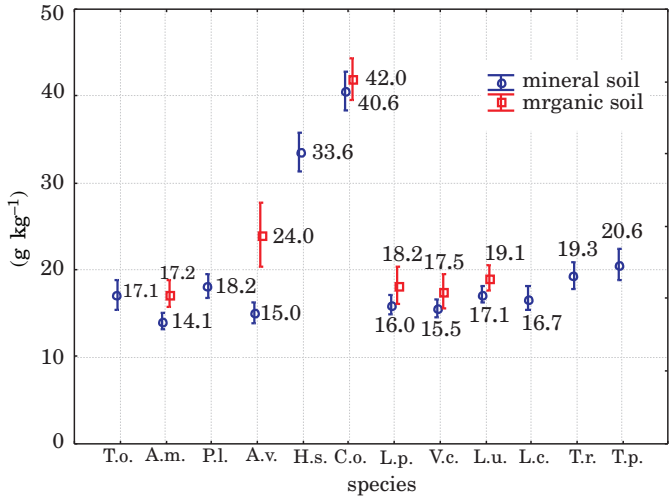


Fig. 6. Calcium content of plants (means and 95.00% confidence interval)

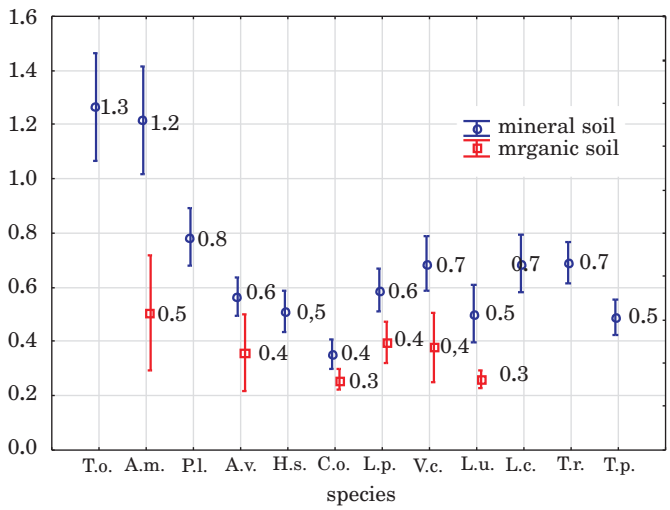


Fig. 7. K: (Ca+Mg) equivalent ratio (means and 95.00% confidence interval)

with a high share of dicotyledonous plants is usually abundant in magnesium and calcium, and poor in potassium. In the present experiment, plants contained also large amounts of potassium.

A synthetic criterion for feed quality assessment is the K: (Ca+Mg) ratio, which should remain within the 1.8-2.2 range. Values higher than 2.2 may be indicative of grass tetany. In the analyzed dicotyledonous plants, the average value of the K: (Ca+Mg) ratio ranged from 0.3 to 1.3, thus being far too low (Figure 7). Dicotyledonous plants accumulate considerable amounts

of calcium and magnesium, and relatively low amounts of potassium, which had a direct effect on the above ratio (TRZASKOŚ et al. 1998). A lower K: (Ca+Mg) ratio was characteristic for PLANTS growing on organic soils. Among the studied species, significantly higher values of the above ratio were noted for *Taraxacum officinale* and *Achillea millefolium*, due to the fact that these species accumulated significantly higher concentrations of potassium than the other species.

## CONCLUSIONS

1. The organic soils were characterized by low abundance of potassium and moderate abundance of magnesium, whereas the mineral soils had a very low or low potassium content and a very high or high magnesium content. The habitats varied widely with respect to calcium abundance.

2. The biomass of the analyzed plant species contained high concentrations of potassium, magnesium and calcium. The plants collected from mineral soils contained more potassium and less magnesium than those growing in organic soils.

*3. Taraxacum officinale* and *Achillea millefolium* were rich in potassium, *Achillea millefolium*, *Lotus uliginosus*, *Heracleum sibiricum*, *Vicia cracca*, *Taraxacum officinale* and *Cirsium oleraceum* had a high magnesium content, whereas *Cirsium oleraceum*, *Heracleum sibiricum* and *Alchemilla vulgaris* accumulated the largest amounts of calcium.

4. The ability of dicotyledonous plants to accumulate high concentrations of calcium and magnesium resulted in a low K: (Ca+Mg) ratio.

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