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FACTORS CONDITIONING THE CONTENT OF MICROELEMENTS IN THE MEADOW SWARD OF THE RADZIEJOWA REGION

UWARUNKOWANIA ZAWARTOŚCI MIKROSKŁADNIKÓW W RUNI ŁĄKOWEJ PASMA RADZIEJOWEJ

Abstract: Investigations were conducted in the Radziejowa Region (20.4079°–20.7147°E and 49.3988°–49.5421°N). 356 samples were collected on grasslands with different habitat conditions (height above sea-level, inclination, exposition) and differing in the way of their utilization. The sward varied in botanical composition and was classified into different phytosociological units. The subject of the analysis was to assess the content of macro- and microelements with the regard to environmental conditions.

In the area of the Radziejowa Region the mean contents of molybdenum and boron in the sward were low, for copper – quite low, for zinc – nearing the satisfactory content, for cobalt – satisfactory and for manganese – very high. Availability of microelements in the soil, except for manganese, was low. Regarding so low contents of analysed elements in the soil the correlation between the amount of the element extracted with 1 mol HCl · dm⁻³ and its content in the plant was not found, except for low correlation in the case of molybdenum. Out of many analyzed elements of particular communities there was correlation only between soil reaction and selected elements.

Keywords: meadow sward, trace elements, environmental factors

Chemical composition of meadow sward is very important in view of animal nutrition. Bulk feeds from permanent grasslands, particularly in mountain areas are the basic source of nutrients for ruminants. Husbandry and nutrition of this group of farm animals in the Carpathian Foothills is maintained in a traditional way. Potential intensification of cultivation measures was stopped due to low profitability. However, the sward use under such conditions most frequently leads to a negative nutrient balance. Systematic harvesting of hay yields at limited mineral fertilization and usually

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at inferior fertilization with natural fertilizers (because of long distance from farms) worsens the already unfavourable situation of plant nutrition. Nutrient bioavailability may be affected also by the habitat conditions.

The investigations aimed at determining the factors conditioning the content of selected microelements in the sward of permanent grasslands from the mountain areas.

Material and methods

The research was conducted in the Radziejowa Region (20.4079°–20.7147°E and 49.3988°–49.5421°N), which is a part of the Beskid Sadecki Mts. Considering the geological structure the Beskid Sadecki is situated in the zone of Krynica Subunit, the Magura Nappe [1]. Mostly gleyed and leached brown soils formed in this area and less frequent acid brown soils (mainly podzolized and typical ones) [2]. According to Hess classification [3] the Radziejowa Region encompasses moderately warm, moderately cool and cool climatic belts.

Soil and plant samples were collected from grasslands with different habitat conditions (altitude above the sea level, land slope and slope aspect) and various types of management (Table 1).

Table 1

Statistics parameters of selected factors taken into account in testing environmental samples

Parameter	pH	Height	Inclination	Share [%]		Available form of soil [mg · kg ⁻¹]	
		[m a.s.l.]	[°]	grasses	papilionaceous plants	P	K
Arithmetic mean	4.29	655.7	17.2	47.8	9.4	25.7	130.1
Standard deviation	0.57	147.2	8.22	14.8	9.0	23.3	72.4
Minimum	3.36	343	0	2.0	0.0	1.68	11.01
Maximum	6.53	963	40	87.1	47.1	167.8	510.1
Lower quartile	3.89	537	10	37.6	0.8	12.1	79.4
Upper quartile	4.57	778	20	57.5	13.3	31.4	161.4

In result the sward was characterized by a variable botanical composition and was classified to various phytosociological units. In 2006 the research conducted the previous year [4] was supplemented and the number of samples was increased about 145. Vegetation was described using Braun-Blanquet method in a total of 356 research points with the area of 100 m². In these areas a collective sample of vegetation was gathered and a collective soil sample from the root layer. The share of individual species groups (grasses, legumes and others) were computed on the basis of average percent of surface cover.

Maps of land use from the eighties of the 20th century were used for the investigations and on the basis of those permanent grasslands and permanent grasslands formed on arable lands were determined. Macroelement and microelement contents in the plant sample were determined by methods commonly used in agricultural chemistry,

mainly ICP-AES technique after sample incineration and dissolving in nitric acid(V) (1:2). The soil pH was assessed by potentiometer in 1 mol KCl · dm⁻³. Heavy metals were extracted from soil with 1 mol HCl · dm⁻³ solution [5] and regarded as potentially bioavailable forms.

Results and discussion

Determined ranges of desirable microelement content in view of forage suitability [6] allow for a conclusion that in the investigated area mean contents of molybdenum and boron in the sward were low, copper content close to a bottom limit of low content, zinc close to upper limit of satisfactory content, cobalt content was satisfactory whereas manganese content was very high (Table 2).

Table 2

Statistics parameters of element contents in the sward of grasslands from the investigated area

Parameters	Cu	Zn	Mn	Mo	B	Co
	[mg · kg ⁻¹]					
Minimum	0.10	4.24	18.0	0.025	0.12	0.01
Maximum	10.4	184.6	952	3.22	20.6	0.40
Arithmetic mean	5.65	53.0	209.3	0.291	7.32	0.078
Standard deviation	1.32	25.5	138.9	0.301	2.84	0.052
Lower quartile	4.70	35.0	115	0.14	5.31	0.04
Upper quartile	6.40	63.2	274	0.36	8.73	0.10

Molybdenum and cobalt in sward revealed considerable variability ($V = 103$ and 66 %, respectively) in comparison with copper ($V = 23$ %) and boron ($V = 38$ %). The ranges of absolute values between the lower and upper quartile for copper and boron contents were equally small, which indirectly confirms the deficient values of these elements in the sward. Very high manganese content results from considerable acidification of the soils in this area. Fifty percent of the analyzed soils revealed reaction within the pH_{KCl} range from 3.89 to 4.57.

Boron abundance in the soil (Table 3) is assessed considering the soil pH. However, irrespective of pH value, mean contents of boron in the analyzed soils were significantly smaller than $0.8 \text{ mg B} \cdot \text{kg}^{-1}$, which has been assumed as the limit value for low content at pH lower than 4.5. The value of upper quartile is lower than the arithmetic mean, which confirms very small contents of boron extracted with $1 \text{ mol HCl} \cdot \text{dm}^{-3}$.

Assuming that these are acid soils and heavy or medium soils, typical for this area, their abundance in manganese may be estimated as medium. The range of mean abundance in soils with pH to 4.5 ranges from 16 to $180 \text{ mg Mn} \cdot \text{kg}^{-1}$ soil. This range comprises 50 % of the analyzed samples between the lower and upper quartile (Table 3).

Table 3

Statistics parameters of element contents extracted of 1 mole HCl · dm⁻³
in the soil from the investigated area

Parameters	Cu	Zn	Mn	Mo	B	Co
	[mg · kg ⁻¹]					
Minimum	0.01	0.03	1.70	0.001	0.012	0.020
Maximum	1.15	4.79	129.9	0.300	1.140	1.106
Arithmetic mean	0.38	1.66	34.7	0.026	0.143	0.266
Standard deviation	0.14	0.63	14.9	0.025	0.184	0.099
Lower quartile	0.29	1.22	26.6	0.010	0.059	0.211
Upper quartile	0.44	1.98	42.1	0.030	0.134	0.313

The soil abundance in zinc extracted by 1 mol HCl · dm⁻³ was low, as has been demonstrated by the maximum zinc content in soil which was on the border of low and medium for soil with medium granulometric structure.

Very low contents of copper, as well as molybdenum (Table 3) were assessed in the soil, assuming its acid reaction and low abundance in bioavailable phosphorus.

Analysis of simple linear regression conducted for the relationship between the metal contents in plants and in 1 mol HCl · dm⁻³ extract demonstrated that the significant dependency was apparent only for molybdenum ($r = 0.41$) and zinc ($r = 0.15$).

Analysis of multiple regression was conducted for individual metal contents in the meadow sward and selected elements of the environment. The altitude were also considered above the different sea levels, land slopes, slope aspects and various types of land management, phytosociological groups, sward fractional composition and chosen elements of the soil chemical composition. The analysis did not reveal any effect of researched elements on the selected trace elements. On the other hand, significant dependencies were registered for the element content in sward:

- for Mn on pH (BETA = -0.38) and legume share (BETA = -0.26); $R^2 = 0.27$, $F = 34.15$;
- for Zn on exchangeable cations Ca (BETA = -0.25) and soil content of zinc extracted with CaCl₂ (BETA = 0.30); $R^2 = 0.21$, $F = 24.8$;
- for Co on pH (BETA = -0.31); $R^2 = 0.09$, $F = 19.4$;
- for Cu on the altitude above the sea level (BETA = -0.25); $R^2 = 0.06$, $F = 12.8$.

Generally the determined values point to a characteristic effect of soil reaction. The more acid the soil, the greater amounts of manganese, zinc and cobalt should be expected.

Copper content in soil revealed a decreasing tendency along with the altitude above the sea level.

The results presented above suggest that systematic use of mountain meadows of the Radziejowa Region leads to exhaustion of soil heavy metal reserves. In practice, fertilization with both mineral and natural fertilizers has decreased over that last years. Farmers do not attach importance to microelement fertilization on grasslands. Balance of trace elements under these conditions is generally negative [7–10]. On one hand

elements are taken up with yields, on the other hand, they are either not supplemented or only a small amount is supplied in the ballast or natural fertilizers. In these conditions, the forage which perhaps several or many years ago met the requirements of the element content, currently reveals the contents below the recommended norms. The situation is getting worse and it is difficult to assess due to a lack of indicator plants. In the sward, species sensitive to possible deficiencies of trace elements will be replaced with others, which tolerate the low abundance. Trace element solubility in conditions of acid soils is also limited. Potentially bioavailable contents of elements in soil diminish. Sparingly soluble forms remain in soil, which not all plants can use during vegetation. Root secretions of some species may enable more intensive uptake to meet the plant requirements. The length of root system in individual plant species may be of crucial importance in these conditions. Formed soil horizons may be variously abundant in trace elements [11] and their potential deficiencies may condition plant regression visible as simplification of community structure and change of species composition. Because of a number of various interdependencies it is difficult to find habitat factors conditioning the variability of element content in the sward [12].

Conclusions

1. Research conducted in the area of the Radziejowa Region revealed that the sward from grasslands in a majority of samples revealed a low content of molybdenum and boron, sufficient content of zinc and cobalt and very high content of manganese, which denoted low abundance of soils from this region in the above-mentioned elements, except for manganese.

2. Statistical analysis of the data revealed a lack of significant correlation dependencies between the forms of potentially active microelements in soil and plants. Among a number of analyzed elements of individual communities only soil reaction revealed relationship with the selected elements.

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UWARUNKOWANIA ZAWARTOŚCI MIKROSKŁADNIKÓW W RUNI ŁĄKOWEJ PASMA RADZIEJOWEJ

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Abstrakt: Badania prowadzono w paśmie Radziejowej (20,4079°–20,7147°E i 49,3988°–49,5421°N), gdzie pobrano 211 próbek na użytkach zielonych o zróżnicowanych warunkach siedliskowych (wysokość nad poziom morza, nachylenie, ekspozycja) oraz o różnym sposobie gospodarowania. Ruń charakteryzowała się zmiennym składem botanicznym i została zaklasyfikowana do różnych jednostek fitosocjologicznych. Przedmiotem analizy była ocena zawartości makroelementów i mikroelementów na tle warunków siedliskowych.

Na obszarze Pasma Radziejowej średnie zawartości w runi molibdenu i boru były niskie, miedzi – bliska dolnej granicy zawartości niskiej, cynku – bliska górnej granicy zawartości wystarczającej, kobaltu – wystarczająca i manganu – bardzo wysoka. Zasobność gleby w mikropierwiastki, z wyjątkiem manganu, była niska. W zakresie tak małych zawartości analizowanych pierwiastków w glebie nie stwierdzono zależności pomiędzy zawartością pierwiastka ekstrahowanego 1 mol HCl · dm⁻³ a ich zawartością w roślinie, z wyjątkiem słabej korelacji dla molibdenu. Spośród szeregu analizowanych elementów poszczególnych zbiorowisk tylko odczyn wykazywał zależność z wybranymi pierwiastkami.

Słowa kluczowe: ruń łąkowa, pierwiastki śladowe, czynniki środowiska