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**EFFECT OF FOLIAR SULPHUR FERTILIZATION
ON THE PRODUCTIVITY OF THE PERMANENT
AND ALTERNATE MEADOW
PART II. THE CONTENT OF MICROELEMENTS**

**WPLYW DOLISTNEJ APLIKACJI SIARKI
NA PRODUKCYJNOŚĆ ŁĄKI TRWAŁEJ I PRZEMIENNEJ
CZ. II. ZAWARTOŚĆ MIKROELEMENTÓW***

Abstract: The experiment was established by means of random block sampling in four replicants on the brown acid soil of V quality class. The study was conducted in the years 2006–2008 on an individual farm in Pilica administrative district, in Zawiercie county, in the region of Krakow–Czestochowa Jura, at the altitude of above 320 m.

Foliar sulphur fertilization of the sward of the permanent and alternate meadows was the determination factor. After the mineralization the hay samples were subjected to the analysis of Zn, Cu, Fe and Mn by ICP-AES method. The effect of sulphur fertilization on the level of selected elements in the plant samples collected from the permanent and alternate meadow was estimated.

The weighted mean content of elements in plants derived from both meadows fluctuated in the range of: 22.81–224.86 mg Zn; 3.82–16.67 mg Cu; 60.90–190.35 mg Fe; 19.58–151.37 mg Mn · kg⁻¹ d.m.

It was stated that applied fertilization had the most spectacular effect on the zinc content in both meadow types and on the iron content in the case of permanent meadow. In our investigations we observed that the herbs were the richest in microelements. The grasses were characterized with the lowest content of these elements with the exception of the manganese level higher in grasses from the fields non-fertilized with sulphur than in leguminous plants.

Keywords: meadow sward, sulphur fertilization, content, microelements

Sulphur is a very important nutrient and its proper supply affects the proper growth and development of plants [1–3]. As sulphur is a component of essential amino acids like: cysteine, cystine and methionine, its deficiency can lead to the decrease of protein synthesis. Moreover, this element can be found in many enzymes responsible for the

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proper proceeding of metabolic pathways. It also takes part in the process of the nitrate reduction, atmospheric oxygen binding as well as regulation of chlorophyll synthesis in chloroplasts. Critical sulphur content, below which the inhibition of grass development may occur is equal to 1.0 g and the respective value for clover amounts to 2.5 g S · kg⁻¹ d.m. The total sulphur content in the forage destined for ruminants should fluctuate in the range of 1.8 to 3.0 g · kg⁻¹ d.m. [4].

The adjustment to the requirements of environmental protection led in recent years to the significant reduction of SO₂ release into the atmosphere, which resulted in lower sulphur concentration in soil. Therefore, the application of sulphur fertilizers is needed because sulphur which is the accidental component of mineral fertilizers cannot cover the plant demand for this element [5]. Moreover, deficiency of sulphur in the soil affects lower level of nitrogen assimilation from the applied fertilizers, which can be dangerous for natural environment [6]. On the basis of the investigations, it was stated that the 3:1 P₂O₅:S as well as 5:1 N:S weight proportions are beneficial for achieving the most effective phosphorus and nitrogen (respectively) action [7].

The beneficial effect of sulphur on the plant condition has been confirmed by the results of many studies [8–10], but to ensure the efficiency of fertilization during the whole vegetation period, the form and amount of the element applied is very important.

The aim of the present study was an estimation of the effect of sulphur foliar application on the content of microelements in permanent and alternate meadow flora.

Materials and methods

The investigations were conducted in the years 2006–2008, in the individual farm located in Pilica administrative district, in Zawiercie county, in the Silesia province, at the altitude of 320 m. The study was established by means of random block sampling in four replicants, on the brown, acid soil (pH_{KCl} = 5.2) of the V quality class. The investigated objects were located on the permanent and newly-established alternate meadow during the second year of the full utilization. The soil contained medium levels of assimilable potassium, manganese and zinc and low levels of phosphorus and copper. During the vegetation period (IV–IX) total rainfall and average air temperatures for each year of the study were as follows: 2006 – 338 mm and 15.2 °C; 2007 – 375 mm and 14.3 °C; 2008 – 320 mm and 14.9 °C.

Foliar fertilization with sulphur constituted the determining factor in the study. Foliar fertilizer in the form of Super S-450 suspension in a dose of 2 dm³ · ha⁻¹ (equal to 900 g S · ha⁻¹) was applied under each regrowth.

In each year of the experiment the following mineral fertilization was used for both meadow types: under the first regrowth – 80 kg N · ha⁻¹, under the second and third regrowths – 60 kg N · ha⁻¹ (for each regrowth) in the form of ammonium saltpetre, phosphorus – once in the spring, in the amount of 120 kg P₂O₅ · ha⁻¹ in the form of triple superphosphate and potassium – under the first and third regrowths – 60 kg K₂O · ha⁻¹ (for each regrowth) in the form of 57 % potassium salt. The experimental fields were characterized with the area of 10 m². Collected plant samples were subjected to the analysis of the forage chemical composition. Dry matter content

was determined by the drying method at 105 °C. The plant trials were mineralized using the dry process in the muffle oven at 450 °C [11]. The content of Zn, Cu, Ni, Fe and Mn was determined by ICP-AES (*inductively coupled plasma-atomic emission spectrometry*) method.

The obtained results were subjected to the statistical analysis of variance. Mean values were compared on the basis of the results of the Duncan test at the significance level of 0.05.

Results and discussion

Our investigations revealed that the permanent and alternate meadow fertilization with sulphur significantly affected the chemical composition of the meadow flora. Foliar application of the sulphur fertilizer had the most spectacular effect on the zinc content in the meadow plants (Table 1).

Table 1

Weighted mean content of microelements [mg · kg⁻¹ d.m.] in examined plant groups as affected by the sulphur fertilization (means of three years)

Species	Permanent meadow				Alternate meadow			
	Zn	Cu	Mn	Fe	Zn	Cu	Mn	Fe
Series without sulphur (-S)								
Grasses	22.81a*	3.82a	25.36b	60.90a	24.68a	4.67a	45.86b	72.90a
Legumes	26.56ab	7.82c	19.58a	83.90b	38.84ab	8.87bc	26.97a	90.05b
Herbs and weeds	33.98b	12.44cd	27.45b	151.48cd	46.42b	13.81c	75.70c	136.41c
Meadow sward	26.47a	5.43b	26.37b	98.70b	44.10b	4.42a	62.50bc	103.20bc
Series with sulphur (+S)								
Grasses	32.87b	5.35b	38.33bc	94.90b	47.54b	5.26a	71.88c	101.00bc
Legumes	116.54c	8.33c	75.78cd	98.40b	199.07cd	11.08bc	73.75c	117.80bc
Herbs and weeds	136.48d	14.62d	85.74d	183.23d	224.86d	16.67cd	151.37d	190.35d
Meadow sward	30.93b	7.35c	29.05b	154.90cd	65.93bc	6.90b	71.80c	105.60bc

* Means marked with the same letter are not statistically different following verification with Duncan test (P = 0.05).

The highest zinc level was stated for the plants collected from the object treated with sulphur fertilizer. In this case the plants from the permanent meadow were characterized with 65 % higher zinc content than plants collected from the non-fertilized object. The respective increase of the zinc level in the plants from the alternate meadow amounted to 71 %. As the result of sulphur foliar application significant increment of the average magnesium content was stated when compared with the control object. The difference amounted to 57 and 43 % respectively for the permanent and alternate meadow. A similar effect of this treatment was observed in the case of average copper content. The level of this element was respectively 17 and 20 % higher for the permanent and alternate meadow fertilized with sulphur. Also the iron content was positively affected by the sulphur fertilization of the meadow sward, which contained 26 (for permanent meadow) and 22 % (alternate meadow) higher concentration of this element. The

obtained results are in some part consistent with the results reported by Kulczycki [12], Kaczor et al [13], Brodowska [14], who stated that sulphur plays an important role in plant metabolism, influencing their chemical composition, what in turn directly affects the quality of crops.

According to established requirements, the amounts of microelements in forage that cover the animals feeding demand are as follows: Zn – 50 mg; Cu – 10 mg; Fe – 50 mg and Mn – 60 mg · kg⁻¹ d.m. [15, 16]. In that light, it can be found from present study that foliar application of sulphur had a beneficial effect on the content of microelements (an increased level when compared with plants from the control object) in all examined plant groups. Higher concentrations of nutrients as a result of sulphur fertilization are also reported by other authors [9, 16].

Our investigations revealed that among all examined species herbs were the richest in microelements. On the contrary, grasses contained the lowest level of these components with exception of manganese content higher than its level in leguminous plants.

Conclusions

1. Application of sulphur fertilization had the most visible effect on the zinc and manganese content. Foliar fertilization with sulphur caused significant growth of mean zinc content on the permanent and alternate meadow by 65 and 71 %, respectively. The respective increase of manganese content amounted to 57 and 43 %.

2. Sulphur fertilization led to a 17 and 20 % (respectively) higher copper level on the permanent and alternate meadow.

3. Application of the sulphur fertilizer resulted in respectively 26 and 22 % higher iron content in the samples derived from the permanent and alternate meadow.

4. Our investigations revealed that among all examined species herbs were the richest in microelements, whereas grasses contained the lowest level of these components.

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Abstrakt: Doświadczenie polowe założono metodą losowanych bloków w czterech powtórzeniach na glebie brunatnej kwaśnej, zaliczonej pod względem bonitacyjnym do klasy V. Doświadczenie prowadzono w latach 2006–2008, w indywidualnym gospodarstwie rolnym położonym w gminie Pilica, powiat zawierciański na Jurze Krakowsko-Częstochowskiej, na wysokości powyżej 320 m n.p.m.

Czynnikiem doświadczenia było dolistne nawożenie siarką runi łąki trwałej i przemiennej. Po mineralizacji próbek siana oznaczono zawartość Zn, Cu, Fe i Mn metodą ICP-AES. Oceniano wpływ nawożenia siarką na zawartość wybranych pierwiastków w roślinności łąki trwałej i przemiennej.

Średnia ważona zawartości wybranych pierwiastków w roślinności obu łąk wahała się w zakresie: 22,81–224,86 mg Zn; 3,82–16,67 mg Cu; 60,90–190,35 mg Fe; 19,58–151,37 mg Mn · kg⁻¹ s.m.

Wykazano, że zastosowane nawożenie największy wpływ wywarło na zawartość cynku na obu typach łąki oraz żelaza na łące trwałej. W badaniach własnych stwierdzono, że największą zasobnością w mikroelementy cechowały się zioła. Trawy zawierały najmniej badanych mikroelementów, jedynie manganu miały więcej niż rośliny motylkowate, ale tylko na obiektach nienawożonych siarką.

Słowa kluczowe: ruń łąkowa, nawożenie siarką, zawartość, mikroelementy