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**EFFECT OF FOLIAR SULPHUR FERTILIZATION  
ON THE PRODUCTIVITY OF THE PERMANENT  
AND ALTERNATE MEADOW  
PART I. THE DRY MATTER YIELD AND THE CONTENT  
OF MACROELEMENTS**

**WPLYW DOLISTNEJ APLIKACJI SIARKI  
NA PRODUKCYJNOŚĆ ŁĄKI TRWAŁEJ I PRZEMIENNEJ  
CZ. I. PLONY SUCHEJ MASY  
ORAZ ZAWARTOŚĆ MAKROELEMENTÓW**

**Abstract:** In the three-year field experiment the dry matter yields and the content of macroelements were compared with the plants derived from permanent and alternate meadows. Foliar fertilization with sulphur was applied in both types of meadows. In the green forage samples dry matter content was determined at 105 °C. On the basis of dry matter content in hay the yield of dry matter was calculated. After the mineralization the hay samples were subjected to the analyses of total nitrogen content – by the Kjedahl method, phosphorus and magnesium content – by colorimetric method, potassium, sodium and calcium contents – using flame photometry and sulphur content – by nephelometric method.

Foliar fertilization with sulphur positively affected the dry matter yield in the case of both permanent and alternate meadows. The application of sulphur in the form of Super S-450 preparation influenced respectively 10.5 and 22.2 % higher dry matter yields in comparison with the fields not supplemented with this fertilizer.

The weighted mean content of macroelements in plants derived from both meadows fluctuated in the range of: 1.8–4.5 gP; 15.9–27.0 gK; 0.7–3.3 gCa; 1.2–3.1 gMg; 0.15–0.95 gNa; 1.3–3.5 gS · kg<sup>-1</sup> d.m.

Fertilization with sulphur resulted in higher content of all macroelements and had the positive effect on the N : S proportion narrowing it to the level of 9.03 and 9.28 for the permanent and alternate meadow, respectively. The lower values of the N:S ratio in the forage are beneficial from the nutritional point of view.

**Keywords:** meadow sward, sulphur fertilization, content of macroelements, dry matter yield

Among all nutrients sulphur is the basic one which is important for the proper growth and development of the plants, together with nitrogen, phosphorus and magnesium

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[1–3]. It is a component of many organic and inorganic compounds which play an important role in plant metabolism. Sulphur can be found in amino acids like: methionine, cystine, cysteine, which are essential for the protein synthesis [4]. Moreover, sulphur is a component of many enzymes whose function is to regulate the plant metabolism and nitrate nitrogen to amide nitrogen transformation. Sulphur deficiency symptoms are especially visible in plants under the conditions of intensive nitrogen fertilization. For the proper plant growth and development the suitable quantitative N : S proportions, 10–15 : 1 being the optimal, are very important [5–7].

The requirements of the reduction of SO<sub>2</sub> release into the atmosphere as well as limited use of mineral and organic fertilizers resulted in significantly lower sulphur concentration in soil [8, 9]. The problem of sulphur deficiency in plant production exists in 73 countries all over the world, involving 18 European countries [10, 11]. In Poland 53 % of soils are characterized with a low sulphur level [12] and according to the predictions of the World Sulphur Institute the deficiency of this element in 2010 will amount to 11.1 mln Mg/year [10].

The aim of the present study was an estimation of the effect of sulphur foliar application on the productivity of the permanent and alternate meadows as well as yields and the content of macroelements.

## Materials and methods

The field experiment was conducted in the years 2006–2008 in an individual farm in Pilica administrative district, in Zawiercie county, in the Silesia province, at the altitude of 320 m. The experiment was established by means of random block sampling, in four replicants, on the acid, brown soil (pH<sub>KCl</sub> = 5.2) which belonged to the V soil quality class. The investigated objects were located on the permanent and on the newly-established, alternate meadow in the second year of full utilization. The soil contained medium levels of potassium, manganese and zinc and it was poor in assimilable forms 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 was the determining factor in the study. Foliar fertilizer in the form of Super S-450 suspension in a dose of 2 dm<sup>3</sup> · ha<sup>-1</sup> (equal to 900 gS · ha<sup>-1</sup>) 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 kgN · ha<sup>-1</sup>, under the second and third regrowths – 60 kgN · ha<sup>-1</sup> (for each regrowth) in the form of ammonium saltpetre, phosphorus – once in the spring, in the amount of 120 kgP<sub>2</sub>O<sub>5</sub> · ha<sup>-1</sup> in the form of triple superphosphate and potassium – under the first and third regrowths – 60 kgK<sub>2</sub>O · ha<sup>-1</sup> (for each regrowth) in the form of 57 % potassium salt. The experimental fields were characterized with the area of 10 m<sup>2</sup>. Collected plant samples were subjected to the analysis of the fodder chemical composition. The dry matter content was determined by drying at 105 °C. Nitrogen content was determined by the Kiejdahl method; phosphorus and magnesium content – by the vanadium-molybdenic method; potassium, sodium and

calcium contents – using flame photometry and sulphur content – by the nephelometric method [13].

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

## Results and discussion

The average yield collected from the fields located on the permanent meadow not fertilized with sulphur amounted to  $6.8 \text{ Mg} \cdot \text{ha}^{-1}$  (Table 1). The application of sulphur in the form of Super S-450 resulted in 10.5 % higher yield. The effect was more significant in the case of alternate meadow, where the obtained yields were higher by 22.2 %. The plants derived from all fields gave the highest yields in the year 2007 and the lowest – in 2008. The difference was equal to 19 % on average and was statistically significant.

Table 1

Dry matter yields of the meadow sward [ $\text{Mg} \cdot \text{ha}^{-1}$ ]

Variant	Years			Mean of years (2006–2008)
	2006	2007	2008	
[ $\text{Mg} \cdot \text{ha}^{-1}$ ]				
Permanent meadow (–S)	6.89a*	7.58a	5.88a	6.8a
Permanent meadow (+S)	7.26a	8.98ab	6.62b	7.6ab
Alternate meadow (–S)	9.65b	10.26b	9.32c	9.7b
Alternate meadow (+S)	12.38c	12.74c	10.41d	11.8c

\* Mean values followed by the same letters are not significantly different according to the results of the Duncan test at  $P = 0.05$ ; (–S) – series without sulphur; (+S) – series with sulphur.

The concentration of mineral components in the investigated objects was diversified. The application of sulphur fertilizer affected higher contents of all macroelements. The weighted mean content of macroelements fluctuated in the range of: 17.2–28.0 gN; 1.8–4.5 gP; 15.9–27.0 gK; 0.7–3.3 gCa; 1.2–3.1 gMg; 0.15–0.95 gNa;  $1.3\text{--}3.5 \text{ gS} \cdot \text{kg}^{-1}$  d.m. (Table 2). According to the feeding requirements the fodder of good quality should contain at least: 15–30 gN; 3.0 gP; 17–20 gK; 7.0 gCa; 2.0 gMg; 1.5–2.5 gNa and  $2.0\text{--}3.0 \text{ gS} \cdot \text{kg}^{-1}$  d.m. [6, 7].

In the conducted study the nitrogen content reached the satisfactory level in all objects. Phosphorus, calcium, magnesium and sodium levels in the examined grasses were low and below the optimal values. Only legumes as well as herbs and weeds were characterized with optimal contents of these elements. Sulphur content was below the optimal value in the case of two objects not fertilized with this element, other objects contained desirable sulphur amounts.

The value of N : S ratio is often reported as the indicator of sulphur content. The N : S = 15 is assumed as the proper value for cereals. The N : S proportion in the meadow sward of the examined fields fluctuated in the range of 8.0–15.7 and lower

Table 2

Weighted mean content of macroelements [ $\text{g} \cdot \text{kg}^{-1}$  d.m.] in analysed plant groups as affected by the sulphur fertilization (mean values for three years of the investigations)

Species	Permanent meadow						Alternate meadow							
	N	P	K	Ca	Mg	Na	S	N	P	K	Ca	Mg	Na	S
Series without sulphur														
Grasses	22.4a	1.8a	17.6a	0.7a	1.2a	0.36ab	2.24a	20.4ab	2.0a	17.4a	0.9a	1.4a	0.35a	2.00b
Legumes	26.8b	3.0b	16.1a	1.2ab	1.7b	0.15a	2.65b	22.6b	3.8cd	15.9a	1.5a	2.0ab	0.16a	1.44a
Herbs and weeds	23.8ab	2.3a	24.0c	2.4c	2.4c	0.95c	2.08a	17.2a	2.8b	26.7c	3.3c	3.1c	0.89c	1.30a
Meadow sward	19.2a	2.4a	19.1b	2.0bc	1.9b	0.52b	1.90a	21.0ab	2.6ab	19.7b	2.5b	2.3b	0.59b	2.00b
Series with sulphur														
Grasses	24.3ab	2.0a	17.7ab	0.8a	1.3a	0.36ab	2.58b	22.1b	2.5ab	17.5a	1.4a	1.5a	0.36a	3.40c
Legumes	28.0b	3.4b	16.3a	1.6b	1.7b	0.16a	3.50c	23.2c	4.5d	16.1a	1.7ab	2.1ab	0.17a	1.84ab
Herbs and weeds	24.2ab	2.5ab	24.3c	2.4c	2.5c	0.93c	2.33ab	18.8a	3.4c	27.0c	3.3c	3.1c	0.89c	1.77ab
Meadow sward	19.9a	2.7b	19.3b	2.1c	1.9b	0.52b	2.40ab	22.2b	2.9b	19.9b	2.8b	2.4ab	0.60b	3.00bc
V %	12.9	20.7	16.6	41.5	25.3	62.4	19.8	9.8	26.1	22.3	42.3	28.5	57.9	35.1

values were stated for the sward fertilized with sulphur (Table 3). Lower values of N : S ratio in fodders are more advantageous from the nutritional point of view. According to Alloway and Thompson the optimal N : S proportion in the fodder destined for ruminants ranges from 10 : 1 to 15 : 1, so it is lower than the value assumed for the optimal plant growth [14]. In the opinion of Falkowski et al [7] critical sulphur concentration, below which the inhibition of plant development may occur, amounts to 1.0 for grasses. In that light, all examined samples were characterized with higher than critical values.

Table 3

Nitrogen to sulphur ratio (means for three years)

Species	Permanent meadow	Alternate meadow
Series without sulphur		
Grasses	10.00	10.20
Legumes	10.10	15.70
Herbs and weeds	11.41	13.20
Meadow sward	10.10	10.50
Mean value	10.40	12.40
Series with sulphur		
Grasses	9.40	6.50
Legumes	8.00	12.60
Herbs and weeds	10.40	10.60
Meadow sward	8.30	7.40
Mean value	9.03	9.28

The highest N and P contents were noticed in legumes, also herbs and weeds were characterized with high K, Ca, Na and Mg levels, which is consistent with the results by Trzaskos [15] as well as Czyz and Dzida [16]. Grasses were the poorest in macroelements, except the content of K and Na, which was higher than legumes.

## Conclusions

1. The 10.5 % and 22.2 % higher dry matter yields were observed for both permanent and alternate (respectively) meadows as a result of sulphur application.
2. Treatment with sulphur fertilizer resulted in increased levels of all macroelements in all plant groups.
3. Fertilization with sulphur in the form of Super S-450 had a positive effect on the narrowing of the N : S ratio, which is beneficial from the nutritional point of view.

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**Abstrakt:** W trzyletnim doświadczeniu polowym porównywano plony suchej masy i zawartość makroelementów w roślinności łąki trwałej i przemiennej nawożonej dolistnie siarką. W próbkach zielonki oznaczono zawartość suchej masy metodą suszarkową w temperaturze 105 °C. Na podstawie zawartości suchej masy w sianie obliczono plony suchej masy. Po mineralizacji próbek siana oznaczono zawartość N – metodą Kjedahla; zawartość fosforu i magnezu – kolorymetrycznie; potasu, sodu i wapnia – metodą fotometrii płomieniowej oraz siarkę – metodą nefelometryczną.

Dolistne stosowanie siarki korzystnie oddziaływało na zwyczaj plonu suchej masy zarówno na łące trwałej, jak i przemiennej. Aplikacja siarki w formie nawozu Super S-450 spowodowała wzrost plonów suchej masy odpowiednio o 10.5 i 22.2 % w porównaniu z obiektami, na których nie stosowano tego składnika.

Średnia ważona zawartości makroelementów w roślinach obu łąk wahała się w zakresie: 1.8–4.5 gP; 15.9–27.0 gK; 0.7–3.3 gCa; 1.2–3.1 gMg; 0.15–0.95 gNa; 1.3–3.5 g S · kg<sup>-1</sup> s.m.

Zastosowane nawożenie siarką spowodowało zwiększenie zawartości wszystkich makroelementów oraz korzystnie wpłynęło na zawężenie stosunku N : S do wartości średnio 9.03 i 9.28 dla łąki trwałej i przemiennej. Niższe wartości stosunku N : S w paszy są korzystniejsze ze względów żywieniowych.

**Słowa kluczowe:** ruń łąkowa, nawożenie siarką, zawartość makroelementów, plony suchej masy