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**EFFECT OF FOLIAR FERTILIZATION WITH TYTANIT  
ON THE DRY MATTER YIELD  
AND MACROELEMENTS' CONTENT  
IN THE MEADOW SWARD**

**WPLYW NAWOŻENIA DOLISTNEGO TYTANITU  
NA PLON SUCHEJ MASY  
I ZAWARTOŚĆ MAKROELEMENTÓW RUNI ŁAKOWEJ**

**Abstract:** One-factor field experiment was designed by the method of random blocks sampling in four replications (fields of the 2.0 × 5.0 m area). The experimental field was characterized with the brown, acidic soil, classified to the V quality class. The field experiment was conducted in the years 2006–2008, in the private, individual farm in the administrative district of Pilica, within Zawiercie County, at the region of Krakow-Czestochowa Jura, located on the altitude of 320 m.

The spraying with the Tytanit fertilizer in three different concentrations: 0.02, 0.04 and 0.08 % constituted an experimental factor. Tytanit applied in a concentration of 0.04 % affected on average 52 % higher dry matter yield when compared with the control object. Moreover, foliar application of Tytanit in the concentration of 0.04 % resulted in the highest growth of the content of all examined macroelements. The difference in relation to the control object amounted to 28 % for phosphorus, 78 % for potassium, 80 % for calcium, 81 % for magnesium and 60 % for sodium. Higher dosage of the preparation (0.08 %) decreased the concentration of the investigated macroelements when compared with the 0.04 % variant and in some cases even with the 0.02 % variant.

**Keywords:** meadow sward, titanium, yield, macroelements

Recently more and more attention has been paid to ensure the proper fertilization to the plants, which cover their requirements for the fundamental components like: nitrogen, phosphorus and potassium as well as suitable amounts of microelements. Although the latter elements are assimilated only in small amounts they are required for the proper proceeding of many biochemical and physiological processes in plants.

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Titanium is one of the very important microelements which positively affects the biochemical processes proceeding in plants leading to the speeding and enhancement of the plant yielding [1–3]. Titanium fertilization stimulates the activity of many enzymes, eg: catalase, peroxidase, lipooxygenase or nitrate reductase. Moreover, it influences the speeding of metabolic processes, promotes pollination, fertilization as well as setting of fruits and seeds. Titanium affects the increase of chlorophyll concentration in leaves, promotes their growth and development. Titanium not only accelerates the plant growth and development but also decreases plant sensitivity to the unfavourable environmental conditions, increases resistance to fungal and bacterial diseases. Fertilization with titanium positively affects the assimilation of other components from the soil and other fertilizers [4]. The investigations on the effect of titanium on the increase of plant yield have been conducted mainly on the vegetables and agricultural plants and the results of these experiments confirm the positive effect of this fertilization. On the other hand, there is a little number of scientific papers concerning the effect of titanium fertilization on the meadow flora yielding. Majority of the foliar microelement fertilizers contain the minimal titanium concentrations.

Thus the aim of three-year field experiment was an estimation of the effect of Tytanit foliar fertilization on the dry matter yield and the content of macroelements in the meadow sward.

## Materials and methods

The field experiment was conducted in the years 2006–2008 in the private farm in Solca, in the Pilica administrative district. It was established by means of random block sampling with four replications on the brown, acidic soil ( $\text{pH}_{\text{KCL}} = 5.2$ ) of a V quality class. The soil contained medium level of assimilable potassium, manganese and zinc and was poor in assimilable phosphorus and copper.

During the vegetation period (April–September) the average rainfall amounted to 338.1; 375.4 and 320.3 mm, respectively in the year 2006, 2007 and 2008, whereas average air temperatures reached the values of 15.2; 14.3 and 14.9 °C, respectively.

The experiment included four objects: the control (without using the preparation) and three variants sprayed with Tytanit in three different concentrations: 0.02, 0.04 and 0.08 %. The preparation was used once for each regrowth. The first spraying was applied at the beginning of the spring vegetation, the next one after the harvesting at the stage of initial sward regrowth but not later than 3 weeks before the next mowing. During the research the fundamental mineral fertilization was also applied which comprised: 80 kg N · ha<sup>-1</sup> for the first regrowth, 60 kg N · ha<sup>-1</sup> for the second and third regrowths in the form of ammonium saltpetre. The phosphorus was utilized once in the spring, in the amount of 120 kg P<sub>2</sub>O<sub>5</sub> · ha<sup>-1</sup> as a triple superphosphate and potassium for the first and third regrowths in a dose of 60 kg K<sub>2</sub>O · ha<sup>-1</sup> for each regrowth as a 57 % potassium salt. The area of each field amounted to 10 m<sup>2</sup>.

The collected plant material was subjected to the analysis of the forage chemical composition, the dry matter content by drying at 105 °C, phosphorus and magnesium

content by the colorimetric vanadium-molybdenic method, potassium, sodium and calcium by the flame photometric method [5].

The results were subjected to the analysis of variance and verified using Tukey test at the significance level of  $\alpha = 0.05$ .

## Results and discussion

The conducted study revealed that foliar application of Tytanit preparation in different concentrations (0.02 %, 0.04 % and 0.08 %) significantly affected the dry matter yield of the meadow sward. In all examined fertilization variants these treatment had a positive yielding effect. The plants treated with foliar fertilizer provided greater dry matter yield than the plants from the control object. The lowest average yields of dry matter for three years were collected with the sward of the control object (Table 1). The sward fertilized with Tytanit in a concentration of 0.02 % increased the yield by  $2.47 \text{ Mg} \cdot \text{ha}^{-1}$ . The following values of the yield were observed for the sward fertilized with Tytanit in a concentration of 0.08 and 0.04 %. The latter treatment resulted in the average  $14.42 \text{ Mg} \cdot \text{ha}^{-1}$  dry matter yield which was higher from the respective value noticed for the control object by 52 %. The sward of the examined objects gave the highest yield in the year 2007 and the lowest level was found in 2008. The difference between the results of dry matter yield observed for these years amounted to 15.5 % for the fertilized objects and 11.1 % for the control and was statistically significant. The positive effect of foliar application of the selected fertilizers on the plant yielding was reported by Faber et al [6], Czuba et al [7], Szewczuk [8], Kocon and Grenda [3] and others. According to Faber et al [6] the beneficial effect of foliar fertilization on the plant condition results from the activation of its metabolism what leads to the higher assimilation of the nutrients by the root systems. Moreover, these results are consistent with the findings of many authors [3, 4, 6, 9–11], who proved that foliar fertilization of wheat, rape and other plants positively affected photosynthesis and efficiency of the nitrogen utilization and in a consequence influenced higher yield of the plants.

Table 1

The dry matter yields of the meadow sward

Tytanit concentration	Years			Means for the years (2006–2008)	
	2006	2007	2008		
	[Mg · ha <sup>-1</sup> ]			[%]	
Control	9.74	9.81	8.83	9.46	100
0.02 %	12.02	12.24	11.54	11.93	126
0.04 %	13.98	15.82	13.45	14.42	152
0.08 %	13.43	14.52	11.84	13.26	140
LSD <sub>0.05</sub>	1.38	2.23	1.67	—	—

Applied foliar fertilization with Tytanit the highest impact had on a calcium content in the meadow flora (Table 2). The highest level of this element was determined for the

Table 2

The effect of different Tytanit concentrations on the macroelements' content in the meadow sward

Tytanit concentration	Content of macroelements [g · kg <sup>-1</sup> d.m.]														
	P			K			Ca			Mg			Na		
	2006	2007	2008	2006	2007	2008	2006	2007	2008	2006	2007	2008	2006	2007	2008
Control	2.83	2.06	3.11	15.10	14.61	15.61	4.28	2.91	8.53	0.98	0.82	1.18	0.16	0.09	0.19
0.02 %	3.00	2.16	3.90	23.97	18.16	31.52	5.35	4.79	13.20	1.27	1.50	1.52	0.16	0.14	0.24
0.04 %	3.03	2.94	4.25	26.27	21.89	32.51	7.69	6.78	13.91	1.61	1.82	1.93	0.22	0.17	0.30
0.08 %	2.87	2.28	3.62	24.30	21.47	26.76	6.79	5.12	13.20	1.53	1.34	1.58	0.18	0.14	0.28
Mean	2.93	2.36	3.72	22.41	19.03	26.60	6.03	4.90	12.21	1.35	1.37	1.55	0.18	0.14	0.25
LSD <sub>0,05</sub>	ns	0.49	0.45	3.28	2.43	5.02	1.41	1.60	1.45	0.22	0.38	0.32	ns	ns	0.04

plants from the object sprayed with the Tytanit preparation in a concentration of 0.04 %. The plants collected from this object contained 92 % higher sodium concentration than plants from the control object (mean contents for three years). As a result of foliar treatment with 0.02 and 0.08 % Tytanit preparation a significant growth of mean calcium content when compared with the control object was also found – the difference reached the level of 48 and 63 %, respectively. High diversity as affected by the foliar application of titanium was found for magnesium content. The most significant increase of this component was observed after the application of 0.04 and 0.08 % concentration. The difference in relation to the control object was equal to 84 and 52 %, respectively.

Our investigations revealed also that foliar application of titanium also affected potassium and sodium contents. As an effect 66 % and 46 % higher mean levels of respectively potassium and sodium were noticed as a result of titanium utilization. Tytanit applied in a concentration of 0.04 % increased potassium and sodium contents, whereas higher dose (0.08 %) slightly decreased the level of these elements. The least diversified were results obtained for the phosphorus content – 17 % in relation to the control object. The highest values were noticed after the treatment with Tytanit in a concentration of 0.04 % and the lowest (without the control object taking into consideration) for the object sprayed with 0.08 % concentration. Marcinek and Hetman [12] also reported the increment of macroelements' content in plants as a result of Tytanit fertilization.

The obtained positive effect on yielding as well as higher concentration of the examined macroelements under the treatment with titanium indicates that the foliar fertilization of the meadow sward with this component is recommended even if the cultivation conditions suggest that availability of the nutrients is good.

## Conclusions

1. The utilization of Tytanit fertilizer in three different concentrations significantly affected dry matter yield of the meadow sward. Tytanit applied in a concentration of 0.04 % increased the dry matter yield by 52 % in relation to the control object.
2. Tytanit application significantly influenced the calcium content in the meadow flora. Foliar treatment with titanium in a concentration of 0.04 % and 0.08 % resulted in significantly increased mean content of this element in comparison with the non-fertilized object. The difference reached the value of 92 and 63 %, respectively.
3. The fertilization with titanium lead to 66, 61 and 46 % higher mean content of potassium, magnesium and sodium, respectively.
4. The highest growth of the content of examined macroelements was found in the object fertilized with Tytanit in a concentration of 0.04 %. This variant resulted in 70 % (on average) higher content of all macroelements in relation to the control object.
5. Higher concentration of the preparation (0.08 %) decreased the content of examined macroelements in comparison with the 0.04 % concentration, and in some cases also in relation to the concentration of 0.02 %.

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## WPŁYW NAWOŻENIA DOLISTNEGO TYTANITU NA PŁON SUCHEJ MASY I ZAWARTOŚĆ MAKROELEMENTÓW RUNI ŁĄKOWEJ

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**Abstrakt:** Jednoczynnikowe doświadczenie polowe założono metodą losowanych bloków, w czterech powtórzeniach (poletka o wymiarach 2,0 × 5,0 m). Na polu doświadczalnym występowała gleba brunatna kwaśna, zaliczana pod względem bonitacyjnym do klasy V. Doświadczenie prowadzono w latach 2006–2008, w indywidualnym gospodarstwie rolnym położonym w gminie Pillica, powiat zawierciański na Jurze Krakowsko-Częstochowskiej, na wysokości powyżej 320 m n.p.m.

Czynnikiem doświadczenia był oprysk nawozem Tytanit w trzech stężeniach: 0,02, 0,04 i 0,08 %. Tytanit stosowany w stężeniu 0,04 % zwiększył plon suchej masy w stosunku do obiektu kontrolnego średnio o 52 %.

Ponadto stwierdzono, iż dolistne zastosowanie Tytanitu w stężeniu 0,04 % spowodowało największy wzrost zawartości wszystkich badanych makroelementów. Różnica ta w porównaniu z obiektem kontrolnym wynosiła dla fosforu 28 %, dla potasu 78 %, dla wapnia 80 %, dla magnezu 81 % i dla sodu 60 %. Większe stężenie preparatu (0,08 %) zmniejszyło zawartość badanych makroelementów w porównaniu do preparatu o stężeniu 0,04, a w niektórych przypadkach nawet do oprysku o stężeniu 0,02 %.

**Słowa kluczowe:** ruń łąkowa, tytan, plon, makroelementy