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EFFECT OF FOLIAR APPLICATION OF GROWTH BIOSTIMULANT ON QUALITY AND NUTRITIVE VALUE OF MEADOW SWARD

WPŁYW DOLISTNEJ APLIKACJI BIOSTYMULATORA WZROSTU NA JAKOŚĆ I WARTOŚĆ POKARMOWĄ RUNI ŁĄKOWEJ

Abstract: The experiment was conducted during 2010–2012 on a private farm in the Slaskie province, at an altitude of 320 m above sea level. A one-factorial field experiment was set up as a randomized block design with four replications. The experimental plots, 10 m^2 in area, had class V acid brown soil. Treatment factors were spraying three concentrations (0.02, 0.04 and 0.08 %) of growth biostimulant (Tytanit fertilizer). The highest dose of the foliar application of Tytanit (0.08 %) caused significant increases in dry matter yield and nutrient content in relation to the control plot. The protein and energy value was also found to increase significantly. Satisfactory results were also obtained in plots where titanium was applied at a concentration of 0.04 %.

Keywords: meadow sward, growth biostimulant, quality and nutritive quality

In addition to basic mineral fertilizers and the application of fungicides and herbicides, increasing use in modern plant cultivation is made of a number of preparations known as plant growth regulators or biostimulants [1]. This is a relatively new group of products used to maximize yield and quality, especially under unfavourable environmental conditions for plant growth and development [2]. These preparations stimulate the development of whole plants or individual plant parts (roots, leaves); increase the rate of life processes; can make plants more resistant to stress factors; and facilitate regeneration after exposure to adverse factors. Biostimulants contribute to better seed germination and stimulate the biological activity of plants [3, 4]. Their mode

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of action makes them environmentally safe and their application helps to reduce the amount of chemicals used in agriculture and plant protection [5, 6]. Titanium is a trace element used as a biostimulant in cultivation of plants. It has a beneficial effect on the biochemical processes in plants that accelerate and enhance crop performance [7]. Titanium stimulates the activity of many enzymes, such as catalase, peroxidase, lipoxygenase and nitrate reductase. Furthermore, it accelerates metabolic processes, and facilitates the pollination, fertilization and setting of fruits and seeds [6]. Titanium increases the chlorophyll content of leaves, accelerates the growth and development of leaves, makes plants less sensitive to adverse environmental conditions, and enhances resistance to fungal and bacterial diseases [8]. Studies investigating the effect of titanium on increasing crop performance, conducted mainly with vegetables and cultivated plants, demonstrated positive effects of titanium fertilization [9, 10]. However, very few reports concern the use of titanium as a biostimulant for meadow vegetation. Therefore, the aim of this study was to determine the effect of foliar application of growth biostimulant (titanium) on the quality and nutritive value of meadow sward.

Material and methods

The field experiment, conducted during 2010–2012 on a private farm, was set up as a randomized block design with four replications. The experimental plots had class V acid brown soil with pH_{KCl} of 5.2. Abundance of available forms of potassium (111.2 $mgK \cdot kg^{-1}$ soil), manganese (52.4 $mgMn \cdot kg^{-1}$ soil) and zinc (5.6 $mgZn \cdot kg^{-1}$ soil) in the soil was intermediate, while the content of available forms of phosphorus (27.0 $mgP \cdot kg^{-1}$ soil) and copper (1.6 $mgCu \cdot kg^{-1}$ soil) was low. During the growth period (April–September), total precipitation in 2010, 2011 and 2012 was 775.1, 423.8 and 365.4 mm, respectively, with air temperatures during the same period averaging 13.1, 15.4 and 15.8 ^{o}C, respectively. The experiment consisted of four plots: a control plot (no preparation) and plots sprayed with Tytanit at the concentrations of 0.02, 0.04 and 0.08 %. The preparation was applied once for each regrowth. The first spraying was done after spring growth began and the second spraying was given after harvest during initial regrowth of sward, but not later than 3 weeks before the next cutting. During the study basic mineral fertilization was also applied: 80 $kgN \cdot ha^{-1}$ for the first regrowth, and 60 $kgN \cdot ha^{-1}$ each for the second and third regrowths in the form of ammonium nitrate. Phosphorus was applied once in the spring (120 $kgP_2O_5 \cdot ha^{-1}$) as triple superphosphate and potassium for the first and third regrowths (each at a dose of 60 $kgK_2O \cdot ha^{-1}$) as 57 % potassium salt. Each experimental plot had an area of 10 m^2. Vegetation resulted from sowing the Country 2015 mixture for extensive utilization, suitable for cutting and grazing, which contained: meadow fescue 25 %, early perennial ryegrass 10 %, intermediate perennial ryegrass 10 %, late perennial ryegrass 10 %, smooth-stalked meadow-grass 10 %, red fescue 10 %, white clover 10 %, red clover 10 %, timothy 5 %. This mixture was sown between 20 and 30 August 2009 at 40 $kg \cdot ha^{-1}$. The sward samples were analysed for chemical composition of the feed in accordance with AOAC procedure [11]. The nutritive value was estimated with the

INRA system using Winwar ver. 1.6. (DJG). The analysed plant material was evaluated using tables with nutrient ruminal and intestinal degradation data. The results were subjected to analysis of variance using Tukey's test at the $\alpha = 0.05$ level of significance.

Results

The present study showed that foliar application of different concentrations of the biostimulant (0.02, 0.04 and 0.08 %) had a significant effect on dry matter yield and organic nutrient content of meadow sward (Table 1).

Table 1

Dry matter yield and content of crude protein, crude fibre, water soluble carbohydrates (WSC), crude fat and crude ash in meadow sward

Research factors	Object	Dry matter yield	Crude protein	Crude fibre	WSC	Crude fat	Crude ash
		[dt · ha^{-1}]	[g · kg^{-1} d.m.]				
A. Growth stimulant	0	42.5	122.2	298.0	61.2	32.9	104.2
	0.02	51.2	140.9	279.0	73.9	34.6	112.6
	0.04	53.5	153.8	265.0	69.5	38.7	118.6
	0.08	60.2	179.0	256.0	67.6	39.3	123.6
	$LSD_{0.05}$	9.1	26.8	18.5	5.8	2.9	8.8
B. Year	2010	55.1	139.9	288.8	75.2	32.9	122.4
	2011	50.5	149.6	269.8	70.3	36.6	113.7
	2012	49.8	157.7	264.8	58.5	39.6	108.2
	$LSD_{0.05}$	2.0	10.3	9.2	6.9	3.1	6.3
C. Cutting	1	70.1	140.7	284.4	76.7	35.1	105.1
	2	47.3	145.1	276.6	64.4	40.4	127.9
	3	38.1	161.2	262.4	62.8	34.0	111.5
	$LSD_{0.05}$	13.4	8.2	15.0	5.1	2.5	9.6
Interaction	A × B	8.2	13.6	12.2	9.1	4.1	8.3
	A × C	ns	ns	ns	ns	ns	ns
	B × C	5.1	ns	ns	ns	ns	ns
	A × B × C	ns	ns	ns	ns	ns	ns

The biostimulant had a positive effect for all fertilizer treatments. Dry matter yield was lowest in plants from the control plot (42.5 dt · ha^{-1}) and significantly higher in plots where titanium was applied at rates of 0.04 % (53.5 dt · ha^{-1}) and 0.08 % (60.2 dt · ha^{-1}). The increasing levels of foliar fertilization with the biostimulant also significantly increased the crude protein content compared to the control plot. Best results, significantly better than others, were obtained when using the highest Ti concentration of 0.08 %. The highest titanium concentration proved most efficient when meadow sward plants were fertilized. The lowest titanium concentration had no significant effect on most of the parameters studied. No significant difference was also observed in nutrient content between the plots treated with 0.04 % and 0.08 % Ti.

During the years of the study, the average dry matter yield of harvested plants ranged from 49.8 dt · ha^{-1} (2012) to 55.3 dt · ha^{-1} (2010) with a statistically significant difference. Analysis of nutrients in different years of the study revealed that the average crude protein content of meadow sward ranged from 139.9 (2010) to 157.7 g · kg^{-1} d.m. (2012) with a statistically significant difference. The present study confirmed an inverse relationship for the content of crude protein and crude fibre. Crude fibre was highest in 2010 and lowest in 2012. A similar relationship was also noted for water soluble carbohydrates and crude ash. In turn, the content of crude fat in meadow sward plants increased in each year of the study. As regards regrowth harvests, dry matter yield was lowest in the third cutting and highest in the first. The crude protein and crude ash content of the plants was lowest for the first cutting and significantly higher for the second and third cuttings. As regards crude fibre and water soluble carbohydrates, the concentration of these nutrients was highest in the first cutting but declined in the next cuttings. A significant interaction was observed between the year of the study and foliar fertilization.

The increasing concentration of the growth biostimulant caused a significant increase in energy value (UFL from 0.65 to 0.76 g · kg^{-1} d.m., UFV from 0.55 to 0.68 g · kg^{-1} d.m.) and protein value (51–76 for PDIN and 67–81 g · kg^{-1} d.m for PDIE) (Table 2).

Table 2

Nutritive value of meadow sward

Research factors	Object	Content in 1 kg feed d.m.			
		UFL	UFV	PDIN [g]	PDIE [g]
A. Growth stimulant	0	0.65	0.55	51	67
	0.02	0.74	0.65	65	77
	0.04	0.75	0.66	78	81
	0.08	0.76	0.68	76	81
	$LSD_{0.05}$	0.04	0.04	10.7	4.6
B. Year	2010	0.71	0.63	65	75
	2011	0.72	0.63	68	77
	2012	0.74	0.64	72	80
	$LSD_{0.05}$	0.01	0.01	3.7	2.6
C. Cutting	1	0.68	0.58	62	67
	2	0.74	0.66	71	81
	3	0.75	0.66	70	82
	$LSD_{0.05}$	0.03	0.03	3.4	5.4
Interaction	A × B	0.015	0.011	4.9	3.4
	A × C	ns	ns	ns	ns
	B × C	ns	ns	ns	ns
	A × B × C	ns	ns	ns	ns

Climatic conditions in particular years had a significant effect on the feed unit values of meadow sward. All the analysed indices of nutritive value increased in each year of the study. Also the nutritive value of sward was higher in successive cuttings.

Discussion

The positive effects of foliar fertilization of plants on yield level and quality were reported by many authors [10, 12–14]. According to Faber et al [12], the beneficial effect of foliar fertilization is due, among others, to stimulating the plant's metabolism, which increases nutrient intake by the root system. Foliar fertilizers that contain macro- and micronutrients increase yields, improve plant health and even reduce damage caused by diseases and plants [15]. One of the micronutrients that stimulates plants is titanium. This element stimulates the pollination and setting of fruit and seeds, enhances resistance to fungal and bacterial diseases, accelerates the growth and development of leaves, and acts as a catalyst to improve the uptake of nutrients from the soil and foliar fertilizers [16]. According to Grenda [8], the stimulatory action of titanium is due to the increased activity of iron ions, which increases the synthesis of assimilation pigments. In another study [17], the co-author of this experiment observed increased chlorophyll content of timothy leaves in response to titanium fertilization. Titanium ions also contribute to higher enzymatic activity and better nutrient intake from the soil solution [9]. In her study, the same author obtained vegetative growth of tomato plants in response to spraying with Tytanit. This stimulant increased plant height, stem diameter, and number of leaves per plant, which resulted in higher total yield and marketable yield of tomato fruits. In practice, growth stimulants are mostly used in the cultivation of vegetables, fruits and flowers [18, 19]. Szewczuk and Juszczak [20] reported a 30 % increase in the yield of the common bean in response to Tytanit. Research with apple trees, maize, sugar beets and yellow lupin also confirms that titanium has a positive effect by increasing yields by around 10–20 % [21]. Janas et al [22] showed a significant effect of Tytanit on yielding of aubergine, particularly under adverse climatic conditions. In the present study, the years 2011 and 2012 were identified as dry years because the growth periods were characterized by considerably lower total precipitation compared to 2010. The current study demonstrated that the application of titanium reduced the adverse effects of drought on the nutrient content of meadow sward. Our experiment shows that the quality of roughages can be improved by titanium fertilization of meadow sward. This issue is of great significance on the national level. Brzoska and Sliwinski [23] reported that the quality of roughages from grasslands in Poland is inferior to that of feeds from France, for example. The differences may reach 15–20 %. The main reason is insufficient and improper fertilization. Therefore, studies aimed at improving the quality of feeds are fully justified.

Conclusions

1. The application of additional foliar fertilization with Tytanit in three different concentrations had a significant effect on nutrient content. Compared to the control plot, a 0.08 % concentration of Tytanit contributed the most to increasing the concentration of nutrients. Satisfactory results were also obtained when the preparation was sprayed at a concentration of 0.04 %.

2. Foliar application of titanium at 0.04 and 0.08 % increased the average content of desirable nutrients, but the differences between these fertilizer treatments were statistically non significant. The highest nutritive value was observed in plots where titanium was applied at 0.08 %.

3. Under adverse atmospheric conditions, Tytanit preparation showed antistress activity and contributed to increases in crude protein content, crude fat content, and protein and enzymatic value.

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Abstrakt: Doświadczenie polowe prowadzono w latach 2010–2012, w indywidualnym gospodarstwie rolnym w województwie śląskim, na wysokości powyżej 320 m n.p.m. Jednoczynnikowe doświadczenie polowe założono metodą losowanych bloków, w czterech powtórzeniach, powierzchnia poletek doświadczalnych wynosiła 10 m^2. Na polu doświadczalnym występowała gleba brunatna kwaśna, zaliczana pod względem bonitacyjnym do klasy V. Czynnikiem doświadczenia był oprysk biostymulatorem wzrostu w postaci nawozu Tytanit w trzech stężeniach: 0,02, 0,04 i 0,08 %. Zastosowanie nawożenia dolistnego Tytanitem w najwyższej dawce (0,08 %) spowodowało istotny wzrost plonów suchej masy oraz zawartości składników pokarmowych w stosunku do obiektu kontrolnego. Ponadto stwierdzono, również istotny wzrost wartości białkowej i energetycznej. Zadowalające efekty uzyskano także w obiektach, gdzie aplikowano tytan w stężeniu 0,04 %.

Słowa kluczowe: ruń łąkowa, biostymulator wzrostu, jakość pokarmowa, wartość pokarmowa