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# The Effect on Tytanit Foliar Application on the Yield and Nutritional Value of *Festulolium braunii*

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**Abstract:** The aim of the research was to assess the content of protein and soluble sugars and the yield of *Festulolium braunii* treated with different fertilizers. The effects of Tytanit foliar application at a concentration of 0.2% and 1% and of mineral nitrogen at a dose of 80 and 160 kg/ha were studied in the experiment. When the grass was fully developed (2015–2017), *Festulolium braunii* was harvested three times a year. Mineral nitrogen fertilizer in combination with Tytanit increased the yield and the concentration of protein in the plants. Each year the highest yield was recorded on plots treated with mineral nitrogen at a dose of 160 kg ha<sup>-1</sup> in combination with the foliar application of Tytanit at a concentration of 1%. In the 1st and 2nd years of the research, *Festulolium braunii* treated with one dose of Tytanit at a concentration of 1% contained more soluble sugars than plants from plots treated with nitrogen.

**Keywords:** *Festulolium braunii*; yield; protein content; soluble sugars

## 1. Introduction

Progressive climate change is not conducive to the growth and development of forage grass species. However, thanks to hybrids, it is possible to produce forage effectively even under such stress conditions like drought, which is increasingly occurring now. In recent years, there has been an increase in interest in cross-genus and cross-species hybrids within the *Lolium-Festuca* complex. Combining many complementary characteristics of these grasses into one genome brings many benefits to agricultural practice [1–3]. *Festulolium* produces a high biomass yield and is resistant to cold and drought [4–8]. Borowiecki [5] reports that in terms of protein content and the amount of energy, *Festulolium braunii* exceeds Skra, a standard variety of *Poa pratensis* L., and is more resistant to cold than *Italian ryegrass* L. var. Lotus. *Festulolium braunii* varieties belong to grasses with high yield potential, especially in the first year and with appropriate fertilizer treatment [9]. The application of mineral nitrogen to grassland should be differentiated according to its botanical composition and the type of soil. The nitrogen dose should be adapted to the way meadows and pastures are managed, more specifically to the frequency of mowing or grazing. Too much mineral nitrogen can decrease forage quality [10]. In recent years, particular attention has been paid to the possibility of using growth regulators and amendments that could replace or supplement nitrogen fertilizer in increasing soil fertility [11–14]. The interest in such biological substances is mainly due to rising concern over the environment and food safety. The aim of the research was to assess the effects of Tytanit foliar application and different doses of mineral nitrogen on the yield and the content of protein and soluble sugars of *Festulolium braunii*.

## 2. Material and Methods

The experiment was set up in the spring of 2014 in the field of the University of Natural Sciences and Humanities in Siedlce, in the Central-Eastern part of Poland, on soil with the granulometric composition of loamy sand, with  $\text{pH}_{\text{KCl}}$  of 6.75. Organic carbon content was  $37.0 \text{ g kg}^{-1}$  with  $1.75 \text{ g kg}^{-1}$  of total nitrogen. In contrast, available forms of phosphorus and potassium determined by the Egner-Rhiem method were within the moderate content of  $39.9 \text{ mg kg}^{-1}$  and  $128 \text{ mg kg}^{-1}$ , respectively. The total content of the macronutrients in the soil was as follows ( $\text{g kg}^{-1}$ ): P–1.05; K–1.00; Ca–2.40; Mg–1.25; S–0.508; Na–0.312. The Felopa variety of *Festulolium braunii* (K. Richt.) A. Camus was used in the experiment. The standard sowing rate was adopted according to the Institute of Land Reclamation and Grassland Farming in Falenty [15]. The area for the experiment was divided into plots of  $1.5 \text{ m}^2$ . In the experiment, growth cycles (harvests) or years of research were the first test factor (A), while the second (B) was fertilizer treatment.

Each combination was replicated three times, in a completely randomized design:

- control (no treatment);
- ammonium nitrate ( $\text{N}_1$ )  $80 \text{ kg N ha}^{-1}$ , ( $24 \text{ g N plot}^{-1}$ );
- ammonium nitrate ( $\text{N}_2$ )  $160 \text{ kg N ha}^{-1}$ , ( $47 \text{ g N plot}^{-1}$ );
- Tytanit ( $\text{Ti}_1$ ) 0.2% ( $1 \text{ cm}^3$  in  $500 \text{ cm}^3$  of water);
- Tytanit ( $\text{Ti}_2$ ) 1% ( $5 \text{ cm}^3$  in  $500 \text{ cm}^3$  of water);
- ammonium nitrate ( $\text{N}_1$ ) + Tytanit ( $\text{Ti}_1$ );
- ammonium nitrate ( $\text{N}_2$ ) + Tytanit ( $\text{Ti}_2$ ).

Each year mineral nitrogen was divided into three doses: the first applied in the early spring, before the start of the growing period, and the others after two subsequent harvests. Phosphorus-potassium fertilizers were not applied due to the moderate soil content of the available forms of those macronutrients. Tytanit spray was applied once during the stem formation stage.

Fertilizers were not used in the first year (2014) when the grass was planted. This period was treated as a preparatory time during which three cuttings were carried out to destroy the weeds. In the years of full use (2015–2017), *Festulolium braunii* (Fb) was harvested three times. The first mowing was carried out in late May, the second in early July and the third in mid-September. The grass was cut at a height of 5–6 cm at the earing stage. Cutting at a height of less than 5 cm deprives the grass of lower leaves and stems containing spare substances necessary for plants to regenerate their organs. At the same time, the soil is too exposed. During the harvest,  $0.5 \text{ kg}$  of green matter was collected from each plot, in which air-dry matter content was determined. In the research, the yield of fresh and dry matter was measured by the oven-drying method. The collected material was dried at  $105 \text{ }^\circ\text{C}$  to constant mass in the drying oven SLN 32 produced by POL-EKO-APPARATURA. Subsequently, the plant samples were ground in the laboratory grinder Wz-1S, purchased at the Research Institute of the Bakery Industry in Bydgoszcz. In the dry plant material, the content of total protein and soluble sugars was determined with the NIRS method [PN-EN ISO 12099, 2013] using the NIRFlex N-500 apparatus with ready-made calibrations for roughage from the INGOT® company. These analyses were carried out at the Institute of Technology and Life Sciences in Falenty, which has the equipment and appropriate personnel for its operation.

The digestible protein content was calculated using the following formula [16]:

$$\text{BS} = 0.946 * \text{N} * 6.25 - 3.52 [\% \text{DM}] \quad (1)$$

The sugar-protein ratio of the plant dry matter was also calculated. Meteorological data for 2015–2017 were obtained from the Hydrological and Meteorological Station in Siedlce. In order to determine the temporary variability of temperatures and precipitation and their effect on the vegetation of the plants, Sielianinov's hydrothermal coefficient was calculated. It is based on the monthly amount

of precipitation (P) and the monthly sum of daily air temperatures (t). Sielianinov's hydrothermal coefficient (K) was calculated using the following formula [17]:

$$K = P \times 10 / \Sigma t \quad (2)$$

$$K\text{--Sielianinov's coefficient,} \quad (3)$$

$$P\text{--monthly sum of precipitation,} \quad (4)$$

$$\Sigma t\text{--monthly sum of daily air temperatures.} \quad (5)$$

The results of the research were processed statistically using a three-factor analysis of variance. The Fisher-Snedecor test was done to determine the significance of the effects of experimental factors on the parameters tested in the research. Tukey's test was used to compare means at the  $LSD_{0.05}$  significance level. All the calculations were carried out with the Statistica 10.0–2011 program [18].

### 3. Results and Discussion

In the first year of full use of *Festulolium braunii* (2015), optimal thermal and humidity conditions were only in April (Table 1). It was moderately wet in May, June, and August, while the remaining months were very dry and extremely dry. In the second year (2016), optimal conditions in terms of precipitation and air temperature were recorded in September. It was very humid in May, but June and August, the most important months for the proper growth and development of plants, were quite dry and extremely dry. In 2017, thermal and humidity conditions were even more unfavorable than in previous years. The beginning and end of the growing season were very humid and quite humid, while the period from May to August was quite dry and dry.

The statistical analysis of the research results (Table 2) indicated that there were significant variations in the biomass yield of *Festulolium braunii* across the growing seasons, depending on the experimental factors. In the first year of full use, the largest biomass yield ( $9.80 \text{ t ha}^{-1}$ ) was on the plot with the mineral nitrogen dose of  $160 \text{ kg ha}^{-1}$  ( $N_2$ ), and when plants were treated with the combination of the above nitrogen dose and 1% Tytanit; compared to control, the increase in the yield on these plots was 40%. In the second and third years, an increase in the yield of *Festulolium braunii* on the plot with the highest dose of nitrogen supplemented with Tytanit was 54.5% and 75%, respectively. Each year Tytanit doses increased the *Festulolium braunii* yield more than  $80 \text{ kg ha}^{-1}$  nitrogen ( $N_1$ ). As an average of all experimental plots, the largest yield ( $8.60 \text{ t ha}^{-1}\text{DM}$ ) was in the third year (2017) and the smallest ( $7.59 \text{ t ha}^{-1}\text{DM}$ ) in the second (2016), while the yield average across all three years was  $8.17 \text{ t ha}^{-1}\text{DM}$ .

Fertilizer treatments, especially nitrogen, significantly increase the quantity and quality of grass yield, according to many authors [19–21], (nitrogen modifies the morphological and chemical properties of grasses, determining their yield and nutritional value. The higher dose of nitrogen applied with the higher concentration of Tytanit ( $N_2 + Ti_2$ ) significantly increased the yield; the  $9.92 \text{ t ha}^{-1}\text{DM}$  yield from this plot, the average across three years, was the largest of all. Plants responded to mineral nitrogen treatment ( $N_2$ ) with an average yield of  $9.01 \text{ t ha}^{-1}\text{DM}$ . By contrast, Tytanit ( $Ti_2$ ) foliar application increased the yield of *Festulolium braunii* to  $8.66 \text{ t ha}^{-1}\text{DM}$ . It was significantly higher than the yield of grass treated with nitrogen at a dose of  $80 \text{ kg N ha}^{-1}$  ( $N_1$ ) and higher than on the plot with the lower dose of nitrogen combined with 0.2% Tytanit ( $N_1 + Ti_1$ ). The average yield on this plot was slightly lower than for grass treated with the standard nitrogen dose ( $N_2$ ), and the differences were not statistically significant. It was observed that Tytanit single foliar application at a concentration of 1% affected the yield as much as the traditional mineral nitrogen fertilizer top dressing ( $160 \text{ kg ha}^{-1}$ ) applied in three split doses.

It was found that *Festulolium braunii* yields significantly varied across harvests, and different forms of fertilizer treatment affected differences between harvests (Figure 1). According to Staniak [22], the first harvest is essential for the forage production on arable land as it accounts for about 50% of the

annual yield. In the present experiment, the first *Festulolium braunii* harvest was also much higher than the other two.

**Table 1.** Average daily air temperatures per month (OC), monthly rainfall (mm), and monthly Sielianinov's index.

Year	Month							
	IV	V	VI	VII	VIII	IX	X	Mean
Temperature								
2015	9.7	13.7	15.1	20.5	17.8	13.7	8.4	14.1
2016	8.2	12.3	16.5	18.7	21.0	14.5	6.5	14.0
2017	8.3	13.9	17.8	16.9	18.4	13.9	9.0	13.8
Mean	8.3	13.3	16.5	18.7	19.1	14.0	8.0	13.9
Mean of 2004–2014	8.5	14.0	17.4	19.8	18.9	13.2	7.9	14.2
Rainfall (mm)								
2015	39.5	79.5	74.2	37.5	105.7	26.3	3.00	52.2
2016	30.0	100.2	43.3	62.6	11.9	77.1	39.0	52.0
2017	59.6	49.5	57.9	23.6	54.7	80.1	53.0	54.1
Mean	43.0	76.4	58.5	41.2	57.4	61.2	31.7	52.8
Mean of 2004–2014	33.0	52.0	52.0	65.0	56.0	48.0	28.0	47.7
Sielianinov's coefficient (K)								
2015	1.36 (o)	1.87 (mw)	1.64 (mw)	0.59 (sd)	1.92 (mw)	0.64 (sd)	0.12 (ed)	-
2016	1.22 (md)	2.63 (sw)	0.87 (d)	1.08 (md)	0.18 (ed)	1.46 (o)	1.94 (mw)	-
2017	2.88 (sw)	1.15 (md)	1.08 (md)	0.45 (sd)	0.96 (d)	1.92 (mw)	1.90 (mw)	-

K ≤ 0.4 extreme drought (ed), 0.4 < K ≤ 0.7 severe drought (sd), 0.7 < K ≤ 1.0 drought (d), 1.0 < K ≤ 1.3 moderate drought (md), 1.3 < K ≤ 1.6 optimal (o), 1.6 < K ≤ 2.0 moderately wet (mw), 2.0 < K ≤ 2.5 wet (w), 2.5 < K ≤ 3.0 severely wet (sw), K > 3.0 extremely wet (ew).

**Table 2.** The yield of *Festulolium braunii* (t ha<sup>-1</sup> DM).

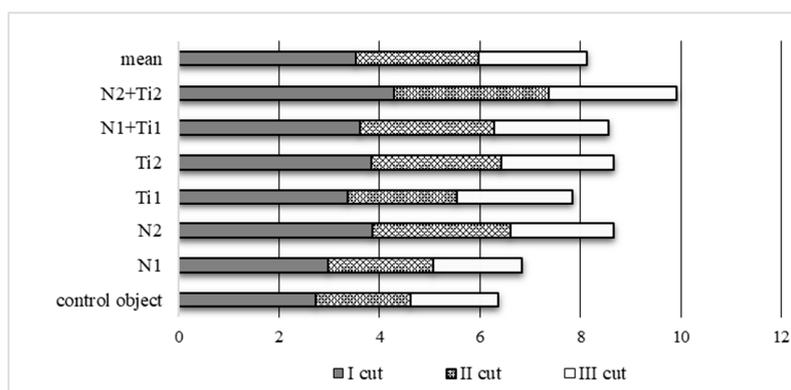
Treatment	Yield of Each Year			Mean for Years
	2015 (1st Year)	2016 (2nd Year)	2017 (3rd Year)	
Control	7.00	6.05	6.08	6.38
N <sub>1</sub>	7.30	6.20	6.99	6.83
N <sub>2</sub>	9.80	7.50	9.73	9.01
Ti <sub>1</sub>	7.40	8.00	8.08	7.83
Ti <sub>2</sub>	8.60	8.20	9.19	8.66
N <sub>1</sub> + Ti <sub>1</sub>	8.30	7.80	9.54	8.55
N <sub>2</sub> + Ti <sub>2</sub>	9.80	9.35	10.61	9.92
mean	8.31	7.59	8.60	8.17

LSD<sub>0.05</sub> for:

A-years A-0.510  
 B-treatment B-0.994  
 A×B, B×A-interaction A×B-1.35  
 B×A-1.72

N<sub>1</sub>-80 kg N ha<sup>-1</sup>; N<sub>2</sub>-160 kg N ha<sup>-1</sup>; Ti<sub>1</sub>-Tytanit 0.2%; Ti<sub>2</sub>-Tytanit 1%.

In conclusion, the largest *Festulolium braunii* yield, averaged across three years, was on the plot with the mineral nitrogen fertilizer dose of 160 kg ha<sup>-1</sup> (N<sub>2</sub>) in combination with 1% (Ti<sub>2</sub>) of Tytanit applied to leaves. A comparable yield was recorded when grass was treated with the following three fertilizer treatments: (1) Tytanit at a concentration of 1%; (2) nitrogen at a dose of 160 kg ha<sup>-1</sup>; (3) nitrogen at a dose of 80 kg ha<sup>-1</sup> with Tytanit at a concentration of 0.2%. The smallest biomass yield of *Festulolium braunii* was from the control plot.



**Figure 1.** The yield of *Festulolium braunii* (t ha<sup>-1</sup>DM) across harvest, a three-year average. N<sub>1</sub>–80 kg N ha<sup>-1</sup>; N<sub>2</sub>–160 kg N ha<sup>-1</sup>; Ti<sub>1</sub>–Tytanit 0.2%; Ti<sub>2</sub>–Tytanit 1%. LSD<sub>0.05</sub> for: A-0.492 (cuts); B-0.253 (treatment); A×B-ns; B×A-ns (interaction).

Increasing the amount of mineral fertilizers applied to crops is only appropriate for farmers if it entails greater cost-effectiveness. It is most often assumed that mineral fertilizer treatment becomes profitable when the value of the yield is at least 50% higher than the costs incurred. The costs involved in the use of Tytanit in the experiment were much lower than the costs of nitrogen treatment. Tytanit is a catalyst for natural physiological processes in plants, positively affecting the quality and yields of crops [23,24]. It was used in the past only in the cultivation of vegetables and fruits [25]. However, in the experiment, it was proven that its foliar application was also very profitable in growing forage crops, as confirmed by the studies of Murawska et al., [26].

It was found that the experimental factors (fertilizer and harvest) significantly differentiated the content of total protein in the grass (Table 3). According to Brzóska [27], the minimum protein content in forage for dairy cows should be 150–170 g kg<sup>-1</sup>. Total protein content in *Festulolium braunii* ranged from 65.65 g kg<sup>-1</sup> to 163.9 g kg<sup>-1</sup>DM. Each year the highest protein content was recorded in grass treated with mineral nitrogen in combination with the foliar application of Tytanit. The smallest content was found in control plants. There were differences in the content of total protein between individual harvests. Its highest content was in the third cut and the smallest in the first. According to Ciepiela and Godlewska [28], the Kelpak biostimulant increased the protein content in Dg and Fb dry matter. Many authors [29–32] in their studies confirmed the effect of the grass harvest on the content of protein in dry matter.

The quantity and quality of protein are important in animal nutrition [33]. The content of digestible protein in control plants was 74.99 g kg<sup>-1</sup>, while in those treated with a higher dose of nitrogen and Tytanit (N<sub>2</sub> + Ti<sub>2</sub>) it was 109.67 g kg<sup>-1</sup> (Figure 2). Protein digestibility in fodder from all plots, except that of the control subject and the lower dose of N<sub>1</sub>, was usually above 90%. Similar results were obtained by Grzelak [34] in hay from the Narew valley meadows. Spychała et al. [35] found that the digestibility of *Camelina sativa* marc protein was 88%. In recent years, the decline in the population of ruminants has contributed to reducing the production of roughage, and the production of concentrated feed has increased. In Poland in the mid-1990s, in the overall production of protein, the share of protein from such feed was around 45%, with 52–53% at the beginning of 2000, and it recently increased to almost 58% [36].

It was found that the concentration of soluble sugars in the biomass of *Festulolium braunii* significantly varied depending on the treatment and harvest (Table 4). Each year, the combination of mineral nitrogen with Tytanit had a positive effect on the concentration of soluble sugars in the grass. Additionally, in the first and second years of the experiment, 1% Tytanit foliar application increased the content of soluble sugars compared to plants treated with mineral nitrogen. According to Ciepiela and Godlewska [28], the average concentration of soluble sugars in the biomass of *Festulolium braunii* was 122.9 g kg<sup>-1</sup>, with 104.1 g kg<sup>-1</sup>DM of protein. In the present experiment, the average content of soluble sugars in plants from all treatment combinations was 104.2 g kg<sup>-1</sup> in the first year of the experiment

and 99.06 g kg<sup>-1</sup> in the third. The air temperature, which was too high, might have lowered sugar content in the grass. According to Grzelak [34] and Czyż et al. [37], the concentration of sugars in forage is dependent on the development stage of plants, air temperature, and many other factors. High temperatures increase the respiration of plants, and sugars are consumed in this process [38].

**Table 3.** Total protein content in *Festulolium braunii* (g kg<sup>-1</sup>DM).

Treatment	2015 (the 1st Year)				2016 (the 2nd Year)				2017 (the 3rd Year)			
	Cuts				Cuts				Cuts			
	I	II	III	Mean	I	II	III	Mean	I	II	III	Mean
Control	71.57	73.40	74.18	73.05	76.32	85.37	84.71	82.13	65.65	114.5	101.3	93.82
N <sub>1</sub>	91.83	87.44	82.94	87.40	86.21	90.11	91.36	89.23	97.23	119.2	122.5	113.0
N <sub>2</sub>	99.83	108.7	127.3	111.9	88.01	95.23	96.23	93.16	92.20	129.4	132.9	118.2
Ti <sub>1</sub>	112.4	109.1	130.9	117.4	90.36	88.36	97.01	91.91	85.53	120.5	121.9	108.6
Ti <sub>2</sub>	111.7	116.1	115.4	114.4	87.12	89.36	90.23	88.90	86.39	125.4	106.9	106.2
N <sub>1</sub> + Ti <sub>1</sub>	124.3	125.0	142.6	130.7	90.23	95.12	100.2	95.18	84.69	162.7	158.6	135.3
N <sub>2</sub> + Ti <sub>2</sub>	109.7	114.8	133.4	119.3	100.2	99.67	112.3	104.06	112.7	130.2	163.9	135.6
mean	103.1	104.9	115.3	107.7	88.35	91.89	96.01	92.08	88.92	128.8	129.7	115.8
LSD <sub>0.05</sub> for:												
A-cuts	A-9.66			A-1.65				A-4.21				
B-treatment	B-4.96			B-3.22				B-8.20				
A×B–interaction	A×B-13.12			A×B-4.37				A×B-11.14				
B×A	B×A-16.73			B×A-5.58				B×A-14.21				

N<sub>1</sub>–80 kg N ha<sup>-1</sup>; N<sub>2</sub>–160 kg N ha<sup>-1</sup>; Ti<sub>1</sub>–Tytanit 0.2%; Ti<sub>2</sub>–Tytanit 1%.

**Table 4.** The content of soluble sugars in *Festulolium braunii* (g kg<sup>-1</sup> DM).

Treatment	2015 (1st Year)				2016 (2nd Year)				2017 (3rd Year)			
	Cuts				Cuts				Cuts			
	I	II	III	Mean	I	II	III	Mean	I	II	III	Mean
Control object	88.51	91.02	100.3	93.28	90.23	88.54	98.74	92.50	82.64	85.57	84.28	84.16
N <sub>1</sub>	92.48	95.66	99.23	95.79	89.97	102.3	96.39	96.22	92.07	93.46	92.80	93.11
N <sub>2</sub>	98.40	90.21	89.56	92.72	100.2	99.78	110.2	103.4	90.18	91.26	94.80	91.99
Ti <sub>1</sub>	95.42	94.56	100.2	96.73	99.87	100.7	89.67	96.73	88.73	87.25	86.40	87.46
Ti <sub>2</sub>	100.4	123.0	132.3	118.6	113.6	100.3	99.07	104.3	92.91	90.25	93.46	92.21
N <sub>1</sub> + Ti <sub>1</sub>	118.9	109.9	109.7	112.8	120.7	118.9	120.5	120.3	129.4	116.7	120.5	122.2
N <sub>2</sub> + Ti <sub>2</sub>	125.4	112.3	120.9	119.5	109.6	118.8	120.0	116.1	124.1	119.3	123.4	122.3
mean	102.8	102.4	107.5	104.2	103.5	104.2	104.9	105.4	100.0	97.83	99.34	99.06
LSD <sub>0.05</sub> for:												
A-cuts	A-0.447			A-ns				A-0.831				
B-treatment	B-0.871			B-3.647				B-1.62				
A×B–interaction	A×B-1.18			A×B-4.95				A×B-2.20				
B×A	B×A-1.51			B×A-6.32				B×A-2.80				

N<sub>1</sub>–80 kg N ha<sup>-1</sup>; N<sub>2</sub>–160 kg N ha<sup>-1</sup>; Ti<sub>1</sub>–Tytanit 0.2%; Ti<sub>2</sub>–Tytanit 1%; ns–no significant difference.

According to Ciepiela et al. [39], in addition to nutrient content, the forage value is also determined by the sugar-protein ratio. The value of this indicator should not be less than 0.4. In the biomass of *Festulolium braunii*, the sugar-protein ratio ranged from 0.709 to 1.53 (Table 5). In the first year, the highest ratio was in control plants. In the other growing seasons, for plants treated with ammonium nitrate at the amount of 80 kg ha<sup>-1</sup> in combination with the Tytanit foliar application at a concentration of 0.2%, the ratio was 1.29 and 1.00, respectively. The statistical analysis indicated that the treatment did not have a significant impact on the value of this parameter. In the research of Sosnowski [7],

the sugar-protein ratio in the biomass of *Festulolium braunii* treated with NPK fertilizers in combination with soil conditioners was much lower, with 0.51.

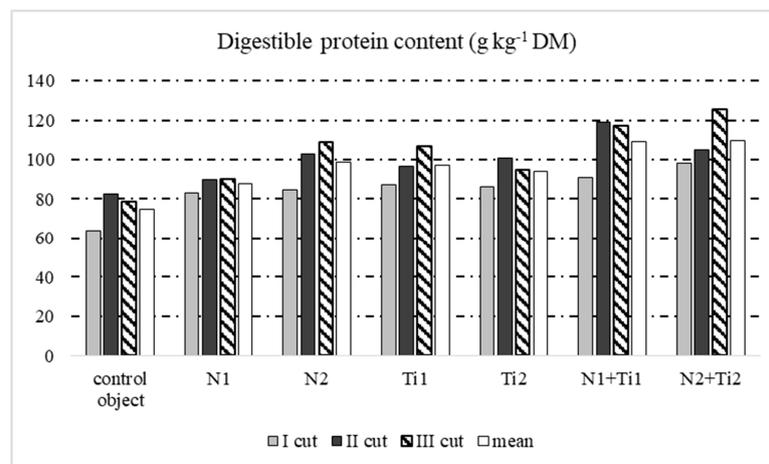
**Table 5.** The sugar-protein ratio in *Festulolium braunii* dry matter.

Treatments	2015 (1st Year)				2016 (2nd Year)				2017 (3rd Year)			
	Cuts				Cuts				Cuts			
	I	II	III	Mean	I	II	III	Mean	I	II	III	Mean
Control	1.24	1.24	1.35	1.28	1.18	1.04	1.17	1.13	1.26	0.747	0.832	0.946
N <sub>1</sub>	1.03	1.09	1.20	1.11	1.04	1.14	1.06	1.08	0.947	0.784	0.758	0.830
N <sub>2</sub>	0.986	0.830	0.704	0.840	1.14	1.05	1.15	1.11	0.978	0.705	0.713	0.799
Ti <sub>1</sub>	0.849	0.867	0.765	0.827	1.11	1.14	0.924	1.06	1.04	0.724	0.709	0.824
Ti <sub>2</sub>	0.899	0.944	1.15	0.998	1.30	1.33	1.11	1.25	1.08	0.720	0.874	0.891
N <sub>1</sub> + Ti <sub>1</sub>	0.957	0.879	0.848	0.895	1.34	1.25	1.27	1.29	1.53	0.717	0.760	1.00
N <sub>2</sub> + Ti <sub>2</sub>	1.14	0.978	0.906	1.01	1.09	1.19	1.15	1.14	1.10	0.916	0.753	0.923
mean	1.01	0.975	0.989	0.993	1.17	1.16	1.12	1.15	1.13	0.759	0.771	0.888

LSD<sub>0.05</sub> for:

A-cuts	A-ns	A-ns	A-0.111
B-fertilization	B-ns	B-ns	B-ns
A×B-interaction	A×B-0.20	A×B-ns	A×B-0.294
B×A	B×A-ns	B×A-ns	B×A-0.375

N<sub>1</sub>–80 kg N ha<sup>-1</sup>; N<sub>2</sub>–160 kg N ha<sup>-1</sup>; Ti<sub>1</sub>–Tytanit 0.2%; Ti<sub>2</sub>–Tytanit 1%; ns–not significant difference.



**Figure 2.** Average digestible protein content in *Festulolium braunii* across cuts (g kg<sup>-1</sup> DM). N<sub>1</sub>–80 kg N ha<sup>-1</sup>; N<sub>2</sub>–160 kg N ha<sup>-1</sup>; Ti<sub>1</sub>–Tytanit 0.2%; Ti<sub>2</sub>–Tytanit 1%. LSD<sub>0.05</sub> for: A-2.31 (cuts); B-4.49 (treatment); A×B-6.10; B×A-7.78 (interaction).

#### 4. Conclusions

1. Across all growing seasons, the largest biomass yield of *Festulolium braunii* was on plots treated with mineral nitrogen at a dose of 160 kg ha<sup>-1</sup> in combination with 1% Tytanit foliar application. The yield was 40 to 75% higher than that on control.
2. Tytanit foliar application with a concentration of 1% increased the yield of plants compared to traditional mineral nitrogen treatment.
3. Mineral nitrogen treatment in combination with Tytanit application positively affected the concentration of protein in the grass.
4. In the first and second years of the experiment, a single Tytanit application with a concentration of 1% increased the content of soluble sugars in *Festulolium braunii*, compared to grass treated with nitrogen.

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