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EFFECT OF NITROGEN FERTILIZATION AND HERBICIDE STARANE 250 EC ON TOTAL PROTEIN EFFICIENCY AND CARBOHYDRATE:PROTEIN RATIO IN MEADOW SWARD

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Abstract. The aim of the study was to evaluate the effect of diversified nitrogen fertilization doses and application of various doses of herbicide Starane 250 EC on the total protein efficiency and carbohydrate:protein ratio of meadow sward. Two-factor field experiment was established on permanent meadow in the spring of 2007 in Żelków near Siedlce in a randomized subblock design in three repetitions. First experimental factor was diversified nitrogen fertilization in the amounts of: A_1 0 kg N·ha^{-1}, A_2 90 kg N·ha^{-1}, A_3 180 kg N·ha^{-1}, and A_4 270 kg N·ha^{-1}. The second experimental factor was herbicide Starane 250 EC applied at the doses of: B_1 control group, B_2 half a dose (150 g basic active substance·ha^{-1}), B_3 one dose (300 g basic active substance·ha^{-1}), and B_4 1.5 dose (450 g basic active substance·ha^{-1}), according to the recommended instruction, namely 1.2 dm^3·ha^{-1}. Plot size was 9 m^2. In every growth season, three cuts were harvested. In the study, total protein content (%) and soluble sugar content (%) in the meadow sward were determined. The obtained results were evaluated statistically with the analysis of variance for two-factor experiments. Mean differentiation was verified with the Tukey's test at the significance level of $P \leq 0.05$. Significant effect of subsequent nitrogen fertilization doses on the protein efficiency of the meadow sward was demonstrated. With the increase in the nitrogen dose, the carbohydrate:protein ratio decreased and reached minimal, border nutritional values with the highest fertilization level. Diversified herbicide Starane 250 EC doses did not cause significant differences in protein efficiency or in the carbohydrate:protein ratio.

Key words: feed value, fertilization, meadow, weed control

INTRODUCTION

Nutrition value of fodder that originates from permanent grasslands determines its usefulness for ruminantia feeding [Varhegyi and Hemenses 1980, Tallowin and

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Jefferson 1999, Brzóska 2005]. Fodder from grasslands is composed of grass, legumes, herbs, and weeds. In the sward of permanent grasslands, weeds occur often in excessive quantities and limit or eliminate valuable grass species, as well as lower the yield. They also cause deterioration of fodder quality and, as an effect, animal health [Jankowska 2012b]. The only effective method of the limitation of undesired dicotyledonous plant population in the sward is the application of proper herbicides [Badowski *et al.* 2007, Jankowska 2012a]. Moreover, as demonstrated in previous research [Borowiecki and Staniak 2001, Borowiecki 2002, Staniak 2004, Grzegorczyk *et al.* 2007), fertilization, especially with nitrogen, has a significant effect on the feed value of sward. Intensification of plant production occurs most often under the influence of an increased mineral fertilization dose, mainly nitrogen. Too high and too low nitrogen doses lead to unfavourable changes in the sward [Stypiński *et al.* 2001, Kryszak 2003, Stępień 2004, Jankowska *et al.* 2008, Sosnowski 2011b]. Therefore, there is a necessity to determine proper fertilizer and herbicide doses, which would not cause deterioration in the quality of fodder obtained from permanent grasslands.

Sugars soluble in water are an important element of the chemical composition, especially of green forage for ensilage [Jankowska-Huflejt and Wróbel 2011]. They are a source of energy for lactic acid bacteria, which are responsible for proper ensilage course. Quality and usefulness of fodder for ruminantia is determined by the ratio of sugars soluble in water to total protein [Sosnowski 2012]. According to Prończuk [1980], its optimum value for ruminantia should oscillate between 0.8 and 1.5, and its minimum value should not be lower than 0.4. Higher value of this ratio indicates better feed value of meadow sward, and also better usefulness of the biomass for ensilage.

It was assumed in the present research that the applied herbicide Starane 250 EC would cause weed elimination from the meadow sward. In literature, however, there is a lack of data on the changes of the chemical composition of fodder, especially total protein efficiency and carbohydrate:protein ratio under the effect of herbicide Starane 250 EC.

The aim of the study was to determine the effect of diversified nitrogen fertilization and various doses of herbicide Starane 250 EC on the chosen parameters of the feed value of meadow sward.

MATERIAL AND METHODS

Field experiment was set up in 2007 in Żelków at the Masovian Centre of Animal Breeding and Reproduction (MCHiRZ) near Siedlce. Geographic coordinates for Żelków are 52°08′ N; 22°11′ E. The experiment was set up on a permanent meadow with random subblocks in three repetitions and its form was static. The experiment was composed of 48 plots, where each had 9 m^2. In the conducted experiment, two study factors were applied. The first factor was nitrogen in the form of ammonium nitrate (34.5 % N) in the amounts of: A_1 0 kg $N \cdot ha^{-1}$, A_2 90 kg $N \cdot ha^{-1}$, A_3 180 kg $N \cdot ha^{-1}$, and A_4 270 kg $N \cdot ha^{-1}$. Nitrogen was applied in three equal parts under every regrowth. The second study factor was herbicide Starane 250 EC, applied at the doses of: B_1 control group, B_2 half a dose (150 g basic active substance$\cdot ha^{-1}$), B_3 one dose (300 g basic active substance$\cdot ha^{-1}$), and B_4 1.5 dose (450 g basic active substance$\cdot ha^{-1}$), according to the instruction recommended by the producer Dow AgroSciences, namely 1.2 $dm^3 \cdot ha^{-1}$.

In every research year, three cuts were collected. After every cut, green matter samples were collected from the plots for botanical and weight analyses and in order to determine the drying coefficient. Dried plant material was ground and underwent chemical analysis. Total protein and soluble sugar contents were determined with near infrared spectroscopy (NIRS) with the use of Inra Analyzer 500 by Bran + Luebbe, which was described in a different article [in print]. Then, protein efficiency per hectare was calculated, as well as the carbohydrate:protein ratio. The obtained study results underwent statistical analysis with the analysis of variance for two-factor experiments [Trętowski and Wójcik 1988]. Mean value diversification was verified with the Tukey's test at the significance level of $P \leq 0.05$.

Weather conditions for the study area were typical for IX – east agricultural and climate district of Poland [Radomski 1977]. The surroundings of Siedlec are part of the Mazovia-Podlachia climate region. In this region, annual precipitation oscillates between 450 and 550 mm, which is below the country average of 600 mm, but it is heavy and rare. Average annual air temperature is 7.5^{o} C, and during summer average daily temperature is 15^{o} C. Meteorological data during the research period was obtained from the Hydrological and Meteorological Station in Siedlce. In order to determine the space and time changeability of the meteorological elements and their effect on plant growth, Sielianinow's hydrometrical index was calculated [Bac *et al.* 1993].

It results from the data presented in Table 1 that in 2009 the most favourable precipitation and temperature conditions occurred. In that particular year, there was no drought in any of the months of the growth season. In the first two research years, light drought was observed in April and drought in August and October 2007.

Table 1. Values of Sielianinow's hydrometrical index (K) in the particular months of the growth period and the study years

Year	Month						
	April	May	June	July	August	September	October
2007	0.85	1.30	1.10	1.22	0.52	1.72	0.67
2008	0.82	1.34	1.08	1.23	0.54	0.69	1.72
2009	1.03	2.24	1.03	1.26	1.36	1.01	1.73

$K < 0.5$ – severe drought, 0.51-0.69 – drought, 0.70-0.99 – light drought, $K > 1$ – no drought

On the basis of the chemical analysis of the soil carried out at the Regional Chemical Station in Wesoła, it was found that the soil was characterized by a very high potassium content (230 mg $K_2O \cdot kg^{-1}$ soil) and average phosphorus content (187 mg $P_2O_5 \cdot kg^{-1}$ soil) (Table 2).

Table 2. Chemical composition of the soil in the experiment

Content, $g \cdot kg^{-1}$	Content of assmilated, $mg \cdot kg^{-1}$ of soil			Content, $mg \cdot l^{-1}$
Total N	K_20	P_2O_5	Mg	Ca
0.56	230	187	57	220

RESULTS AND DISCUSSION

Contents of the particular nutrients in the meadow sward determine its feed value. Protein quality and quantity is of significant effect on fodder usefulness in ruminantia feeding [Ciepiela *et al.* 2008]. The assessment of sward usefulness for fodder production may be carried out on the basis of total protein efficiency [Grzegorczyk *et al.* 2007, Nowak *et al.* 2008, Jankowska 2012a].

In the conducted research, it was demonstrated that protein efficiency depended on the dose of the applied nitrogen fertilization and was diversified in the study years (Tables 3-5). Results in Table 3 indicate that protein efficiency significantly increased with the increase in the nitrogen dose. The lowest efficiency was noted on the control plot (no nitrogen fertilization) and amounted to 955.5 $kg \cdot ha^{-1}$, and the highest one was 1940.2 $kg \cdot ha^{-1}$ with the highest nitrogen dose (270 $kg\ N \cdot ha^{-1}$). Similar tendency of protein efficiency change under the effect of increasing nitrogen doses was demonstrated by Ciepiela *et al.* [2008]. In the present research, differences in protein efficiency as an effect of nitrogen doses were statistically significant. In protein efficiency, statistically proven differences were obtained for the interaction between the nitrogen doses and study years. Moreover, significant differences were also found for the interaction between the study years, nitrogen doses, and herbicide. In the present experiment, it was shown that in the subsequent study years at all nitrogen fertilization levels, protein efficiency decreased significantly. On the other hand, Staniak [2008] in her analysis of average protein efficiency as an effect of fertilization with various nitrogen doses demonstrated that increasing nitrogen fertilization did not contribute to significant growth.

Diversified doses of herbicide Starane 250 EC applied in the present study significantly interacted with diversified doses of nitrogen fertilization (Table 4). The highest protein efficiency (2014.6 $kg \cdot ha^{-1}$) was obtained on the control plot with no herbicide Starane 250 EC application, with the simultaneous fertilization with the highest nitrogen dose (270 $kg\ N \cdot ha^{-1}$). The efficiency differed significantly from the efficiencies obtained on the remaining plots with nitrogen fertilization.

Diversified doses of herbicide Starane 250 EC applied in the present study did not cause significant differences in protein efficiency (Table 5). The highest protein efficiency was obtained from the sward from the control plot, especially in the first two research years (2007 and 2008). The results were confirmed in a different experiment by Jankowska [2012b], who also obtained the highest protein efficiency in the control group. Efficiency also decreased as an effect of the applied chosen herbicides. According to many researchers [Moyer and Acharya 2006, Badowski and Sadowski 2007, Grzegorczyk *et al.* 2007], herbicides negatively affect the botanic composition of plants through the elimination of dicotyledonous plants, which consequently leads to a decrease in yield and its quality. In the present research, the interaction between the herbicide dose and the study years proved to be significant in the assessment of protein efficiency. Under the effect of diversified doses of herbicide Starane 250 EC, the highest protein efficiency was obtained in the first research year and differed significantly only from the yield collected in 2009. In the study years, significant effect on the studied characteristic was found. The highest protein efficiency (1743.9 $kg \cdot ha^{-1}$) was obtained in the first research year and in the subsequent years it underwent a significant decrease to 1160.7 $kg \cdot ha^{-1}$ in 2009. Also in the study by Jankowska [2012a] on different methods of common dandelion control in meadow sward, the highest total protein efficiency was obtained in the first research year. Staniak [2008] did not find significant diversification in the research years on protein efficiency.

Table 3. Total protein yield (kg·ha^{-1}) of meadow sward depending on the nitrogen dose and herbicide Starane 250 EC

Nitrogen dose (A)	Herbicide dose (B)	Year 2007	Year 2008	Year 2009	$\overline{x}$
Mean for A_1	Control	1311.6	1176.2	457.9	955.5
	B_2	1202.3	966.9	579.0	
	B_3	1272.3	949.7	639.5	
	B_4	1195.7	1068.0	646.9	
A_1		1245.5	1040.2	580.8	
Mean for A_2	Control	1721.0	1181.8	998.0	1276.0
	B_2	1598.6	1133.6	850.6	
	B_3	1611.9	1234.6	1147.4	
	B_4	1602.1	1140.8	1091.8	
A_2		1633.4	1172.7	1021.9	
Mean for A_3	Control	1866.8	1543.9	1240.7	1555.4
	B_2	1963.3	1466.3	1353.7	
	B_3	1926.6	1477.8	1353.5	
	B_4	1829.6	1443.8	1198.2	
A_3		1896.6	1483.0	1286.5	
Mean for A_4	Control	2376.2	1844.0	1823.7	1940.2
	B_2	2077.0	1917.0	1785.9	
	B_3	2113.5	1689.1	1877.5	
	B_4	2234.7	2016.6	1527.1	
A_4		2200.3	1866.6	1753.5	
$LSD_{0.05}$ for:					
A	279.3				
interaction:					
A × years	120.0				
years × A × B	28.7				

A_1 – 0 kg N·ha^{-1}, A_2 – 90 kg N·ha^{-1}, A_3 – 180 kg N·ha^{-1}, A_4 – 270 kg N·ha^{-1}
B_1 – no dose, B_2 – half a dose, B_3 – one dose, B_4 – 3/2 dose of Starane 250 EC according to the instruction

Table 4. Total protein yield of meadow sward depending on the nitrogen dose and herbicide (mean for the study years), kg·ha^{-1}

Nitrogen dose (A)	Herbicide dose (B_1)	Herbicide dose (B_2)	Herbicide dose (B_3)	Herbicide dose (B_3)
A_1	981.9	916.1	953.9	970.2
A_2	1300.3	1194.3	1331.3	1278.2
A_3	1550.5	1594.5	1586.0	1490.5
A_4	2014.6	1926.6	1893.3	1926.1
$LSD_{0.05}$ for:				
interaction :				
B × A	464.0			

for explanations, see Table 3

Table 5. Total protein yield of meadow sward depending on the dose of herbicide Starane 250 EC, $kg \cdot ha^{-1}$

Herbicide dose (B)	Year			$\overline{x}$
	2007	2008	2009	
B_1	1818.9	1436.5	1130.1	1461.8
B_2	1710.3	1370.9	1142.3	1407.8
B_3	1731.1	1337.8	1254.5	1441.1
B_4	1715.5	1417.3	1116.0	1416.3
$\overline{x}$	1743.9	1390.6	1160.7	
$LSD_{0.05}$ for:				
B	ns			
years	229.8			
interaction :				
B × years	564.3			

for explanations, see Table 3
ns – non-significant difference

Differences in the values of the carbohydrate:protein ratio between the particular nitrogen fertilization levels were statistically significant (Table 6).

Table 6. Carbohydrate:protein ratio of meadow sward depending on the nitrogen dose and herbicide Starane 250 EC (mean for the study years)

Nitrogen dose (A)	Herbicide dose (B)	Year			$\overline{x}$
		2007	2008	2009	
Mean for A_1	B_1	0.57	0.77	1.22	0.88
	B_2	0.72	0.91	1.21	
	B_3	0.63	0.84	1.13	
	B_4	0.71	0.57	1.23	
A_1		0.66	0.77	1.20	
Mean for A_2	B_1	0.47	0.99	0.92	0.73
	B_2	0.69	0.86	0.86	
	B_3	0.56	0.72	0.65	
	B_4	0.60	0.74	0.66	
A_2		0.58	0.83	0.77	
Mean for A_3	B_1	0.51	0.75	0.78	0.57
	B_2	0.51	0.62	0.55	
	B_3	0.45	0.56	0.54	
	B_4	0.52	0.55	0.56	
A_3		0.50	0.62	0.61	
Mean for A_4	B_1	0.35	0.45	0.51	0.44
	B_2	0.50	0.35	0.49	
	B_3	0.46	0.32	0.55	
	B_4	0.34	0.35	0.64	
A_4		0.41	0.37	0.55	
$LSD_{0.05}$ for:					
A		0.12			
interaction:					
A × years		0.18			
years × A × B		0.34			

for explanations, see Table 3

Also the relation between nitrogen fertilization and the research years was significant, especially in the control group and in the fertilization with the lowest nitrogen dose. Only at those two levels of nitrogen fertilization, the value of the carbohydrate:protein ratio in the fodder was optimum from the animal nutrition point of view [Prończuk 1980], particularly in 2008 and 2009 (0.77-1.20). After the application of the highest nitrogen fertilization (270 kg $N \cdot ha^{-1}$), the value of this ratio was low, especially in 2008 (0.37) and 2007 (0.41), which indicates that the nutritional value of the fodder was minimum. Like in the present research, Ciepiela *et al*. [1998] demonstrated that, with the increase in the nitrogen fertilization in the sward, the ratio narrowed. Sosnowski [2011a], on the other hand, proved an increase in the carbohydrate:protein ratio as an effect of soil fertilization.

In the assessment of the value of the carbohydrate:protein ratio, interaction between the herbicide and nitrogen doses was significant (Table 7). Significantly highest values of this ratio were obtained in the fodder with no nitrogen fertilization under the effect of all the applied doses of herbicide Starane 250 EC, and with lower herbicide doses also at the level of fertilization with a lower nitrogen dose (90 kg $N \cdot ha^{-1}$). Significance of those differences was also related to the fodder from the plot fertilized with the highest nitrogen dose (270 kg $N \cdot ha^{-1}$).

Table 7. Carbohydrate:protein ratio of meadow sward depending on the nitrogen dose and herbicide Starane 250 EC (mean for the study years)

Nitrogen dose (A)	Herbicide dose (B_1)	Herbicide dose (B_2)	Herbicide dose (B_3)	Herbicide dose (B_3)
A_1	0.85	0.95	0.87	0.84
A_2	0.79	0.80	0.64	0.67
A_3	0.68	0.56	0.52	0.54
A_4	0.44	0.44	0.45	0.45
$LSD_{0.05}$ for:				
interaction:				
B × A	0.26			

for explanations, see Table 3

As the research results show, the applied doses of herbicide Starane 250 EC did not cause significant differences in the values of the carbohydrate:protein ratio (Table 8). On the other hand, differences in the values of this characteristic for fodder between the research years were significant. The highest value of the carbohydrate:protein ratio was attributed to fodder in 2009 (0.78), and the lowest one in 2007 (0.54). Small but significant increase in the value of the carbohydrate:protein ratio in the subsequent research years was also demonstrated by Ciepiela *et al*. [1998]. Decrease in legumes in the sward could contribute to that. According to Preś and Fritz [1981], this is because the legumes contain significantly less soluble sugars in relation to grass.

Table 8. Carbohydrate:protein ratio of meadow sward depending on the dose of herbicide Starane 250 EC

Herbicide dose (B)	Year			$\overline{x}$
	2007	2008	2009	
B_1	0.47	0.74	0.86	0.69
B_2	0.60	0.68	0.78	0.69
B_3	0.53	0.61	0.72	0.62
B_4	0.54	0.55	0.77	0.62
$\overline{x}$	0.54	0.65	0.78	
$LSD_{0.05}$ for:				
B	ns			
years	0.10			
interaction:				
years × B	0.23			

for explanations, see Table 3

CONCLUSIONS

1. With the increase in the nitrogen dose, protein efficiency increased, whereas the carbohydrate:protein ratio decreased to minimum from the animal nutrition point of view.
2. Increased doses of herbicide Starane 250 EC did not cause significant diversification both in the total protein efficiency and the carbohydrate:protein ratio.
3. The highest protein efficiency was obtained after the application of nitrogen in the dose of 270 kg $N \cdot ha^{-1}$ with no herbicide application. The best value in regard to the carbohydrate:protein ratio was obtained by the fodder from plants with no nitrogen fertilization and sprayed with herbicide Starane 250 EC at the dose of B_2.
4. In the research years, the weather conditions significantly affected the values of the evaluated parameters of the fodder from the meadow sward. The highest protein efficiency was obtained in the first research year, and the lowest one in the third research year, in spite of the fact that in that particular year humidity was the most favourable.

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WPŁYW NAWOŻENIA AZOTEM I HERBICYDU STARANE 250 EC NA WYDAJNOŚĆ BIAŁKA OGÓLNEGO I STOSUNEK CUKROWO-BIAŁKOWY RUNI ŁĄKOWEJ

Streszczenie. Celem badań była ocena wpływu zróżnicowanych dawek nawożenia azotem i stosowania różnych dawek herbicydu Starane 250 EC na wydajność białka ogólnego i stosunek cukrowo-białkowy runi łąkowej. Doświadczenie dwuczynnikowe założono na łące trwałej wiosną 2007 roku w Żelkowie pod Siedlcami w układzie losowanych podbloków w trzech powtórzeniach. Pierwszym czynnikiem doświadczalnym było zróżnicowane nawożenie azotem w ilości: A_1 – 0 kg N·ha^{-1}, A_2 – 90 kg N·ha^{-1}, A_3 – 180 kg N·ha^{-1} i A_4 – 270 kg N·ha^{-1}. Drugi czynnik badawczy stanowił herbicyd Starane 250 EC, zastosowany w dawkach: B_1 – kontrola, B_2 – 0,5 dawki (150 g s.b.cz·ha^{-1}), B_3 – 1 dawka (300 g s.b.cz·ha^{-1}) i B_4 – 1,5 dawki (450 g s.b.cz·ha^{-1}) według zalecanej instrukcji, tj. 1,2 dm^3·ha^{-1}. Powierzchnia poletka wynosiła 9 m^2. W każdym okresie wegetacyjnym zbierano trzy pokosy. W badaniach określono zawartość białka ogólnego

(%) oraz cukrów rozpuszczalnych (%) w runi łąkowej. Uzyskane wyniki poddano ocenie statystycznej, wykonując analizę wariancji dla doświadczeń dwuczynnikowych. Zróżnicowanie średnich weryfikowano testem Tukeya przy poziomie istotności P ≤ 0,05. Wykazano istotny wpływ kolejnych dawek nawożenia azotem na wzrost wydajności białka runi łąkowej. W miarę zwiększania dawki azotu zmniejszał się stosunek cukrowo-białkowy, osiągając minimalne, graniczne pod względem żywieniowym wartości przy najwyższym poziomie nawożenia. Zróżnicowane dawki herbicydu Starane 250 EC nie powodowały istotnych różnic w wydajności białka ani w stosunku cukrowo-białkowym.

Słowa kluczowe: łąka, nawożenie, wartość paszowa, zwalczanie chwastów

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