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EFFECT OF DIFFERENT FACTORS ON CHEMICAL COMPOSITION OF GRASS-LEGUMES SWARD

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Abstract

The biological value of fodder is estimated on the basis of its content of particular macroelements (N, P, K, Ca, Mg). Concentration of these components in fodder depends on many factors, mainly on the properties of soil, type of land use and growth phase of crops.

The aim of this paper was to estimate the effect of soil properties, land use and species composition of a sward mixture on the content of macroelements, total protein and acid detergent fibre in grass-legumes sward. In 2002-2005 a field study was carried out on mineral and organic soil in Sosnowica (near the Wieprz-Krzna Canal). Two land use types were tested: pasture (sward grazed by cattle) and simulated (sward frequently cut, proportionally to the grazings). Six grass-legumes mixtures were sown, including the following species: *Poa pratensis*, *Festulolium braunii*, *Festulolium loliaceum* (2 strains), *Lolium perenne* and *Festuca pratensis*. Tetraploid hybrids of *Festulolium loliaceum* [*Festuca pratensis* (4x) x *Lolium perenne* (4x) were obtained at the Institute of Plant Genetics PAS in Poznań. Pasture sward was grazed by Limousine cattle 5-6 times during the grazing season, while the simulated sward was cut at the same time. Chemical composition of fodder (total protein, ADF, P, K, Ca, Mg) was estimated. Sward on organic soil was characterized by a significantly higher content of total protein, phosphorus, calcium and magnesium as well as a significantly lower content of potassium in comparison to sward on mineral soil. Moreover, a significantly higher content of potassium and significantly lower content of magnesium in pasture sward were observed. Sward was of perfect quality (content of ADF) and had an optimum content of basic macroelements. No influence of the examined species in the mixtures on feed quality was observed. Consequently, compared to the other species, *Festulolium loliaceum* hybrids prove to be suitable for to pasture mixtures in a postboggy habitat. .

Keywords: ADF, macroelements, soil, total protein, utilization method.

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WPŁYW RÓŻNYCH CZYNNIKÓW NA SKŁAD CHEMICZNY RUNI TRAWIASTO-MOTYLKOWATEJ

Abstrakt

Wartość biologiczną paszy oceniana się na podstawie zawartości poszczególnych składników pokarmowych, zwłaszcza makroelementów (N, P, K, Ca, Mg). Koncentracja tych składników w paszy zależy od wielu czynników, takich jak warunki glebowe, sposób użytkowania, faza rozwojowa roślin.

Celem badań była ocena wpływu warunków glebowych, sposobu użytkowania i składu gatunkowego mieszanki na zawartość makroelementów, białka ogólnego i kwaśnego włókna detergentowego w runi trawiasto-motylkowatej. Badania przeprowadzono w latach 2002-2005 w Sosnowicy (rejon Kanału Wieprz-Krzna) na glebie mineralnej i organicznej. Ponadto uwzględniono pastwiskowe użytkowanie runi (naturalny wypas zwierząt) oraz symulowane, czyli częste, koszenie, proporcjonalne do ilości wypasów. W doświadczeniu wysiano 6 mieszanek trawiasto-motylkowatych z gatunkami testowanymi (*Poa pratensis*, *Festulolium braunii*, *Festulolium loliaceum* – 2 rody, *Lolium perenne* i *Festuca pratensis*). Tetraploidalne mieszańce *Festulolium loliaceum* [*Festuca pratensis* (4x) x *Lolium perenne* (4x)] wyhodowano w Instytucie Genetyki Roślin PAN w Poznaniu. Ruń wypasano bydłem rasy mięsnej Limousine 5-6 razy w ciągu sezonu pastwiskowego, natomiast ruń w użytkowaniu symulowanym koszono w tym samym czasie. W badaniach określono skład chemiczny paszy: białko ogólne, ADF (kwaśne włókno detergentowe), P, K, Ca i Mg. Ruń na glebie organicznej zawierała istotnie więcej białka ogólnego, fosforu, wapnia i magnezu oraz istotnie mniej potasu, w porównaniu z runią na glebie mineralnej. W warunkach użytkowania pastwiskowego zanotowano istotnie wyższą zawartość potasu, natomiast w użytkowaniu symulowanym – istotnie wyższą zawartość magnezu. Ruń odznaczała się doskonałą jakością (zawartość ADF) oraz optymalną zawartością podstawowych makroskładników. Nie zaobserwowano wpływu gatunku testowanego w mieszance na jakość paszy, w związku z tym, na tle innych gatunków, mieszańce *Festulolium loliaceum* potwierdzają swoją przydatność do mieszanek pastwiskowych w siedlisku pobagiennym.

Słowa kluczowe: ADF, białko ogólne, makroelementy, sposób użytkowania, gleba.

INTRODUCTION

One of the most important factors which determine the quality of grasslands is the chemical composition of sward, which conditions determines the value of feed produced from the grass. Content of different nutrients, particularly macroelements (N, P, K, Ca, Mg), as well as the digestibility and the ADF (acid detergent fibre) determine the biological value of sward. The concentration of the above components in fodder depends on many factors, mainly on soil conditions, land use and growth phase of plants (BORAWSKA-JARMUŁOWICZ 2003). On pasture, the most important is the influence of cattle's faeces on abundance of soil nutrients and their availability to plants (ROGALSKI et al. 2000). The nutritive value of fodder is also dependent on species composition of sward. In their search for better species of pasture grass, breeders focus on intergeneric hybrids. Recently, *Festulolium loliaceum* (Huds.) P.V. Fourn hybrids [*Festuca pratensis x Lolium perenne*] have been

bred at the Institute of Plant Genetics PAS in Poznań. They are now available for further research (KULIK et al. 2005). The aim of this paper was to estimate the effect of soil conditions, land use and species composition of a sward mixture on the content of macroelements, total protein and acid detergent fibre in grass-legumes sward.

MATERIAL AND METHODS

The study were carried out in 2002-2005 in Sosnowica (near theWieprz-Krzna Canal). The experiments were set up in a 4-replication split-plot design on mineral soil (degraded black soil) and on organic soil (peat-muck soil). Chemical properties of the soils were varied, depending on the type of soil, land use and year of the study (Table 1).

Table 1

Chemical properties of soil

Specificatiom	2001		2003				2004			
	M	O	M		O		M		O	
			S	P	S	P	S	P	S	P
pH 1n KCl	5.3	4.8	5.6	6.0	5.0	5.2	6.0	5.3	5.2	5.7
P (mg·100 g^{-1} soil)	4.1	27.3	4.7	4.1	20.7	30.5	7.5	2.6	19.5	32.0
K (mg·100 g^{-1} soil)	6.7	20.7	6.8	7.5	18.9	19.9	3.7	2.1	14.1	16.6
Mg (mg·100 g^{-1} soil)	6.4	34.4	7.8	13.6	116.5	176.5	3.9	13.3	159.1	281.2

M – mineral soil; O – organic soil; S – simulated use; P – pasture

Two types of grassland use were considered: pasture (5-6 grazings by Limousine cattle) and simulated (frequent cuts at pasture maturity, proportionally to the number of grazingz). In the study, 6 grass-legumes mixtures including such species as *Phleum pratense* cv. Obra (35%), *Dactylis glomerata* cv. Areda (10%) and *Trifolium repens* cv. Romena (25%) were sown. Every mixture contained a 30% share of the tested species as follows: 1. *Poa pratensis* cv. SKIZ, *2. Festulolium braunii* cv. Felopa, 3. *Festulolium loliaceum* I strain – spreading type, 4. *Festulolium loliaceum* II strain – erect type, 5. *Lolium perenne* cv. Solen and 6. *Festuca pratensis* cv. Skra. The initial hybrids between tetraploid forms of *Festuca pratensis* and *Lolium perenne* were obtained at the Institute of Plant Genetics PAS in Poznań. During the whole study controlled mineral fertilization was applied, including: N – 75, P – 31 and K – 75 kg ha^{-1} (in spring N – 24, P – 31, K – 60 kg ha^{-1}; after 2^{nd} regrowth – N – 17, K – 15 kg ha^{-1}; after 3^{rd} and 4^{th} regrowth – N – 17 kg ha^{-1}). The area of a pasture plot was 30 m^2 and that

of a simulated grassland was 15 m^2. Before every regrowth, yield of pasture sward was assessed by mowing part of a plot covering 5.5 m^2. Representative samples of plants were collected in order to determine the chemical composition of fodder: protein, ADF – acid detergent fibre, P, K, Ca and Mg. Chemical analyses were performed at the Szelejewo Plant Breeding Station (protein and ADF) and at the District Chemical-Agricultural Station in Lublin (P, K, Ca and Mg). The content of protein was determined with Kiejdahl's method, while the amount of ADF was measured on an American Ankom Fiber Analyzer (Ankom Technology – 10/99). Phosphorus was determined colorimetrically, potassium and calcium were tested by flame photometry, and magnesium was detected by the ASA method. The results underwent statistical analysis of variance with Tukey's test.

RESULTS AND DISCUSSION

Each grass-legumes sward contained the species sown in a mixture, herbs and weeds as well as grass species which had not been sown in the mixture. The sward value of the tested mixtures was assessed on the basis of the content of total protein, acid detergent fibre (ADF) as well as macroelements (phosphorus, potassium, calcium and magnesium). In this paper, the mean results of 2003-2005 are presented, namely 1st and 3rd regrowths and the mean of both regrowths. The content of the particular components in the sward was dependent on the soil type and grassland use. No significant differentiation depending on the sown mixture was observed, which is why these results were not put in the figures. However, it should be noticed that the *Festulolium loliaceum* strains compared favourably to other valuable pasture species. The sward with the tested hybrids was characterized by good quality, which was confirmed by an appropriately good content of total protein, ADF as well as the basic macroelements with respect to animals' nutritional needs. The study confirms suitability of these hybrids for pasture mixtures in postboggy habitats.

The content of total protein was varied depending on the type of soil. The sward on the organic soil was characterized by a higher content of total protein compared with the sward on mineral soil. However, significant variation was observed only in the 3rd regrowth and the mean of regrowths (organic soil (o) – 23.76% d.m; mineral soil (m) – 20.77% d.m.). This is undoubtedly connected with a higher content of nitrogen in organic soils (Baryła 1992). In contrast, the grassland use did not significantly affect the total protein content in sward (Figure 1). In our study, more protein was found in the 1st regrowth than in the 3rd one.

Another analyzed macronutrient was phosphorus, which plays an important role in the photosynthesis process, breathing, metabolism of fats as

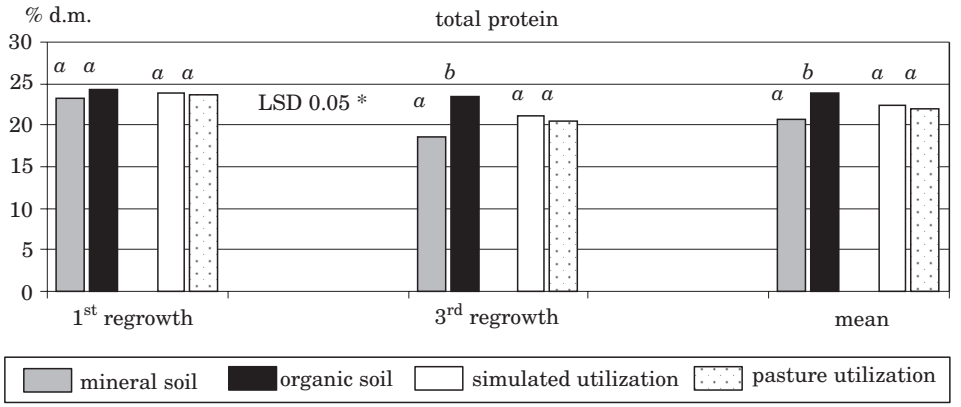

Fig. 1. Mean content of total protein in the sward in 2003-2005

well as nitrogen transformations. It is an essential macroelement, whose optimal content in feed, according to animals' nutritional needs, is approximately 0.3% of dry matter (FALKOWSKI et al. 1990). The analysis of phosphorus concentrations showed the same tendencies as those noticed for the total protein content. Significantly more phosphorus was determined in the 3rd regrowth and the mean of the regrowths of swards on peat-muck soil (0.40% d.m.). This could be attributed to the better moisture conditions of such soils. According to FALKOWSKI et al. (1990), phosphorus content in dry matter sward is lower in habitats where there is shortage of water.

There were no significant differences in the phosphorus content with respect to the grassland use type. Analogously to other studies (ĆWINTAL 1999, KRZYWIEC 2000), the feed we analyzed contained on average more phosphorus when produced from the first regrowth (0.43% d.m.) than the third one (0.34% d.m.) – Figure 2.

Another macronutrient which is important for the growth and development of plants is potassium, which has a positive impact on photosynthesis and plays an important role in the plant water management. The optimum content of this element in sward is about 1.7% d.m. (FALKOWSKI et al. 1990). In our study, sward on mineral soil contained significantly more potassium than that growing on organic soil (Figure 2). Such a relationship is confirmed by other researchers (ĆWINTAL 1999, KRZYWIEC 2000). Organic soils are characterized by a lower availability of potassium than mineral soils (Guz 1982). In addition, the analyzed sward contained more potassium when maintained as pasture (mean 2.18% d.m.) than when cut (mean 1.96% d.m.) – Figure 2. This was caused by a large concentration of this element in spots covered by animals' faeces (ROGALSKI et al. 2000). Enrichment of soil in nutrients derived from excrements of grazing animals increases potassium in dry matter of pasture sward (WARDA 1994).

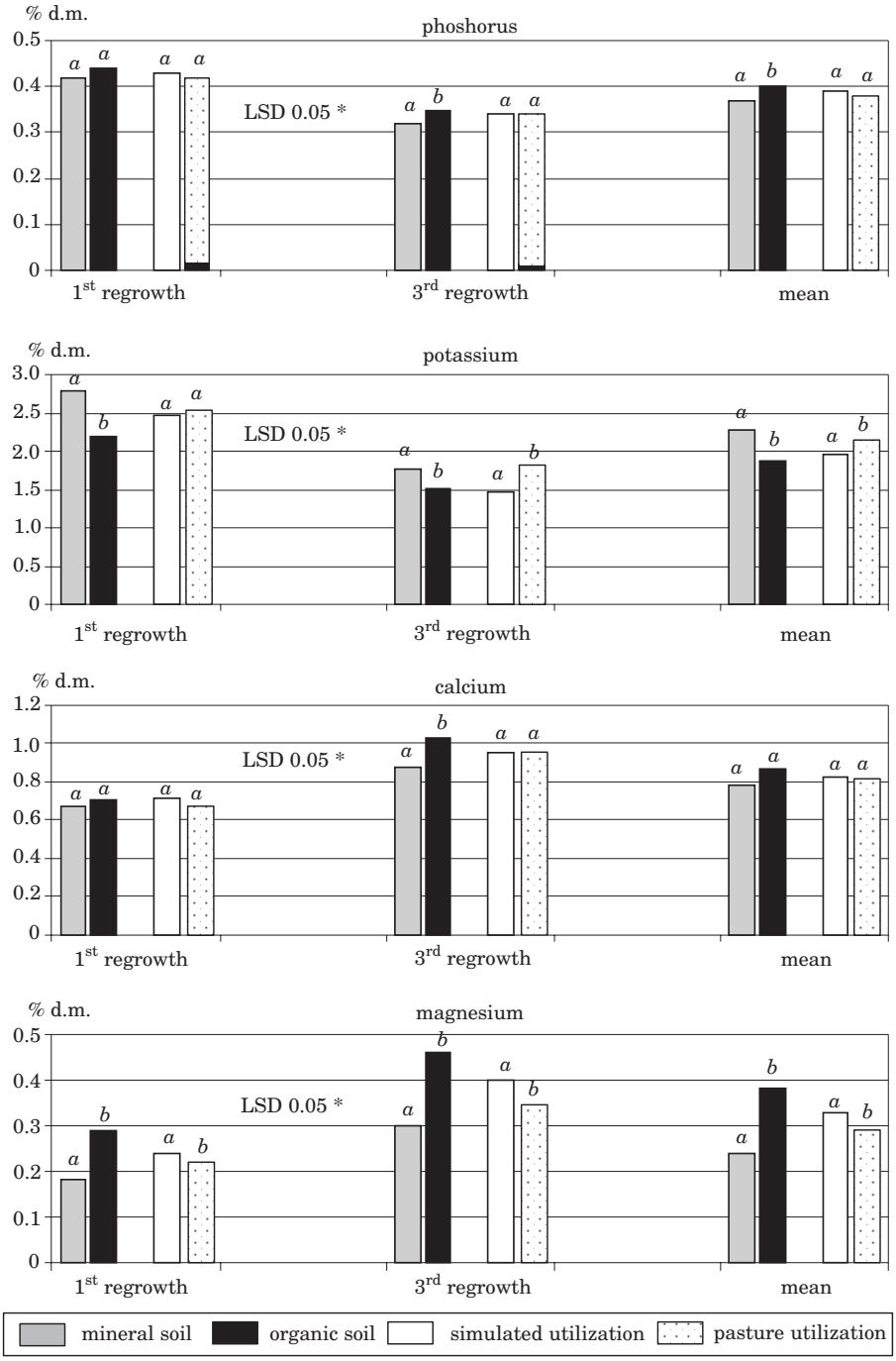

Fig. 2. Mean content of macroelements in the sward in 2003-2005

Calcium is another essential macronutrient. It plays a selective regulatory function in the uptake of mineral salts by plant roots. The optimal calcium content in grassland plants is about 0.7% of dry matter (FALKOWSKI et al. 1990). Significant variation was observed only in the 3rd regrowth, when sward on organic soil characterized by a higher calcium content (1.03% d.m.) than sward on mineral soil (0.88% d.m.) – Figure 2. Similar results were obtained by ĆWINTAL (1999), although a more intensive mineralization process on organic soil reduces the amount of calcium absorbed by plants (ŁĘKAWSKA 1989). However, a higher calcium content in the dry matter of sward on organic soil was caused by a larger share of *Trifolium repens* as well as herbs and weeds, especially species with a large ability to accumulate calcium (TRZASKOŚ 1997). Another factor which led to a higher calcium content was the improved water status of soil, which affects the uptake of calcium by plants (FALKOWSKI et al. 1990).

Being a component of chlorophyll magnesium, a life essential element, affects photosynthesis, phosphorus management and the formation of protein compounds in plants. The optimum content of magnesium in animal feed, according to nutritional needs, is about 0.2% of the dry matter (FALKOWSKI et al. 1990). While analyzing the effect of soil, it should be noticed that sward on organic soil had a significantly higher content of magnesium (0.38% d.m.) than sward on mineral soil (0.24% d.m.). The sward on peat-muck soil comprised more *Trifolium repens* as well as herbs and weeds, especially species such as *Ranunculus repens* or *Taraxacum officinale*, which are markedly better at accumulating magnesium (TRZASKOŚ 1997). Significant differences were also observed in the content of magnesium depending on the land use (simulated – 0.33% d.m, pasture – 0.29% d.m.) – Figure 2. The differences were mainly due to a higher share of herbs and weeds in the simulated grassland, especially species capable of accumulating much magnesium, such as *Achillea millefolium* or *Taraxacum officinale* (TRZASKOŚ 1997).

For assessment of feed digestibility, it is important to know the content of the ADF. The acid detergent fibre combines cellulose and lignin, which are bulk compounds, only incidentally digested by monogastric animals. The content of the ADF ranges from 18 to 44% d.m. (DUFRASNE et al. 1998, GUTMAN, ADAMOVICH 2004, HARASIM 2001). The content of this fibre fraction is growing very quickly during the growth and subsequent phases of plant development (KRZYWIECKI, KOZŁOWSKI 2003). In our study, sward was cut on optimum dates, i.e. during the phase of pasture maturity, so it was characterized by good parameters. The results regarding the ADF content were not processed statistically as an analysis of an average sample from 4 replications was performed. Nonetheless, the ADF levels formed part of the feed quality assessment.

The content of the ADF in the sward ranged between 24.74% d.m. (1st regrowth – mineral soil) to 28.63% d.m. (3rd regrowth – mineral soil) – Figure 3. Comparing these results to the American ranges of the ADF

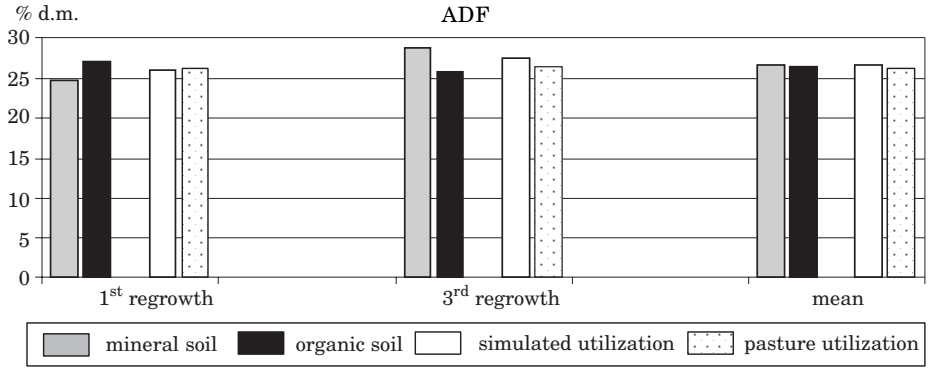

Fig. 3. Mean content of acid detergent fiber (ADF) in the sward in 2003

(STEEVENS 1998), it can be concluded that the feed obtained in our study was of almost perfect quality with respect to this component.

CONCLUSIONS

1. Sward on organic soil was characterized by a significantly higher content of total protein, phosphorus, calcium and magnesium as well as a significantly lower content of potassium compared to sward on mineral soil.

2. Sward maintained as pasture had a significantly higher content of potassium and significantly lower content of magnesium compared to sward on simulated grassland.

3. Regardless of the factors taken into account, the tested sward was characterized by excellent quality (the ADF) and an optimum content of the basic macronutrients with respect to the dietary needs of animals.

4. No influence of the mixture species studied on feed quality was observed, which proves that *Festulolium loliaceum* hybrids are suitable for pasture mixtures in postboggy habitat.

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