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Comparison of changes in structural carbohydrates and enzyme digestibility during vegetation in permanent and temporary grazing pastures

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Abstract

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Pastures are considered as the primary and most economical source of nutrients for herbivores. The purpose of this study was to compare changes in chemical composition, plant cell wall fiber component and *in vitro* enzyme digestibility of the forage from first growth of natural and temporary pasture. In 2017, samples of both pastures were given from Mid-April in 7 days to determine changes in composition and *in vitro* digestibility. The average crude protein is approximately the same for both grasses (12.39% and 12.94%) and showed a tendency to decrease from the beginning to the end of the period. The rate of change in CF was more dynamic in temporary pasture, which increased by 49.37%. For the same period, the increase in CF in natural pasture was 40.80%, respectively. NDF content increased from 46.67 to 58.16%, or average by 3.57% units per week in natural grassland, and in temporary pasture by 45.71% to 57.77% respectively, or by 3.68 % units per week. ADF of temporary pasture increased by 4.35% units per week, while in natural pasture increased by 3.57% units per week. ADL in natural pasture increased by 0.974% per week, while in temporary pasture more dynamic changes were found and ADL increased more than twice for 4 weeks. Digestibility reduced at approximately the same rates in both pastures – temporary and natural by 24.21% and by 25.52%, respectively for period of 4 weeks.

Keywords: chemical composition; protein; fiber; *in vitro* digestibility; natural pasture; temporary pasture

Introduction

Pastures are considered as the primary and most economical source of nutrients for herbivores. In Bulgaria pastures occupy about 1/3 of the agricultural area of the country. Most of these areas (over 60%) are located in foothills and mountainous regions of the country, on steep terrain with predominant participation of grasses (up to 85-90%) (Kirilov & Todorova, 2004; Kirilov & Mihovski, 2014). Pasture systems are usually based on sown and natural pastures (Vasileva et al., 2016). Both types of grasslands play a major role. During the pasture season, it is mainly relied on natural pastures whose yield and nutritional composition do not in most cases cover the needs of the higher dairy animals. In Bulgaria the yields from the natural pastures depend on the type of grassland and in the mountainous regions they are in the range of 250 to 350 kg per hectare (Kirilov & Todorova, 2004), but in the lowlands are lower. In natural pasture prevail grasses, up to 85-90% (Kirilov & Todorova, 2004), which is a precondition for a low nutritional value. During the vegetation, the chemical composition of pastures changes, their nutritional value decreases, solutions and approaches must be sought to provide grazing with relatively constant levels and high nutritional value. This can be achieved by grazing on temporary pastures with a regular grass composition, with higher, both, yield and proportion of legumes that are more digestible and with higher crude protein content, energy and minerals (Luscher

et al., 2014; Vasileva & Ilieva, 2017; Vasileva & Enchev, 2018). Changes in the composition of different pastures in Bulgaria have been studied by Naydenova & Pavlov (2001, 2005); Naydenova (2012, 2014); Todorova & Kirilov (2002); Naydenova et al. (2003, 2013). In our conditions, the grass mixtures with participation of cocksfoot and sainfoin are suitable (Kirilov, 2010).

The purpose of this study was to compare changes in chemical composition, cell wall fiber component and *in vitro* enzyme digestibility of the forage from first growth of natural and temporary pasture.

Materials and Methods

The objects of this study were natural and temporary pastures owned by the Institute of Forage Crops – Pleven, Bulgaria. The temporary pasture was sown in 2014 of cocksfoot (*Dactylis glomerata* L.) and sainfoin *(Onobrychis sativa)*, 50% of the sowing rate for each species. In 2017, samples of both pastures were given from Mid-April in 7 days to determine changes in composition and *in vitro* digestibility. The dried samples were milled by *Retsch SM 100* mill through a 1 mm mesh size. For each sample, the chemical composition according to the commonly agreed *Weende Method* (AOAC, 2007) was determined: Crude Protein (CP) by *Kjeldahl* (BDS-ISO 5983) and Crude Fibers (CF) (AOAC, 2007); Structural carbohydrates or cell wall components: Neutral-detergent fiber (NDF), Acid-detergent fiber (ADF), Acid-detergent lignin (ADL) as a percentage of the dry matter of the feed were determined by the method of *Goering and Van Soest* (1970) (EN ISO13906 2008). The *in vitro* enzyme digestibility of dry (IVDMD) and organic (IVOMD) matter was determined as a percentage by Aufrere two-step pepsin-cellulase enzyme method by Aufrere (Todorov et al., 2010).

Results and Discussion

Table 1 presents the changes in the chemical composition and the development stage of the temporary and natural pasture. The average CP over the period was approximately the same for both pastures (12.39% and 12.94%) and showed downward trend from the beginning to the end of the period. Unlike CP, the CF increases from the first to the fourth week.

The rate of change in the CP during the weeks of vegetation in natural pasture was more dynamic than that in temporary pasture. In natural pasture, the reduction of CP for the 4-week period was 29.88%. The content of the CP for the 4-week period was reduced by 18.15%. The rate of change in CF was more dynamic in temporary pasture, which increased by 49.37%. For the same period, the increase in CF in natural grassland was 40.80%, respectively. The changes observed in the content of structural carbohydrates are presented in Figures 2 and 3. It has been found that with the progression of vegetation and aging of plants, the content of

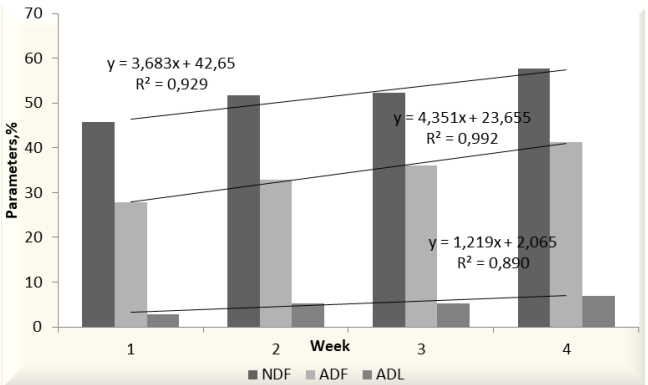

Fig. 1. Plant cell walls fiber components content in 4 weeks of temporary pasture

Table 1. Chemical composition of temporary and natural pasture, % of dry matter

Weeks/2017	Development stage	Crude protein	Crude fiber
Temporary pasture			
1 -15.04.	Without generative stems	14.33	17.48
2	Without generative stems	12.86	21.35
3	With generative stems	12.85	23.22
4	Beginning of flowering	11.73	26.11
Mean±SD		12.94±0.92	22.04±1.98
Natural pasture			
1 -15.04.	Without generative stems	15.13	16.96
2	Without generative stems	13.41	20.98
3	With generative stems	10.40	23.88
4	Grasses-earring,	10.61	25.15
Mean±SD		12.39±1.97	21.74±3.15

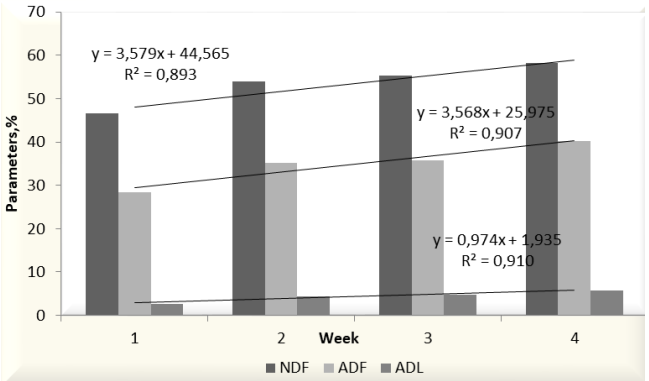

Fig. 2. Plant cell walls fiber components content in 4 weeks of natural pasture

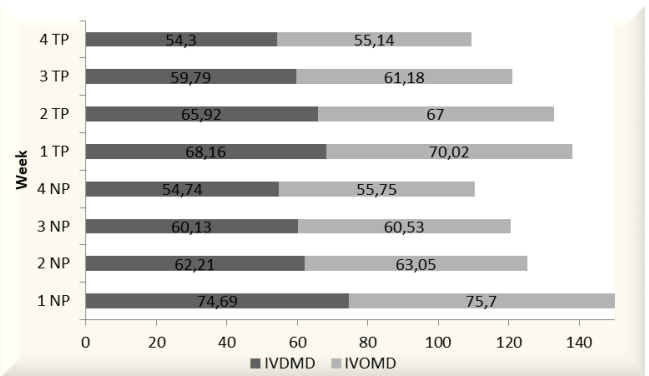

Fig. 3. Enzyme *in vitro* dry matter (IVDMD) and organic matter digestibility (IVOMD) in 4 weeks of temporary (TP) and natural pasture (NP)

NDF, ADF and ADL increased, these trends being described by the corresponding linear equations (Figures 1 and 2).

For a period of four weeks, an increase in NDF from 46.67 to 58.16% or average of 3.57% units per week (R^2 = 0.893) was observed in natural pasture. NDF in temporary pasture has a higher content – from 45.71% to 57.77%, or average it increased by 3.68% units per week (R^2 = 0.929).

More dynamic changes were also observed in ADF content in temporary pasture compared to natural pasture. The content of ADF from the first to fourth week ranges from 27.82% to 41.26% or average increase of 4.35% per week (R^2 = 0.992), while in natural grassland the values were from 28.47% to 40.20%, or growth by 3.57% units per week (R^2 = 0.907). ADL was also increased, that in natural pasture being 0.974% units per week (R^2 = 0.910), while in the temporary pasture the changes were more dynamic and ADL increased by 1.219% units per week (R^2 = 0.890), its content rising more than twice for the period.

The average of NDF for 4-week study period was lower for temporary pasture (51.86%), compared to natural pasture (53.51%). The average values of ADF for the period were approximately the same for both grasses – from 34.53 to 34.89%. Mean values of lignin were lower for natural grassland (4.37%) and higher for temporary pasture (5.11%).

At the first growth of vegetation of natural and temporary pasture the usual trends of changes in the chemical composition, related to the stage of grass growth were observed (Todorova & Kirilov, 2002, Jochims et al., 2013). The composition and nutritional value of grasses changes during the vegetation period. There was a constant tendency of decreasing the nutritional value with the progression of vegetation (Naydenova & Pavlov, 2001, 2005; Todorova & Kirilov, 2002, Naydenova et al., 2003, Bovolenta et al., 2008).

The more dynamic changes observed in most of the chemical indicators in the temporary pasture were probably due to faster growth rates as well as to the biological characteristics of sainfoin as legume crop (Kirilov, 2010). The share of sainfoin decreased in grasses mixtures during the years after sowing (Pavlov, 1996) and the increases in the share of cocksfoot lead to higher share of generative stems in the total mass in the first growth (Damianova, 1989). They have lower protein content and higher fiber components. The data correspond to those obtained by Kirilov (2010) for temporary pasture. Similar trends of change have been found by Glindemann et al. (2009) and Bovolenta et al. (2008). Naydenova & Pavlov (2001) found that as advancing growth of grasses, the fiber components increased and their nutritional value decreased. These changes in vegetation of grasses of two types of pastures were common as a trend and they were also found by other authors (Todorova & Kirilov, 2002; Bovolenta et al., 2008; Kirilov et al., 2009; Jochims, 2013), but the changes in basic chemical indicators were different. The rates of change according to Safari et al. (2011) are influenced by the season and climatic conditions during the year. Digestibility of both pastures decreased with the progress of vegetation (Figure 3). The enzyme digestibility of dry and organic matter decreased in the direction from the first to the fourth week. The changes in this indicator were approximately the same for both grasses, which was determined by the approximately equal content of ADF in both pastures (Figures 1 and 2). The reduction of digestibility in temporary pasture was average of 25.52%, and in the natural pasture was 24.21%. IVDMD in both grasses was 63.33 to 63.75% and IVOMD was from 62.04 to 62.94%. This finding corresponds to the results obtained by Safari et al. (2011) who found that with aging plants, the digestibility of grasses goes from 68% to 40% at the end of the grazing period. Askar et al. (2014) found that the digestibility of pas-

tures decreased from 73.4% at the beginning of grazing to 53.8% at the end of the period. The results obtained were not unexpected in view of the biological features of legumes and grasses. Legumes have a faster rate of development at the beginning of vegetation, while the cocksfoot grows slower at the beginning, but is a longer-lasting crop. In support of this finding were the results of Kirilov (2010) who also found a lesser durability of the cocksfoot in mixtures with grasses. According to Pavlov (1996), in mix of grasses, the sainfoin exhibits the smallest competitive power, which explains the approximate digestibility of both types of pasture. Decreasing the share of the sainfoin as a legume component in mixtures with grasses was also observed in studies by Vasilev (2008). The observed share of legumes in both pastures (natural and temporary) in 2017 has similar values. This makes the nutritional value of the pastures roughly the same as the amount of intake protein during the study period.

Conclusions

The results obtained in determining the changes in composition, plant cell walls fiber components and *in vitro* enzyme digestibility from first growth of natural and temporary pasture allow the following conclusions to be drawn:

The average crude protein was approximately the same for both grasses (12.39% and 12.94%) and showed a tendency to decrease from the beginning to the end of the period.

The rate of change in CF was more dynamic in temporary pasture and increased by 49.37%. For the same period, the increase in CF in natural pasture was 40.80%, respectively.

NDF content increased from 46.67 to 58.16%, or average by 3.57% units per week in natural grassland, and in temporary pasture by 45.71% to 57.77%, respectively, or by 3.68% units per week.

ADF of temporary pasture increased by 4.35% units per week, while in natural pasture increased by 3.57% units per week.

ADL in natural pasture increased by 0.974% per week, while in temporary pasture the changes were more dynamic and ADL increased more than twice for 4 weeks.

Digestibility reduced at approximately the same rates in both pastures – temporary and natural, by 24.21% and by 25.52%, respectively for period of 4 weeks.

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