

Biotechnology in Animal Husbandry 34 (1), p 21-31, 2018
Publisher: Institute for Animal Husbandry, Belgrade-Zemun

ISSN 1450-9156

UDC 633.2.03

<https://doi.org/10.2298/BAH1801021S>

YIELD AND NUTRITIONAL VALUE OF PERMANENT GRASSLAND FORAGE UNDER SIMULATED ROTATIONAL GRAZING

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Original scientific paper

Abstract: A cutting experiment was conducted to test the changes in botanical composition, yield and nutritional value of forage, obtained in conditions of simulated rotational spring grazing on permanent grassland. The experiment was carried out on permanent pasture in vicinity of Šabac, Serbia in 2015 included three cuttings as a simulated rotational spring grazing. The highest share of grasses was noted in the first cut and decreased in the second and third cut, with increased forbs participation, and relatively constant percentage of legumes. The highest dry matter (DM) yield was obtained for the first harvest, followed by the second cut, and the lowest forage production was determined for the third harvest, with only 11.04 and 17.42% of the first and second cut yield. There were not found the significant differences between cuts for herbage DM and crude protein content. Markedly lower value for non-protein N concentration ($p < 0.05$) was determined in the third cut. The fiber content increased during the grazing season ($p < 0.05$), with the highest value determined in the herbage obtained in the second cut. The highest energy values ($p < 0.05$) had the herbage produced in the first cut (DM basis), wherein the lowest values were found in the forage from the second harvest. These results indicate that especially herbage yield of analyzed grassland as chemical composition and nutrition value are highly variable during the growing season. The accurately defined optimal period for using is necessary to provide the high-quality forage for grazing animals.

Key words: forage production, pasture quality, nutrition, ruminants, pigs

Introduction

Grassland vegetation of Serbia occupying about 1.5 million ha or 27% of the total agricultural area of the country as the most represented type of the agroecosystem (*Simić et al., 2015*). Permanent grasslands, serve both for production and environmental purposes, as the most represented type of the

agroecosystem, and they are the main source of forage on farms with animals which are raised on pasture (*Adamović et al., 2005*). Besides the importance of grazing in rations for ruminants – cattle, sheep and goat, in organic pig production the requirement is that the animals be allowed access to pasture. In general the permanent grasslands in Serbia are situated on soils with low natural fertility, are of low productivity and have sub-optimal botanical composition (*Simić et al., 2015*). Perennial legumes as clovers and medics play a special role as a pasture components in the Serbia through their production, quality and ability to fix atmospheric nitrogen. However, acidic soils of low fertility on Serbian hilly-mountainous grasslands cause lack of legumes, their low share and the longevity, as well as limitations in successful forage production (*Simić and Vučković, 2014*). Forage quality encompasses many factors, including content of crude protein (CP) and nonprotein N, fiber (neutral detergent fiber-NDF and acid detergent fiber-ADF), available energy concentration, as important indicators of nutritive value for grazing forages. The DM content of pasture has a significant effect on forage intake of grazing animals (*Stojanović et al., 2016*). Temperature and rainfall are climatic factors that can affect forage quality. Seasonal variation in environment alters forage quality, even when forages are harvested at similar maturity stages (*Buxton and Casler, 1993*). The depressed digestibility associated with elevated temperatures is usually attributed to higher NDF concentrations, whereby the NDF of forages grown under higher temperatures is usually less digestible than that of forages grown under lower temperatures because of increased lignification (*Buxton and Fales, 1994*). During spring growth, the effect of increasing temperatures interact with advancing maturity to cause a more-rapid decline in forage quality with time than occurs during summer growth (*Van Soest, 1994*). According to *Mandaluniz et al. (2015)* the CP content was decreased, and NDF and ADF content increased for grazing herbage mass during the spring grazing period (April - June), with 20-25 days of resting period. *Wilkins et al. (2000)* found that the seasonal variation in protein concentration of perennial ryegrass herbage was much larger than the differences among cultivars.

To meet the nutritional requirements of grazing animals, throughout the plant growing season, beside the yield, the determination of energy and nutrients content in obtained forage is necessary. For this reason, we conducted a cutting experiment to test the changes in yield and nutritional value of herbage obtained in conditions of simulated rotational spring grazing on permanent grassland. The objective of this study was also to investigate and launch sustainable pasture exploitation in Serbia.

Material and methods

The trial was conducted on pasture in 2015 included three cuttings as a simulated rotational grazing. The field experiment was established in Western

Serbia, 11 km southern of Šabac (44°40' N, 19°39' E) on poor quality soils. Experimental plots were 5 × 2 m in 5 replications, designed by RCB method. Pasture was situated on poor quality soils and has been exploited permanently for dairy cattle grazing. Harvesting dates were 1 May, 24 May and 19 June. The plots were harvested at 9:00-9:30 a.m. with a rotary cutter to a residual stubble height of 7 cm. The herbage was weighed after cutting, sub-samples were taken for chemical and botanical analyses.

Identified plant species were classified by their quality into three categories: quality grasses, quality legumes and forbs (harmful, useless or conditionally useful plant species from other plant families), (Tomić *et al.*, 2005), and the percentage of these yield-contributing species per cut were noted (botanical composition by covering).

Table 1. Chemical properties of soil

Depth	pH		OM, %	AL-P ₂ O ₅ mg/100g	AL-K ₂ O mg/100g	Total C, %	Total N, %
	CaCl ₂	H ₂ O					
0-20 cm	5.07	5.73	4.31	1.98	11.51	1.37	0.16

Meteorological data for this site were collected from the Sremska Mitrovica Weather Stations, respectively, located near the experimental sites.

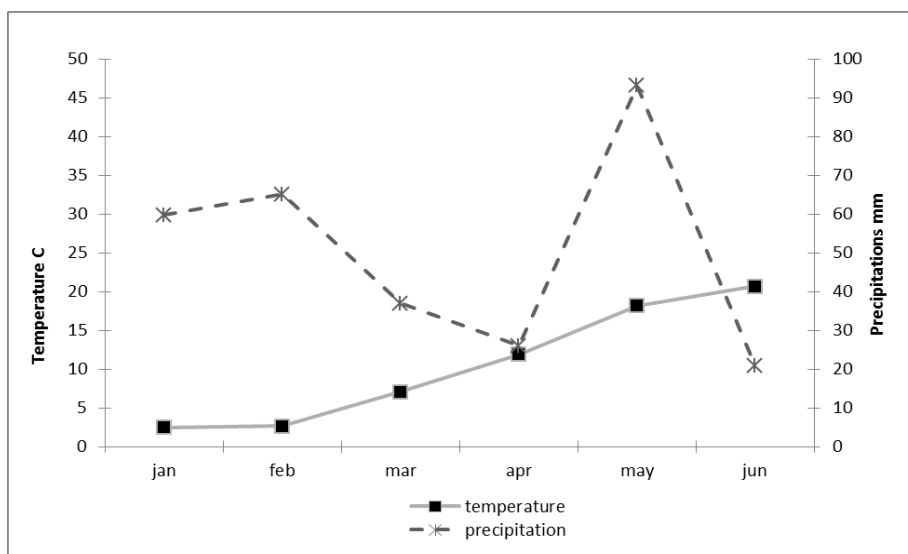


Figure 1. Average monthly temperature and monthly precipitation sum, during spring grazing season

Samples of harvested material for chemical analysis were placed in plastic bags, stored in a cooled portable refrigerator, and transported to the laboratory for processing. Chemical analysis of herbage samples was done in the Laboratory for the animal nutrition at the Faculty of Agriculture - Belgrade. All samples were dried before chemical analyzes. Parameters of proximate analysis, NDF, ADF and ADL (acid detergent lignin) were determined according to the procedure of AOAC (2002). The protein fractions (true protein and NPN) were determined using standardizations of *Licitra et al. (1996)*. The energy values of forage DM for ruminants and pigs were estimated according to the *NRC (2001)*, *INRA (2004)*, *Noblet and Perez (1993)* and *NRC (1998)*:

$$NE_L \text{ (MJ/kg DM)} = 0.703 \times ME - 0.795 \text{ (NRC, 2001)}$$

$$NE_{\text{Em-rum.}} \text{ (MJ/kg DM)} = ME \times (0.287 \times q + 0.554) \text{ (INRA, 2004)}$$

$$NE_{\text{f-rum.}} \text{ (MJ/kg DM)} = ME \times (0.78 \times q + 0.006) \text{ (INRA, 2004)}$$

$$NE_{\text{l-rum.}} \text{ (MJ/kg DM)} = ME \times ((0.60 + 0.24 \times (q - 0.57))) \text{ (INRA, 2004)}$$

$$ME_{\text{swine}} \text{ (kcal/kg DM)} = DE - 0.68 \times CP, \text{ g (Noblet and Perez, 1993)}$$

$$NE_{\text{swine}} \text{ (kcal/kg DM)} = 328 + (0.599 \times ME) - (15 \times \text{Ash, \%}) - (30 \times \text{ADF, \%}) \text{ (NRC, 1998)}$$

NE_L – Net energy lactation for dairy cows; $NE_{\text{Em-rum.}}$, $NE_{\text{f-rum.}}$, $NE_{\text{l-rum.}}$ - Net energy maintenance, fattening and lactation for ruminants, respectively; ME_{swine} – Metabolizable energy for swine; NE_{swine} – Net energy for swine.

An ANOVA-procedure using the STATISTICA v.6 (*StatSoft, 2003*) was conducted to assess the effects of different harvests on yield, composition and nutritional value of herbage from permanent grassland. Differences among treatment means were tested for significance using LSD test. Statistical significance was determined at $p < 0.05$.

Results and discussion

Soil on the experimental field had limited productive abilities, and frequent lack of precipitation during period May-June influenced grazing capacity of pasture. The total precipitation was 302.0 mm in the first part of vegetation season (Fig. 1). The average monthly temperatures registered in May and June also negatively influenced grazing capacity of pasture. Soil from experimental field had a low P content and moderately acidic pH (Table 1). *Áčić et al. (2013)* reported that the most influencing factors determining development of permanent grassland used as a pasture are the quantity of nutrients in the soil and the habitat moisture.

Three cuts were reached in the part of vegetation season, before summer drought period. The obtained results indicate that yield of forage DM depends on the cutting period (Table 2). In the first cut, the highest DM yield was obtained, followed by the second cut with markedly lower yield (36.62%), and the lowest

forage production was determined for the third harvest, only 11.04 and 17.42% of the first and second cut yield.

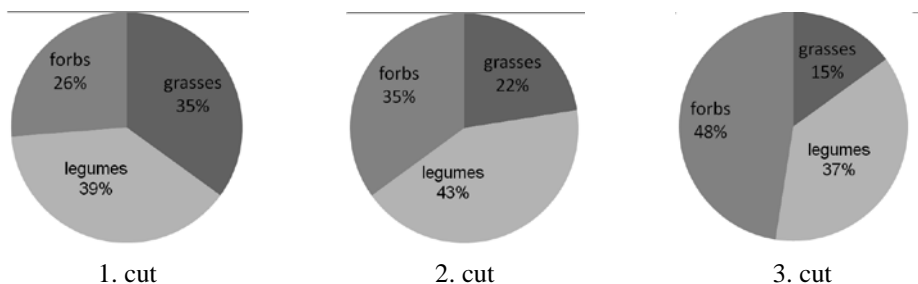


Figure 2. Botanical composition of pasture by covering

The highest share of grasses was noted in the first cut, mainly *Poa pratensis*, *Dactylis glomerata* and *Lolium multiflorum*, and decreased in the second and third cut. However, a notable contribution of forbs to the canopy formation was seen (*Ranunculus sp.*, *Taraxacum officinale*, *Stellaria media*), and increased by harvests. The percentage of legume species was relatively constant for different cuts during analyzed period and main species were: *Trifolium repens*, *T. campestre*, *T. pratense*, and *Vicia sp.* High numbers of forbs suggest high biodiversity of species, but also underline poor quality and low production for livestock farming. In the second and third cut, a combination of weather conditions had the influence on the botanical composition. According to Simić *et al.* (2015) on areas that are not permanently managed, forbs (i.e. weeds in forage production) make over half of the plant production. Due to poor fertility of the soil and relatively severe climate, pastures are often overgrown with plant species of low nutritional value. In south Eastern Europe, the growth of legumes is seriously limited by the ability of each species to grow during usually cold winters (Simić and Vučković, 2014). There, the distribution of legumes on Serbian natural grasslands ranges from 6.73% to 34.12%, depending on plant nutrition (Đurić *et al.*, 2007).

This research showed significant effect of different cuts during spring growing season on a forage quality, with determined marked changes as the grazing season progresses. Results for chemical composition of herbage for three harvests from the 1 May to 19 June are presented in table 2.

Table 2. Chemical composition of permanent grassland forage from consecutive spring harvests

Cuts	DM yield kg/ha	DM, %	CP, %DM	NPN, %CP	NDF, %DM	ADF, %DM	Lign., %DM	NFC, %DM	EE, %DM	Ash, %DM
1.	770 ^a	26.28	15.30	19.55 ^a	39.09 ^a	25.54 ^a	3.19 ^a	36.15 ^a	3.39 ^a	8.87
SEM	86	1.53	0.60	0.84	1.38	0.84	0.25	0.79	0.16	0.19
2.	488 ^b	28.46	13.72	19.69 ^a	48.61 ^b	31.22 ^b	5.20 ^b	27.12 ^b	3.86 ^{ab}	10.00
SEM	58	1.04	0.83	1.10	1.95	0.79	0.34	1.25	0.13	0.58
3.	85 ^c	28.79	14.55	15.79 ^b	43.62 ^a	28.61 ^c	4.06 ^a	31.79 ^c	4.21 ^b	8.95
SEM	12	1.31	0.69	1.11	1.03	0.68	0.36	0.83	0.19	0.23

¹SEM: Standard Error of the Mean. ^{a, b, c} Means in the same column with different superscripts differ ($p < 0.05$); DM-dry matter; CP-crude protein; NPN-nonprotein nitrogen; NDF-neutral detergent fiber; ADF-acid detergent fiber; Lign.-lignin; NFC-nonfiber carbohydrate; EE-ether extract;

There was found the slightly increase in forage DM content while the CP values were lower, during the analyzed spring grazing period, where in these differences were not significant. Markedly lower value for NPN concentration ($p < 0.05$) was determined in forage from the third cut. There was found the increase of fiber content (NDF and ADF) for the different cuts, during the season, with the highest values for herbage obtained in the second cut ($p < 0.05$) where the lowest concentration of nonfiber carbohydrate - NFC ($p < 0.05$) was determined, too. Observed results are in accordance with the research of *Rayburn (1991)* where it was found the reduction of forage quality of intensive rotationally grazed pastures (mixed mostly grass and mixed mostly legume) with increased NDF content in DM, while the NSC (nonstructural carbohydrate) and CP concentration was decreased, as the grazing season progresses (May - August interval). When temperatures rise above the optimum range for plant growth, the nutritive value of forage declines (*Reid, 1988*). According to *Elgersma and Sjøgaard (2016)* for grass-legume swards, NDF and ash contents were lower in the first harvest in May, than during June – September, whereas, contents of water-soluble carbohydrates and crude fat, as *in vitro* OM digestibility were highest in the first harvest in May. Determined increase in fiber content with the advancement of vegetation, which also reported by *Elgersma and Sjøgaard (2016)*, is a result of lower temperatures during May and vegetative, leafy plant materials as opposed to generative, stemmy plant materials during summer. Obtained results which indicated the markedly lowest value for NPN concentration in forage from the third cut (second regrowth) are likely correlated with the lower protein solubility at greater NDF and ADF content in forage DM (*Rayburn, 1991*). *Wilson and Brigstocke (1981)* reports that the proportion of non-protein nitrogen in typical pastures may be 18% CP, what is in agreement with the obtained results.

The net energy concentration in herbage from the three consecutive harvests during the spring growing season are shown in table 3.

Table 3. Net energy content of permanent grassland forage, for three harvests during the May – June interval

Cuts	NE _L , MJ/kg DM	NEm-rum., MJ/kg DM	Nef-rum., MJ/kg DM	NEI-rum., MJ/kg DM	MEswine, MJ/kg DM	NEswine, MJ/kg DM
1.	6.17 ^a	8.26 ^a	5.52 ^a	6.91 ^a	9.51 ^a	3.31 ^a
SEM ¹	0.10	0.18	0.18	0.15	0.22	0.24
2.	5.36 ^b	7.19 ^b	4.41 ^b	6.01 ^b	7.64 ^b	1.40 ^b
SEM	0.04	0.07	0.09	0.06	0.11	0.13
3.	5.94 ^a	7.80 ^c	4.99 ^c	6.52 ^c	8.89 ^c	2.55 ^c
SEM	0.09	0.11	0.12	0.09	0.13	0.15

¹SEM: Standard Error of the Mean. ^{a, b, c} Means in the same column with different superscripts differ ($p < 0.05$); NE_L – Net energy lactation for dairy cows (NRC, 2001); NEm-rum., Nef-rum., NEI-rum. - Net energy maintenance, fattening and lactation for ruminants, respectively (INRA, 2004); MEswine – Metabolizable energy for swine (Noblet and Perez, 1993); NEswine – Net energy for swine (NRC, 1998).

Determined the greatest values ($p < 0.05$) for net energy contents of the herbage produced in the first cut (DM basis) could be expected, considering the highest NFC and CP content, with the lowest NDF and ADF concentration (Stojanović *et al.*, 2002). The most prominent decrease of herbage energy content was determined for the second cut. With exception of the concentration of net energy lactation for dairy cows (NRC, 2001), forage produced in the third cut had significantly lower energy values compared to the first cut. According to Van Vuuren and Van Den Pol-Van Dasselaar (2006) the energy value of grass pasture is highest in April, but remains rather stable throughout the year, also the highest crude protein concentrations were found in spring and autumn, wherein the sugar concentration decreases throughout the season, too. In this research, in particular, the significantly lower content ($p < 0.05$) of NE for pigs in forage that was obtained from second harvest, only 42.30 and 54.90% of NE content in first cut forage, certainly could be attributed to the markedly higher fiber (NDF and especially ADF) content (Noblet and Le Goff, 2001). Our findings which indicate on reduction of nutritional value of pasture during the spring grazing season are in accordance with study of Vestergaard *et al.* (1995) where dried grass meal derived from the first three cuts from the ryegrass - red clover pasture, showed reduced sugar content, increased content of dietary fiber and decreased energy value.

Conclusion

The significant reduction of forage DM yield was determined for analyzed three cuts during the growing season before summer drought period. Considering the botanical composition of pasture, it was determined the reduction of grass species portion for different cuts as the grazing season progresses, with increased percentage of forbs, while the participation of legume species was relatively

constant. In general, it can be concluded that different harvests during spring growing season, have a significant effect on nutritional value of forage from analyzed permanent grassland. With approximate DM content of herbage from different cuts, the greatest values for CP, NFC and content of net energy for ruminants, as metabolic and net energy for swine, was found in first cut forage, and these parameters have decreased as the grazing season progresses (first and second regrowth), while the concentration of NDF, ADF and ether extract have increased. These results indicate that accurately defined optimal period for using of permanent pastures, as also required regrowth interval throughout the season, are necessary to provide the high-quality forage for pasture raised animals.

Prinos i hranljiva vrednost zelene mase sa permanentnog travnjaka u uslovima simulacije prolećne ispaše

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Rezime

Istraživanje u kome je košenjem simulirana pregonska ispaša, sprovedeno je u cilju utvrđivanja razlika u botaničkom sastavu, prinosu i hranljivoj vrednosti dobijene zelene mase sa permanentnog pašnjaka, tokom prolećne sezone. Eksperiment je izveden tokom 2015. godine na prirodnom pašnjaku u okolini Šapca, Srbija i uključivao je tri otkosa kao simulaciju pregonske prolećne ispaše. Najveći udeo trava je zabeležen u prvom otkosu, dok je zastupljenost trava u drugom i trećem otkosu bila smanjena, uz istovremeno povećanje učešća zeljanica, i relativno ujednačen udeo leguminoza po ciklusima iskorišćavanja. Najveći prinos suve materije (SM) je utvrđen u prvom ciklusu iskorišćavanja, zatim u drugom, dok je najmanja produkcija zelene mase izmerena u trećem otkosu, samo 11,04 i 17,42% prinosa u prvom odnosno drugom otkosu. Nisu nađene značajne razlike između ciklusa iskorišćavanja u pogledu sadržaja SM i sirovih proteina. Značajno manje učešće neproteinskog N ($p < 0,05$) je utvrđeno u biljnoj masi dobijenoj iz trećeg otkosa. Determinisano je povećanje sadržaja vlakana ($p < 0,05$) u SM biljne mase, tokom pašne sezone, pri čemu su najveće vrednosti utvrđene u drugom otkosu. Najveću energetske vrednost ($p < 0,05$) imala je zelena krma iz prvog otkosa (u SM), pri čemu je najniži sadržaj iskoristive energije utvrđen u zelenoj masi dobijenoj iz drugog ciklusa iskorišćavanja. Rezultati do kojih se došlo, ukazuju na naročito izraženo variranje prinosa, kao i hemijskog sastava i hranljive vrednosti zelene mase sa permanentnog pašnjaka, tokom prolećne sezone porasta vegetacije. U skladu sa tim, u cilju dobijanja kvalitetne pašne za ishranu životinja, neophodno je

precizno definisanje optimalnog perioda za iskorišćavanje pašnjaka tokom sezone ispaše.

Ključne reči: proizvodnja zelene krme, kvalitet pašne, ishrana, preživari, svinje

Acknowledgment

This study is realized by financial support of Ministry of Education, Science and Technological Development, Republic of Serbia, through the Technological Development Project TR-31086.

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Received 13 December 2017; accepted for publication 20 March 2018