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ASSESSMENT OF YIELD, QUALITY AND NITROGEN INDEX OF *AGROSTIETUM CAPILLARIS* GRASSLAND AS AFFECTED BY FERTILIZATIONS

Aleksandar Simić[1], Violeta Mandić[2], Savo Vučković[1], Zorica Bijelić[2], Rade Stanisavljević[3], Ratibor Štrbanović[3], Dejan Sokolović[4]

[1]Faculty of Agriculture, University of Belgrade, Nemanjina 6, 11080 Zemun-Belgrade, Serbia;
[2]Institute for Animal Husbandry, Autoput 16, 11080 Zemun-Belgrade, Serbia
[3]Institute for Plant Protection and Environment, Teodora Drajzera 9, Belgrade, Serbia
[4]Institute for Forage Crops, 37251, Globoder, Krusevac, Serbia
Corresponding author: Violeta Mandić, violeta_randjelovic@yahoo.com
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Abstract: Managing N, P and K inputs in semi-natural meadow production systems is important for achieving maximum yields in livestock farming. The objective of the present study was to estimate the effect of different NPK levels ($N_0P_0K_0$, $N_{50}P_{50}K_{50}$, $N_{100}P_{50}K_{50}$, $N_{100}P_{100}K_{100}$, $N_{150}P_{100}K_{100}$ and $N_{200}P_{150}K_{150}$ kg ha^{-1} yr^{-1}) on the yield, quality and nitrogen nutrition index (NNI) in a grassland community of *Agrostietum capillaris* (semi-natural meadow) in western Serbia. The study was conducted during the seasons of 2005-2008. The values of the investigated parameters, except for the unit N uptake, were the highest in 2004/2005 due to favorable climate conditions. The levels of nitrogen significantly increased all of the studied parameters compared to the control treatment, except for unit N uptake. Mineral fertilizers at $N_{200}P_{150}K_{150}$ provided the highest green forage yield (25.12 t ha^{-1}), dry matter yield (8.12 t ha^{-1}), crude protein yield (876.3 kg ha^{-1}), nitrogen uptake (140.2 kg ha^{-1}) and nitrogen nutrition index (70.2%), and the lowest unit N uptake (0.0022 kg N kg DMY^{-1}). The use of mineral fertilizers increased green forage yield, dry matter yield and crude protein yield, increasing fertilizer from lowest to highest rate increased fresh and dry matter yield, as well as protein yield. Based on the results of the study, monitoring of nutrition indices would be necessary in order to increase productivity and economic benefits.

Key words: *Agrostietum capillaris,* fertilization, nitrogen indices, quality, yield

Introduction

The impacts of climate and biodiversity on biomass are well known, but the relative significance of these two factors with regard to management and utilization has not been studied extensively *(Bernhardt-Römermann et al., 2011)*. In order to recommend suitable agrotechnical measures that will maximize biomass yields, the individual effects of climate drivers and the functional diversity of the flora on the biomass after different treatments of grasslands needs to be examined.

There are abandoned grasslands in many mountain villages in Serbia, due to population migration and consequent reduction in livestock headcounts. Anthropogenic and zoogenic activities (such as irrigation, fertilization, grass cutting, and grazing) in the abandoned grasslands have ceased, such that apart from the dominant plants there are numerous weed and ruderal species. In addition, the dry mass yield of used meadows and pastures is much lower than the production potential of the grassland *(Simić et al., 2015)*. A large number of factors affect the uptake of nutrients by plants, such as the total nutrient concentration, soil pH, organic substances, redox potential, plant species, stage of growth, weather conditions, and interaction of different chemical elements *(Halvin et al., 2005)*. The interpretation of the content of plant macronutrients and, based on them, the quality of grassland for animal feed is a highly complex issue due to varying botanical compositions, nutrient concentration changes during growth, and interactions among the elements *(Liebisch et al., 2013)*. These authors have investigated the use of P nutrient indices (PNI) for grass fractions and proposed the following ranges for grassland fertilization: N:P 5.5–9.0 and K:P 6.0–10.5. They also concluded that the differences in biomass between the management approaches were much more pronounced than between the years of use. The application of nitrogen fertilizers to grasslands in Turkey had a negative impact on the proportion of protein in animal feed because it reduces the share of legumes from 47% on untreated plots to 5% on those treated with high doses of nitrogen *(Aydin and Uzun, 2005)*. According to them, adding P can compensate for the negative impact of nitrogen. Economically optimal levels were achieved with the highest rates of P and K (52 kg P ha^{-1} + 180 kg N ha^{-1}), which resulted in 4810 kg ha^{-1} of dry forage mass, with a raw protein concentration of 124 g kg^{-1} and a 12% share of legumes. However, smaller amounts of nutrients should be applied to grasslands to conserve biodiversity *(Isselstein et al. 2005)*. Fertilization can cause major changes in the vegetation cover and lead to a rapid decrease in biodiversity *(Păcurar et al. 2014)*. Generally speaking, fertilization of grasslands with nitrogen is on the decline in Europe, due to restrictive EU policies (EU Directive 91/676/EEC), as is grazing in dairy farming for various reasons, but cut grass is becoming increasingly important. There are different opinions about critical values and economically viable NPK ratios for grassland fertilization, depending on the type of grassland, the approach to maintenance and use, and local weather conditions *(Whitehead, 2000)*.

The goal of the present research was to assess the effect of added nutrients on the plant biomass of a permanent grassland of *Agrostietum capillaris*, which was managed to arrive at recommended critical values of N, P and K. The paper aims to highlight the significance of mineral fertilizers in terms of the productivity, quality, and optimal use of typical permanent grassland.

Materials and Methods

Experiment details and treatments

The study was carried out during a period of four years (2005-2008), in type of semi-natural meadow dominated by *Agrostis capillaris* in western Serbia, near the City Valjevo (44°10'40.1" N and 19°49'38.5" E, at 750 m altitude). The following species were represented on the meadow: *Holcus lanatus, Cynosurus echinatus, Trisetum flavescens, Arrhenatherum elatius* and *Anthoxanthum odoratum*. The experiment was a set up by randomized block design, with four replications. In 2004, 24 plots of 3x4 m each were arranged in a multifactorial design, combining five levels of N (0, 50, 100, 150 and 200 kg ha^{-1} year^{-1}), four levels of P (0, 50, 100, 150 kg ha^{-1} year^{-1}) and four levels of K (0, 50, 100, 150 kg ha^{-1} year^{-1}) in following ratios ie. the six fertilization treatments ($N_0P_0K_0$, $N_{50}P_{50}K_{50}$, $N_{100}P_{50}K_{50}$, $N_{100}P_{100}K_{100}$, $N_{150}P_{100}K_{100}$ and $N_{200}P_{150}K_{150}$ kg ha^{-1} yr^{-1}) per year. The fertilizer NPK 15:15:15 was applied in autumn, and additional amount of KAN (27%) in spring after the snow melt (early April), as a spring N application (50 kg N) in treatments $N_{100}P_{50}K_{50}$, $N_{150}P_{100}K_{100}$ and $N_{200}P_{150}K_{150}$.

At the beginning of the fourth year, after regular grass cutting and fertilizer application, the botanical composition was determined and compared with a control variant. The identified plant species were classified by their quality and forage importance into three categories: grasses, legumes and forbs (useless or conditionally useful plant species from other plant families) *(Tomić et al., 2011)*.

Soil properties and climate conditions

The soil was analyzed before the experiment was set up. The *Agrostietum capillaris* grasslands in the experiment is formed on shallow to medium-deep soils, skeletal to varying degrees, with a high organic content (5.4%) and an acidity of 4.9 in KCl. The soil features medium potassium concentrations (18.4 mg 100g^{-1}) and very low phosphorus concentrations (2.8 mg 100g^{-1}).

A modified climate diagram *(Walter and Lieth, 1967)* shows that the season of 2004/2005 (total seasonal rainfall 895.0 mm) was not a period of drought (Figure 1). Contrary, in 2005/2006 (total seasonal rainfall 833.4 mm) there were droughts in July and September, in 2006/2007 (total seasonal rainfall 706.6 mm) in April and July, and in 2008 (total seasonal rainfall 799.3 mm) in August.

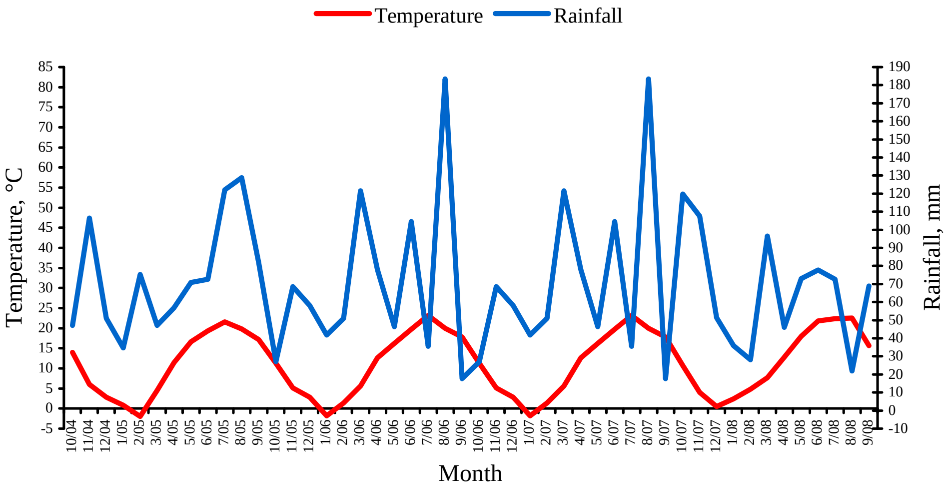

Figure 1. Modified climate diagram of the study site

Data collection

The plots were harvested during flowering of the dominant meadow plants. The green forage yield (GFY) was weighed immediately after harvest. During the study period only one harvest was in July, because of no summer regrowth, caused by a period without rainfall. Samples of 1 kg were collected from all the plots to determine dry matter yields (DMY). DMY was the difference in mass before and after oven drying to constant mass at 60°C. The botanical composition was determined in fresh biomass samples, collected from 1 m^2 per experimental plot. Nitrogen content was determined according to Kjeldahl *(AOAC, 1990)*. Crude protein (CP) was calculated as N × 6.25 and crude protein yield (CPY) as CP × DMY. The nitrogen uptake (NU) is the nitrogen absorbed by a plant and was calculated as a percentage of the amount of N accumulated in the plant (except roots) × DMY (kg ha^{-1}) / 100 *(Kabir et al., 2012)*. The unit nitrogen uptake (UNU) was calculated as the amount of N accumulated in the plant (except roots) / DMY *(Hermanson et al., 2000)*. The nitrogen nutrition index (NNI) was determined using the formula: $NNI = N / 4.8 \times (DMY)^{-0.32}$ *(Lemaire and Meynard, 1997)*. A value of NNI from 80 to 100% indicated normal nitrogen levels, NNI < 80% indicated nitrogen insufficiency and NNI > 100% indicated excessive nitrogen.

Statistical analysis

The data were analyzed using ANOVA with Statistica 10 (version 10). The significant differences among the treatments were estimated by Duncan's Multiple Range Test at P≤0.05. The significances levels were set at P≤0.05 and P≤0.01. Pearson's correlation coefficients were used to determine direct correlations between the studied parameters.

Results

Seasonal effect on the studied parameters

The seasons had a very significant effect on GFY, DMY, NC, NU, UNU and NNI (P<0.05), and a highly significant effect on CPY (P<0.01) (Table 1). GFY (20.23 t ha^{-1}), NC (18.78 g kg^{-1} DM), NU (113.57 kg ha^{-1}) and NNI (68.62 %) were the highest in the season of 2004/2005. DMY was significantly lower in 2006/2007 (4.43 t ha^{-1}) than in 2004/2005 (5.88 t ha^{-1}), 2005/2006 (5.72 t ha^{-1}) and 2007/2008 (5.70 t ha^{-1}). UNU was the highest in 2006/2007 (0.0043 kg N kg DMY^{-1}). Generally, the rainfall distribution was unfavorable in 2006/2007 because in April high temperatures and a small amount of rainfall shortened the regrowth stages of grass.

Table 1. Season and NPK fertilization rate effects on meadow productivity

Factor		GFY*	DMY	NC	CPY	NU	UNU	NNI
Season (A)	2004/2005	20.23^a	5.88^a	18.78^a	709.8^a	113.57^a	0.0037^b	68.62^a
	2005/2006	16.85^b	5.72^a	14.64^c	540.5^a	86.48^b	0.0030^c	52.90^b
	2006/2007	12.04^c	4.43^b	14.84^b	415.6^b	66.49^c	0.0043^a	48.87^c
	2007/2008	15.93^b	5.70^a	12.83^d	460.7^b	73.72^c	0.0029^c	45.74^d
NPK fertilizer rate, kg ha^{-1} (B)	$N_0P_0K_0$	5.15^e	1.96^e	14.22^d	175.5^e	28.08^e	0.0075^a	36.69^f
	$N_{50}P_{50}K_{50}$	12.67^d	4.43^d	13.68^f	382.4^d	61.18^d	0.0032^b	45.77^e
	$N_{100}P_{50}K_{50}$	16.95^c	5.75^c	13.99^e	497.6^c	79.62^c	0.0025^c	50.68^d
	$N_{100}P_{100}K_{100}$	17.57^c	5.75^c	14.95^c	532.4^c	85.19^c	0.0027^c	54.24^c
	$N_{150}P_{100}K_{100}$	20.50^b	6.58^b	17.50^a	725.7^b	116.11^b	0.0027^c	66.59^b
	$N_{200}P_{150}K_{150}$	24.73^a	8.12^a	17.29^b	876.3^a	140.20^a	0.0022^d	70.22^a
F test	A	**	**	**	*	**	**	**
	B	**	**	**	**	**	**	**
	A × B	ns	ns	**	**	*	**	**
M		16.60	5.43	15.27	531.65	85.06	0.0035	54.03

*GFY – green forage yield (t ha^{-1}), DMY – dry matter yield (t ha^{-1}), NC – nitrogen content (g kg^{-1} DM), CPY – crude protein yield (kg ha^{-1}), NU – nitrogen uptake (kg ha^{-1}), UNU – unit nitrogen uptake (kg N kg DMY^{-1}) and NNI – nitrogen nutrition index (%); Means followed by the same letter in a column are not significantly different according to Duncan's Multiple Range Test at the 5% level (P<0.05); NS = not significant P value 0.05; * = P value < 0.05; ** = P value <0.01.

Effect of NPK fertilization rate on the studied parameters

The NPK fertilizers had a highly significant effect on all the investigated parameters. Compared to the other treatments, $N_{200}P_{150}K_{150}$ (with nitrogen content 17.29 g kg^{-1} DM) resulted in significantly higher values of GFY (24.73 t ha^{-1}), DMY (8.12 t ha^{-1}), CPY (876.3 kg ha^{-1}), NU (140.20 kg ha^{-1}) and NNI (70.22 %), and a significantly lower UNU (0.0022 kg N kg DMY^{-1}). NC was significantly higher in the $N_{150}P_{100}K_{100}$ treatment (17.50 g kg^{-1} DM), compared to the other treatments. Treatments $N_{100}P_{50}K_{50}$ and $N_{100}P_{100}K_{100}$ did not differ with regard to GFY, DMY, CPY, NU and UNU.

The interaction of the season and the nitrogen fertilization level had a highly significant effect on NC, CPY, NU, UNU and NNI (data are not shown). The highest nitrogen content (22.79 g kg^{-1} DM), crude protein yield (1172.8 kg ha^{-1}), nitrogen uptake (187.65 kg ha^{-1}) and nitrogen nutrition index (93.10%) were recorded with $N_{200}P_{150}K_{150}$ in 2004/2005. The control treatment had the highest UNU in 2006/2007.

Botanical composition

The control treatment, which was not cut or fertilized, exhibited the largest biodiversity, including 45 different species of which 73% were forbs, 18% grasses 9% legumes (Table 2). Cutting reduced biodiversity (29 species), but the proportions of the grasses, legumes and forbs did not really change (76% forbs, 17% grasses and 7% legumes). Biodiversity decreased with increasing fertilizer rates. The proportion of useful grass species increased, and those of the legumes and forbs decreased.

Table 2. Selected botanical composition parameters of the studied treatments

Treatment	Proportion (%)			Number of species				Dominant species
	G	L	F	G	L	F	Total	
Uncut meadow $N_0P_0K_0$	18	9	73	8	4	33	45	**Ac, Hl, Ce, Tf, Ae, Ao, Fr, Sm, Tc, Lc*
$N_0P_0K_0$	17	7	76	5	2	22	29	*Ac, Fr, Ae, Hl, Pl, Vc, Vo*
$N_{50}P_{50}K_{50}$	35	5	60	7	1	12	20	*Ae, Ac, Hl, Tf, Fr, Ce, Ca*
$N_{100}P_{50}K_{50}$	35	6	59	6	1	10	17	*Ae, Ac, Hl, Tf, Fr, Fp, Pl*
$N_{100}P_{100}K_{100}$	26	16	58	5	3	11	19	*Ac, Hl, Ae, Tf, Fr, Ea, Vc, Sm*
$N_{150}P_{100}K_{100}$	35	6	59	6	1	10	17	*Ae, Ac, Hl, Tf, Fr, Pl, Sg, Dg*
$N_{200}P_{150}K_{150}$	86	14	0	6	1	0	7	*Ac, Hl, Ae, Tf, Fr*

**Ac-Agrostis capillaris, Ao - Anthoxanthum odoratum, Ae - Arrhenatherum elatius, Ca - Convolvulus arvensis, Ce - Cynosurus echinatus, Dg - Dactylis glomerata, Ea - Erigeron annuus, Fp - Festuca pratensis, Fr - Festuca rubra, Hc - Holcus lanatus, Lc - Lotus corniculatus, Pl - Plantago lanceolata, Sm - Sanguisorba minor, Sg - Stellaria graminea, Tc - Trifolium campestre, Tf - Trisetum flavescens, Vo - Veronica officinalis, Vc - Vicia cracca, G- grasses; L – Legumes; F – Forbs*

Correlations among the studied parameters

The results in Table 3 show that CPY exhibited a very strong positive correlation with NU, NNI, GFY and DMY, and GFY with DMY and NU and NU with NNI and DMY, as did NC with NNI, CPY and NU and NNI with GFY and DMY. There was a weak positive correlation between GFY and NC, and between DMY and NC. UNU strongly and negatively correlated with GFY and DMY, and had a moderate negative correlation with CPY, NU and NNI, and a very weak to negligible negative correlation with NC. Correlation coefficients showed that many of the parameters were inter-related.

Table 3. Pearson correlation coefficients (r) of green forage yield (GFY), dry matter yield (DMY), nitrogen content (NC), crude protein yield (CPY), nitrogen uptake (NU), unit nitrogen uptake (UNU) and nitrogen nutrition index (NNI) in different seasons and at different NPK fertilization rates.

	GFY	DMY	NC	CPY	NU	UNU
DMY	0.96**					
NC	0.54**	0.34**				
CPY	0.96**	0.90**	0.71**			
NU	0.96**	0.90**	0.71**	1.00**		
UNU	-0.75**	-0.83**	-0.03^{ns}	-0.62**	-0.62**	
NNI	0.86**	0.73**	0.89**	0.95**	0.95**	-0.46**

*GFY – green forage yield, DMY – dry matter yield, NC – nitrogen content, CPY – crude protein yield, NU – nitrogen uptake, UNU – unit nitrogen uptake and NNI – nitrogen nutrition index; Means followed by the same letter in a column are not significantly different according to Duncan's Multiple Range Test at the 5% level (P<0.05); ns – not significant; ** – significant at P<0.01

Discussion

Seasonal effect

Among the seasons, significant differences were recorded in all the studied parameters. GFY, NC, NU and NNI were significantly higher under the favorable environmental conditions in 2004/2005. GFY was significantly higher in 2004/2005, whereas in 2005/2006 and 2007/2008 there was no difference. Contrarily, DMY did not differ in 2004/2005, 2005/2006, and 2007/2008.

In spring, during early growth, plants of the semi-natural meadow type *Agrostietum capillaris* are in a vegetative stage, with emerging leaves. Also, roots and shoots begin to develop. The formation of new leaves and stems depends on the extent of tillering, caused by climate conditions. The *Agrostis* tiller density peaked in late summer and varied in spring due to tiller birth rate variations (*Bullock, 1994)*. Year-to-year weather variation affected the dynamics.

Favorable weather conditions in the second half of November and in April can improve tillering rates of grass, whereas high temperatures and little rainfall lower tillering rates. Generally, tillers formed in autumn and spring are important for winter and summer survival, respectively. Also, in Serbia's climate, meadow species begin to grow intensively in April. Drought stress significantly reduces productive tillering and total biomass due to a decrease in the rates of photosynthesis and dry matter accumulation (*Tomaškin, 2013)*. Unfavorable climate conditions can shorten this stage and the growing season of plants, inducing jointing (internode elongation) and rapid aging (drying of leaves). In general, meadow species reduce the formation of new leaves because of stopped regrowth. As a result, the drought stress in April 2007 led to poor regeneration of grasses and legumes, which was attributable to lower GFY (12.04 t ha^{-1}) and DMY (4.43 t ha^{-1}). By contrast, in the other seasons there was drought stress in July, when the meadow was cut. Favorable spring and summer weather conditions improved grassland productivity, especially in 2004/2005. A timely first cut favored regrowth, but summer heat and drought stress in July had an adverse effect on tillering. Basically, the drought stress in July had a negative impact on the regrowth of grass and there was no second cut. As a result, grassland productivity was poor.

NC, CPY, NU, UNU and NNI depended on climate factors during the season. The highest values of NC, CPY, NU and NNI were recorded in 2004/2005, the season with the highest GFY and DMY. The highest values of UNU were recorded in 2006/2007. The NNI index ranged from 45.74 % in 2007/2008 to 68.62 % in 2004/2005 and the nitrogen nutritional status was lower than normal, ranging from 80 to 100 %.

In general, favorable climate condition in the vegetative state of plants, especially the large amount of rainfall in the growing season of 2005, had a positive effect on nutrient uptake and therefore resulted in the highest productivity of green forage, dry matter and CPY. In 2006/2007, dry weather conditions caused a reduction in the nutritional value of forage because of slower plant growth and a larger percentage of synthetized fibers.

Effect of NPK fertilization rate

In western Serbia, and across Serbia in general, fertilizers are not applied on meadows in spring. However, our results show that fertilization has benefits as it boosts GFY and DMY, and can thus maximize yield per unit area. It is very important for the development of livestock farming in this region. GFY and DMY significantly increased with increasing NPK levels. The increase in GFY ranged from 12.67 t ha^{-1} (246.0 %) in the $N_{50}P_{50}K_{50}$ treatment to 24.73 t ha^{-1} (480.2 %) in the $N_{200}P_{150}K_{150}$ treatment, compared to the control treatment (5.32 t ha^{-1}). DMY increased from 2.47 t ha^{-1} (223.5%) in the $N_{50}P_{50}K_{50}$ treatment to 6.16 t ha^{-1} (414.7%) in the $N_{200}P_{150}K_{150}$ treatment, relative to the control treatment (1.96 t ha^{-1}). GFY and DMY of treatments $N_{100}P_{50}K_{50}$ and $N_{100}P_{100}K_{100}$ did not differ significantly. Accordingly, GFY and DMY depended on N because the same amount of nitrogen (100 kg ha^{-1}) and different amounts of P (50 and 100 kg ha^{-1}) and K (50 and 100 kg ha^{-1}) resulted in similar yields of green mass and dry matter. Further increases of nitrogen, from 100 to 150 kg ha^{-1}, and from 150 to 200 kg ha^{-1}, increased GFY and DMY. This confirmed that nitrogen application had the greatest effect on GFY and DMY. Therefore, high-yielding meadows need large amounts of N for regrowth and proper development of plants. Nitrogen is the crucial nutrient that limits meadow yield. However, in Serbia meadows are generally degraded, with low yields, poor quality and little or no fertilizers used. The application of 1kg of NPK fertilizer increased hay yield by 16.2 kg in the case of natural grassland, type *Agrostietum capillaris (Vučković et al., 2010)*. Also, the application of NPK fertilizer significantly increased GFY and DMY of an *Agrostietum capillaris* meadow.

Nitrogen levels significantly increased CPY. The highest CPY (876.3 kg ha^{-1}) was recorded in the $N_{200}P_{150}K_{150}$ treatment, with the highest DMY, and the lowest in the $N_0P_0K_0$ treatment (175.5 kg ha^{-1}), with the lowest DMY. The proportion of forage crude protein in ewe, lamb and cow nutrition should be 9.4%, 12.8% and 11%, respectively *(National Research Council, 1996)*. In our research, the CP content resulting from $N_{150}P_{100}K_{100}$ and $N_{200}P_{150}K_{150}$ treatments met protein requirements for livestock. Many researches have shown that NPK fertilization of natural *Agrostietum capillaris* grasslands increased the ratio of high-quality plants and hence the level of protein production *(Đurić et al., 2007; Tomić et al., 2009; Radić et al., 2014, Radić et al., 2017)*. It should be emphasized that nitrogen application had a positive effect on forage production and CPY, even under drought condition in 2007. Accordingly, nitrogen fertilizer input is a limiting factor for the production of high quality forage. The availability of N limited forage production of rangeland and pastures more than rainfall in southeastern Alberta, in arid regions *(Blonski et al, 2004)*.

NU and NNI significantly increased, while UNU significantly decreased with increasing nitrogen rates. The minimum values of NU and NNI and the maximum value of UNU were recorded in the $N_0P_0K_0$ treatment. There was a wide variation in NU and UNU due to different fertilizer treatments. The average NU and UNU of all the fertilization rates were 85.06 kg ha^{-1} and 0.0035 kg N kg DMY^{-1}, respectively. DMY of the control treatment was low compared to the other treatments, so NU was minimal. By contrast, in the $N_{200}P_{150}K_{150}$ treatment DMY was higher, as was NU. Lower values of NNI, less than 80%, indicated that the nutritional status of the plants was too low. Also, the nitrogen rates were low and needed to be increased. Similarly, in the Romanian mountain grasslands of *Festuca rubra* L. and *Agrostis capillaris* L. increased NNI with increasing N fertilization, and that low values of NNI indicated nutrient deficiencies in the soil *(Samuil et al., 2018)*.

Botanical composition

In the untreated and uncut meadow there were 45 different plant species, of which 73% of the total count were forbs. The dominant species was *Agrostis capillaris*, followed by *Holcus lanatus, Cynosurus echinatus, Trisetum flavescens, Arrhenatherum elatius* and *Anthoxanthum odoratum.* The proportions of grasses and legumes were relatively small: 18% and (9%), respectively. Cutting decreased biodiversity (29 species), but the proportions of the grasses (17%), legumes (7%) and forbs (76%) remained virtually the same. Fertilizer treatments increased the number of grasses but decreased the number of legume and forb species. The proportion of the tall grass *Arrhenatherum elatius* and other useful species increased, while the overall biodiversity decreased to less than 20 species. At the maximum nutrient rate, the grass species became absolutely dominant, with only one legume and no significant representatives of forbs. This is attributable to the fact that nitrogen favors faster and ampler growth of grasses than of the other identified species. In general, legumes are a weak competitor of grasses *Andreata-Koren et al., 2009)*. Furthermore, an increase in the amount of nitrogen from 40 to 120 kg ha^{-1} increased the proportion of grasses and significantly reduced those of the legumes and other plant species in a natural meadow of the *Agrostietum capillaris* type *(Stevović et al., 2011)*. Moreover, the fertilization of natural grasslands with nitrogen increased the share of C3 plants, decreased biodiversity and reduced the proportions of C4 plants and legumes *(Gough et al., 2000; Stevens et al., 2004)*. It is believed that this is a consequence of more competition for light *(Xia and Wan, 2008)*.

Conclusions

Managing NPK fertilization of semi-natural *Agrostietum capillaris* meadows is important for achieving yields of satisfactory quality for nutrition of small ruminants in the mountainous regions of Serbia. The *Agrostietum capillaris* association had the highest GFY, DMY, NC, CPY, NU and NNI in the season of 2004/2005, when the rainfall distribution was the most favorable, and had a positive effect on grass tillering and accelerated plant growth. As the nitrogen level increased, GFY, DMY, CPY, NU and NNI tended to increase as well. By contract, UNU exhibited a downward trend. However, the value of NNI indicated that the nutritional status of the soil was too low. Consequently, the nitrogen rate of 200 kg ha^{-1} was low and needed to be increased

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Aleksandar Simić, Violeta Mandić, Savo Vučković, Zorica Bijelić, Rade Stanisavljević, Ratibor Štrbanović, Dejan Sokolović

Rezime

Unošenje N, P i K inputa u poluprirodnim livadama je važno za postizanje maksimalnih prinosa na stočarskim farmama. Cilj ove studije bio je procena uticaja različitih nivoa N, P i K ($N_0P_0K_0$, $N_{50}P_{50}K_{50}$, $N_{100}P_{50}K_{50}$, $N_{100}P_{100}K_{100}$, $N_{150}P_{100}K_{100}$ and $N_{200}P_{150}K_{150}$ kg ha^{-1} yr^{-1}) na prinos, kvalitet i indeks ishrane azotom (NNI) u livadskoj zajednici *Agrostietum capillaris* (poluprirodna livada) u zapadnoj Srbiji. Studija je sprovedena tokom perioda 2005-2008. Vrednosti ispitivanih parametara, izuzev usvajanja azota po jedinici mase, bile su najviše u 2004/2005 zbog povoljnih klimatskih uslova. Nivoi azota su značajno povećali sve ispitivane parametre u poređenju sa kontrolnim tretmanom, osim usvajanja azota po jedinici mase. Đubrenje sa $N_{200}P_{150}K_{150}$ obezbedilo je najveći prinos zelene krme (25.12 t ha^{-1}), prinos suve materije (8.12 t ha^{-1}), prinos sirovih proteina (876.3 kg ha^{-1}), usvajanje azota (140,2 kg ha^{-1}) i indeks ishrane azotom(70,2%), kao i najmanji (0,0022 kg N kg PSM^{-1}). Upotreba mineralnih đubriva povećala je prinos zelene krme, prinos suve materije i prinos sirovih proteina, povećavanjem đubriva od najmanje do najveće količine je povećalo prinos sveže i suve mase, kao i prinos proteina. Na osnovu rezultata studije, praćenje indeksa ishrane azotom bi bilo neophodna mera u cilju porasta produktivnosti i ekonomske efikasnosti.

Ključne reči: *Agrostietum capillaris,* đubrenje, azotni indikatori, kvalitet, prinos

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