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The effect of organic fertilizer on biomass yield and quality of natural meadows

D. Djukic*, V. Stevovic, D. Djurovic** and O. Ilic***
*****Faculty of Agriculture, Trg Dositeja Obradovica 8, 21000 Novi Sad, Serbia
******Faculty of Agronomy, Cara Dusana 34, 32000 Cacak, Serbia

SUMMARY – Natural meadows and pastures are the most vital forage production resource of the Zlatibor district. The paper examines the effect of mature manure (15 t/ha) on the biomass yield and quality of natural meadows of the Mokra Gora (500 m altitude) and Zaovine localities (800 m). In the Mokra Gora natural meadows, non-fertilisation resulted in a yield of 2.60 t/ha of green forage (1.0 t/ha) dry matter and manure application gave a yield of 7.50 t/ha of green forage (2.50 t/ha DM). On the contrary, in the Zaovine locality, a yield of 5.35 t/ha of green forage (2.70 t/ha DM) was produced without fertilization, whereas 9.50 t/ha of green forage (4.30 t/ha DM) was obtained with manure application. As regards dry matter quality, 65.9 g/kg DM and 81.9 g/kg DM were achieved, on average, in the Mokra Gora and Zaovine localities, respectively.

Key words: Natural meadows, manure application, biomass yield, quality.

RESUME – *"Effet de la fertilisation organique sur le rendement en biomasse et la qualité des prairies naturelles". En Serbie de l'ouest, sur le territoire de la montagne Zlatibor, les prés naturels et les alpages représentent la plus importante ressource dans la production du fourrage encombrant. Dans ce travail, on distingue l'utilisation du fumier consommé (15 t ha^{-1}) sur le rendement et la qualité de la biomasse des prés naturels concernant les localités de Mokra Gora (500 mètres d'altitude) et Zaovine (800 mètres d'altitude). Sans l'utilisation du fumier, sur les prés naturels de Mokra Gora on a récupéré 2,6 t ha^{-1} de fourrage vert ou 1,0 t ha^{-1} de matière sèche, par rapport à l'utilisation du fumier 7,5 t ha^{-1} de fourrage vert ou 2,5 t ha^{-1} de matière sèche. Sur la localité de Zaovine, sans le fumier, on a récupéré 5,35 t ha^{-1} de fourrage vert ou 2,7 t ha^{-1} de matière sèche, et avec du fumier 9,5 t ha^{-1} de fourrage vert ou 4,3 t ha^{-1} de matière sèche. Concernant la qualité de la matière sèche sur la localité de Mokra Gora on a obtenu en moyenne (PV) 65,9 g de protéine verte / kg^{-1} de matière sèche (MS), et sur la localité de Zaovine (PV) 81,9 g de protéine verte / kg^{-1} de matière sèche (MS).*

Mots-clés :*Prés naturels, utilisation du fumier, rendement de la biomasse, qualité.*

Introduction

Grasslands account for more than 27% of the total agricultural area in the Republic of Serbia. In the Zlatibor District, natural meadows and grasslands cover about 94,162 ha and 14,588 ha respectively, or 54.64% of the acreage. Forage crop cultivation is restricted mainly to natural meadows and grasslands and partly to fields, the crops including red clover, alfalfa, grass and legume mixtures, vetch, etc. Nothwithstanding the substantial acreage under natural meadows (about 600,000 ha) and pastures (over 800,000 ha), forage production is relatively low. Adequate mineral and organic fertilisation of meadows and grasslands, coupled with their rational utilisation, can under these very conditions result in both severalfold hay increase (up to 15 t ha^{-1}) and biomass quality increase (Nesic *et al*., 2004; Stevanovic *et al*., 2004; Vuckovic *et al*., 2004). The objective of the paper was to examine the effect of organic (manure) fertilisation on the biomass yield and quality of natural meadows and grasslands in the Zlatibor District, i.e. Mokra Gora (500 m altitude) and Zaovine (800 m altitude) localities.

Materials and methods

The study of the effect of organic fertilisation on the biomass yield and quality of natural grasslands in the villages of Mokra Gora (500 m altitude) and Zaovine (800 m altitude) was conducted over 2005 and 2006 growing seasons, involving two treatments which were as follows: (I) manure application in the previous growing season and (II) manure application before the onset of the growing season,

including a non-fertilised treatment (Ø). The manure dressing included the application of 15 t ha^{-1} over the trial plots, whereupon harrowing was conducted. The applied manure contained 17.40 % dry matter, 13.30% organic matter, 0.37 % N, 0.23 % P and 0.48 % K.

The trial was established on shallow humus-siliceous soil formed from serpentine rocks. The following soil chemical characteristics were found at 0-25 cm depth: pH H_2O 6.2; pH KCl 5.45; humus 12.2 %; total N 0.67%; P_2O_5 4.5 and K_2O 11.0 mg $100g^{-1}$ soil (Mokra Gora); and pH H_2O 6.6; pH KCl 5.70; humus 14.7 %; total N 0.85%; P_2O_5 7.3 and K_2O 18.1 mg $100g^{-1}$ soil (Zaovine).

The Mt. Tara region, where the above sites are located, is characterised by specific climatic conditions. The interface between a warm air mass coming from the south and a cold air mass moving from the north occurs above the mountain, frequently causing unstable weather. Mean annual air temperature is 7.7°C. The average seasonal temperatures amount to 3.0°C in spring, 13.4°C in summer, 5.7°C in autumn and -2.9°C in winter. Average annual precipitation is 977.3 l m^{-2}. Of the total annual sum, the highest rainfall is recorded in May (13%), followed by June and July with about 10%. Rainfall is almost evenly distributed over the remaining months, varying from 6 to 8 %. The average annual number of days with snow cover is 109.

The green biomass yield was checked immediately upon cutting which was carried out at the optimal plant growth and development stage. The plot size was 20 m^{-2} (5 x 4 m). The trial was set up as a randomised block design in four replications. The dry matter yield was established subsequently upon drying of 1000 g green biomass sample at 65°C. Standard methods were employed to examine the dry matter quality (in g/kg DM), viz. the crude proteins (CP), crude cellulose (CC), crude fats (CF) and crude ash (CA) contents which were used to establish the proportion of nitrogen-free extracts. Glamocic (2000) system was used to calculate the dry matter energy value (in MJ/kg DM) expressed as the net energy for lactation (NEL). The biomass yield results were analysed by the Analysis of Variance (ANOVA) and the differences between the treatments were determined by the *t*-test.

Results and discussion

The use of manure in both Zlatibor District localities significantly affected the biomass yield of natural meadows examined. Manure application in the Mokra Gora and Zaovine localities in previous growing season (I) resulted in 9.0 t ha^{-1} GF i.e. 2.5 t ha^{-1} DM, and 7.5 t ha^{-1} GF i.e. 4.7 t ha^{-1} DM, respectively. In the second manure treatment (II), 6.0 t ha^{-1} GF(2.40 t ha^{-1} DM) were produced in the former locality and 11.5 t ha^{-1} (4.0 t ha^{-1} DM) in the latter, amounting to an average of 6.99 t ha^{-1} GF i.e. 2.88 t ha^{-1} DM (for three treatments) (Table 1).

Table 1. The green forage or dry matter (DM) yield (t ha^{-1}) of natural meadows as achieved with and without the application of organic fertiliser

Locality (A)	Green forage (GF)			$\overline{X}$	Dry matter (DM)			$\overline{X}$
	Treatments (B)				Treatments (B)			
	Fertilised (I)	Fertilised (II)	Control (Ø)		Fertilised (I)	Fertilised (II)	Control (Ø)	
M.Gora	9.00	6.00	2.60	5.87	2.50	2.40	1.00	1.97
Zaovine	7.50	11.50	5.35	8.12	4.70	4.00	2.70	3.80
$\overline{X}$	8.25	8.75	3.98	6.99	3.6	3.20	1.85	2.88
Lsd	A	B	AB		A	B	AB	
0.05	0.40	0.50	0.63		0.44	0.55	0.76	
0.01	0.55	0.69	0.98		0.60	0.75	1.04	

As compared to the Mokra Gora locality, where an average of 5.87 t ha^{-1} GF (1.97 t ha^{-1} DM) was obtained, significantly higher yields were produced in the Zaovine locality (8.12 t ha^{-1} GF i.e. 3.80 t ha^{-1} DM), the lowest ones being recorded in non-fertilised treatments. According to Vuckovic *et al*. (2004),

the application of 160 kg N ha^{-1} resulted in a 153% biomass yield increase, as compared to the control.

Changes in plant species composition (a higher share of legumes compared to that of other species and grasses) were evidenced in both fertilisation treatments (Table 2). The effect of fertilisation on both plant distribution change and increased biomass production was reported by Linnuson *et al*. (1998) and Santa-María *et al*. (2004). According to Sawicki and Szymona (2004), manure dressings applied on natural grasslands brought about a substantial increase in dry matter yield (86% as compared to the control) and a higher legume percentage in the following years.

Table 2. Plant group percentage (%) in natural grasslands with and without the application of organic fertilisers

Locality	Mokra Gora			Zaovine		
	Grasses	Legumes	Other species	Grasses	Legumes	Other species
Fertilised (I)	22.22	44.44	33.33	40.00	36.67	23.33
Fertilised (II)	16.66	58.33	25.00	45.25	40.25	14.50
Control (Ø)	38.46	23.08	38.46	42.99	14.95	42.05
$\overline{X}$	25.78	41.95	32.26	42.75	30.62	26.63
Cv %	43.94	42.34	21.05	6.15	44.71	52.83

According to the results obtained by Stosic *et al*. (1996) and Lazarevic *et al*. (2004), natural meadow biomass yield is significantly affected not only by fertiliser types and rates but also by the fertilisation dynamics. This particularly refers to higher-altitude grasslands exhibiting lower regeneration capacity after cutting. As underlined by the stated authors, nitrogen fertilisation of grasslands is not economically justifiable at altitudes exceeding 1000 m.

Apart from biomass yield, dry matter quality and energy value are major natural-meadow quality indicators (Table 3). In the Mokra Gora locality, the first manure treatment (I) produced averagely CP 81.9 g kg^{-1} DM, CC 214.1 g, CA 88.0 g, CF 30.0 g and NFE 586.0 g kg^{-1} DM. In the Zaovine locality, somewhat higher CP and CC and lower CA, CF and NFE contents were reported. The use of manure in the former locality prior to the onset of the growing season (II) resulted in CP 51.3 g kg^{-1} DM, CC 240.3 g, CA 70.2 g, CF 13.0g and NFE 625.2 g kg^{-1} DM. As opposed to that, in the Zaovine locality, the same fertilisation treatment brought about the highest CP content (100.0 g kg^{-1} DM) and somewhat lower contents of CC (233.7 g kg^{-1} DM) and NFE (563.9 g kg^{-1} DM). In both localities, however, the average dry matter quality obtained in the treatments with and without fertilisation was as follows (CP 73.9 g kg^{-1} DM, CC 247.3 g, CA 80.6 g, CF 20.6 g, NFE 577.6 g kg^{-1} DM).

Table 3. Dry matter (DM) quality of natural meadows in treatments with and without the application of organic fertilisers

Locality	Treatments	In g/kg DM					NEL (MJ/kg DM)
		CP	CC	CA	CF	NFE	
Mokra Gora	Fertilised (I)	81.9	214.1	88.0	30.0	586.0	2.21
	Fertilised (II)	51.3	240.3	70.2	13.0	625.2	2.21
	Non-fertilised (Ø)	64.4	250.4	94.3	9.0	581.9	2.22
	$\overline{X}$	65.9	234.9	84.2	17.3	597.7	2.21
Zaovine	Fertilised (I)	88.8	321.0	72.1	28.0	490.1	2.20
	Fertilised (II)	100.0	233.7	78.4	24.0	563.9	2.21
	Non-fertilised (Ø)	56.9	224.3	80.2	20.0	618.6	2.22
	$\overline{X}$	81.9	259.7	76.9	24.0	557.5	2.21
$\overline{X}$ (I and II)		73.9	247.3	80.6	20.6	577.6	2.21
CV %		26.08	15.48	11.49	40.30	8.43	0.33

As regards the dry matter energy value, it was found to be highly uniform between the localities and fertilisation treatments, being 2.21 MJ kg^{-1} DM on average (Table 3). Ocokoljic *et al*. (1983) reported a considerable increase in both protein content and yield, whereas Alibegovic-Grbic *et al*. (2004) underlined that the increase in dry protein yield in fertilised treatments was primarily due to the increase in dry matter yield. Without determining any significant changes in the chemical composition of dry matter, Ivanovski *et al*. (2004) stated comparable effects of manure and mineral fertiliser top dressings in the spring season.

Conclusions

The application of organic fertilisers significantly increased the biomass yield and enhanced the quality of natural meadows in the Mokra Gora and Zaovine localities. Average yields of 5.87 t ha^{-1} and 8.12 t ha^{-1} of green forage were attained in the Mokra Gora and Zaovine natural meadows respectively, in the treatments with and without fertilisation. In other words, the produced dry matter yield amounted to 1.97 t ha^{-1} and 3.80 t ha^{-1} in the stated localities, respectively. Manure application brought about change in the floristic composition, involving a higher legume percentage compared to that of other species and grasses. Average contents of CP 73.9 g kg^{-1} DM, CC 247.3 g, CA 80.6 g, CF 20.6 g and NFE 577.6 g kg^{-1} DM were recorded in the treatments with and without fertilisation in both localities. The average energy value was 2.21 MJ kg^{-1} DM. Organic and mineral fertilisation, along with utilisation of appropriate cultural practices on natural meadows and grasslands as natural resources, can result in forage production stability and livestock improvement in the Western Serbian uplands.

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