

EFFECT OF NITROGEN FERTILIZATION AND UNDERSOWING ON YIELD AND QUALITY OF CYNOSURETUM CRISTATI-TYPE MEADOWS IN HILLY-MOUNTAINOUS GRASSLANDS IN SERBIA

UTICAJ ĐUBRENJA AZOTOM I PODSEJAVANJA NA PRINOS I KVALITET TRAVNJAKA CYNOSURETUM CRISTATI U PLANINSKOM PODRUČJU SRBIJE

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Manuscript received: July 22, 2005; Reviewed: September 26, 2005; Accepted for publication: October 28, 2005

ABSTRACT

The trial was carried out during two years (2003 and 2004) on Cynosuretum cristati-type meadow in the hilly-mountainous region of Serbia (altitude 1158 m). The investigation included five nitrogen fertilizer rates (0, 40, 80, 120 and 160 kg ha⁻¹ yr⁻¹) and undersowing with red clover and birdsfoot trefoil. Increase in nitrogen fertilization level resulted in corresponding increases in the quantity and quality of grass, while legumes and other herbage decreased. Maximum two-year average dry matter yield of 4.44 t ha⁻¹ was achieved with the highest N rate (160 kg ha⁻¹). The increase was 2.03 t ha⁻¹ or 85.0% compared with the control. Increased N rates increasing the contents of protein, ash, fat, Cu, Co, and NO₃, and reduced the contents of cellulose, K, P, Ca, Mg, S, Zn, and B. Dry matter yield in the undersowing treatment was low, only slightly over that of the control in both study years. Furthermore, undersowing failed to affect the chemical and mineral composition of dry matter.

KEYWORDS: nitrogen fertilization, meadow, undersowing, DM yield, chemical and mineral composition

ABSTRAKT

Istraživanje je obavljeno na travnjaku tipa Cynosuretum cristati u planinskom području Srbije, na nadmorskoj visini oko 1158 m, tokom dve godine (2002 - 2003. g.). U istraživanju je proučavan uticaj azotnog đubriva i podsejavanja sa crvenom detelinom i žutim zvezdanom na prinos suve materije (SM) u sledećim varijantama đubriva (0, 40, 80, 120 i 160 kg/ha). Sa povećanjem količine azotnog đubriva povećao se udeo i kvalitet trava a udeo leptirnjača i bioljaka iz ostalih familija se smanjivao.

Maksimalan dvogodišnji prosečan prinos SM je iznosio 4.44 t ha⁻¹ a postignut je sa najvećom količinom azotnog đubriva (160 kg ha⁻¹). Povećanje je iznosilo 2.03 t ha⁻¹ ili 85.0% u odnosu na kontrolu. Sa povećanjem količine primenjenog azotnog đubriva povećavao se sadržaj proteina, pepela, masti Cu, Co i NO₃, a smanjivala količina celuloze, K, P, Ca, Mg, S, Zn i B. Prinos SM sa primenom podsejavanja je bio nizak, nešto viši u odnosu na kontrolu u obe godine istraživanja. Primena podsejavanja nije imala uticaja na promenu hemijskog i mineralnog sastava u SM prinosa.

KLJUČNE REČI: Đubrenje azotom, travnjaci, podsejavanje, prinos SM, hemijski i mineralni sastav.

INTRODUCTION

Natural meadows cover large areas in the hilly-mountains region of Serbia. They are of considerable importance for forage and soil utilization and protection. Because of poor management and careless utilization these grasslands are rather degraded, with low production and poor quality. The use of N fertilizer is an important factor in intensive grass-based dairy farming, as nitrogen affects dry matter yield and crude protein content of herbage, and thus the amount and protein concentration in supplementary feed, and rate of nitrogen losses through ammonia volatilization, nitrate leaching, nitrous-oxide emission and denitrification (Jarvis, 1996; Whitehead, 2000). The results of other tests performed in Serbia showed that nitrogen fertilizer had a favorable effect on the yield, protein, ash and fat content while decreasing the cellulose content of herbages (Vuckovic et al., 2004). Recommendations for application rates of N fertilizer have been defined as a function of soil, grassland type and climate (Vellinga and André, 1999). The criteria for optimum application rates of N fertilizer were merely economic, for example, a marginal N response of 10-5 kg DM of herbage per kg N (Unwin and Vellinga, 1994; Whitehead, 1995; Reid, 1970; Morrison et al., 1980).

Bearing in mind the above mentioned, the objective of this study was to assess the effect of nitrogen fertilization and undersowing on the yield and quality of natural meadow type *Cynosuretum cristati*, with respect to agro-ecological and economical conditions as well. The study is of importance from both scientific and practical points of view.

MATERIAL AND METHODS

The trial was carried out during two year (2003 and 2004) on natural meadows dominated by *Cynosuretum cristati* in the hilly-mountainous region of Serbia (Sjenica-Pester plateau, 1158 m altitude). Soil analysis was made before the experiment was established. The experiment was a randomized block design with four replications. It included five nitrogen fertilizer levels (0, 40, 80, 120 and 160 kg ha⁻¹ yr⁻¹) and undersowing with red clover and birdsfoot trefoil. All fertilizers were broadcast directly after the melting of snow (early May). The grassland composition was determined by botanical analysis of green mass according to Sostaric and Pisacic (1968). Dry matter (DM) yield was determined on the basis of total DM amount per plot and calculated as DM yield per unit of area. Chemical composition of dry matter is represented by crude protein (CP), ash, fat and cellulose contents (g kg⁻¹ DM). DM mineral composition (K, P, Ca, Mg, S, Zn, Cu, Co, B and N-NO₃) (g kg⁻¹ DM) was

also determined. Samples were analyzed by conventional methods.

Soil properties

The grasslands vegetation of *Cynosuretum cristati* on Sjenica-Pester Plateau is formed on the humus-silicate soil. These are shallow to medium deep soils, skeletal to different degrees, with high humus level (7.5%) and the acidity of 5.2. According to phosphorus and potassium content (11.1 and 9.6 mg 100g⁻¹, respectively) the soil belongs to a medium type.

Weather conditions

Sum of precipitation (particularly for growing season) and temperatures affected the number of cuttings and annual DM yield. Observation of important meteorological elements was done only for 2002-2003 (Table 1). The mean monthly and annual temperatures were rather low. The mean annual temperature was 7.6°C in 2002 and 6.4°C in 2003. Late spring frosts occur even in May (or even later), while early frosts start in September and October.

The amount of precipitation (Table 1) is relatively high. Although the amount of precipitation has a high effect on the productivity of meadows and pastures, especially during growing season, it is not so on Sjenica-Pester Plateau. Rainy periods are frequently accompanied by significant temperature drops, which retard the growth and development of grasses, and hence reduce forage yield.

RESULTS AND DISCUSSION

Effect of nitrogen fertilizers on meadow-pasture vegetation is complex. The grass cover responds not only in terms of yield and quality but also in plant composition. Continued use of nitrogen fertilizers changes the botanical composition of plant association. The data obtained in this study indicate that nitrogen fertilization has a considerable influence on natural meadows dominated by *Cynosuretum cristati*, regarding their DM yield and quality as well as botanical composition.

Botanical composition of sward

The analysis of botanical composition showed that species from the family Poaceae were predominant (48.4-56.0%). According to Sostaric and Pisacic (1968), most of these grasses have moderate to low feeding value (Table 2).

The portion of other species amounted to 42.0-34.7%, in which species with no feeding value dominated. Plant species from the family Fabaceae participated with 9.2%-9.6%, among which *Genista sagittalis* predominated. The other legumes were of high feeding value but low

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Table 1. Mean monthly temperatures (°C) and monthly precipitation (mm) during 2002 and 2003

Tabela 1. Prosečne mesečne temperature (°C) i količine padavina (mm) u periodu 2002 i 2003.

Year God.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I-XII
Temperatures - °C-Temperature °C													
2002	-5.5	2.1	4.3	6.3	12.6	15.7	17.4	15.7	10.3	8.3	5.2	-0.5	7.66
2003	-1.8	-8.3	-0.5	4.9	14.2	16.2	16.9	18.0	10.7	7.0	4.8	-4.9	6.43
Amount of precipitation – mm – Količina padavina - mm													
2002	21.8	31.3	58.4	85.7	110.0	21.1	118.0	73.7	120.0	99.4	35.1	67.3	842.0
2003	133.0	46.7	6.4	52.4	64.9	77.1	63.2	63.4	68.0	148.0	31.0	49.0	803.0

Table 2. Botanical composition of the sward (%)

Tabela 2. Botanički sastava travnjaka (%)

Plants-Biljke	2002	2003
<i>Poaceae</i>	48.40	56.04
Other species- Druge vrste	42.00	34,74
<i>Fabaceae</i>	9.60	9.20

Table 3. Effect of nitrogen rate on the DM yield (t ha⁻¹)

Tabela 3. Uticaj đubrenja azotom na prinos SM (t ha⁻¹)

Year-God. N -rate N-doze	2002		2003		Average Prosek (t ha ⁻¹)	Relative yield Relativan prinos
	(t ha ⁻¹)	%	(t ha ⁻¹)	%		
0	3.20	100	1.62	100	2.40	100
40	4.02	126	3.35	207	3.68	153
80	4.66	145	3.57	219	4.10	170
120	4.58	143	3.91	241	4.25	177
160	4.78	150	4.10	253	4.44	185
Under sowing Podsejavanje	3.27	102	2.69	166	2.98	134
Average Prosek	4.08	133	3.21	203	3.77	157
LSD-0.05	0.22	-	0.35	-	-	-

Table 4. Chemical composition of grassland depending on N rate (2002)

Tabela 4. Hemijski sastav travnjaka u zavisnosti od količine azota (2002)

Fertilizer- Đubrenje N (kg ha ⁻¹)	CP	Ash	Fat	Celul.	K	P	Ca	Mg	S
	(g kg ⁻¹ DM-SM)								
0	81.8	55.3	15.9	332.6	17.8	4.4	11.7	4.2	4.8
40	96.9	57.2	26.2	311.0	15.8	4.2	10.6	4.1	4.2
80	116.4	63.2	29.8	309.5	14.2	3.8	9.7	3.4	3.4
120	120.3	67.8	32.3	295.3	13.3	3.6	8.8	3.3	2.9
160	146.5	70.1	35.7	277.6	13.1	3.4	7.5	3.3	2.7
Undersowing Podsejavanje	97.7	57.7	19.1	321.7	14.7	3.5	8.9	4.7	2.9
Average-Pros.	109.9	61.8	26.5	307.9	14.8	3.8	9.5	3.8	3.5
LSD ₀₀₅	4.32	1.52	3.44	7.15	1.23	0.15	0.61	0.82	0.66

Table 5. Chemical composition of grassland depending on N rate (2003)
 Tabela 5. Hemijski sastav travnjaka u zavisnosti od količine azota (2003)

Fertilizer Đubrenje	CP	Ash	Fat	Celul.	K	P	Ca	Mg	S
N (kg ha ⁻¹)	(g kg ⁻¹ DM-SM)								
0	78.4	53.2	12.3	344.1	24.8	3.7	7.8	3.2	3.4
40	88.9	55.8	18.7	331.7	21.8	3.6	6.6	2.3	3.1
80	107.6	59.7	24.4	309.7	19.2	3.2	5.7	2.2	2.8
120	112.3	66.4	28.6	286.5	18.3	3.1	4.8	2.0	2.6
160	124.4	68.1	30.1	280.4	17.1	2.9	2.9	1.6	2.2
Undersowing Podsejavanje	90.4	55.4	18.1	331.3	19.7	3.1	6.9	2.7	2.6
Average-Pros.	100.3	59.8	22.0	313.9	20.1	3.3	5.8	2.3	2.8
LSD ₀₀₅	5.12	1.10	2.98	8.13	1.45	0.12	0.54	0.73	0.44

Table 6. Mineral composition of grassland depending on N rate (2002)
 Tabela 6. Mineralni sastav travnjaka u zavisnosti od količine azota (2002)

Fertilizer Đubrenje	Zn	Cu	Co	B	NO ₃ -N
N (kg ha ⁻¹)	(mg kg ⁻¹ DM-SM)				
0	72	27	0.6	27	180
40	75	24	0.7	26	230
80	73	26	0.9	24	290
120	70	30	1.0	23	370
160	68	31	1.2	22	430
Undersowing Podsejavanje	71	28	0.7	27	180
Average-Prosek	71	27	0.8	25	280
LSD ₀₀₅	1.3	3.2	0.2	0.9	50

Table 7. Mineral composition of grassland depending on N rate (2003)
 Tabela 7. Mineralni sastav travnjaka u zavisnosti od količine azota (2003)

Fertilizer Đubrenje	Zn	Cu	Co	B	NO ₃ -N
N (kg ha ⁻¹)	(mg kg ⁻¹ DM)				
0	52	18	0.4	24	150
40	58	19	0.6	22	180
80	54	22	0.6	20	230
120	51	23	0.7	16	250
160	49	23	0.9	12	290
Undersowing Podsejavanje	50	19	0.6	23	160
Average-Prosek	52	21	0.6	19	210
LSD ₀₀₅	1.1	3.1	0.1	1.8	20

presence. Increase in nitrogen fertilization level tends to increase the portion of grasses, especially those with high quality, while decreasing the portions of legumes and other herbage. According to Vuckovic et al. (2004) phosphorus and potassium application is of particular importance for increase of the legume portion.

Dry matter yield

DM yield varied depending on the year of study, i.e., on precipitation sum and schedule of individual years. The obtained data indicate that nitrogen fertilizer had a favorable effect on DM yield (Table 3). Maximum two-year average DM yield of 4.44 t ha⁻¹ was achieved with the highest N rate (160 kg ha⁻¹), which was an increase of 2.03 t ha⁻¹ or 85.0% compared with the control. Although the total average DM yield was lower in the year with the lower amount of precipitation (growing season), its relative yield (%) was higher compared with the year with the higher precipitation. Thus, in the dry year (2003), the highest nitrogen rate increased the yield by 153%, while in 2002 the yield was increased by 50%. The obtained results showed also that nitrogen fertilization not only provided higher yields but also stabilized fodder production, since better nourished grasses used water more economically. DM yield with undersowing treatment was low, only slightly higher than that in the control in both test years. With undersowing, DM yield was lowest in the humid year, but it was still significantly higher than the yield in the control in the dry year. In the year with the lower amount of precipitation (2003), the undersowing treatment increased the yield by 1.07 t ha⁻¹ (66%), while in the humid year (2002) the increase was 0.07 t ha⁻¹.

Dry matter chemical and mineral composition

Forage quality of the natural meadow dominated by *Cynosuretum cristati* was affected by the nitrogen rates (Tables 4 and 5). The increased N rates average also increased the contents of proteins, ash and fat, while cellulose content decreased. The undersowing treatment could not be justified regarding the improvement of the chemical composition. Protein and fat contents were increased more efficiently by N fertilization than by undersowing, in both study years. Krautzer and Bohner (2002) claim that only indigenous plants should be used for successful undersowing. For achieving appropriate effects with the undersowing method, drilling, raking or use of undersowing machines is also of special importance.

The content of mineral elements in the herbage from the natural meadow dominated by *Cynosuretum cristati* varied significantly (Tables 6 and 7). The obtained data indicate that nitrogen fertilizer had a favorable effect

on macronutrient composition. Increased N rates and undersowing contributed significantly to the variation. The increased N rate tended to decrease the concentrations of most macro elements, while the undersowing increased Ca and Mg contents and decreased the S content.

The increased N rates increased the contents of Cu, Co and NO₃, while decreasing the contents of Zn and B. The content of micro minerals with undersowing treatment was minimum, only slightly over those in the control in both test years (Tables 6 and 7).

CONCLUSIONS

Increases in N rate had a favorable effect on DM yield. The maximum two-year average DM yield of 4.44 t ha⁻¹ was achieved with the highest N rate (160 kg ha⁻¹), which was an increase of 2.03 t ha⁻¹ or 85.0% compared with the control.

The application of N fertilizers changed the botanical composition of the plant association *Cynosuretum cristati*. The increase in nitrogen fertilization level, increased the portion of grasses and improved their quality, while the portions of legumes and the other herbage decreased.

The increased N rates increased the contents of proteins, ash, fat, Cu, Co and NO₃, and reduced the contents of cellulose, K, P, Ca, Mg, S, Zn and B.

The effect of undersowing on DM yield and chemical and mineral compositions was negligible.

ACKNOWLEDGEMENTS

This research was supported by Norwegian SEE Programme in Agriculture (Project No.2020096)

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