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DRY MATTER AND PROTEIN YIELD OF ALFALFA, COCKSFOOT, MEADOW FESCUE, PERENNIAL RYEGRASS AND THEIR MIXTURES UNDER THE INFLUENCE OF VARIOUS DOSES OF NITROGEN FERTILIZER

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Abstract: Grass-leguminous mixtures and pure crops are important for ensuring of sufficient quantities of high quality roughage, especially in conditions of low land livestock production, in conditions of farm housing system as well as in the system of free grazing of animals. Studies were carried out on pure crops of three grass species and their mixtures with different component ratios. Fertilization using different doses of nitrogen led to considerable increase of yield of pure crops and their mixtures. The highest yields were recorded in treatment with 100 kgN ha^{-1}, and the lowest yield in treatment without fertilization. Fertilization led to decrease of share of alfalfa, meadow fescue and perennial ryegrass in dry matter, and increased the content of cocksfoot. The highest protein yield of pure crops was recorded for perennial ryegrass - 495.5, and in mixtures, the highest protein yield was recorded for four component mixture of alfalfa, cocksfoot, meadow fescue and perennial ryegrass of 568.0 kg ha^{-1}. Fertilization with N increased protein yield considerably in pure crops as well as in their mixtures.

Key words: grass-legume mixture, DM yield, protein production

Introduction

Grass-leguminous mixtures, as well as pure crops, are important for production of roughage of good quality, especially in low land livestock production, in conditions of farm housing system as well as in the system of free grazing of animals. Alfalfa is forage leguminous plant most often used in animal nutrition *(Radović et al., 2009)*. It is often cultivated in mixture with one or several grass species: Timothy grass, meadow fescue or cocksfoot *(Jönsson, 1982)*.

Growing of alfalfa and other leguminous plants in mixtures with grasses has many advantages, such as possibility for their use by grazing, i.e. use of fresh plants, which reduces the risk of incidence of bloat *(Ocokoljić et al., 1984),* reduces the weed infestation of crops, ensures better conservation of water and mineral matters in the soil *(Lazaridou et al., 2006)* and enables more successful ensiling because of higher sugar content *(Đorđević and Dinić, 2003, 2005)*. By comparing the pure grass crop with mixture of grasses and leguminous plants, mixtures have the advantage due to greater and more uniform yield of mixtures over grasses *(Spandl and Hesterman, 1997)*, better forage quality, *(Gil and Fick, 2001),* better utilization of nutritious substances from the soil and more economically efficient production due to reduced use of nitrogen fertilizers *(Tekeli and Ates, 2005)*. However, regardless of the nitrogen fixation abilities of leguminous plants, nitrogen fertilizers applied in certain quantities, in the grass-leguminous crop increases the yield of dry matter and protein content and yield. *Komarek et al. (2007)* in their research of the effect of complex mineral fertilizers with and without nitrogen on yield of grasslands concluded that by adding 90 kgN ha^{-1} the yield of dry matter increased by 1.89 t ha^{-1}, and adding of 180 kgN ha^{-1} by 3.03 t ha^{-1}. In studies by *Ocokoljić et al. (1974)* fertilization influenced significantly the increase of crude protein content in mixture of alfalfa and cocksfoot by 17,6 %.

Objective of this study was to investigate the effect of different N quantities from mineral fertilizers on production and quality characteristics of forage crops as mono-culture and in mixtures.

Materials and Methods

Trial was set at the trial field of the Institute for Animal Husbandry, according to random block system in four repetitions. The effect of three nitrogen doses (0, 50 and 100 kg ha^{-1}) on yield of dry matter and protein was studied in pure crops (alfalfa, cocksfoot, meadow fescue and perennial ryegrass) and grass-leguminous mixtures (Alfalfa 50%: Cocksfoot 50%, Alfalfa 50%: Cocksfoot 25%: Meadow fescue 25%, Alfalfa 25%: Cocksfoot 50%: Meadow fescue25%, Alfalfa 40%: Cocksfoot 20%: Meadow fescue20%: Perennial ryegrass20%). For sowing the alfalfa cultivar K-28 was used in the amount of 20 kg ha^{-1}, cocksfoot cultivar Baraula, 50 kg ha^{-1}, meadow fescue cultivar K-21, 50 kg ha^{-1} and perennial ryegrass cultivar Esquire also 50 kg ha^{-1}. Sowing was done in the fall of 2010 on main parcel of area of 10 m^2.

General agro-chemical properties of soil used in the trial are presented in Table 1.

Table 1. Main chemical properties of soil

Depth cm	pH	Humus	Total N	C/N	Available N mg kg^{-1}			Ready available mg $100g^{-1}$	
	H_2O	%			NH_4-N	NO_3-N	Suma	P_2O_5	K_2O
0 – 30	6.2	0.19	3.31	10	23.1	23.8	46.9	5.4	18.4

In the autumn preparation of soil for sowing super phosphate was applied (18%). Necessary amount of phosphorus fertilizer was determined based on the content of easy available phosphorus in the soil and requirements of plants that are being grown *(Kresović, 2010)*. Calculated amount of pure nutrient (phosphorus) was 165 kg ha^{-1}. Fertilization of crops was carried out at the end of March 2011 using mineral fertilizer KAN (27%).

Based on obtained results for pH values of the soil, it can be concluded that the soil on which the trial was carried out, belonged to the group of acid soils. According to the humus content, it is medium humus soil *(Muckenhausen, 1975)*, and the total nitrogen content of soil was medium *(Bogdanović et al., 2005)*. C/N ratio was usual for cultivable soils. According to the content of ready available phosphorus, this soil belonged to poor soils, and in regard to the ready available potassium medium soils. Content of ammonium and nitrate nitrogen was balanced and total content of available nitrogen was 46,9 mg kg^{-1}.

Results and Discussion

Based on obtained results presented in Table 2, in regard to pure crops it can be observed that DM yield showed significant differences. The highest DM yield was recorded for perennial grass in pure crop (5.53 t ha^{-1}), and the lowest in pure alfalfa crop (2.71 t ha^{-1}), which can be explained by agro-climatic conditions which favoured growth of grasses in the period of first cut. Realized yields of mixtures were somewhat higher than yields reported by *Lazarević et al. (1999)*, who recorded the highest yield of mixtures from the first cut of 4.86 t ha^{-1}. Fertilization had significant effect on yield of dry matter in pure crops. It led to increase of yield in all studied cultures. The highest yield was realized by perennial ryegrass in fertilization treatment with 100 kgN ha^{-1}, and the lowest alfalfa in treatments without fertilization. DM yield of mixtures also showed statistically significant differences. The highest yield was recorded in the four component mixture of alfalfa, cocksfoot, meadow fescue and perennial ryegrass (4.49 t ha^{-1}), and the lowest in mixture of alfalfa and cocksfoot (3.48 t ha^{-1}). In pure crops as well as mixtures, fertilization caused increase of DM yield. The highest yields were recorded in treatments with 100 kgN ha^{-1}, and the lowest in treatments without fertilization. Obtained results are in concordance with results obtained by *Nešić (2006)*, *Nešić et al. (2007)* and *Bijelić (2009)* who concluded that treatments with the greatest amount of nitrogen added increased the yield of dry matter of grasslands in the first production year by 18.7%, and in subsequent years from 10.0 to 20.0%. Also, numerous authors report of similar results and conclusions *(Hoveland et al., 1995; Malhi et al., 2002, Simić et al. 2006)*. Proportionally to the sowing level as well as to increase of number of species in mixture, the share of alfalfa and grasses in the yield of dry matter changed significantly. Fertilization with N also had significant effect on share of all species in mixture. It led to

decrease of the alfalfa content by 124.80 g $kg^{-1,}$ and increase of cocksfoot by 95.60 g kg^{-1} in dry matter of mixtures.

Table 2. Yield of DM in pure crops of alfalfa, cocksfoot, meadow fescue and perennial ryegrass and their mixtures, as well as content of certain species in yield depending on nitrogen fertilization

Mixture	Fertilization N (kg ha^{-1})			Mean value (A)
	0	50	100	
Mono culture (t ha^{-1}) ($LSD_{0.05}$=0.242)				
Alfalfa	2.14	2.79	3.19	2.71
Cocksfoot	3.05	3.96	4.04	3.68
Meadow fescue	4.52	4.68	5.20	4.80
Perennial ryegrass	5.38	5.22	6.01	5.53
Mean B ($LSD_{0.05}$=0.210)	4.16	3.77	4.61	
Mixture (t ha^{-1}) ($LSD_{0.05}$=0.157)				
Alfalfa+Cocksfoot	3.13	3.40	3.91	3.48
Alfalfa+Cocksfoot+Meadow fescue	3.48	4.38	4.37	4.07
Alfalfa+Cocksfoot+Meadow fescue	2.62	3.94	4.61	3.72
Alfalfa+Cocksfoot+M.fescue+Perennial ryegrass	3.20	5.10	5.19	4.49
Mean A ($LSD_{0.05}$=0.136)	3.11	4.20	4.52	
Alfalfa (g kg^{-1}) ($LSD_{0.05}$=14.361)				
Alfalfa+Cocksfoot	427.70	365.00	112.00	301.60
Alfalfa+Cocksfoot+Meadow fescue	151.25	150.00	120.00	140.40
Alfalfa+Cocksfoot+Meadow fescue	88.00	80.75	50.25	73.00
Alfalfa+Cocksfoot+ M.fescue +Perennial ryegrass	194.50	67.50	80.00	114.00
Mean B ($LSD_{0.05}$=12.437)	215.40	165.80	90.60	
Cocksfoot (g kg^{-1}) ($LSD_{0.05}$=20.761)				
Alfalfa+Cocksfoot	575.20	630.00	888.00	696.75
Alfalfa+Cocksfoot+Meadow fescue	374.00	363.50	375.75	371.10
Alfalfa+Cocksfoot+Meadow fescue	723.25	515.50	622.75	620.50
Alfalfa+Cocksfoot+M.fescue +Perennial ryegrass	46.75	227.75	212.25	167.25
Mean B ($LSD_{0.05}$=17.980)	429.10	437.90	524.70	
Meadow fescue(g kg^{-1}) ($LSD_{0.05}$=20.053)				
Alfalfa+Cocksfoot+Meadow fescue	474.75	486.50	504.25	488.50
Alfalfa+Cocksfoot+Meadow fescue	188.75	403.75	327.00	306.50
Alfalfa+Cocksfoot+M.fescue+Perennial ryegrass	167.50	456.75	494.00	372.75
Mean B ($LSD_{0.05}$=20.053)	449.00	277.00	441.75	
Perennial ryegrass(g kg^{-1})				
Alfalfa+cocksfoot+M.fescue+Perennial ryegrass	591.25	248.00	213.75	
Mean B ($LSD_{0.05}$=48.620)				

A- factor crop, pure crop and grass-leguminous mixture; B- fertilization N; $LSD_{0.05}$ – Least significant difference at $P \leq 0.05$

The highest content of meadow fescue was recorded in treatment without fertilization - 449.00 g kg^{-1}, as well as perennial ryegrass - 591.25 g kg^{-1}. *Halling and Wallgren (1996)* in their study of the effect of N fertilization, in the amount of 0-200 kg ha^{-1}, on production characteristics of alfalfa and red clover in mixture with grasses concluded that the share of grasses in mixture increased and share of alfalfa and red clover decreased with the addition of different amounts of nitrogen.

In Table 3 the production of protein in pure crops and grass leguminous mixtures depending on fertilization treatment with different amounts of N is presented. Alfalfa and cocksfoot realized significantly lower protein yield compared to meadow fescue and perennial ryegrass, as well as mixture of alfalfa and cocksfoot compared to other mixtures.

Perennial ryegrass and grass-leguminous mixture realized the highest protein yield of 495.5 and 568.0 kg ha^{-1}. This can be explained by the fact that N fertilization, in addition to the increase of CP content, also influenced increase of DM yield of perennial ryegrass.

Table 3. Production of proteins in pure crops and their mixtures depending on N fertilization

	Fertilization N (kg ha^{-1})			Mean value (A)
	0	50	100	
Mono culture (kg ha^{-1})				($LSD_{0.05}$=27.23)
Alfalfa	266.2	415.3	497.1	392.9
Cocksfoot	312.9	450.2	463.0	408.7
Meadow fescue	336.3	406.5	600.8	447.7
Perennial ryegrass	417.1	521.5	547.9	495.5
Mean of factor B ($LSD_{0.05}$=23.57)	333.1	448.4	527.2	
Mixture (kg ha^{-1})				($LSD_{0.05}$=19.40)
Alfalfa + Cocksfoot	376.2	422.9	532.9	444.0
Alfalfa + Cocksfoot + Meadow fescue	354.1	628.7	641.9	541.6
Alfalfa + Cocksfoot + Meadow fescue	238.9	468.0	599.0	435.3
Alfalfa + Cocksfoot + Meadow fescue +Perennial ryegrass	319.7	576.2	807.9	568.0
Mean of factor B ($LSD_{0.05}$=16.80)	322.2	523.9	645.4	

A- factor crop, pure crop and grass-leguminous mixture; B- fertilization N; $LSD_{0.05}$ – Least significant difference at $P \leq 0.05$

Fertilization had significant effect on protein yield in mono culture as well as grass-leguminous mixtures Protein yield increased proportionally with the amount of added nitrogen. So, treatment with 100 kgN ha^{-1} had the highest PY of 527.2 kg ha^{-1} in mono culture and 619.0 kg ha^{-1} in mixtures. Achieved results are in concordance with results obtained by *Nešić (2006)* and *Bijelić (2009)* where it was also established that by adding n fertilizer in amounts of 0, 70, 140 and 210 kg ha^{-1} gradual increase of protein yield occurs in pure alfalfa crop and its mixtures with grasses. *Stringer et al. (1996)* stated that N fertilization significantly influenced the increase of CP in alfalfa mixture in average by 0,83 kg CP kg^{-1} N.

Conclusion

Based on results of presented research, it can be concluded that alfalfa and grass mono cultures, as well as their mixtures realized significantly different yields of dry matter. The highest DM yield of pure crops was recorded for perennial ryegrass (5.53 t ha^{-1}), and the lowest alfalfa (2.71 t ha^{-1}). Fertilization using different amounts of nitrogen led to significant increase in yield of pure crops and mixtures. The highest yields were determined in treatments with 100 kgN ha^{-1}, and the lowest in treatments without fertilization.

The highest protein yield in pure crops was recorded for perennial ryegrass (495.5 t ha^{-1}), and in mixtures – the four component mixture of alfalfa, cocksfoot, meadow fescue and perennial ryegrass (568.0 kg ha^{-1}). Nitrogen fertilization significantly influenced the increase of protein yield in pure crops and their mixtures.

Application of N fertilizers in pure crops of forage plants in the amount from 0-100 kg ha^{-1}, was completely justifiable since it had positive effect on production of DM and on quality of forage.

This amount of fertilizer is considered economically justifiable, since investment in 100 kg of nitrogen results in increase of yield of dry matter and protein quality, and quality of forage basis of animal nutrition is improved in this way.

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Prinos suve materije i produkcija proteina lucerke, ježevice, livadskog vijuka, engleskog ljulja i njihovih smeša sa različitim dozama azotnog đubriva

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Rezime

Travno-leguminozne smeše kao i usevi čistih kultura su od značaja za obezbeđenje kvalitetne kabaste stočne hrane, naročito u uslovima nizijskog stočarstva, u uslovima farmskog držanja kao i pri slobodnom sistemu ispaše

životinja. Istraživanja su obavljena na čistim usevima tri vrste trava i lucerke, najzastupljenije leguminoze kod nas, kao i njihovih smeša u različitom odnosu učešća pojedinih komponenti. Đubrenje različitim količinama azota dovelo je do značajnog povećanja prinosa kako čistih useva tako i njihovih smeša. Najvećim prinosima odlikuju se tretmani sa 100 kgN ha^{-1}, a najmanjim tretmani bez đubrenja. Đubrenje je smanjilo sadržaj lucerke, livadskog vijuka i engleskog ljulja u suvoj materiji travnjaka, a povećalo sadržaj ježevice. Najvećim prinosom proteina od čistih useva odlikuje se engleski ljulj (495,5 kg ha^{-1}), a od smeša četvorokomponentna smeša lucerke, ježevice, livadskog vijuka i engleskog ljulja (568,0 kg ha^{-1}). Đubrenje N je značajno povećalo prinos proteina kako kod čistih useva tako i kod njihovih smeša.

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