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YIELD POTENTIAL AND QUALITY OF FORAGE MIXTURES OF ALFALFA WITH COCKSFOOT AND TALL FESCUE DEPENDING ON THE NITROGEN FERTILIZATION

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Abstract: The study was performed at the Institute for Animal Husbandry in the three year period, in field and laboratory conditions. The experiment involved two mixtures of grasses and legumes: mixture A (alfalfa (cv. K -28), 50% and cocksfoot (cv. K-40), 50%) and mixture B (alfalfa (cv. K -28), 33.3 % , cocksfoot (cv. K -40) , 33.3 %, and tall fescue (cv. K -20) , 33.3 %), and pure stand of alfalfa (M). The experiment was conducted in a randomized block design with four replications. Fertilization was carried out using the split method, in quantities of of 0, 70 and 140 kg N ha $^{-1}$. The aim of this study was to determine the phytocoenological stability of mixture of alfalfa (*Medicago sativa* L.) with cocksfoot (*Dactylis glomerata* L.) and tall fescue (*Festuca arundinacea* Schreb.), the yield and quality of fodder obtained from the grassland, depending on the mixture composition and nitrogen fertilization. Studied factors had a statistically significant impact on dry matter yield and protein yield. Alfalfa has achieved significantly higher yields compared to its mixtures. Dry matter yield increased with the addition of N fertilizers. Protein yield was highest in pure alfalfa crop, followed by its mixture cocksfoot. Fertilization has also increased protein yield.

Key words: yield, quality, alfalfa, mixtures, N fertilization

Introduction

Grasslands can provide sufficient quantities of inexpensive and high - quality forage for livestock production, for feeding of large and small ruminants. However, this option requires the proper use of grassland areas, whether natural or sown, that is very precise planning and management systems. In Serbia, according to the statistical data from the 2012, there were 590 927 hectares of meadows and 702,887 hectares of pastures (SBS, 2012). Comparing statistics from previous

years, we can conclude that the production area decreased. For these reasons, attention should be directed towards sown grasslands, or mixtures of grasses and legumes. There are numerous benefits of grass - legume mixtures that lead to thir use, such as: nitrogen fixating ability of legumes where grass can use adopted nitrogen (*Tekeli and Ates, 2005*), the high productivity of mixtures during the entire growing season (*Nešić at al. 2007*) as well as high nutritional value as compared to pure grass crops (*Berdahl et al., 2001*). Cattle can be fed green food because the possibility of bloat is reduced and the performance is better compared to cattle fed monocrops (*Sanderson et al. , 1999*) .

When planning a grass-legume surfaces, it is very important to choose the adequate species for the mixture, which should be primarily based on the adaptation of species to growing conditions, purpose of the grassland, consistency, yield and its seasonal distribution and nutritional value (*Tekeli and Ates, 2005*). The exmination/study of the botanical composition of grass - legume mixtures led to the conclusion that cocksfoot was the most compatible species suitable for growing in mixtures with very competitive legumes, and in some cases its competitiveness exceeds the competitiveness of legumes forcing them out of the mixture, (*Casler and Walgenbach, 1990*). In addition to cocksfoot, tall fescue is also suitable grass species for growing mixed with clover (*Hannaway et al., 1999*) . Grass- legume mixtures are energy high-quality forage with a well-balanced contents of protein, carbohydrates, minerals and vitamins.

The aim of this study was to determine the phytocoenological stability of the mixture of alfalfa (*Medicago sativa* L.) with cocksfoot (*Dactylis glomerata L.*) and tall fescue (*Festuca arundinacea* Schreb.), the yield and quality of fodder obtained from the grasslands, depending on the mixture composition and nitrogen fertilization.

Material and methods

In order to solve the given task, tests were carried out at the Institute for Animal Husbandry in three year period, in two phases: in field and laboratory conditions. The study included two mixtures of grasses and legumes : A mixture (alfalfa (cv. K -28), 50% and cocksfoot (cv. K-40), 50% and mixture B (alfalfa (cv. K -28), 33.3 % cocksfoot (cv. K-40), 33.3 %, and tall fescue (cv. K -20, 33.3 %), and pure alfalfa crop (M). The experiment was conducted in a randomized block design with four replications, the size of the experimental plots of 10 m^2. Sowing experiment was performed in the 2003. Meadow fertilization was carried out using the split method, at the beginning of the vegetation and after first cutting in the total weight of 0, 70 and 140 kg N ha^{-1}. Botanical composition (% grasses, legumes, weeds) of samples has been done in green, sampling 1m^2 by separating and measuring the species. The chemical composition of the feed was analyzed in

the laboratory of the Institute for Animal Husbandry, using standard laboratory analyses. Chemical analyzes included the content of crude protein (CP), crude fiber (CF) and mineral substances. The content of metabolizable energy (ME) was calculated by the formula :

ME(MJ/kg DM) = 14,06-0,0137gCF+0,00483gCP-0,0098gCA (*Schenkel,* 1998, quoated by *Petkova*, 2006)

The data obtained in the botanical analysis, dry matter yield and chemical quality of dry mass were analysed by ANOVA two-factorial analysis of the variance for studied factors, the type of mixture and N fertilization, and significance of differences was tested using LSD test (Stat.Soft., STATISTICA 8, 2001).

The land/soil on which the grassland was established was low carbonate chernozem, of favourable water, air, thermal regime and a very good particle-grain structure (pH = 7.3, N = 1975 ppm, P_2O_5 = 9.0 mg $100g^{-1}$, K_2O = 16 mg $100g^{-1}$).

Average temperatures for vegetation period according to investigation years were 12.6, 13.24 and 14.09 ^{0}C, and total precipitation 486.1, 543.2 and 532.3 mm which was 72.34%, 77.5% and 69.05% of total annual precipitation.

Results and discussion

Botanical analysis of samples of green mass from grasslands A and B showed that participation in these mixtures of legumes, grasses and weeds for years quite varied, but the studied factors did not express their effect in any of the years studied. (Table 1).

Table 1. The percentage of species in the mixture (%) depending on the mixture and N fertilization for three year study period

Mixture	I exp. year			II exp. year			III exp. year		
	L	G	F	L	G	F	L	G	F
Mixture A	52.10	46.33	1.57	56.76	41.80	1.44	67.58	30.43	1.99
Mixture B	52.00	46.25	1.75	59.44	39.92	0.64	66.33	32.24	1.43
Level of signific.	ns	ns	ns	ns	ns	**	ns	ns	ns
N fertilization									
0	60.87	37.96	1.17	68.11	31.16	0.73	71.42	26.75	1.83
70	50.38	47.96	1.66	56.44	42.48	1.08	68.05	30.41	1.54
140	44.90	52.96	2.14	49.77	48.93	1.30	61.38	36.85	1.77
Level of signific.	ns	ns	ns	ns	ns	ns	ns	ns	ns

L-legumes; G-grass; F-forbs

In the mixture A the percentage of alfalfa increased from 52.10 to 67.58%, as well as the percentage of weeds, while the share of cocksfoot decreased from 46.3 to 30.43%. In the three-component mixture B also share of alfalfa increased each

year from 52.0 to 66.3% and the share of grass reduced from 46.25 to 32.24%. In the mixture A the percentage of both species is similar to the sowing level with small variations of ≈ 10 % depending on the year, which according to *Casler et al. (1990)* is a sign of good competitive abilities for cocksfoot grown in mixture with alfalfa. In the grass mixture B, share of grasses was lower than it was at the time of sowing, which means that although tall fescue has good capacity for growing in mixture with alfalfa (*Hannaway et al., 1999*) nevertheless it has lower competitiveness than cocksfoot in the given environmental conditions. Increasing the share of alfalfa in the mixture could be explained by a greater adjustment ability of alfalfa to grow on existing soil conditions in relation to cocksfoot and tall fescue, which can be seen from the study of dry matter yield of alfalfa, cocksfoot and tall fescue on chernozem by *Nešić et al. (2005)* and *Tomić et al. (2006).*

Although fertilization had no statistically significant effect slight increase in share of grass and weeds was noticeable, and decrease in share of legumes which is consistent with the research by *Stoeva and Vateva* (2010).

Total yield, quality and seasonal distribution of forage are of great importance for livestock production. The total dry matter yield and quality of forage grass are shown in Table 2. The most important aspect of forage quality is the content and availability of nutrients for animals. Many factors affect the quality of forage such as: stage of maturity of crops at the time of cutting, the ratio of grasses and legumes, the presence of weeds, diseases, etc. Crude protein is one of the most important parameters of food quality. Crude protein content determines the biological value of food.

The yields of both mixtures varied considerably by years of study. Both studied factors had statistically significant impacts on the achieved yields of dry matter in all three years.

Table 2. Total dry matter yield (t ha^{-1}) of alfalfa and its mixtures with cocksfoot and tall fescue, monitored in regard to N fertilization in three year investigation period

Treatments	DM yield t ha^{-1}			
	I exp. year	II exp. year	III exp.	Average
Mixture				
Alfalfa	10.34^{a}	9.97^{a}	10.36^{a}	10,51^{a}
Alfalfa +cocksfoot	10.74^{a}	9.13^{b}	8.88^{b}	9,77^{b}
Alfalfa +cocksfoot +tall fescue	9.70^{b}	8.87^{b}	8.87^{b}	9,53^{b}
Level of significance of mixtures	**	**	**	**
Fertilization with N (kgN ha^{-1})				
0	9.92^{b}	9.09^{b}	8.88^{b}	9,10^{b}
70	10.67^{a}	9.40^{ab}	9.76^{a}	9,80^{a}
140	10.21^{ab}	9.48^{a}	9.49^{ab}	9,64^{ab}
Level of significance of N fertilization	*	*	*	**

In the first experimental year, the two-component mixture A had the highest yield of 10.74 t ha^{-1}, which was not significantly different from the yield of pure alfalfa crop, whereas mixture B achieved significantly lower yield of 9.70 t ha^{-1} compared to monoculture and two-component mixture A. *Vassilev (2004)* presented in his research that alfalfa mixtures with cocksfoot achieved higher dry matter yield of 15.6-16.8 t ha^{-1} compared to mixtures with tall fescue 15.1-15.6 t ha^{-1}. In the next two years, alfalfa has achieved a significantly higher yield compared to its mixture. The results were consistent with the results of *Halling and Wallgren (1996)* and *Kunelius et al. (2005),* but slightly higher than the results obtained by *Vassilev and Chakarov (1999),* and *Loges et al. (2000*), whose studies reported yields of 6.86 and 7.53 t ha^{-1}. Average for the three-year test period of research alfalfa achieved significantly higher yields of dry matter in relation to its mixtures with grasses, while fertilization with 70 kg N ha^{-1} proved to be the most effective.

In all three investigated years, fertilization significantly increased the yield, but the differences between the quantities of 70 and 140 kg N ha^{-1} were not significant so that the increased investment in higher amounts of nitrogen fertilization were not economically justified.

Table 3. Quality, protein yield and content of metabolic energy of alfalfa and its mixtures in all three investigation years

Treatments	CP	CF	ASH	YP	ME
	gkg^{-1}			t ha^{-1}	Mcal
I exp. year					
Alfalfa	168.6	309.9	84.5	1.7^{a}	9.80
Alfalfa +cocksfoot	163.2	310.3	83.6	1.6^{a}	9.78
Alfalfa +cocksfoot +tall fescue	157.8	322.8	83.4	1.4^{b}	9.58
Level of significance	ns	ns	ns	**	ns
II exp. year					
Alfalfa	185.1^{a}	270.8	96.2	1.9^{a}	10.30
Alfalfa +cocksfoot	170.9^{ab}	285.4	89.8	1.5^{b}	10.09
Alfalfa +cocksfoot +tall fescue	158.3^{b}	279.7	93.2	1.4^{c}	10.08
Level of significance	**	ns	ns	**	ns
III exp. year					
Alfalfa	181.6	290.8	86.9	1.9^{a}	10.10
Alfalfa +cocksfoot	174.4	300.9	86.7	1.5^{b}	9.93
Alfalfa +cocksfoot +tall fescue	180.3	297.4	80.9	1.6^{b}	10.06
Level of significance	ns	ns	ns	**	ns

With the increase of share of legumes in the mixture the crude protein content also increases, and the crude fibre content decreases. The tested mixtures were not significantly different in regard to the content of crude protein ranging in mixture A from 163.2 to 174.4 g kg^{-1} DM, depending on the investigation year, in mixture

of B from 157.8-180.3 g kg $^{-1}$ DM. Pure crop of alfalfa had a higher crude protein content than alfalfa mixtures. The content of crude fibre, ash and metabolic energy showed no significant differences between monocultures and mixtures. Protein yield was highly dependent on the type of mixture. In all three years alfalfa achieved significantly higher protein yield compared to mixture B, and the value of the protein yield in mixture A for the first experimental year was not statistically significantly different from the yield of pure crop. A mixture of alfalfa and cocksfoot achieved significantly higher protein yield compared to mixture of alfalfa, cocksfoot and tall fescue in the first two years of testing, while in the final year of examination yields were not statistically different. Similar to our results *Chakarov and Vassilev (1992)* obtained the higher values of protein yield (1.15 t ha $^{-1}$) for mixtures of alfalfa and cocksfoot compared to the mixture of alfalfa, cocksfoot and tall fescue (1.04 t ha $^{-1}$).

According to the NRC (2001) the daily needs of small and large ruminants (sheep and cattle) for the specific content of crude protein in animal feeds range from 9.1 to 15.0% DM for sheep and 7.4 to 16.6% DM for cattle. Comparing the results of analysis of crude protein in forage of alfalfa mixtures with cocksfoot and tall fescue, with data from the NRC (2001), we recognize the very good quality of forage of examined mixtures that can fully meet the daily requirements of sheep and cattle.

Table 4. Quality and yield of protein and content of metabolizable energy of alfalfa and its mixtures depending on nitrogen fertilization in all three years

Treatments	CP	CF	ASH	YP	ME
	gkg^{-1}			t ha^{-1}	Mcal
I exp. year					
0	157.1	318.9	84.5	1.48^{b}	9.62
70	163.8	311.4	82.0	1.65^{a}	9.78
140	168.7	312.7	85.0	1.62^{a}	9.75
Level of significance	ns	ns	ns	*	ns
II exp. year					
0	165.3	277.2	91.0	1.49^{b}	10.17
70	172.2	279.6	95.1	1.59^{a}	10.13
140	176.8	279.1	93.0	1.66^{a}	10.18
Level of significance	ns	ns	ns	*	ns
III exp. year					
0	173.8	296.1	84.2	1.52^{b}	10.02
70	178.8	299.7	85.2	1.73^{a}	9.98
140	183.7	293.3	84.9	1.77^{a}	10.10
Level of significance	ns	ns	ns	*	ns

CP-crude proteins; CC-crude fiber; YP-protein yield; ME-metabolizable energy

N fertilization had no statistically significant effect on the crude protein content, although the results show that the content slightly increased with the addition of N. In the control treatment CP content ranged from 157.1-173.8 g kg^{-1} DM, and treatment with 140 kg N ha^{-1} from 168.7-183.7 g kg^{-1} DM. Like in the case of mixtures, fertilization had no significant effect on the content of crude fiber, ash and metabolic energy. Contrary to our study, in the research carried out by *Samuil et al. (2012)* mixture and fertilization had a significant impact on the quality of forage. According to them, increasing the participation of legumes in the mixture and N fertilization increased the content of total nitrogen and decreased the crude fiber content. Protein yield was dependent on the N fertilization at the level of of $P \leq 0.05$. Adding of N resulted in an increase of protein yield. Variations in the amount of protein yield between the amount of nitrogen 70 and 140 kg N ha^{-1} were not significant, so in this case, greater quantity of nitrogen, 140 kg N ha^{-1} was not justified.

Conclusion

Alfalfa achieved significantly higher yields of DM compared to its mixtures, the mixture of alfalfa and cocksfoot had higher yields than mixtures with tall fescue. Yields increased with addition of N fertilizers, but the difference in yield between the medium and the highest dose of nitrogen were not statistically significant, and consequently economically justified. Protein yield was the highest in pure alfalfa crop, followed by the mixture of alfalfa and cocksfoot, while fertilization increased the yield of protein, but also high nitrogen rate of 140 kg N ha^{-1} was not justified because it did not not significantly increase the yield of protein in relation to the fertilization dose of 70 kg N ha^{-1}.

Mixture of alfalfa and cocksfoot are giving satisfactory DM yield and fodder quality,and could be recommended in practice. In order to achieve satisfactory yields, crops should be fertilized with N mineral fertilizers but with smaller amounts of nitrogen (70 kg N ha^{-1}), because only this is economically justified considering the difference in the yields compared to the larger amount of nitrogen (140 kg N ha^{-1}).

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Prinos i kvalitet krmnih smeša lucerke sa ježevicom i visokim vijukom u zavisnosti od djubrenja azotom

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Rezime

Ispitivanja su radjena u Institutu za stočarstvo u trogodišnjem periodu ispitivanja u poljskim i laboratorijskim uslovima. U eksperiment su uključene dve smeše trava i leguminoza: Smeša A (lucerka (K-28), 50% i ježevica (cv. K-40), 50%) i Smeša B (lucerka (K-28), 33,3%, ježevica (cv. K-40), 33,3% i visoki vijuk (cv.K-20), 33,3%), kao i čist usev lucerke (M). Ogled je izveden po metodu slučajnog blok sistema u četiri ponavljanja, Đubrenje travnjaka je obavljeno split metodom, količinama od 0, 70 i 140 kgN ha^{-1}. Cilj ovih istraživanja je da odredi fitocenološku postojanost smeša lucerke (*Medicago sativa* L.) sa ježevicom (*Dactylis glomerata* L.) i visokim vijukom (*Festuca arundinacea* Schreb.), prinos i kvalitet dobijene stočne hrane sa travnjaka u zavisnosti od sastava smeše i djubrenja azotnim djubrivima. Ispitivani faktori imali su statistički značajnog uticaja na prinos suve materije i prinos proteina. Lucerka je ostvarila značajno veće prinose u odnosu na njene smeše. Prinosi suve materijeSM su se povećavali dodatkom N mineralnih djubriva. Prinos proteina bio je najveći u čistom usevu lucerke, a zatim u smeši lucerke i ježevice. Djubrenje je takođe povećalo prinos proteina.

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