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YIELD AND NUTRITIVE VALUE OF ALFALFA CULTIVARS SOWN AT DIFFERENT DENSITIES **

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Abstract: The effect of cultivar and plant density on dry matter yield and nutritive value of alfalfa was studied. The trial was conducted at the first cutting of alfalfa plants in their second and third years of growth, and four cultivars and two different crop densities were tested. The cultivars were found to have significant effect on dry matter yield, proportion of leaf in total yield and content of crude proteins under both densities. The highest forage yield was achieved in first density (20 cm row spacing with 15 $kgha^{-1}$ seed rate). The wide row spacing (50 cm) with low seed rate (9 $kgha^{-1}$) was showed lower forage production. The effect of cultivars and plant density on other parameters of forage nutritive value was insignificant. A high positive correlation with the proportion of leaf was found for the content of crude proteins (r=0.961), concentration of potassium (r=0.876), phosphorus (r=0.561), calcium (r=0.550) and content of crude fat (r=0.500). Crude fiber was highly negatively correlated with leaf proportion (r=0.916), while the latter showed no correlation with crude ash (r=0.185) and nitrogen-free extract (0.010).

Key words: alfalfa, density, cultivars, yield, quality, correlation

Introduction

Alfalfa is cultivated on some 200,000 ha in Serbia and it is currently the primary source of forages. Its yield and the nutritive value of dry matter make it a leading perennial leguminous forage crop (*Sauvant et al.* 2002*; Đukić* 2002*; Radović et al.* 2004*; Dinić and Đorđević,* 2005).

Numerous cultivars have been created worldwide, and in Serbia as well, by using highly divergent genetic materials and different breeding methods. Cultivars and their genetic characteristics crucially determine the volume and stability of yield, as well as the quality of feed (*Beković,* 1997*; Radović, et al.,* 2004*; Stanisavljević,* 2006).

Plant density is also very important factor of production, yield stability and persistance of alfalfa during all period of utillization. In agroecological conditions of south Banat three way of sowing (A_1- 20 cm row spacing, 15 $kgha^{-1}$ seed rate; A_2 - 50 cm row spacing with seed rate of 6 $kgha^{-1}$; A_3 – 80 cm betwen rows and 3 $kgha^{-1}$ seed rate) were estimated (*Vučković* et *al*., 1996). The significantly higher green and dry matter yield was achieved in A_1 density with seed rate of 15 $kgha^{-1}$ and 20 cm row spacing. Significant effect of row spacing on alfalfa forage yield in Kosovo and Metohija was obtained in investigation of *Beković and Savić* (1996).

Materials and methods

A trial was conducted under the agro-ecological conditions of eastern Serbia on a smonitza soil, employing a randomized block design with four replicates. Over the study period (2003-2004), nnual precipitation (610 and 641 lm^{-2}) and average air temperature (11.1 and 11.0 ºC) were favourable, which stimulated alfalfa growth.

In the second and third years of growth (2003-2004), dry matter yield and nutritive value of forage of three domestic alfalfa cultivars (Novosađanka H – 11, NS – Slavija and Zaječarska – 83) and one French cultivar (Europe), all sown at two densities (18 kg ha^{-1} seeds per sowing and 20 cm inter-row spacing - A_1; and 9 $kgha^{-1}$ seeds per sowing and 50 cm inter-row spacing - A_2) were investigated.

As forage yield is highest at first cutting, the study of density effect was conducted using the primary growth. Dry matter yield was determined by measuring green forage in each replicate, drying the samples in a dryer unit at 60ºC until constant weight, and calculating tha^{-1} of dry matter (DM). The proportion of leaf (%) was determined on a sample of ten stalks with four replicates by separating leaves from stems and drying them.

Standard methods with four replicates were employed to determined the chemical composition of absolutely dry matter and content of mineral nutrients, and to calculate feeding energy. Those include:

- content of total nitrogen according to Kjeldahl, and crude proteins (CP) $N_{(\%)}$ x 6.25;

- content of crude fibre (CF) according to Scharner-Kurschner;

- content of crude fat (EE) according to Soxlet;
- content of crude ash (CA) by burning at 550ºC to constant weight;
- concentration of phosphorus by spectrophotometry;
- concentration of potassium by flame photometry;
- concentration of calcium by AAS.

Based on the results of chemical analysis, the proportion of nitrogen-free extract (NFE) was computed.

Feeding energy was determined according to *Obračević*, (1990). Under an international system of measurement, the feeding energy of dry matter is expressed as net energy lactation (NEL), or net energy for gain (NEM) in MJ/kg DM.

Results and Discussion

Under the agro-ecological conditions of eastern Serbia, the cultivar Novosađanka H-11 achieved the highest total dry matter yield (14.61 tha^{-1}) at A_1 density, while Europe had a significantly lower yield (13.51 tha^{-1}). Compared to A_1 density, the average dry matter yield recorded at A_2 density was lower by 2.83 tha^{-1}. The domestic cultivars again had a significantly higher DM yield than Europe at A_2 density (Table 1).

In a study by *Svirskis et al.* (2003), 12 alfalfa cultivars of different origin were tested and the highest DM yield was achieved with the domestic cultivars Žydrune (16.2 t ha^{-1}) and Birute (15.8 t ha^{-1}) and lowest with the Canadian cultivar Alfagraze (12.9 t ha^{-1}). The first cutting accounted for 34.1% of total DM yield.

Regarding leaf proportion, the cultivar NS-Slavija achieved the highest result (A_1-42.56% and A_2-41.25%) and Europe the lowest (A_1-40.03% and A_2-29.05%). *Beković* (1997) has reported a slightly higher average proportion of leaf at the first cutting (47.7%), while *Prudnikov et al.* (1988) found leaf proportion in total yield to be 46.2 %.

The highest crude protein content under A_1 density was recorded for the cultivar NS-Slavija (198.21 gkg^{-1} DM), significantly more than for Europe (189.21 gkg^{-1} DM). The investigated cultivars had by 1.13 gkg^{-1} DM higher average contents of crude proteins at A_1 density than at A_2. According to *Haby et al*. (1999), alfalfa grown at 23 cm inter-row spacing had 211.0 gkg^{-1} DM crude protein content, and 203 gkg^{-1} DM at 92 cm spacing.

A high positive correlation (r=0.962) was detected between crude protein content and leaf proportion.

Table 1. Total yield and average chemical composition of dry matter of different alfalfa cultivars at first cutting under densities A_1 and A_2
Tabela 1. Ukupan prinos i prosečni hemijski sastav suve materije sorti lucerke iz prvog porasta pri gustinama A_1 i A_2

Density A_1 Gustina A_1	DM Yield Prinos SM (tha^{-1})	Leaf proportion Udeo lista (%)	Chemical composition DM (gkg^{-1}) Hemijski sastav suve materije (gkg^{-1})				
Cultivar Sorte			CP SP	CC SC	CF SMM	CA SPe	NFE BEM
NS H-11	14,61	41,51	194,42	259,38	42,36	85,49	418,52
Slavija	14,56	42,26	198,21	258,91	42,54	85,78	415,06
ZA-83	14,52	41,78	196,73	258,90	42,42	86,10	416,73
Europe	13,51	40,03	189,60	262,13	42,40	85,12	416,34
$\bar{X}$	14,37	41,42	194,74	259,58	42,43	85,64	416,66
LSD 0,05	0,98	0,97	4,76	4,22	0,73	0,99	-
LSD 0,01	1,41	1,78	6,84	6,06	1,04	1,45	-
CV (%)	-	-	-	-	-	-	0,3
Density A_1 Gustina A_1	DM Yield Prinos SM (tha^{-1})	Leaf proportion Udeo lista (%)	Chemical composition DM (gkg^{-1}) Hemijski sastav suve materije (gkg^{-1})				
Cultivar Sorte			CP SP	CC SC	CF SMM	CA SPe	NFE BEM
NS H-11	11,93	40,45	194,85	266,71	42,53	86,05	409,35
Slavija	11,91	41,25	197,21	262,12	42,54	86,80	410,55
ZA-83	12,80	40,35	195,70	262,25	42,26	86,21	410,30
Europe	10,51	39,05	185,71	268,85	42,25	86,22	414,65
$\bar{X}$	11,54	40,27	193,42	264,98	42,39	86,55	411,21
LSD 0,05	1,39	1,22	7,44	10,73	1,04	1,21	-
LSD 0,01	2,02	1,76	10,70	15,43	1,49	1,74	-
CV (%)	-	-	-	-		-	0,51

Under A_2 density, NS-Slavija had the highest content of crude proteins (197.21 gkg^{-1} DM), while Europe again had the lowest value (185.71 gkg^{-1} DM).

Sown at higher densities, alfalfa plants develop more fragile stems, so that the content of fibres was consistently lower (A_1-259.58 gkg^{-1} DM; A_2-264.98 gkg^{-1} DM). Cultivars were not found to have a significant effect under

the densities investigated, although Europe (A_1-262.13 gkg^{-1} DM; A_2-268.85 gkg^{-1} DM) had slightly more crude fibre than the other cultivars (Table 1).

A highly negative correlation (r=-916) was found between leaf proportion and content of crude fibre, as well as between crude fibre and proteins (r=-806). The data are consistent with findings reported by *Katić et al.* (2002).

Table 2. Average content of nutrients and feeding energy of different alfalfa cultivars under densities A_1 and A_2
Tabela 2. Prosečni sadržaj mikroelemenata i energetska vrednost krme sorti lucerke pri gustinama A_1 i A_2.

Density A_1 Gustina A_1	Concentration (gkg^{-1}DM) Koncentracija (gkg^{-1}SM)			Energetic value (MJ/kg^{-1} DM) Energetska vrednost (MJ/kg^{-1} SM)	
Cultivar Sorta	P	K	Ca	NEL	NEM
NS H-11	2,41	14,95	16,93	4,89	4,64
Slavija	2,45	15,29	17,42	4,91	4,70
ZA-83	2,44	15,19	17,15	4,92	4,71
Europe	2,40	14,69	16,91	4,87	4,62
$\bar{X}$	2,43	15,03	17,10	4,90	4,67
LSD 0,05	0,09	0,80	0,98	-	-
LSD 0,01	0,13	1,48	0,32	-	-
CV (%)	-	-	-	0,55	0,90
Density A_1 Gustina A_1	Concentration (gkg^{-1} DM) Koncentracija (gkg^{-1}SM)			Energetic value (MJ kg^{-1} DM) Energetska vrednost (MJ/kg^{-1} SM)	
Cultivar Sorta	P	K	Ca	NEL	NEM
NS H-11	2,41	14,68	17,11	4,90	4,67
Slavija	2,51	14,98	17,35	4,89	4,66
ZA-83	2,49	14,91	17,29	4,89	4,67
Europe	2,40	14,65	17,10	4,88	4,62
$\bar{X}$	2,45	14,81	17,21	4,89	4,66
LSD 0,05	0,17	0,85	0,92	-	-
LSD 0,01	0,25	1,22	1,23	-	-
CV (%)	-	-	-	0,21	0,52

The average content of crude fat at both densities was 42.41 gkg^{-1} DM. This characteristic was found to have negligible variability both under the influence of cultivar and crop density. The leaf contained more crude fat, which resulted in a highly positive correlation between leaf proportion and crude fat (Table 3).

The average crude ash content was 85.64 gkg^{-1} DM at A_1 density, and 0.91 gkg^{-1} DM less at A_2. The cultivars were not found to have a significant effect on this characteristic. Also, there was no significant correlation between leaf proportion and crude ash content (r=0.185). *Đukić* (2002) found the proportion of crude ash, depending on alfalfa cultivar, to range from 78.0 to 85.0 gkg^{-1} DM.

Nitrogen-free extract (NFE) amounted to 416.66 gkg^{-1} DM at A_1 density and 411.21 gkg^{-1} DM at A_2. Cultivars were not a significant factor affecting this characteristic, and no significnt correlation was detected between NFE and leaf proportion (r=-0.010)

Concentration of phosphorus in alfalfa forage was 2.43 gkg^{-1} DM at A_1 density and lower by 0.02 gkg^{-1} DM at A_2. A somewhat higher concentration of this element was found in the cultivar NS-Slavija (A_1-2.45 gkg^{-1} DM; A_2-2.51 gkg^{-1} DM) but differences among cultivars were insignificant.

Marković *et al.* (2007) has recently measured phosphorus concentration of 2.9 gkg^{-1} DM in alfalfa forage at first cutting, and 0.2 gkg^{-1} DM higher concentration at second cutting. Data collected by *Slamka and Šimko* (1996) indicate that the conversion stage has a significant effect on phosphorus concentration in alfalfa feed.

Potassium concentration was 15.03 gkg^{-1} DM on the average at A_1 density, and 0.22 gkg^{-1} DM less at A_2. Contrary to these results, *Mišković et al.* (1975) had reported an insignificantly higher concentration of this nutrient in crops sown at low density. Data presented in Table 2 show that the cultivar NS-Slavija had somewhat higher concentration of this nutrient (A_1-15.29 gkg^{-1} DM; A_2-14.98 gkg^{-1} DM), while Europe had the lowest concentration (A_1-14.69 gkg^{-1} DM; A_2-14.65 gkg^{-1} DM). A positive and highly positive correlation was detected between leaf proportion and potassium concentration (Table3).

Table 3. Coefficients of correlation of leaf proportion (%) and DM quality parameters of different alfalfa cultivars
Tabela 3. Koeficijenti korelacije udela lista (%) i parametara kvaliteta suve materije sorti lucerke

Traits Osobina	Content of CP Sadržaj SP (gkg^{-1} SM)	CC Sadržaj SC	CF Sadržaj SMM	CAsh Sadržaj SPe	NFE BEM (gkg^{-1} SM)	cion of P Koncentracija P	ion of K Koncentracija K	cion of Ca Koncentracija Ca
Leaf proportion Udeo lista (%)	0,962	-0,916	0,500	0,185	-0,010	0,561	0,876	0,550
Content of CP Sadržaj SP (gkg^{-1} SM)	-	-0,806	0,564	0,341	-0,257	0,681	0,763	0,618
Content of CC Sadržaj SC (gkg^{-1} SM)		-	-0,277	-0,109	-0,309	-0,455	-0,923	-0,386
Content of CF Sadržaj SMM (gkg^{-1} SM)			-	-0,201	-0,224	0,216	0,379	0,365
Content of CAsh Sadržaj Spe (gkg^{-1} SM)				-	-0,677	0,792	0,123	0,657
NFE BEM (gkg^{-1} SM)					-	-0,525	0,261	-0,520
Concentracion of P Koncentracija P (gkg^{-1} SM)						-	0,477	0,785
Concentracion of K Koncentracija K (gkg^{-1} SM)							-	0,587
Concentracion of Ca Koncentracija Ca (gkg^{-1} SM)								-

Erić et al. (1996) found potassium content to decrease in the feed from the early blooming stage until the later stages of alfalfa growth and development. Data from research conducted under the agro-ecological conditions of Kruševac also showed that calcium concentration in alfalfa feed

was highest in the early blooming stage and decreasing in later stages (Ignjatović 1998).

Calcium concentration ranged between 17.42 gkg^{-1} DM (NS-Slavija) and 16.91 gkg^{-1} DM (Europe), depending on cultivar, and differences were insignificant under the different densities (Tab. 2). Calcium concentration was higher in the leaf, which resulted in a higer positive correlation (r=550) between these two characteristics. *Sauvant et al.* (2002) reported around 18.6 g kg^{-1} DM average calcium concentration in alfalfa hay.

The average feeding energy, expressed as net energy lactation (NEL), was 4.90 MJ kg^{-1}DM at A_1 density, and 4.89 MJ kg^{-1}DM at A_2.

Feeding energy expressed as net energy for gain (NEg) was 4.67 MJ kg^{-1}DM on the average at A_1 density and 4.66 MJ kg^{-1}DM at A_2. Cultivars were not a significant factor affecting these two parameters (Table 2).

Conclusion

Alfalfa cultivars investigated at first cutting during their second and third years of growth achieved DM yield higher by 2.83 tha^{-1} at A_1density than at A_2.

Under both investigated densities, the domestic cultivars achieved significantly higher DM yields, significantly greater proportion of leaf and contained significantly more crude proteins in DM than the cultivar Europe. No significant difference was found among the domestic cultivars regarding the characteristics examined.

The effect of cultivars on other parameters of feed quality was insignificant.

The proportion of leaf was highly positively correlated with the content of crude proteins (r=0.962), concentration of potassium (r=0.876), phosphorus (r=0.561), calcium (r=0.550) and content of crude fat (r=0.500). A highly negative correlation with leaf proportion was found for crude fibre (r=-0.916), while the correlation of leaf proportion with crude ash (r=0.187) and nitrogen-free extract (r=0.010) was insignificant.

Prinos i hranljiva vrednost krme, sorti lucerke pri različitim gustinama useva

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Rezime

Ispitivan je uticaj sorte na prinos suve materije i hranljivu vrednost krme lucerke. Istraživanja su obavljena u drugoj i trećoj godini života u prvom porastu, pri dve različite gustine useva. U obe ispitivane gustine useva, sorta kao faktor je pokazala značajan uticaj na prinos suve materije, udeo lista u ukupnom prinosu i na sadržaj sirovih proteina. Na ostale parametre hranljive vrednosti krme, uticaj sorte nije bio značajan. Visoku pozitivnu korelativnu vezu sa udelom lista su ostvarili sadržaj sirovih proteina (r=0,961), koncentracija kalijuma (r=-0,876), fosfora (r=0,561), kalcijuma (r=0,550) i sadržaj sirovih masnih materija (r=0,500). U visoko negativnoj korelaciji sa udelom lista je bila sirova celuloza (r=-0,916), dok udeo lista sa sirovim pepelom (r=0,185) i bezazotnim ekstraktivnim materijama (r=-0,010) nije pokazao korelativnu vezu.

Ključne reči: lucerka, gustine, sorte, prinos, kvalitet, korelacioni odnosi

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