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EFFECT OF CROP DENSITY ON YIELD AND QUALITY OF ALFALFA FORAGE FROM COMBINED USE (FORAGE-SEED)

R. Stanisavljević[1], J. Milenković[1], D. Đokić[1], D. Terzić[1], J. Marković[1], D. Beković[2], L. Đukanović[3]

[1]Institute for Forage Crops, Kruševac, 37251 Goboder, Republic of Serbia
[2]Faculty of Agriculture Priština, 38228, Zubin Potok, Republic of Serbia
[3]Agricultural Extension Service Sremska Mitrovica, Svetog Dimitrija 22, 22000 Sremska Mitrovica, Republic of Serbia
Corresponding author: rade.stanisavljevic@ikbks.com
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Abstract: In Serbia, alfalfa is the most important perennial forage legume that is grown at 180-200 thousand hectares. Except for the classic production of forage, alfalfa is very important for seed production. In our conditions Alfalfa seed are produced from the second cut of alfalfa. Higher seed yields are achieved in larger distances between rows. In this system of production first and third cut are used for fodder. This trial tests three different densities and four varieties in order to determine the impact on yield and quality of forage dry matter. In the year of establishment, cultivars from the treatment A_1 achieved higher yields of dry matter for 2.3 t ha^{-1} in relation to the treatment A_2. In the second year, yield was higher by 1.4 t ha^{-1}, and in the third higher for 3.1 t ha^{-1}. Treatment A_1 compared to A_3 treatment had a higher yield of 3.5 t ha^{-1} (52%). In the second year treatment A_1 achieved higher yields of forage then treatment A_3 for 3.8 t ha^{-1} (44%), and in the third year for 4.6 t ha^{-1} (56%). Cultivars were also significantly affected the yield of forage dry matter at all densities. Influence of density and variety to the chemical composition of forage and the content of macro elements in the forage had no significant effect.

Key words: alfalfa, crop density, forage, combined use

Introduction

Alfalfa, as the most important perennial forage legume, is cultivated in Serbia at about 200 thousand hectares. In seed production of alfalfa, first and third growth usually used to forage production and the second for seed. Alfalfa seed production requires low plant densities in the year of establishing and a small amount of seed for sowing *(Askarian et al., 1995; Beković et al., 2005 and 2008; Zhang et al., 2008)*. However, getting more seeds based on low densities impact on

reducing forage yield of alfalfa in the first and third growth *(Vučković, 1992; Beković, 2005)*.

It seems that it is very important to find the optimal crop density for the best compromise between yield of seed obtained from second growth and yield of forage obtained from the first and third growth. Domestic cultivars are the most represented in Serbia, for the both productions – forage and seed. Foreign varieties represented in the minimal surfaces.

Previous studies in the world and in our country showed that proper selection of varieties and optimum use of interaction cultivar and external environment can significantly affect the forage yield *(Annicchiarico and Pecetto, 2010)*. In our conditions, however, it often happens that (due to the strong drought in August and September) alfalfa not achieved the third growth and had no forage yield in the fall.

The aim of this study was to find how the combined (forage-seed) production of different varieties of alfalfa influenced on the forage yield obtained from the first and third growth, chemical composition, and the content of macro elements.

Materials and Methods

A trial was conducted in 2002-2004 on soil type smonitza in the agro-ecological conditions of Zajecar (43^0 53' N; 22^0 17' E and 159 m a.s.l.). Randomized block design with four replications used.

Crop density, as the first factor (factor A), had three treatments:

- 18 kg ha^{-1} seed and inter-row spacing of 20 cm (A_1),
- 9 kg ha^{-1} seed and inter-row spacing of 50 cm (A_2),
- 4.5 kg ha^{-1} seed and inter-row spacing of 80 cm (A_3).

Variety was the second factor and we used three domestic cultivars: (Novosadjanka H-11 (B_1); NS-Slavija (B_2); Zaječarska-83 (B_3) and one French variety Europe (B_4).

Sowing was in mid-April 2002. In the year of sowing the seeds usually have low yields, and forage yields were determined from the two cuts. In the first year of use (2003) because of pronounced dry period in summer (Table 1) the third cut was reduced (C_3). In the second year of use (2004) the yield and quality of forage were determined from the first (C_1) and third growth (C_3).

Chemical composition and content of mineral nutrients were done in four replicates and component concentrations were corrected to a 100º C dry matter basis. Energy feeding was also calculated according to the appropriate equations adapted from common formulas for forages. Using standard methods of chemical analysis was determined:

- Crude protein (CP),
- Crude fiber (CF),
- Nitrogen free extract (NFE),

- Phosphorus (P),
- Potassium (K),
- Calcium (Ca),

Statistical analysis of results was performed using the SPSS software *(SPSS, 2000)*.

Table 1. Agroecological conditions in Zajecar

Month	Average month temperatures (°C)			Precipitations (l m^{-2})		
	2002	2003	2004	2002	2003	2004
January	0.4	-0.3	-2.1	15.7	53.1	90.6
February	6.1	-3.3	2.2	1.9	19.4	41.8
March	8.8	4.2	6.6	15.3	7.8	46.6
April	10.3	10.2	11.9	50.3	89.0	46.4
May	18.6	22.9	14.9	45.2	60.5	27.6
June	22.6	22.5	19.5	43.5	43.3	81.3
July	23.8	22.3	21.9	117.3	55.6	49.0
August	20.8	24.3	20.5	118.0	1.3	62.1
September	15.7	15.6	15.9	73.1	67.6	35.6
October	10.6	9.1	12.2	53.6	149.0	45.9
November	6.6	6.5	6.6	30.3	27.2	78.6
December	-2.2	-0.5	1.9	63.3	35.7	34.8
Year average	11.8	11.1	11.0	627.5	609.5	641.2
Period (IV-IX)	18.6	19.6	17.4	447.4	317.3	302.0

Results and Discussion

Eastern Serbia is characterized by a pronounced dry periods in summer (Table 1), which is generally good for seed production, but in the same time these conditions affect on the reducing forage growth. Or even the lack of growth as it was in 2003.

Table 2. Statistical probabilities of *F* test for years, main effects, and their interactions on yield of dry forage, and content of CP, CF, NFE, P, K, Ca in forage

Source	df	Forage dry matter (t ha^{-1})	Content in dry matter (g kg^{-1} DM)					
			CP	CF	NFE	P	K	Ca
Year (Y)	2	**	NS	NS	NS	NS	NS	NS
Density (G)	2	**	NS	NS	NS	NS	NS	NS
Cultivar (C)	3	**	NS	NS	NS	NS	NS	NS
Yx G	4	**	NS	NS	NS	NS	NS	NS
Yx C	6	**	NS	NS	NS	NS	NS	NS
Gx C	6	**	NS	NS	NS	NS	NS	NS
Yx GxC	12	**	NS	NS	NS	NS	NS	NS

*Significant at the 0.05 probability level. **Significant at the 0.01 probability level. †NS, not significant.

Crop density, cultivar and year, as well as their interaction had a significant effect ($p \leq 0.01$) on forage yield (Table 2). The highest density achieved the highest yield of forage in all years (Table 3).

Treatment with the highest quantity of seeds in the sowing and the lowest inter-row spacing, compared to the average density, achieved in the first year (average of all varieties) better yield of dry forage for 2.3 t ha^{-1}; in the second year for 1.4 t ha^{-1}; and for 3.1 t ha^{-1} in third year. Also the highest density (treatment A_1) compared to the A_3 treatment had a higher yield for 3.5 t ha^{-1} (or by 52%); over the second year for 3.8 t ha^{-1} (44%), and for 4.6 t ha^{-1} in the third year (or 56%).

Table 2. Dry matter yield (t ha^{-1}) from combined production

Year	2002			2003			2004		
Density / Cultivar	A_1 C_1+C_2	A_2 C_1+C_2	A_3 C_1+C_2	A_1 C_1	A_2 C_1	A_3 C_1	A_1 $C_{1+}C_3$	A_2 $C_{1+}C_3$	A_3 $C_{1+}C_3$
A1	7.9ab	5.4b	3.9b	6.7ab	5.4b	2.9b	10.3a	7.3a	5.6b
A2	8.1a	5.8a	4.2a	6.9a	5.5a	3.1a	10.9a	7.5a	6.3a
A3	8.4a	5.9a	4.4a	7.0a	5.4a	3.2a	10.7a	7.6a	6.5a
A4	7.1b	5.1c	3.7b	6.6b	5.1b	2.8b	9.5b	6.8b	4.6c
Average	7.9	5.6	4.1	6.8	5.4	3.0	10.4	7.3	5.8

LSD significant level for column 5%.

In all years and all densities Zaječarska-83 and NS-Slavija showed superiority for forage yield. There is no significant difference between them ($p \leq 0.05$). In relation to the cultivar Europe, cultivars NS-Slavija and Zaječarska-83 had a significantly higher yield of forage during all three years with all densities. In compare to NS H-11, cultivars NS-Slavija and Zaječarska-83 did not show significant difference ($p \leq 0.05$) only in 2004 at the highest and high densities.

Several researchers pointed out that there are significant differences between domestic and foreign cultivars of alfalfa dry matter yield and forage production, and given the priority to domestic varieties, which are generally associated with better adaptability of local varieties. So *Svirskis (2003)* examined the yield of 12 varieties of alfalfa with different backgrounds (three from the Czech Republic, six from France, one from the Slovak Republic, two from Canada, and two from Lithuania). The highest dry matter yield was achieved with local varieties Birute and Žydrune (20.6 and 20.9 tha^{-1}). With the lowest yield was Canadian Alfagraze.

Table 3. Effect of density and cultivar on chemical composition dry matter forage yield (2002-2004)

Trait	CP (g kg^{-1} DM)			CF (g kg^{-1} DM)			NFE (g kg^{-1} DM)		
Density / Cultivar	A_1	A_2	A_3	A_1	A_2	A_3	A_1	A_2	A_3
B_1	199	198	198	258	269	269	421	410	409
B_2	200	200	199	259	263	264	417	413	411
B_3	199	198	197	259	262	270	417	413	408
B_4	193	193	190	269	269	273	413	414	413
Average	198	197	196	261	266	269	417	413	410
CV (%)	1.62	1.51	2.08	1.99	1.42	1.39	0.78	0.42	0.54

Examined factors yield, density and variety as well as their interaction did not significantly ($p \leq 0.05$) the content of crude protein, crude fiber and nitrogen free extracts (Table 2, and 3).

However, the forage of the treatment A_1 compared to forage from treatment A_3 (average of all varieties), over the three years period had a higher content of CP for 2 g kg^{-1} DM, lower content of CF for 8 g kg^{-1} and higher content of NFE for the 7 g kg^{-1} DM.

Similar results of density impact on CP content showed *Haby et al. (1999)*, in which the alfalfa grown in the inter-row distance of 23 cm had a crude protein content of 211.0 g kg^{-1} DM, respectively, and at 92 cm inter-row distance 203 g kg^{-1} SM. According to *Đukić (2002)*, effect of cultivar on CP content was higher (Leninskaja - 212 g kg^{-1}, NS Mediana - 188.0 g kg^{-1} DM).

Results about content of the CF and NFE in DM depending on the density and cultivars are similar with the results of *Negovanović et al. (1992)* and *Mišković et al (1975), 435.4-414.1 g kg-1 DM.*

Also, the density and variety impact as well as their interaction did not significantly ($p \leq 0.05$) affect the macro elements content in alfalfa forage (Table 4). However, the crop with high density (A_1) compared to low density (A_3) was found slightly higher concentration of P (for 0.02 g kg-1 DM), the concentration of K (0.6 g kg^{-1} DM) and Ca (0.5 g kg^{-1} DM).

Table 4 Effect of density and cultivar on macro element concentration in dry matter (g kg^{-1} SM) (2002-2004)

Trait	P (g kg^{-1} DM)			K (g kg^{-1} DM)			Ca (g kg^{-1} DM)		
Density / Cultivar	A_1	A_2	A_3	A_1	A_2	A_3	A_1	A_2	A_3
B_1	2.41	2.40	2.40	14.8	14.7	14.5	14.8	14.7	14.5
B_2	2.44	2.42	2.41	15.3	14.9	14.6	15.1	14.9	14.6
B_3	2.43	2.43	2.41	15.3	14.5	14.4	15.3	14.7	14.5
B_4	2.40	2.40	2.39	14.9	14.5	14.5	14.9	14.6	14.5
Average	2.42	2.41	2.40	15.1	14.7	14.5	15.0	14.7	14.5
CV (%)	0.75	0.62	0.40	1.74	1.31	0.56	1.48	0.85	0.34

Depending on the variety (the average density for all) the content of P differed for 0.03 g kg^{-1} DM, content of K for 0.5 g kg^{-1} DM and Ca content for 0.1 g kg^{-1} DM.

The results about the crop density impact on the concentration of macro elements are similar to *Mišković (1975)*, (K = 15.0 g kg^{-1} DM, Ca = 17.3 g kg^{-1} DM). While *Djukić (2002)* reported significant effects of genotype on microelement concentration in alfalfa dry matter forage.

Conclusion

Alfalfa forage production from the combined use (forage-seed) and a classic crop (12 -24 cm inter row density) provides less density and inevitably leads to a significant reduction in dry matter forage yield. Using of interaction of cultivar x environmental conditions and proper choice of cultivar could have a significant impact on the yield of dry matter forage crops at all densities.

Year, crop density, cultivar and their interactions did not show significant effect ($p \leq 0.05$) on the chemical composition and concentration of macro elements in the forage. However, althout they were not statistically significant, varieties NS-Slavija and Zaječarska-83 with higher density, showed better quality of forage.

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Uticaj gustine useva na prinos i kvalitet krme lucerke iz kombinovanog korišćenja (krma-seme)

R. Stanisavljević, J. Milenković, D. Đokić, D. Terzić, J. Marković, D. Beković, L. Đukanović

Rezime

Lucerka, kao najznačajnija krmna leguminoza se u Srbiji gaji na 180-200 hiljada hektara. Osim klasične proizvodnje za krmu, u širokoj proizvodnji je uobičajeno da se lucerka koristi kombinovano za seme i krmu, pri čemu se prvi i treći otkos koriste za krmu, a drugi otkos za seme. Semenska proizvodnja zahteva manju gustinu biljaka u godini zasnivanja i malu količinu semena za setvu, međutim, manja gustina useva utiče na smanjenje prinosa krme u prvom i trećem otkosu.

U ovom radu su ispitivane tri različite gustine i četiri sorte lucerke Novosađanka H-11 (B_1); NS-Slavija (B_2); Zaječarska-83 (B_3) i francuska sorta Europe (B_4), da bi se ispitala interakcija između sorti, gustina i ekoloških uslova na zadovoljavajući prinos i kvalitet kako krme, tako i semena.

Korišćenjem interakcije sorta x spoljna sredina može se značajno uticati na prinos suve materije krme pri svim gustinama useva. U poređenju sa sortom Europe, sorte NS-Slavija i Zaječarska-83 su imale signifikantno veći prinos krme tokom sve tri godine i pri svim ispitivanim gustinama, što se može objasniti boljom adaptabilnošću domaćih sorti.

Godine, gustina useva, sorta, kao i njihove interakcije nisu pokazale značajan ($p \leq 0.05$) uticaj na hemijski sastav i koncentraciju makroelemenata u krmi. Međutim, iako nije statistički značajno ipak je na usevu iz gustorednog useva (tretman A) kod sorti NS Slavija i Zaječarska - 83 utvrđen nešto bolji kvalitet krme.

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