Biotechnology in Animal Husbandry 25 (5-6), p 465-475, 2009 ISSN 1450-9156
Publisher: Institute for Animal Husbandry, Belgrade-Zemun UDC 633.31

ALFALFA-MOST IMPORTANT PERENNIAL FORAGE LEGUME IN ANIMAL HUSBANDRY

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Invited paper

Abstract: Important role of alfalfa in development of animal husbandry, is based on high potential for production of biomass. Reaching of high green (over 80 t ha^{-1}) and dry matter yield (approx. 20 t ha^{-1}) with low investment during all period of utilization makes alfalfa production very economical. Divergent selection materials were used to create high productive domestic alfalfa cultivars with excellent field persistence, which is important factor for high and stable yield during entire exploitation period. On the other hand, alfalfa is a rich source of crude protein with excellent digestibility. Proteins from alfalfa herbage are the cheapest source of protein in animal feed. Content of crude protein strongly depend on development stage of plant material and can be 200 to 240 g kg^{-1} DM, while crude protein yield can be over 3.5 t ha^{-1}. Besides that, alfalfa herbage had a high content of macro and micro element, which are so important for animal health. It is usually grown in pure stand, although it's a good component of grass-legumes mixtures. Alfalfa biomass can be used in several ways, usually as hay, but also as high quality silages, haylages, dehydrated in form of briquettes or by grazing. Symbiotic N_2 fixation gives alfalfa not just economical, but very high ecological importance, too. It's a reason why alfalfa, besides important role in conventional husbandry is getting great role in sustainable agriculture and organic production. All those characteristics confirm, that alfalfa is a really "queen" of forages.

Key words: alfalfa, forages, yield, quality

Introduction

Perennial legumes have important role in providing cheap forages of high nutritive value and digestibility. Among them the most familiar and widespread in world agriculture is alfalfa. This species was cultivated before recorded history and it has had a long and rich history, as forage crops. Due to rich and variable genetic base it has good adaptability on different environment condition and wide area of growing. Now it is cultivated in more than 80 countries in every continent of the globe in an area exceeding 35 million ha. It can grow between 55° northern and

50° southern latitude, and at 2500 m above sea level *(Ivanov, 1988)*. It is cultivated without irrigation in dry regions whit 200 mm annual precipitation as well as in humid region that receive 2500 mm precipitation. Deep, strongly develop root enables to alfalfa good tolerance to drought and high temperature and even in year with very low precipitation, it realizes satisfactory yield.

The importance of alfalfa in world agriculture can be attributed to a number of variable morphological and physiological characteristics *(Radović et al., 1996),*that contribute to its high and stable yield of nutritious herbage. The allogamy of this species and its autotetraploidy contribute to large within-population or within-variety genetic variation *(Radović et al., 2003, Radović, 2005)*. Its economical significance is based on high potential for production of biomass, over 80 t ha^{-1} of green and close to 20 t ha^{-1} of dry matter *(Nešić et al., 2005, Radović et al., 2004)*. The alfalfa forages is characterized by a high content of crude protein *(Dinić et al.,2005, Marković et al., 2007a)*, well balanced with respect to amino acid. It is enrich with vitally important vitamins, and various microelements essential for the normal growth and development of animal *(Marković et al., 2007b)*. Alfalfa is the basic component in feeding program for dairy cattle as well as for beef cattle, horses, sheep, birds and other classes of livestock.

Beside that, rapid recovery after cutting, longevity and tolerance to environmental stress is important for stabile yield during all period of exploitation. Also, symbiotic N_2 fixation in alfalfa eliminates the need for chemical N and adds a beneficial carryover effect in crop rotation.

In Serbia, alfalfa is a second most important forage crops behind maize. It is grown on over 200 000 ha in pure stand, which is about 4% of total agricultural area in Serbia *(Đukić et al., 2007)*. Sustainable agriculture and organic production are the important part of research project and agricultural development in Serbia, and the special role in those productions belongs to alfalfa.

Herbage Production

Alfalfa has a capacity to produce high yields of high quality forage. Regarding to its importance as forage crops, great attention in breeding program was paid on this species all over the world. Considerable that, scientific efforts has been and is being devoted annually to improvement of both yield and quality of alfalfa. Variability for agronomic and morphological traits of alfalfa is frequently used in breeding program for developing cultivars with high forage production and quality *(Jullier et al., 2000; Radović et al., 2001; Radović et al., 2009)*. As a result, numerous alfalfa cultivars have been created in last fifty years. In spite of that, genetic increases in alfalfa yield have been small compared with those realized in most grain crops. There a number of reasons for the slower rate of progress in increasing yield with alfalfa. One of the most obvious is the perennial growth habit of alfalfa, so one experimental strain must be evaluated for several years before decisions can be made in selection program. Large portion of the yield increase in many crops had been achieved by altering regulatory processes and increased the proportion of plant assimilates going into the desired plant organs without increasing total plant growth. But, it isn't possible in alfalfa, because the total plant is used for forage *(Evans, 1980)*.

Depends on soil and environment conditions, alfalfa achieves green matter yield from 50 to 100 t ha^{-1} and 12 to 19 t ha^{-1} dry matter yield *(Katić, 2000; Nešić et al., 2005; Stanisavljević et al., 2006)*. Unfortunately, the average dry matter yield obtained in farms in Serbia is about 5-6 t ha^{-1} (Table 1).

Table 1. Average alfalfa dry matter yield (t ha^{-1}) on farm in Serbia in last five years

	2004	2005	2006	2007	2008
Serbia	5.88	6.00	5.88	4.86	5.53
Central Serbia	5.77	5.68	5.46	4.37	5.17
Vojvodina	6.32	6.76	6.67	5.83	6.37

The main reason is failure of crop protection and production technology measures. The failures in sowing year usually have negative effect on plant density, which is most important for longevity alfalfa field.

Table 2. Average alfalfa yield in second and third year of utilization *(Radovic et al., 2004)*

Cultivar	Green matter yield t ha^{-1}			Dry matter yield t ha^{-1}		
	2th year	3th year	Average	2th year	3th year	Average
1. Poltavčianka	86.83	89.5	88.16	17.11	17.71	17.41
2. Nadežda	77.50	89.33	83.42	16.29	18.40	17.35
3. VNIOZ	71.83	82.17	77.00	16.24	17.03	16.63
4. Čišminskaja	66.15	76.83	71.42	14.05	15.28	14.66
5. Kapčiagaiska	74.00	84.50	79.25	15.91	17.45	16.67
6. Raduga	72.00	84.17	78.05	14.62	16.71	15.66
7. Bijska	64.17	55.17	59.66	13.78	10.99	12.38
8. Zarnica	69.83	86.83	78.34	15.34	18.64	16.99
9. Lada	63.67	69.67	66.66	13.06	13.39	13.23
10. Apšeron	77.67	90.67	84.16	16.66	17.57	17.12
11. Zydrune	66.17	93.00	79.58	13.92	18.14	16.03
12. Pop. Paraćin	87.83	86.00	70.25	18.60	17.09	17.85
13. Pop. Virine	74.50	84.33	79.41	16.49	17.58	17.03
14. Pop. BelaVoda	83.50	78.00	80.75	16.64	16.29	16.46
15. Pop. Poljna	70.50	80.67	75.58	14.92	15.52	15.22
16. K-22	89.93	84.50	87.16	20.42	18.56	19.50
17. Novosađanka	81.83	87.50	84.66	18.20	17.74	17.96
Average	75.17	82.52	77.85	16.01	16.71	16.36
LSD 0,05	20.604	15.427	15.66	4.343	3.060	2.441
0,01	27.700	19.678	21.06	5.839	4.116	3.284

Anyway, created alfalfa cultivars realizes high green mass and dry matter yield, in four to five cuts in years of full exploitation (Table 2).

Domestic alfalfa cultivars were created in Institute for forage crops in Krusevac, Center in Zajecar and Institute for field and vegetable crops in Novi Sad. They are characterized by high genetic potential for green and dry matter yield (over to 20 t ha^{-1} DM), excellent tolerance to environment stress conditions, which is responsible for stable and high forage yield during entire exploitation period *(Đukić et al., 2007; Radović et al., 2007)*. Domestic cultivars get higher yield, and better field persistence than introduced cultivars *(Radović et al.,1997; Radović et al., 2004; Stanisavljević et al., 2008)*.

Nutrition value

Alfalfa was regarded as a highly nutritious animal feed and it is preferred to other forages in feeding ruminants. The demand arises because its primary nutritive values is based on rapid passage through gastrointestinal tract, the large amount of soluble protein provided for rumen microorganisms for resyntesis of protein, synthesis of B vitamins and stimulation of cellulose digestion, the value of vitamin A, E and K or their precursor all of which are vital protective nutrients when alfalfa forages are fed to dairy cattle and the fact that alfalfa has relatively large amounts of cell soluble and lowest amount of cell walls in comparison with other forages *(Tomić et al., 2001)*.

The main effect on alfalfa forage quality belongs to plant stage. Differences between alfalfa cultivars are not significant *(Julier et al., 2000; Radović et al., 2004)*. The decline in alfalfa forage quality with advancing maturity is well documented *(Marković et al., 2008)*. This decline in quality is associated primarily with a decrease of crude protein content and to an increase in fibrous constituents of the steam. Digestibility and crude protein content of steam declined at a faster rate than those of leaves with increased maturity (Table 3).

Table 3. Chemical composition in leaves and stems of alfalfa (g kg^{-1} DM) ***(Marković et al., 2008)***

Stage	Crude protein		NDF		ADF		Hemicellulose	
	Leaf	Stem	Leaf	Stem	Leaf	Stem	Leaf	Stem
I	308	160	380	537	133	424	247	113
II	304	138	452	569	150	436	302	113
III	261	137	514	590	205	456	309	154
Av.	291	145	449	565	163	439	286	127
	SG	AF	SG	AF	SG	AF	SG	AF
P	***	***	***	***	***	***	***	***
$LSD_{0.05}$	1.31	1.06	10.1	8.2	11.2	9.1	12.7	10.3

NDF – neutral detergent fibre, ADF – acid detergent fibre, SG – stage of growth, AF – anatomical fraction

I stage – full boot, II stage – around 40% flowering, III stage – full flowering, Av. – average, ***- P<0.001

With increasing alfalfa maturity in a regrow cycle, forage nutrient concentrations decrease while forage dry matter yield and root carbohydrates generally increase to about mid-flowering. Cutting at first flower (10% blooms) has generally resulted in the best combination of seasonal herbage and nutrient (energy and protein) yield and stand persistence.

A number of inorganic elements are essential for normal growth and reproduction of animals, that why mineral content of forages are important for animal feeding. Amount of N, P, Ca and K decrease in later development stages, but even in latest stages the amount of stated macro elements satisfy the needs of cattle and dairy cows, as well as in all microelements (Table 4).

Table 4. Macro and microelements in different growth stages of alfalfa (mgkg^{-1}DM) ***(Marković et al., 2007b)***

Stage	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn
I	40.5	2.9	22.1	24.8	3.0	221.3	36.0	27.5	51.2
II	35.2	3.0	21.4	18.0	2.8	215.2	21.4	14.9	39.4
III	31.4	2.7	18.3	14.0	2.7	143.4	17.7	14.6	48.2
LSD 0.05	0.32	0.28	1.01	1.02	0.22	4.100	0.900	1.050	1.050
0.01	0.48	0.43	1.54	1.55	0.33	6.213	1.364	1.592	1.592

Utilization

Alfalfa is used for livestock nutrition in different forms, most frequently as hay, but also dried/dehydrated in form of briquettes, as silage, haylage or for grazing. Alfalfa is harvested and stored primarily as hay or silage for use on the farm. The feeding value of harvested alfalfa may be changed by postharvested factors as much as by precutting environment and history of plant. Conservation and storage system are designed to minimize the loss and deterioration of nutrients (Table 5).

Table 5. Effect of utilization way on dry matter lost

Harvesting method	Harvesting loss (%)
Drying in field	30-50
Silage	5-20
Dehydrate	5-7

Usual method of alfalfa exploitation is preparation of hay but this is usually associated with high losses of nutritive substances. The greater loss in digestible energy of hay was associated with increased leaf loss in rain-damaged hay, which is very often in first alfalfa cut which is a more productive.

Alfalfa is not suitable to ensilage alone because it has high buffer capacity, low level of sugar and low rate of dry matter (Table 6).

Table 6. Convenience of alfalfa forage for ensilage (g kg^{-1}DM) ***(Dinić et al., 2005)***

Stage of grown	Blooming				Flowering			
Parameters	Leaves	Stem	Whole plant		Leaves	Stem	Whole plant	
			Fresh	Wilted			Fresh	Wilted
Dry matter	162	158	170.7	303.7	179	174	234.3	373.7
Sugar (S)	67.9	84.3	52.7	69.9	94.0	76.7	54.5	73.1
B. capacity (BC)	120	100	114.7	117.3	120	84	116.0	97.3
S/BC	0.56	0.84	0.46	0.60	0.78	0.91	0.47	0.75
Crude protein	298.5	126.9	207.3	213.1	228.8	98.7	157.6	156.3
Crude fibre	111.6	324.2	252.6	247.6	103.2	357.6	294.2	301.1
Ash	128.5	107.5	130.6	131.7	127.2	92.1	116.8	110.1
Ca	22.2	9.0	15.3	15.9	25.3	10.4	16.2	18.4
P	4.7	4.5	4.7	4.3	3.9	4.1	4.1	4.0

In spite of that, by application of adequate preservation methods and procedures of fermentation stimulation *(Dinić et al., 1994ab)* biomass of alfalfa can successfully be ensiled, which would considerably reduce the losses of nutritive substance and enable its use throughout the year *(Dinić et al., 2005)*.

Alfalfa is mainly grown as pure crop, although it realizes satisfactory results even grown in mixture with grasses *(Lazarević et al., 1998; Nešić et al., 2007)*. It's a valuable pasture species. In the last decade, the interest for grazing tolerant alfalfa has increased in southern Europe together with a growing demand of sustainable agricultural and multipurpose utilization *(Battini et al., 2006)*.

Alfalfa role in sustainable and organic production

The practical value of alfalfa is not restricted to its fodder qualities alone. It also performs other important economic and biological functions: it enriches the soil with nitrogen, it is a good predecessor for many agricultural crops, serves as desalinator crop, it's a good green-manure and nectar producing crop and reduces effect of water and wind erosion by binding the soil. The well developed root system on alfalfa in the second to third year of growth produced 80 to 120 quintals per hectare of root mass and stubble in the arable layer of soil, which is equivalent to the application of 40-60 t of manure in terms of content of nitrogen, phosphorus, potash and other elements *(Ivanov, 1988)*. Nitrogen stored in subterranean organs and residues of alfalfa becomes available to companion or succeeding crops after phytomass degradation. Cultivation of alfalfa in crop rotation fields not only improves soil fertility, but also increases the yield of subsequent crops. All this traits make alfalfa essential in organic agriculture *(Torricelli, 2006)*.

Alfalfa symbiotically fixes greater amounts of atmospheric nitrogen than most other legumes species, and it's possible to introduce larger quantities of fixed nitrogen into agricultural cropping system as a replacement for fertilizer nitrogen. Alfalfa consistently shows greater amounts of N_2 fixation and percentage N derived from symbiosis, than most other legume species on a seasonal basis. Estimates of N_2 fixation in alfalfa vary from 50 to 463 kg per hectare per year (average 200 kg). Amount of fixed N depend of presence, density and effectiveness of *Sinorhizobium meliloti* on the soil type and land use regimes *(Delić et al., 1998)*.

Table 7. Dry matter yield (t ha^{-1}) in inoculated and inoculated alfalfa by strains of *S. meliloti* *(Delić et al., 2007)*

Strains	2006			2007		Total yield
	I cut	II cut	III cut	I cut	II cut	
236	4.565	5.220	3.400	6.895	7.500	27.580
234	4.205	4.590	3.175	8.645	8.100	28.715
224	4.195	4.370	2.600	7.350	5.800	24.315
Mix	4.050	4.295	2.125	5.005	4.500	19.975
Control	3.765	4.150	2.400	5.250	4.900	20.465
LSD 0.05	0.206	0493	0.386	0.631	0.812	

However, autochthonous strains are often insufficiently effective in field conditions and applying of effective strains with sowing can increased alfalfa dry matter yield about 30-40 % (Table 7).

Legumes have long been known to improve the yield of subsequent nonlegumes crops. The role of N_2 fixation by legumes as one factor in this yield improvement became known early in this century. Only the symbiotically fixed N in alfalfa dry matter can be considered as a net input to the soil-plant system in crop rotations, as the soil N contribution to alfalfa N content represents a temporary storage until it is recycled to the soil N pool. A variable proportion of the N_2 fixed by alfalfa is typically returned to the soil for possible use by the following crop. This is because a portion of the symbiotically fixed N_2 is removed from the land when alfalfa is harvested, with the balance remaining in unharnessed roots and crown.

Alfalfa is one of the few cultivated plants that can produce high level of biomass with minimum inputs. Sustainability of farming system under organic management may be increase by the introduction of alfalfa in the crop rotation *(Annicchiarico et al., 2006)*.

Conclusion

Alfalfa is the most important perennial forage crops species in Serbia. It is a remarkable crop in comparison with others. Alfalfa is a recognized as the most widely adapted agronomic crops, important and the cheapest source of protein rich forages of excellent amino acid composition and high digestibility, which is so valuable in economical animal husbandry.

Beside that, this species is important for soil improving, especially as effective source of biological nitrogen fixation and it has important place in crop rotation. It is one of the few cultivated plants that can produce high level of biomass with minimum inputs. It's a reason why alfalfa, besides important role in conventional husbandry is getting great role in sustainable agriculture and organic production. All those characteristics confirm, that alfalfa is a really "queen" of forages.

Acknowledgment

Research was financed by the Ministry of Science and Technological Development of Republic Serbia, project TR 20048.

Lucerka-najvažnija višegodišnja krmna leguminoza u ishrani domaćih životinja

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Rezime

Značaj lucerke u razvoju stočarstva, pre svega se zasniva na visokom potencijalu za prinos biomase. Visoki prinosi sena u višegodišnjem periodu iskorišćavanja (preko 20 t ha^{-1} suve materije), uz relativno niska ulaganja čine je rado gajenom i veoma rentabilnom vrstom. Varijabilni genski fond obezbeđuje lucerki dobru prilagođenost promenljivim agroekološkim uslovima. Korišćenjem divergentnog selekcionog materijala kreiran je veliki broj domaćih visokoprinosnih sorti lucerke odlične poljske perzistencije, što omogućava postizanje visokih i stabilnih prinosa biomase u toku dugogodišnjeg perioda iskorišćavanja. Na drugoj strani, lucerka se odlikuje visokim sadržajem hranljivih materija, posebno proteina odlične svarljivosti i predstavlja najvažniji i najjeftiniji izvor proteina, koji može nadomestiti njihov deficit u ishrani domaćih životinja. U zavisnosti od vrste i faze iskorišćavanja sadržaj sirovih proteina u suvoj materiji lucerke iznosi do 240 g kg^{-1}

suve materije, dok je prinos proteina i preko 3.5 t ha^{-1}. Pored toga, biomasa lucerke se odlikuje visokim sadržajem makro i mikroelemenata. Lucerka se najčešće gaji kao čist usev, mada može biti i komponenta travno leguminoznih smeša. Koristi se za ishranu stoke u raznim oblicima, najčešće kao seno, ali i dehidrirana u obliku briketa, kao silaža, senaža ili za napasanje. Značaj lucerke povećava činjenica da se primenom odgovarajućih metoda konzervisanja, proizvedena biomasa, uz minimalne gubitke hranljive vrednosti, može koristiti tokom cele godine. Proces biološke fiksacije azota daje lucerki, ne samo ekonomski, već i veoma visok ekološki značaj, pa pored velikog značaja u konvencionalnoj stočarskoj proizvodnji, lucerka ima sve veću i nezaobilaznu ulogu u održivoj i organskoj poljoprivrednoj proizvodnji.

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Received 31 May 2009; accepted for publication 15 August 2009