

Calcification of Acid Soils and Seed Inoculation as Preconditions for Alfalfa Cultivation

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Abstract: Aiming at seeking the best possible alfalfa cultivation technology on the poorly productive and acid soils over 2001, the trials were set up on the two localities (Cacak, Kraljevo). Two cultivars NS- Medijana, ZMS V and NS - Slavija coupled with calcification and pre-seeding inoculation were tested. CaO rated 3 t/ha was used for calcification and two strains *Rhizobium*, i.e. R₁ and R₂ for inoculation.

Two mowings were achieved over the year in the tested cultivars and the green matter yield was also high (42.64 and 42.95 t/ha), with the average stalk height of 68.61-70.01 cm. The application of calcification and pre-seeding seed inoculation outstandingly favoured the alfalfa green matter yield increase in both localities.

Key words: alfalfa, calcification, *Rhizobium*, green matter yield, high.

Introduction

Alfalfa is one of the most significant perennial roughages. High green matter yields, the share of and quality of proteins, longevity, abilities of nitrogen fixing are some of the properties ranking alfalfa as the unprecedented one in good quality roughage production. However, alfalfa is also highly sensitive to soil acidity so that for its growing neutral to the weakly alkaline reaction soils are considered to be the most suitable ones.

In the Republic of Serbia, weak-acid, acid and the extremely acid reaction soils (of over 60% arable lands) with an expressed deficiency of calcium and, as a rule, low yields of the most significant plants, are dominating (Stevanovic et al., 1995). This mainly implies lowlands and highlands of the following types: pseudogley, podzolic deluvial brown and brown acid soils in the highlands with extremely poorly contained alkalia of the medium to the strongly acid reaction, of the extremely improper structure and lowly contained organic matters, which are more or less suitable or even completely useless for the alfalfa cultivation.

In addition to their indigenous acid reaction and limited Ca absorption, these soils are featured with high presence of the readily available Al, Fe and Mn forms, unfavouring success of the field crops (alfalfa, sugar beet, soya, cabbage). As the result of phosphate ions immobilization, phosphorus becomes rather depleted in the plants, hence their root system grows inefficiently, and carbohydrates metabolism, N and P₂O₅ in the plants get poorer, too (D. Orlov, 1985). Therefore, alfalfa may be grown provided that sufficient calcium amounts are introduced in the soil.

When remedying acid soils, the application of lime substrates is outstandingly favouring the number and activity of the symbiotic nitrogen fixers. The number and microbiological activity of symbiotic nitrogen fixers in alfalfa and clover are limited due to low pH (Jarak M. et al., 1998). In acid soils, the viability of knotty bacteria on the alfalfa is being made difficult, their propagation slowed down, leading to a noticeably lower legume yield (Nutman, 1979). Better to say, due to calcification in acid soils, readily available Al decreases, whereas pH and nodulation on the plant root system, increases. Petrovic and Vojinovic (1968), Vojinovic (1973) found out that introduction of lime in acid soils is necessary for knotty bacteria growth and for a higher alfalfa yield. Also, Saric et al., (1983) pointed to the necessity of soil calcification aiming at the acid soil nodulation. By introducing lime, physical properties, in the first place soil structure and water permeability are markedly improved. Soil replenishment with Ca is enabling the availability of Ca, Mg, P and Mo. The alfalfa yield increases with pH increase or addition of Mo (Mulic et al., 1983, Katic et al., 1998).

The paper was, therefore, aimed at studying the effects of calcification and seed inoculation on the yield and its components in alfalfa and their contribution to the alfalfa green matter high quality production, as well.

Material and Method

Two experiments were arranged aiming at the optimal alfalfa growing technology on the sparsely productive and acid soils on the two localities over 2001:

The locality of Cacak - Mojsinje - trial field of the Faculty of Agronomy of the smonitza type of soil;

The locality of Kraljevo -Adrani - the individual holding of the sandy soil type over the process of its becoming smonitza.

The experiment was arranged according to the random split block design with three replications on the area of 342.4 square meters. The area of the elementary plot amounted to six square meters.

The research included the following factors:

Factor A-calcification level (with CaO and without R₁ and R₂);

Factor B-cultivar (NS Medijana ZMS V and NS Slavija) and

Factor C- seed inoculation (Ø -without inoculation, R₁ and R₂).

Maize was a preceding crop on the locality of Cacak and wheat on that of Kraljevo. The basic tillage implied autumnal deep plough up to the depth of 35 cm. By the end of March, some time before pre-seeding soil preparation, the lime was introduced in the amount of 3 t/ha. After the lime had been introduced in the soil, the pre-seeding of soil proceeded by means of harrow disc with fine top dressings by means of seeding equipment. The seeding was carried out on 27th March, 2001 on the locality of Kraljevo and on 3rd April, 2001 on that Cacak.

2-2.5 g/m², i.e. 10-15 g/ per elementary plot, were used for seeding. Weeds control was performed, using Pivot 100-E chemical in the amount of 1l/ h.

The trials were performed in dry crop growing conditions without irrigation.

Prior to setting up of the trial, soil samples for chemical analysis at the depth of 0-20 cm had been taken for more important chemical properties determinations.

In order to determine the basic morfo-metric parameters in the stage of flowering, the two samples were taken for the plant height determination.

The organic mass yield of the green alfalfa part was determined gravimetrically at the moment of mowing.

The results were statistically processed, using the analysis of variance method for the three-factor trial (calcification level x cultivar x inoculation) while the individual and interaction differences were determined by LSD test.

Environmental conditions

The natural factors indigenous to Serbia are considered to be mainly suitable for the crop and vegetable production allowing for the fact that precipitations, particularly over the recent years, are deficient or unsuitably distributed over the vegetation, which is a limiting factor of the high and stable yields.

All the other environmental parameters have a pronounced effect on the plant yield, while the precipitation amounts and distribution and air temperatures have the most significant one.

From the data in tab.1, one can see that the average air temperature over 2001 was 12.6° C, i.e. by 1.5°C higher than the long-term average. The total precipitation amount was 781.4 mm, slightly higher than the long-term average. The warmest months appeared to be July, August with 23.5°C and 24.3°C, respectively, but rainfall amounts were enough, i.e. 100.6 mm (July) and 72.3 mm (August), respectively. Over the year, an even rainfalls distribution was

noticed, from germination and emergence and, to some extent, over the vegetation, resulting in a satisfactory yield in the seeding year.

Tab,1 Air Temperature (°C) and Precipitation Amounts

		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	$\overline{X}$
°C	2001.	3.1	4.6	11.9	11.2	19.0	19.7	23.5	24.3	16.4	14.2	5.8	-2.1	12.6
	1965-1994	-3.3	2.4	6.4	11.5	16.2	19.5	20.9	20.5	16.9	11.8	5.8	1.5	11.1
mm	2001.	27.0	34.2	43.3	132.4	50.3	78.5	100.6	72.3	146.6	5.8	72.4	18.0	781.4
	1965-1994	34.2	44.8	53.8	57.8	88.6	98.2	76.0	59.5	56.5	47.8	58.6	57.6	749.4

The experiment was performed on the smonitza type of soil characterized with fairly acid reaction (pH - 5.01), well supplied with potassium (26.38mg/100 g soil) but poor in readily available phosphorus (1.78 mg/100 g soil).

Results and Discussion

Plant height - In addition to being varietal property, plant height also depends upon the environmental conditions and age. The average plant height in the cultivars studied in Cacak ranged from 69.15 cm to 70.01 cm, while that in those studied in Kraljevo ranged from 68.61 cm to 68.87 cm (tab.2.). Somewhat shorter stalk was established in the cultivar Slavija in both localities.

Tab. 2. Plant height of Alfalfa per mowings in the Year of Establishing Alfalfa Plot

locality		Cacak				Kraljevo			
cultivar		Medijana ZMS V		Slavija		Medijana ZMS V		Slavija	
mowings		I	II	I	II	I	II	I	II
With CaO	Ø	71.90	71.60	68.45	69.57	71.85	73.15	71.80	71.45
	R ₁	74.60	75.17	72.68	74.10	72.57	72.65	73.55	76.60
	R ₂	73.70	73.53	74.95	75.08	74.45	75.20	75.10	72.35
	$\bar{X}$	73.40	73.43	72.06	72.91	72.95	73.66	73.48	73.46
Without CaO	Ø	64.80	66.30	63.95	64.72	64.95	63.80	60.85	62.50
	R ₁	66.20	67.00	66.00	66.00	65.20	64.20	63.35	64.50
	R ₂	65.20	70.07	66.77	67.30	65.10	63.40	65.76	65.50
	$\bar{X}$	65.40	67.79	65.57	66.00	65.08	63.80	63.32	64.16
$\bar{X}$		70.005		69.135		68.872		68.605	

Green matter yield - Domestic alfalfa cultivars are characterized with the high genetic potential for the green matter yield.

The highest green matter yields were achieved between the second and fourth year, and the lowest ones in the first and fifth one (Djukic, 1989).

In the year of establishing alfalfa plot, two mowings with the remarkably high green matter yields on both localities, were achieved (Tab.3.)

Tab.3. Alfalfa Green Matter Yield per Mowings in the Year of Establishing Alfalfa Plot

locality		Cacak				Kraljevo			
cultivar		Medijana ZMS V		Slavija		Medijana ZMS V		Slavija	
mowings		I	II	I	II	I	II	I	II
With CaO	Ø	20.94	21.34	20.94	19.92	21.71	21.41	22.69	22.22
	R ₁	22.94	23.88	22.39	22.12	23.05	24.60	24.28	25.43
	R ₂	25.50	26.68	23.89	23.92	25.11	25.63	25.32	25.46
	$\bar{X}$	23.13	23.97	22.41	22.00	23.29	23.88	24.10	24.37
Without CaO	Ø	19.055	19.611	17.778	18.700	18.39	20.30	15.78	16.27
	R ₁	19.294	21.333	19.500	20.322	18.89	19.28	18.11	19.57
	R ₂	21.055	21.461	18.944	19.133	19.78	20.98	18.67	16.70
	$\bar{X}$	19.801	20.801	18.740	19.385	19.02	20.19	17.52	17.51
Average		21.93		20.63		21.59		20.87	

The total alfalfa green matter yield on the locality of Cacak averaged 42.64 t/ha (tab.4.). Thus, Katic et al., (2002) attained the long-term green matter yield of 55.2 t/ha with the NS alfalfa cultivars.

The cultivars studied were found to positively respond to lime application. The difference between the variant with (45.92 t/ha) and without lime (39.36 t/ha) seemed to be highly significant statistically (tab. 4, fig. 1). That calcification favours yield was corroborated by findings of Bosnja and Stepanovic (1987), Saric et al., (1980).

Also, microbiological fertilizers were found to highly significantly increase the yield, primarily in the variants with calcification performed.

The viability of knotty bacteria was rather difficult in acid soils, which reduced legumes yield (Nutman, 1979).

Tab.4. Alfalfa Green Matter Total Yield in the Alfalfa Plot Establishing Year (2001) -the locality of Cacak

	With CaO				Without CaO				$\bar{X}$			$\bar{X}$
	Ø	R ₁	R ₂	$\bar{X}$	Ø	R ₁	R ₂	$\bar{X}$	Ø	R ₁	R ₂	
Medijana	42.29	46.83	52.18	47.10	38.67	40.63	42.52	40.60	40.48	43.78	47.35	43.85
Slavija	40.86	44.56	48.81	44.74	36.48	39.82	38.08	38.13	38.67	42.19	43.44	41.43
$\bar{X}$	41.57	45.69	50.49	45.92	37.57	40.23	40.30	39.36	39.57	42.96	45.40	42.64

LSD	A	B	AB	C	AC	BC	ABC
0,01	1.32	1.32	1.87	1.62	2.29	2.29	3.25
0,05	1.80	1.80	2.55	2.21	3.12	3.12	4.41

The average green matter yield of 42.50 t/ha was achieved with two mowings in Kraljevo with lime application enhancing yield to a great extent (47.88 t/ha) compared to the variant without CaO (37.12 t/ha), (tab.5, fig. 2). Thus, Medijana was found to averagely produce higher yield by 1.38 t/ha than Slavija did, which was significant statistically. In fact, the cultivar Slavija responded better to this agrotechnical measure in the locality concerned.

Tab.5. The Total Alfalfa Green Matter Yield over the Seeding Year (2001)- the locality of Kraljevo

	With CaO				Without CaO				$\bar{X}$			$\bar{X}$
	$\emptyset$	R ₁	R ₂	$\bar{X}$	$\emptyset$	R ₁	R ₂	$\bar{X}$	$\emptyset$	R ₁	R ₂	
Medijana	43.12	47.65	50.75	47.17	38.69	38.17	40.76	39.21	40.90	42.91	45.75	43.19
Slavija	44.92	49.71	51.12	48.58	32.04	37.68	35.37	35.03	38.48	43.69	43.24	41.80
$\bar{X}$	44.02	48.68	50.93	47.88	35.37	37.92	38.06	37.12	39.69	43.30	44.50	42.50

LSD	A	B	AB	C	AC	BC	ABC
0,01	1.14	1.14	1.61	1.39	1.97	1.97	2.79
0,05	1.55	1.55	2.19	1.90	2.68	2.68	3.79

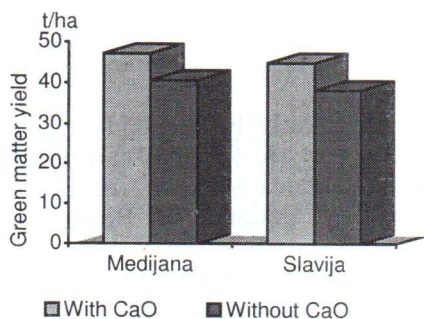


Fig. 1. The Alfalfa green matter Yield - Cacak

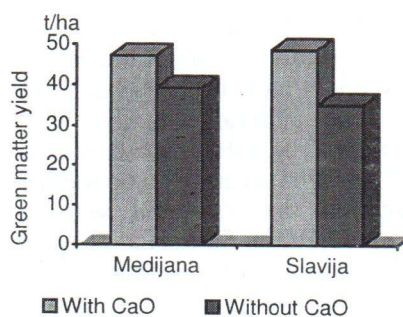


Fig. 2. The Alfalfa green matter Yield - Kraljevo

Also, the pre-seeding seed inoculation resulted in the highly significant yield increase compared to the control.

Conclusion

In the Republic of Serbia, the acid soils are considered to be a significant problem arising in agricultural production. These soils occupy around 60% arable land areas on which yields appear to be regularly low. Without previously performed remedial measures, no successful production may be expected on acid soils.

Two mowings with high yield of green matter (42.64 and 42.95 t/ha) were accomplished in the year of the alfalfa plot establishing, with the average stalk height of 68.61-70.01 cm.

Calcification was found to highly significantly enhance yield in both localities.

Pre-seeding seed inoculation resulted in the highly significant yield increase compared to the control.

Finally, calcification can be recommended as a necessary measure when establishing alfalfa plot with seed inoculation previously performed.

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KALCIFIKACIJA KISELIH ZEMLJIŠTA I INOKULACIJA SEMENA KAO PREDUSLOV UNAPREĐENJA GAJENJA LUCERKE

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Rezime

U cilju iznalaženja optimalne tehnologije gajenja lucerke na slabo produktivnim i kiselim zemljištima tokom 2001.god. postavljeni su eksperimentalni ogledi na dva lokaliteta (Čačak i Kraljevo). U ogledu su ispitivane dve sorte lucerke NS -Medijana ZMS V i NS - Slavija i to uz primenu kalcifikacije i predsetvene inokulacije semena. Za kalcifikaciju korišćen je CaO u količini 3 t/ha, a za inokulaciju su korišćena dva soja Rhizobiuma označeni kao R₁ i R₂.

Sa ispitivanim sortama ostvarena su dva otkosa u godini zasnivanja sa visokim prinosom zelene krme (42,64 i 42,95 t/ha) i prosečnom visinom stabljike od 68,61-70,01 cm. Primena kalcifikacije i predsetvene inokulacije semena su uticale na visoko značajno povećanje prinosa krme lucerke u oba lokaliteta.