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THE IMPACT OF FOLIAR APPLICATION OF MOLYBDENUM ON ALFALFA GERMINATION ENERGY AND SHARE OF HARD SEEDS

UTICAJ FOLIJARNE PRIMENE MOLIBDENA NA ENERGIJU KLIJANJA I UDEO TVRDIH SEMENA LUCERKE

Dragan TERZIĆ, Rade STANISAVLJEVIĆ**,Ranko KOPRIVICA***,*
Jasmina MILENKOVIĆ, Dragoslav ĐOKIĆ*, Jasmina KNEŽEVIĆ ****, Dobrivoj POŠTIĆ***
**Institute for forage crops Kruševac; 37251, Goboder, Kruševac, Serbia*
***Institute for plant protection and environment, Teodora Drajzera 9, 11000 Belgrade, Serbia*
****University of Kragujevac, Agronomic Faculty, Cara Dušana 34, Čačak, Serbia*
*****University of Priština , Faculty of Agriculture, 38219 Lešak, Kopaonička bb, Serbia*
e-mail: dragan.terzic@ikbks.com

ABSTRACT

The aim of this study was to investigate the influence of foliar application of molybdenum on the germination energy and share of hard alfalfa seeds. Climatic conditions during the year had the greatest impact on the germination energy and share of hard seeds. Energy of germination was influenced by climatic conditions during the development of crops, ranging from 68.5 % to 84.1 %. Minimum germination energy was generated in the year with the most rainfall during seed formation, and the highest germination energy was achieved in the year with less rainfall during seed formation. The share of hard seeds ranged from 5.1 % to 6.7 %. Treatments with molybdenum in our research did not realize the difference in the germination energy and share of hard seeds that is statistically justified in any year of study.

Key words: *Alfalfa, molybdenum, germination energy, hard seeds.*

REZIME

Molibden je veoma važan u simbiotskoj fiksaciji azota i lucerka spada u grupu biljaka koja je osetljiva na nedostatak molibdena. U trogodišnjem periodu obavljena su ispitivanja na oglednom polju Instituta za krmno bilje u Kruševcu. Cilj ovih istraživanja bio je ispitati uticaj folijarne primene molibdena na energiju klijanja semena lucerke i udeo trvdih semena. Folijarana prihrana molibdenom (0,1% amonijum molibdata $(NH_4)_6\ Mo_7O_4\ x\ 4H_2O$ je obavljena preko dve aplikacije (prva aplikacija je obavljena u fazi intezivnog porasta, a druga aplikacija u fazi butonizacije i početka cvetanja useva) sa količinom vode 1000 l ha^{-1}. Energija klijanja je bila pod uticajem klimatskih uslova u toku razvoja useva i kretala se od 68,5% do 84,1%. Najmanja energija klijanja je ostvarena u godini sa najviše padavina u periodu formiranja semena. Energija klijanja se razlikuje po godinama ali je prosečna energija klijanja na kontrolni i varijatni tretiranoj molibdenom ujedančena. Udeo tvrdih semena se kretao od 5,1% do 6,7%. Najmanji udeo tvrdih semena je ostvaren u godini sa najviše padavina u letnjem peridu a najveći u godini sa manje padavina u periodu formiranja semena. Prosečni udeo tvrdih semena na kontrolnoj i tretiranoj varijanti nije ostvario značajne razlike. Tretmani sa molibdenom u našim istraživanjima nisu ostvarili razliku u energiji klijanja i udelu tvrdih semena koja je i statistički opravdana ni u jednoj godini ispitivanja.

Ključne reči: *lucerka, molibden, energija klijanja, tvrda semena.*

INTRODUCTION

The great importance of alfalfa (*Medicago sativa* L.) is reflected in the production of high-quality roughage, but the alfalfa seed is valuable commodity circulating in the domestic and foreign markets. In Serbia, the production of alfalfa seed is significant in order to meet the domestic needs, but alfalfa seed has also been exported in certain years. In the production of alfalfa seed objective is to achieve high seed yields and produce high quality seed. Seed quality is monitored through the vigour/germination energy and germination capacity of alfalfa seed *(Bolanos-Aguilar et al., 2002; Iannucci et al., 2002)*. In order to achieve the maximum seed yield, all nutrient elements must be available in sufficient quantity *(Hall et al., 2002)*. In studies of *Du et al. (2009)*, molybdenum increased alfalfa seed yield from 27 to 47 %, the number of inflorescences per stem from 38 to 55 %, number of pods per inflorescence 100-133 %, the number of seeds per pod 48 to 61 % and 1000 seeds weight by 24 %. The same authors cite the results of *Zhao and Hong (1998)* who have stated that the application of 0.05 % ammonium molybdate increases germination of alfalfa seed, while in the study of *Du et al. (2009)*, fertilization with micronutrients has no effect on seed germination of alfalfa. *Stjepanović et al. (1986),* have achieved yield increase from 10.6 to 38.9 % by treatment with molybdenum, contrary to *Terzić (2010)* who has not determined significant impact of foliar application of molybdenum on seed yield. Germination energy is high and positively correlated with total germination (*Beković, 2005; Stanisavljević, 2006)*. On the other hand, the hard seeds are negatively correlated with germination. They are alive but with an impermeable seed coat for water, gases, etc., so they do not germinate. This seed will germinate after a period of seed storage or treatment application, i.e. when the seed coat becomes permeable. Therefore, seedlings from hard seed occurring later on already formed alfalfa crop, can not withstand the competition and do not contribute to establishing crops (*Bass et al., 1988*). Environmental conditions during the year have considerable impact on yield variation impact on considerable variation in yield, absolute mass, seed germination, germination energy and share of hard seeds (*Karagić, 2004; Stanisavljević, 2006; Terzić et al., 2014*).

The aim of this study was to examine the impact climatic condtions of the year and foliar application of molybdenum on germination energy and number of hard alfalfa seeds.

MATERIAL AND METHOD

Research was carried out at the experimental field of the Institute of Forage Crops in Kruševac during 2005, 2006 and 2007. The soil used in the studies, in regard to its chemical properties, belongs to the group of low acidity soils, but in regard to the content of molybdenum (0.21 ppm) this soil is considered as medium contents.

Foliar fertilization with molybdenum (0.1 % ammonium molybdate $(NH_4)_6\ Mo_7O_4$ x $4H_2O$ was carried outin two applications (first application was made in the phase of intensive increase/growth, and the second application in the bud phase and initial flowering of crops) with the amount of water of 1000 l ha^{-1}.

After the harvest of seeds and completion of field tests, germination energy, total germination and percentage of hard seed were determined in the laboratory conditions on filter paper at a temperature of 20 ^{0}C in the dark. Germination energy read on the fourth day, total germination read on the fourth day, total germination read the tenth day. The seed was analysed according to the provisions of the Rulebook about seed quality of agricultural plants (*Official Gazette no*. 74/87, 60/87, 55/88, 81/8 9, 16/92, 8/93, 21/93, 30/94, 43/96, 10/98, 15/2001, 58/2002), which is in accordance with international rules on the quality of seeds (ISTA, 1987).

Statistical processing of the data was done using the analysis of variance (ANOVA). Significance of differences was tested using LSD test. The correlation coefficient (r) was determined by the correlation analysis

Table 1. Agro-ecological characteristics of the examined years

Year	Total precipitation sum (mm)		Number of days with precipitation (June, July, August)	Mean annual temp. (ºC)	Average t ºC (June, July and August)
	Annual	June, July and August			
2005	808	274	29	10.9	20.3
2006	651	167	24	11.4	21.1
2007	745	136	15	12.7	21.3
Average (1989-2008)	614	175	20	11.6	21.3

RESULTS AND DISCUSSION

Germination energy varied from year to year. The lowest value of germination energy 68.5 % was generated in 2005. Climatic conditions, especially rainfall, are important in alfalfa seed production. In the production of alfalfa seed, summer rainfall during flowering, pollination of alfalfa and seed formation is especially important *(Terzić et al., 2014)*. High total precipitation (808 mm), and particularly large amount of rainfall in June, July and August (274 mm) led to the lodging of crops at the beginning of flowering and later to bad pollination and regrowth of seed crop which all affect the germination energy in year 2005. Higher germination energy was observed in 2007 (80.6 and 80.7 %). The highest germination energy was observed in 2006 both in the control variant (84.1 %) and in the molybdenum treatment (83.8 %). The germination energy has exhibited a strong positive correlation (tab. 3) to with total germination (0.99). The germination energy has exhibited a strong negative correlation to with the annual sum of precipitation and with the sum of precipitation in June, July and August (-0.91). In comparison to the precipitation, temperatures were in positive correlation with the energy of germination. The average annual temperature had a mean correlation value (0.56) as well as and mean temperatures in June, July and August (0.44).

Table 2. Influence of foliar application of moliybdenum on germination energy and percentage of hard seed

Year	Treatment					
	Control		Molibdenum treatment		Average	
	Germination energy (%)	Hard seeds (%)	Germination Energy (%)	Hard seeds (%)	Germination energy*	Hard seeds
2005	68.5b	5.1b	68.5b	5.3b	68.5b	5.2b
2006	84.1ab	5.5b	83.8ab	5.7ab	83.9ab	5.6ab
2007	80.6a	6.3a	80.7a	6.7a	80.7a	6.5a
Average	77.7	5.6	77.7	5.9	77.7	5.77
F test	Factor/trait		Germination		Hard seeds	
	Year		x		x	
	Molibdenum		ns		ns	
	Year x molibdenum		ns		ns	

**Values followed by different letters within columns are significantly different (p≤0.05) according to the LSD test. ns - not statistically significant*

The achieved results are within the values obtained by (*Vučković, 1994; Karagić, 2004; Beković, 2005; Stanisavljević, 2006*). The authors also emphasized variations in germination energy influenced by environmental conditions during the year.

When observed by years, share of hard seeds ranged from 5.1 (2005) to 6.3 (2007). The lowest percentage of hard seeds was obtained in the year with plenty of rainfall (2005), while the most of hard seeds was recorded in a dry year (2007), which is consistent with the statements of *Beković (2005)*, who concluded that the share of hard seeds in years with more rainfall is lower (5.15 %), and higher in the arid/dry years (7.95 %).

Similar results were also mentioned by *Vučković (1994)*, who has determined the highest number of hard seeds in an exceptionally dry year (7.99 %), while the percentage was below in average dry year (3.3 %). In addition, research by *Fick et al. (1988)* stated that water stress increases the percentage of hard seeds.

Foliar treatments with molybdenum showed no significant differences in germination energy and realized germination average was the same in the control and the molybdenum variants, which is consistent with the results of *Vučković (1994)* and *Du et al. (2009)*. In the study of the supply of microelements

in alfalfa in plant material obtained in central Serbia and Southeast Serbia, carried out (*Terzić et al., 2013*), no molybdenum deficiency has been established.

Table 3. The correlation coefficients (r) between the studied factors and characteristics

Trait			Germination energy	Total germination	Hard seeds	Precipitation			Mean temp °C Annual
							Sum (mm)	No of days	
						Annual (mm)	June July Aug		
Total germination			0.99**						
Hard seeds			0.58ns	0.66ns					
Precipitation	Sum (mm)	Annual	-0.91*	-0.85ns	-0.19ns				
		June July Aug	-0.91*	-0.95*	-0.86ns	0.66ns			
	No of days		-0.63ns	-0.77ns	-0.99**	0.24ns	0.89ns		
Mean Temp. °C	Annual		0.56ns	0.65ns	0.99**	-0.16ns	-0.85ns	-0.99**	
	Average (June July Aug)		0.44ns	0.50ns	0.99**	-0.02ns	-0.83ns	-0.97**	0.99**

*ns not significant P >0.05, *Significant P < 0.05, **Significant P <0.01.*

Foliar application of molybdenum showed no significant difference in the proportion of hard seeds. The share of hard seeds showed negative correlation with precipitation in June, July and august (-0.86) and negative correlation with the number of days with precipitation (-0.99). Unlike precipitation, the share of hard seeds had a positive correlation (0.99) with temperatures in June, July and August.

CONCLUSION

Foliar fertilization with molybdenum had no impact on germination energy and share of hard seeds.

Weather conditions had impact on germination energy. Germination energy was the lowest in the year when high total sum of rainfall and high sum of rainfall during flowering, pollination and seed filling period (June, July, August) were recorded.

Precipitation and number of days with precipitation showed a negative correlation with germination energy and share of hard seeds.

Unlike precipitation, temperatures during June, July and August were positively correlated with the energy of germination and share of hard seeds

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