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EFFECTS OF FOLIAR APPLICATION OF ZINC ON GERMINATION ENERGY OF ALFALFA SEED AND SHARE OF HARD SEEDS

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

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ABSTRACT

In three year study, the influence of foliar application of zinc on seed germination energy and share of hard alfalfa seeds was examined. The experiment was conducted at the experimental field of the Institute of Forage Crops, Kruševac. The soil on which the trial was conducted is of weakly acidic reaction and zinc content which is considered adequate. Zinc fertilization was performed by foliar split application. In the investigation years, meteorological factors showed large variations. Treatment with zinc achieved on average slightly higher germination energy, but differences were not statistically significant. Zinc fertilization had no effect on the number of hard seeds. Climatic conditions had impact on the germination energy and the proportion of hard seeds.
Key words: *Alfalfa, zinc, germination energy, hard seeds.*

REZIME

Cink je jedan od mikroelementa koji se često nalazi u nedostatku kod gajenih biljaka. Cilj ovih istraživanja bio je ispitati uticaj folijarne primene cinka na energiju klijanja semena lucerke i udeo tvrdih semena. U trogodišnjem periodu obavljena su ispitivanja na oglednom polju Instituta za krmno bilje u Kruševcu. Zemljište na kome je izveden ogled je slabo kisele reakcije a sadržaj cinka u zemljištu je za lucerku bio u adekvatnom rangu. Folijarna primena cinka (1% cink sulfata ($ZnSO_4$ x $7H_2O$) je obavljena u podeljenoj aplikaciji. Prosečna energija klijanja je iznosila 78.0% sa velikim variranjem po godinama od 68,5% do 84,8%. Velika ukupna količina padavina u 2005. godini (808 mm), odnosno velika količina padavina u junu, julu i avgustu je dovela do poleganja useva još na početku cvetanja i do kasnije loše oplodnje i prorastanja semenskog otkosa što je uticalo da energija klijanja u toj godini bude znatno niža (68,7%) u odnosu na ostvarenu energiju klijanja u 2006. (84,5%) i 2007. godini (80,8%). Tretman sa cinkom je u proseku ostvario nešto veću energiju klijanja (78,2%) u odnosu na kontrolu (77,7%), ali razlike nisu i statistički opravdane. Energija klijanja je pokazala jaku negativnu korelacionu zavisnost sa ukupnom količinom padavina i količinom padavina u junu, julu i avgustu a srednju negativnu korelaciju sa brojem kišnih dana. Najveći udeo tvrdih semena ustanovljen je u sušnoj i toploj godini (6,2%), a najmanji u godini sa dosta padavina (5,1%). Đubrenje cinkom nije imalo uticaja na broj tvrdih zrna.
Ključne reči: *lucerka, cink, energija klijanja, tvrda semena.*

INTRODUCTION

In the production of alfalfa seed the main 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 (*Marble, 1989; Hall et al., 2002*).

Zinc (Zn) is among those microelements which are most often deficient (*Roy et al., 2006*). Availability of Zn is largely dependent on the soil pH value and it is higher in acid soils. Contrary to this, in alkaline soils, its availability is very low. Therefore, the Zn deficiency observed in soils with high pH (> 6.0). *Viets (1966)* has classified alfalfa as medium sensitive crop to zinc deficiency. Symptoms of its deficiency on alfalfa occur as reduced and twisted young leaves (*Undersander et al., 2004*). Zinc accelerates the maturing of plants, increases the pollen vitality and fertilization. Certain results (*Grewal and Williams, 2000*) suggest that the ability of alfalfa to cope with stress due to the lack and excess moisture during the early vegetative stage is increased by adequate zinc fertilization. The authors state that also varieties exhibit different behaviour due to a lack of zinc in stressful conditions.

Data of the impact of zinc on seed yield vary. In studies of the zinc impact on seed yield (*Stjepanović et al., 1986*), an average increase in seed yield of 12.9 to 21.2 % has been achieved. In a surveys conducted by *Vučković (1994)*, *Du et al. (2009)* and *Terzić (2014)*, zinc did not have a positive effect on seed yield. Some researches (*Zhang et al., 2005; quoted by Du et al., 2009*) have reported that a small concentration of Zn (80 mg l^{-1}) increases the germination of alfalfa, but higher quantity (600 mg l^{-1}) decreases it.

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 applied, i.e. when the seed coat is 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)*.

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

MATERIAL AND METHOD

In the course of realization of the research goals, researches were carried out at the experimental field of the Institute for forage crops in Kruševac. Trial was established in 2002 with alfalfa varieties K-28. The results obtained in years 2005, 2006 and 2007 are presented in this paper.

The experiment was conducted in three replications in completely randomized block design and the plot size was 10.5 m^2. The soil on which the studies were carried out, in regard to the chemical properties, belong to the category of low acidity soils, and in regard to the content of zinc (1.6 ppm), under criteria for alfalfa which cite *Koenig et al. (1999)* belong to appropriate rank. Foliar zinc fertilization (1 % zinc sulphate ($ZnSO_4$ x $7H_2O$) was performed by foliar split application (the first application was made in the phase of intensive growth and the second application in the early stages of budding and flowering of crops) with 1000 litres of water ha^{-1}.

After the harvest of seeds and completion of field tests, germination energy and percentage of hard seed were determined in the laboratory conditions. The seed was analysed according to the provisions of the Rulebook on determining of the seed quality (*Official Gazette no*. 74/87), 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 is important biological characteristic of seed and also an important indicator of its quality. During the year 2005 (Table 2) the lowest germination energy was determined compared to other years. The minimum germination energy (68.5 %) was obtained in the control treatment while the slightly higher energy was observed in the treatment with zinc (68.9 %), but the differences were not statistically significant. Higher germination energy was obtained in 2007 (80.6 and 80.9 %). The highest germination energy was observed in 2006, in the zinc treatment (84.8 %) and the control variant (84.1 %). Considerable differences in germination energy are the result of different climatic conditions in the study period (Table 1.).

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

Year	Treatment					
	Control		Zinc treatment		Average	
	Germination energy (%)	Hard seeds (%)	Germination Energy (%)	Hard seeds (%)	Germination energy*	Hard seeds
2005	68.5	5.1	68.9	5.1	68.7b	5.1b
2006	84.1	5.5	84.8	5.3	84.5ab	5.4ab
2007	80.6	6.3	80.9	6.0	80.8 a	6.2a
Aver.	77.7	5.6	78.2	5.5	78.0	5.6
F test	Factor/trait		Germination		Hard seeds	
	Year		x		x	
	Zinc		ns		ns	
	Year x Zinc		ns		ns	

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

Germination energy showed a strong negative correlation (Table 3) with total annual rainfall (-0.92) and rainfall in June, July and August (-0.91) and medium negative correlation with the number of rainy days in June, July and August (-0.71). 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, i.e. significantly lower than the energy of germination in 2006 and 2007. The mean annual temperature and mean temperature in June, July and August had positive correlation with germination energy (0.54 and 0.42). In all three experimental years, the average germination energy was 78.0 % with a large variation in years from 68.7 % in the 2005 to 84.5 % in 2006 (Table 2). The achieved results are within the values obtained by (*Erić, 1988; Vučković, 1994; Karagić, 2004; Beković, 2005; Stanisavljević, 2006*). The authors also emphasize varying of germination energy under the influence of environmental conditions during the year.

Growing conditions in some years have affected the share of hard seeds. The highest average proportion of hard seeds was established in 2007 (6.2 %) and the lowest in 2005 (5.1 %). The share of hard seeds showed very strong positive correlation with mean annual temperature and average temperature in June July and August (0.99). The lowest share of hard seeds was recorded in 2005. In the treatments with zinc, the average treatment options realized lower share of hard seed but the differences were not justified statistically.

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

Trait			Germination energy	Hard seeds	Precipitation			Mean temperature ºC Annual
						Sum in mm	No of days	
					Annual (mm)	June July Aug		
Hard seeds			0.54					
Precipitation	Sum (mm)	Annual	-0.92	-0.15				
		June July Aug	-0.91	-0.85	0.66			
	No of days		-0.71	-0.99	0.24	0.89		
Mean temperature ºC	Annual		0.54	0.99	-0.16	-0.85	-0.99	
	Average (June July Aug)		0.42	0.99	-0.02	-0.83	-0.97	0.99

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 *Mijatović (1960)* who concluded that in the dryer years, the presence of hard seeds is higher than in wet and rainy years. Similar results are stated also 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 %). Researches of *Erić (1988)* has pointed out that in years when production was low, the share of hard seeds was also lower. Similar results are stated also by *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 %). In addition, research by *Fick et al. (1988)* stated that water stress increases the percentage of hard seeds.

Fertilization with zinc had no effect on the number of hard seeds which is in accordance with the results of *Vučković (1994)*. In the study of the supply of zinc in alfalfa in plant material obtained in central and Southeast Serbia, no zinc deficiency has been established *(Terzić et al., 2013)*. Also, growing alfalfa on slightly acid soil has likely contributed to absence of significant impact of zinc fertilization on studied treatments.

CONCLUSION

Environmental conditions during the year affected the germination energy and the lowest germination was recorded in the rainy year with plenty of rain in June, July and August.

Germination energy showed a strong negative correlation with total precipitation (-0.92) and rainfall in June, July and August (-0.91) and medium negative correlation to the number of rainy days in June, July and August.

The highest share of hard seeds was observed in dry and warm years. The share of hard seeds showed a negative correlation with rainfall in June, July and August, and positive correlation with mean annual and average temperature in June, July and August.

Foliar application of zinc had no effect on germination energy and the number of hard seeds.

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