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THE EFFECT OF FOLIAR APPPLIACATION OF ZINC ON YIELD OF ALFALFA SEED

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Abstract

The effect of foliar application of zinc on yield of alfalfa seed was investigated in the present study. Objective of the study was to investigate the influence of fertilization with zinc on yield of alfalfa seed in the model of seed production of dual utilization (production of forage and production of seed). In foliar zinc fertilization 1% zinc sulphate was used. Fertilization was foliar with divided application. The most pronounced effect on yield and yield components was recorded for meteorological factors during the year. Ecological conditions, among which the most important were the amount and distribution position of precipitation, had the most prominent influence on the yield and the components of alfalfa seed yield. Foliar Zn application had no influence on the number of plants, height of plants, number of stems per plant, number of stems per m^2, number of branches per plant as well as seeds per pod. The treatments with foliar fertilization with zinc formed a slightly higher number of pods per unit area, but the differences were not significant in either year. The use of zinc averaged slightly increased seed yield, but these differences were not significant justified.

Key words: *alfalfa, zinc, foliar application, seed, yield*

Introduction

All nutrients must be available in sufficient quantity in order to be able to achieve the maximum seed yield (Marble, 1989; Hall et al., 2002). Microelements are essential for normal physiological activity of the plant, and some are important also as macro-elements (Razmjoo and Henderlong, 1997). Symptoms of nutrient deficiency, however, often become clearly visible only after a deficiency is acute and growth and yield are already severally depressed (Bell, 1997, Roy et all., 2006). These critical values were determined based on the analysis of plant tissue on visual symptoms and not on yield response especially in crops grown for seed production (Bergmann, 1992). Terzić et al. (2012) have reported that foliar fertilization with boron affected the increase in alfalfa seed yield were plant tissue nad soil analysis showed appropriate range.

Some authors (Rincker et al., 1988) reported that application of microelements did not contribute to significant increase in alfalfa seed yield. Hall et al. (2002) have stated that none of the foliar applied micronutrients increased the number of stems, yield, or quality of alfalfa in the environment where the pH was 6.5. Compared to the maintaining of the adequate pH in soil, fertility through the standard application of lime and fertilizer, the additional cost of foliar application of products is not covered by the yield or quality.

Stjepanović et al. (1986) have achieved an average increase in yield of 12.9 to 21.2%, with zinc treatment. Vučković (1994) has reported that zinc fertilization through soil had no effect on seed yield. Also, in the research conducted by Du et al. (2009) zinc had no positive effect

on seed yield. Grewal and Williams, (2000), indicate that the ability of alfalfa to cope with stress is increased if adequate zinc nutrition is provided. The authors note that also varieties exhibit different behaviour due to the lack of zinc in stressful conditions.
Objective of the study was to investigate effect of foliar application of zinc on yield of alfalfa seed.

Materials and Methods

The experiments were performed at the experimental field of the Institute for Forage Crops in Kruševac, Serbia. Trial was established in 2002, and the results obtained in 2005, 2006 and 2007 are presented in the present paper. The experimental plot was 10.5 m^2. Pre-forage harvest was done in different phases. In foliar zinc fertilization 1% zinc sulphate was used. Fertilization was foliar with divided application with 1000 litres per ha of water/application. First application was carried out in the stage of intensive plant growth, and the second application at the beginning of blossoming of crops. The land on which the research was conducted was low acidity soils and Zn content in the soil was 1.6 ppm.
Statistical processing of obtained data was done by variance analysis. Statistical analysis was performed for each year separately. Testing of the significance of differences was done by LSD test.

Results and Discussion

The data effect of foliar application of zinc on alfalfa yield components are shown in the table 1. The number of plants is the basic component of seed yield, because through the impact on the total number of stems the crop density is determined, on which all alfalfa seed yield components are dependent. Number of plants decreases with age. In our research, the number of plants decreased from 91.1 and 92.4 plants per m^{-2} (2005 - fourth year of exploitation) to 48 and 51.2 plants per m^{-2} (2007).

Thinning of the alfalfa crop during the period of exploitation is a regular occurrence due to aging of plants and effects of external factors, particularly low temperatures, heavy machinery trampling, diseases and pests (Sheffer at al., 1988; Undersender et al., 2004).
Decrease in the number of plants leads to increase in the number of stems per plant and the ability of alfalfa to compensate small number of plants with the larger number of stems. The minimum number of stems per plant was formed in 2005 and the most stems in 2007. The formation of a large number of stems per plant with a reduction in the number of plants has been proven by numerous authors (Vučković, 1994; Karagić, 2004; Beković, 2005; Stanisvljević, 2006), and confirmed in this study. Observed per unit area, on average the highest number was recorded in year 2005, then 2006 and the lowest in 2007. The decrease of the number of stems per unit area can be explained by the decrease in the number of plants per unit area and considerably worse climate conditions in 2006 (arid May and July), and especially in 2007 (arid June, July and August).
Plant height is an important indicator of alfalfa forage yield and seed yield. Greater height provides opportunities for forming of increased number of flowers, but also the ability to facilitate lodging which may be one of the causes of low seed yield. Plant height on average ranged from 69.6 i 70.5 cm in 2006, when in May the rainfall amount was only 34 mm, to 91.1 and 92.5 cm when in the same period in year 2005, precipitation recorded was 104 mm. The results indicate that the plant height is heavily influenced by climatic factors, and the drought conditions greatly reduce plant height, which is consistent with the results of numerous authors (Fick et al., 1988; Marble, 1989; Vučković, 1994; Beković, 2006).

Table 1. Yield components and seed yield of alfalfa

Yield components	Year						Average	
	2005		2006		2007			
	∅	Zn	∅	Zn	∅	Zn	∅	Zn
Number plant per m^{-2}	92.4	91.1	77.9	78.1	48	51.2	72.77	73.47
Number stems per plant	2.96	3.00	4.93	5.1	5.57	5.66	4.49	4.59
Number stems per m^{-2}	411	461	372	389	246	265	343.00	371.67
Plant height	92.5	91.1	69.6	70.5	78.3	78.5	80.13	80.03
Number branches per plant	20.7	21	41.1	42	35.7	35.8	32.50	32.93
Number branches per m^{-2}	1860	1836	3194	3212	1565	1716	2206.33	2254.67
Number pods per plant	13.19	13.57	67.2	68.8	157.5	154.6	79.30	78.99
Number pods per m^{-2}	1192	1179	4994	5164	6797	7159	4327.67	4500.67
Number seeds per pods	3.58	3.54	4.71	4.7	4.43	4.51	4.24	4.25
Seed yield per plant (g)	0.086	0.088	0.61	0.63	1.41	1.39	0.70	0.70
Seed yield per ha (kg)	70.2	72.9	433.3	452.2	579.3	603.1	360.93	376.07

* significantly different $P<0.05$; ** significantly different $P<0.01$

The application of zinc had no effect on the number of plants, plant height, number of stems per plant, number of branches per plant.

The number of pods per inflorescence is important component of alfalfa seed yield, which directly affects yield. Terzić et al. (2012) state that the number of pods and number of seeds per pod have significant effect on seed yield of alfalfa in foliar treatment with boron.

The number of pods per plant ranged from 13.19 (2005) to 157.5 (2007) due to reduction in the number of plants and also increase in the number of pods. Observed according surface unit, the number of pods increased from 1179 m^{-2} and 1192 m^{-2} (2005) to 4994 m^{-2} and 5164 m^{-2} (2006) to 6797 and 7159 m^{-2} in 2007. The numbers of pods per unit area differs significantly. A higher number of pods was formed also per unit area in 2007, slightly lower in 2006, and the lowest in 2005. This indicates that in the studied periods conditions for pollination and fertilization were significantly different, which caused that in years 2006 and 2007 significantly more pods were formed compared to 2005.

The total amount of precipitation during the month of July were the highest in 2005 (86 mm), slightly lower in 2006 (20 mm), while significantly lower precipitation was recorded (8 mm) in 2007. During June, July and August in the 2005, precipitation amount was 274 mm, and in 2006 was 167 mm. The lowest precipitation (136 mm) was in 2007. Smaller amounts of rainfall in 2006 and especially in 2007 summer (June, July, August) created better conditions for pollination, which led to forming of significantly higher number pod per plant, seed per pod and significantly higher yields of seed kg ha^{-1} in 2006 and especially in 2007, in comparison with 2005.

It can be observed that the number of pods per unit area in the later years showed lower relative increase compared to the increase in the number of pods per plant as a result of reducing the number of plants per year, which further contributed to increase of the number of pods per plant. Also, in research by Vučković (1994), Beković (2005), Stanisavljević (2006) plants growing in the greater vegetation area regularly formed higher number of pods per stem compared to plants on a smaller vegetation area.

The treatments with foliar fertilization with zinc did not result in larger number of pods per plant, but slightly higher number (4%) of pods per unit area was recorded. The results cited by Vučković (1994) have showed that fertilization with zinc through soil did not affect the number of pods per plant. Also, in research by Du et al. (2009), foliar application of zinc had no effect on the formation of reproduction organs in alfalfa, which is consistent with our results. The results are in agreement with those obtained by Korjakina (1974) that zinc significantly affects the formation of reproduction organs.

Foliar application of zinc did not contribute to the formation of more seeds per pod and which was at the average level. The effect of zinc on the number of seeds per pod is not established in the study Vučković (1994) and Du et al. (1999).

The average seed yield realized with the foliar zinc fertilization (376.1 kg ha^{-1}) was slightly higher (4.2%) compared with the control (361 kg ha^{-1}). Broken down by years, in all the years variants with the zinc achieved slightly higher yields, but these differences were not statistically significant. These results are consistent with those obtained by Vučković (1994), Hall et al. (2002), Du et al. (2009), and different from those stated by Stjepanović et al. (1986).

The availability of Zn is largely dependent on the pH, it is higher in acid soils, and lower in alkali soils. Therefore, the absence of Zn was observed in the soils with pH>6.0 (Katayal and Randhawa, 1983; Roy et al., 2006). Our studies were conducted on soil with a pH value of 6.5 in H_2O and 5.7 in N KCl, which probably contributed to Zn not exerting significant influence on seed yield. The soil analysis determined the content of 1.6 ppm of Zn, which can be regarded as an adequate amount of (Zn>1.0 ppm), according to Koenig et al. (1999), Brown and Barbour (2004). Also, the analysis of the plant material, in the beginning of flowering, of the top 15 cm, 31 ppm Zn was determined, which presents a satisfactory level (20-60 ppm), according to the Undersander et al. (2004), i.e. adequate level, according to Koenig et al. (1999). This is likely to have affected that foliar fertilization with zinc has not exerted a stronger influence on seed yield.

The agro-ecological conditions during the year have the highest influence on seed yield. Seed yield showed very large variation in year and ranged from 70.2 kg ha^{-1} in 2005 to 603 kg ha^{-1} in 2007, which is in accordance with the findings of numerous authors.

The world yields range from 0 kg ha^{-1} (crop failure) (Rincer et al., 1988) to more than 2200 kg ha^{-1} when *Megachile rotundata*is used in pollination (Strickler, 2000).

Karagić et al. (2003) have reported the average alfalfa seed yield in agro-ecological conditions of Serbia of about 250 kg ha^{-1}, with large variations depending on the year from 50 to 700 kg ha^{-1}. According Vučković (2003), yield seeds range from 100-1500 kg ha^{-1}, and usually 300-500 kg ha^{-1}. In the research by Stanisavljević (2006), the average (2002-2004) of 352.2 kg ha^{-1} has been achieved. Beković (2005), in the first full year of exploitation, has realized 245.7, and in the second year - 426.7 kg ha^{-1} or an average of 336.1 kg ha^{-1}. In the research of Jevtić (2007), in the first year, yield of 600 kg ha^{-1} is recorded, in the second year 648.2 kg ha^{-1}, in the third 694.9 kg ha^{-1}, while in the fourth year significantly lower yield of 232.5 kg ha^{-1} is achieved.

Conclusions

Seed yield showed great variation in different years under the influence of environmental conditions during the year, primarily the amount and distribution of rainfall in June, July and August. The lowest yield was formed in years with the highest rainfall in this period, and the highest yield in the year with the least rainfall in this period.
The foliar Zn application had no influence on the number of plants, height of plants, number of stems per plant, number of stems per m^{-2}, as well as the number of branches per plant.
Slightly higher number of pods per unit area was realized in the treatments with foliar zinc fertilization, but the differences were not significant in either year. Foliar application of zinc did not affect the number of seeds per pod. The application of zinc increased seed yield by 4.2% relative to the average, but the differences were not statistically significant.

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