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The Effect of Foliar Application of Iron, Zinc, and Selenium on the Level of Glucose and Fructose of Alfalfa under Rainfed Conditions

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ABSTRACT

This factorial experiment with a randomized complete block design was performed in 4 replicates in order to examine the effect of foliar application of iron, zinc, and selenium on alfalfa's yield under rainfed conditions in Aligoudarz, Iran. The experimental treatments included the iron at 3 levels: the control (non-use of iron), iron sulfate at the concentration of 3/1000, and complete liquid iron 5%; zinc at 3 levels: the control (non-use of zinc), zinc sulfate at the concentration of 3/1000, and complete liquid zinc 5%; and selenium at 2 levels: the control (non-use of selenium) and sodium selenite at the concentration of 20 g/ha. The table of variance analysis showed that the effect of foliar application of iron, zinc, and selenium was significant in terms of all properties at significance level of 1%. The maximum level of fructose was found in treatments with complete liquid iron, complete liquid zinc, and sodium selenite at the concentration of 20 g/ha, which increased the level of fructose by 13%. Moreover, maximum level of glucose, 2.56%, was found in treatments with complete liquid iron, complete liquid zinc, and sodium selenite at the concentration of 20 g/ha, which increased the level of glucose by 15.8%.
KEYWORDS: nutrients, selenium, iron sulfate, zinc sulfate, fructose, glucose

INTRODUCTION

The high compatibility of alfalfa has extended it widely all over the world. Once the alfalfa is cultivated, it would grow for 4-20 years depending on the conditions of the soil and climate. In each growth period, 3-12 cuttings are harvested depending on the climatic conditions and variety (Majidi, 1998).

Iron is an essential element for growth of all plants. In case of iron deficiency, chlorophyll is not produced enough in the cell, and leaves seem faded (Malakouti & Tehrani, 2005). Zinc is an essential element for plants and plays an important role in many biochemical activities of plants. It contributes to the main structure of over 300 enzymes (Keshavarz & Malakouti, 2003). Selenium is an essential micronutrient for humans and animals and is effective in reduction of the effects of the environmental stress. Changing the structure of free radicals, selenium eliminates the adverse effects of these compounds and changes these compounds into harmless materials used by the plants. Selenium also helps the protection of the structure of proteins and macromolecules through increasing antioxidants, such as proline and enzymes (Hasanuzzaman *et al*., 2010). Selenium inhibits damages to the cells when the oxidative stress occurs following the drought stress and formation of free radicals. In fact, plants cannot activate the antioxidation system (Timothy, 2001). Ceylan et al. conducted a study on the effect of different levels of zinc (0, 40 kg/ha, 80 kg/ha, & 120 kg/ha) on the yield of alfalfa and clover and concluded that the different levels of zinc significantly affected the measured properties. They obtained the maximum yield of alfalfa when using 80 kg/ha of zinc sulfate (Ceylan et al., 2009). In a study on the effect of foliar application of micronutrients on the yield of alfalfa seed, Terzic et al. found that the foliar application was effective in increasing the yield of alfalfa seed and number of pods and seeds per pod (Terzic et al., 2011). Chamlys and Witty explained that the foliar application of the iron micronutrient increased the height of stem and, consequently, the dry matter yield of corns (Amini & Dadkhah, 2011). Kohnaward et al. performed a study on the effect of foliar application of micronutrients on yield and yield components of the sunflower under conventional and regional conditions and found the significant effect of the foliar application on the number of seeds per head, number of heads per sunflower, weight of thousands seed, the seed yield, and the biological yield. In the above study, maximum weight of thousand seed and seed yield was related to zinc (Kohnaward et al., 2012). In a study on the effect of foliar application of micronutrients on the soybean under water deficit condition, Kobraee and Shamsi concluded that the foliar application of micronutrients and magnesium increased the yield of soybean under dry conditions, and the micronutrients reduced the adverse effects of drought (Kobraee & Shamsi, 2013). Jezek et al. conducted a study on the effect of foliar application of

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selenium on the level of selenomethionine in potato tubers and concluded that the foliar application of selenium increased the aminoacids, namely, aspartic acid, glutamic acid, taurine, and tyrosine compared to the control treatment. Furthermore, the results of the above study showed the positive effect of selenium on the level of the aminoacids, namely, leucine, methionine, valine, alanine, glycine, cysteine, proline, arginine, and histidine (Jezek et al., 2011). Therefore, this study was conducted to examine the effect of the foliar application of iron, zinc, and selenium on nutrient uptake and yield of alfalfa under rainfed conditions.

Materials and Methods

This experiment was performed in rainfed lands of the village KhomehOlya 12 km away from Aligoudarz, Iran, with longitude of 49° 42″ and latitude of 33° 23″. The village was 2034 m above the sea level. Based on the statistics of Meteorological Organization, mean precipitation, mean temperature, and mean total hours of sunshine in the year of the study were 395.1 mm, 12.3°C, and 3158.7 lux, respectively. The soil was sandy loam with pH = 8.1. This factorial experiment was performed within a randomized complete block design with 4 replications under rainfed conditions in 2012. The studied factors included the iron at 3 levels: the control (non-use of iron), iron sulfate at a concentration of 3/1000, and completely liquid iron 5%; zinc at 3 levels: the control (non-use of zinc), zinc sulfate at a concentration of 3/1000, and completely liquid zinc 5%; and selenium at 2 levels: the control (non-use of selenium) and 20 g/ha of sodium selenite. The studied block were 12 m; the distance between block was 1 m; and the distance between replications was 2 m. The studied piece of land was plowed in the middle of summer, 2011, and 70 kg/ha of the fertilizer ammonium triple phosphate was added to the soil before cultivation. Then, 35 kg/ha of the seed was manually spread over the land in late August. For the complete establishment of the plants, they were not harvested in the first year. The first and the second foliar application were carried out manually when the plants' stem was 10-15 cm high and 30-35 cm high, respectively. The plants were harvested at 10%-20% of flowering, and the samples harvested from ten square meter of land were weighed using an accurate digital scale. One kilogram of the samples of each block was dried in an oven at the temperature of 75°C for 48 hours, and the yield of alfalfa was calculated. To determine the concentration of the elements, the dried samples were powdered, the concentration of calcium and phosphorus were determined using near-infrared spectroscope (NIR) (Jafari et al., 2003), and the concentration of iron, zinc, and selenium was determined after acid digestion with nitric acid and perchloric acid through atomic absorption spectrometry (Hosseini, A. 2013). The data were analyzed using Mstat-c software, and the obtained means were compared together using Duncan's multiple range test at probability value of 5%.

DISCUSSION AND CONCLUSION

The level of glucose and fructose

Based on the table of data variance analysis, the effect of the foliar application of iron, zinc, and selenium on the level of fructose and glucose of plants was significant at significance level of 1%. The comparison of mean data showed a significant difference between treatments. The comparison of the mean simple effect of iron-based treatments on the level of fructose and glucose showed that maximum level of fructose and glucose was related to complete liquid iron that increased fructose by 2.7% and glucose by 3.4% as that in the control treatment. The comparison of the mean simple effect of zinc- and selenium-based treatments on the level of fructose and glucose showed that completely liquid zinc, zinc sulfate at the concentration of 3/1000, and sodium selenite at the concentration of 20 g/ha increased the level of glucose and fructose of the alfalfa. The comparison of the mutual effect of zinc, iron, and selenium on the level of fructose showed the maximum level of fructose pertained to treatments with complete liquid iron, complete liquid zinc, and sodium selenite at the concentration of 20 g/ha, which increased the level of fructose by 13%. The comparison of the mutual effect of zinc, iron, and selenium on the level of glucose showed the maximum level of fructose, 2.56%, was related to treatments with complete liquid iron, complete liquid zinc, and sodium selenite at the concentration of 20 g/ha, which increased the level of fructose by 15.8%.

Table 1: Variance analysis of the measured properties

Glucose	Fructose	Source of variation	Degree of freedom
.000$^{n.s}$	.000$^{n.s}$	3	Replication
.030**	.559**	2	Iron
.031**	.750**	2	Zinc
.085**	1.551**	4	Iron × zinc
.017**	1.279**	1	Selenium
.011**	.244**	2	Selenium × iron
.058**	1.260**	2	Selenium × zinc

.036**	.470**	4	Selenium × zinc × iron
.000	.000	51	Error
.20	.12		Coefficient of Variation
^{ns}, *, **respectively refer to non-significant, significant at the level of 5%, and significant at the level of 1%.			

Table 2: Comparison of mean normal effects of the treatments

Glucose (%)	Fructose (%)	(Fe) Treatment Iron
2.293 c	12.037 c	Fe1
2.323b	12.098 b	Fe2
2.373 a	12.368 a	Fe3
		(Zn) Treatment Zinc
2.314 b	12.147 b	Zn1
2.298 c	11.975 c	ZN2
2.377 a	12.382 a	Zn3
		(Se) Treatment Selenium
2.312 b	12.014 b	Se1
2.348 a	12.322 a	Se2

Means with common letters do not differ significantly from each other.
Fe1=Control treatment (non-use); Fe2=Iron sulfate at the concentration of 3/1000; Fe3=Completely liquid iron 5%
Zn1=Control treatment (non-use); Zn2=Zinc sulfate at the concentration of 3/1000; Zn3=Completely liquid zinc 5%
Se1=Control treatment (non-use); Se2=Sodium selenite at the concentration of 20 g/ha

Table 3: Comparison of mean dual effects of the treatments

Glucose (%)	Fructose (%)	Treatmentwith zinc× iron
2.268 f	11.922 f	Zn1×Fe1
2.240 g	11.740 h	Zn2×Fe1
2.370 c	12.450 b	Zn3×Fe1
2.320 e	12.160 e	Zn1×Fe2
2.415 b	12.425 c	Zn2×Fe2
2.235 h	11.710 i	Zn3×Fe2
2.355 d	12.360 d	Zn1×Fe3
2.240 g	11.760 g	Zn2×Fe3
2.525 a	12.985 a	Zn3×Fe3
		Treatment with Selenium× iron
2.259 f	11.839 f	Se1×Fe1
2.327 d	12.236 b	Se2×Fe1
2.333 c	12.077 e	Se1×Fe2
2.313 e	12.120 d	Se2×Fe2
2.343 b	12.127 c	se1×Fe3
2.403 a	12.610 a	Se2×Fe3
		Treatment with zinc×Selenium
2.249 e	11.789 f	Zn1×Se1
2.380 b	12.506 b	Zn1×Se2
2.343 c	12.120 d	Zn2×Se1
2.253 d	11.830 e	Zn2×Se2
2.343 c	12.133 c	Zn3×Se1
2.410 a	12.630 a	Zn3×Se2
Means with common letters do not differ significantly from each other.		
Fe1=Control treatment (non-use); Fe2=Iron sulfate at the concentration of 3/1000; Fe3=Completely liquid iron 5%		
Zn1=Control treatment (non-use); Zn2=Zinc sulfate at the concentration of 3/1000; Zn3=Completely liquid zinc 5%		
Se1=Control treatment (non-use); Se2=Sodium selenite at the concentration of 20 g/ha		

Table 4: Comparison of mean triple effects of the treatments

Glucose (%)	Fructose (%)	Treatment with zinc×iron×selenium
2.217 k	11.597 n	Fe1×Zn1×Se1
2.320 f	12.247 f	Fe1×Zn1×Se2
2.280 h	11.940 j	Fe1×Zn2×Se1
2.200 l	11.540 o	Fe1×Zn2×Se2
2.280 h	11.980 h	Fe1×Zn3×Se1
2.460 c	12.920 c	Fe1×Zn3×Se2
2.250 j	11.810 m	Fe2×Zn1×Se1
2.390 e	12.510 e	Fe2×Zn1×Se2
2.560 a	12.930 b	Fe2×Zn2×Se1
2.270 i	11.920 l	Fe2×Zn2×Se2
2.190 m	11.490 p	Fe2×Zn3×Se1
2.280 h	11.930 k	Fe2×Zn3×Se2
2.280 h	11.960 i	Fe3×Zn1×Se1
2.430 d	12.760 d	Fe3×Zn1×Se2
2.190 m	11.490 p	Fe3×Zn2×Se1
2.290 g	12.030 g	Fe3×ZN2×Se2
2.560 a	12.930 b	Fe3×Zn3×Se1
2.490 b	13.040 a	Fe3×Zn3×Se2
.Means with common letters do not differ significantly from each other.		
Fe1=Control treatment (non-use); Fe2=Iron sulfate at the concentration of 3/1000; Fe3=Completely liquid iron 5%		
Zn1=Control treatment (non-use); Zn2=Zinc sulfate at the concentration of 3/1000; Zn3=Completely liquid zinc 5%		
Se1=Control treatment (non-use); Se2=Sodium selenite at the concentration of 20 g/ha		

Conclusion: Regarding the foregoing and the results obtained from tables, it can be concluded that the foliar application of iron, zinc, and selenium affected the quantitative yield of alfalfa and resulted in an increase in the sugar content and palatability of alfalfa. The results showed that the foliar application of zinc sulfate and iron sulfate at the concentration of 3/1000 affected the nutritional value of the alfalfa more than the complete liquid iron and zinc 5% did. Considering the results and the increased yield of alfalfa, it can be concluded that the foliar application adjusted the drought and increased the yield of alfalfa. Given the shortage of alfalfa in Iran and also the shortage of water for cultivating alfalfa, farmers of rainfed farming can be encouraged to use this method for cultivating alfalfa under rainfed conditions in different parts of Iran with a minimum rainfall of 350 mm.

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