TURKISH J. OF FIELD CROPS 14(2): 136 – 143 2009

EFFECT OF ZINC ON YIELD AND SOME RELATED TRAITS OF ALFALFA

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ABSTRACT

Effects of increasing dozes of zinc application (0, 40, 80, 120 kg ha^{-1}) were studied on herbage, hay, dry matter, crude protein and zinc contents yields of alfalfa (*Medicago sativa L.*) for three years (2003-2005). The results indicated that different zinc doses had significant effects on these properties. The highest yields were obtained in 80 kg ha^{-1} zinc treatment. By this application, increase in yields were determined as 30.9% in herbage, 34.7% in hay and 32.1% in dry matter yield compared to control. The yields differed significantly among the experimental years. In the second year of experiment, average herbage, hay, dry matter and crude protein yields were higher than the first and third years but the highest zinc concentrations of plant were in the first year. Average data of the 3 years revealed that the least yields were obtained from control

Key words: Alfalfa, zinc, herbage, hay, dry matter, crude protein yield.

INTRODUCTION

Zinc is an important limiting factor in sustainable crop production in deficit soils (Çakmak et al., 1996a; Rengel and Graham, 1995). Zinc deficiency is more common under the condition of high pH, calcareous, light and sandy soils, high phosphorus levels and wet soils (Marschner, 1993; Çakmak et al., 1996b).

Zinc is an essential element for several biochemical processes, such as cytochrome and nucleotide synthesis, auxin metabolism, chlorophyll production, enzyme activation and membrane integrity (Benett, 1993; Özbek et al., 1984; Marschner, 1995). It plays both a catalytic and structural role in enzymatic reactions (Vallee and Auld, 1990). RNA polymerase, carbonic anhidrase, phospholipase are believed to be the most important enzymes containing Zn.

Alfalfa is deeply rooted perennial legume and is grown as a high quality animal feed on a wide range of soils. This perennial forage legume play a vital role in animal husbandry in Ödemiş district. Legumes such as alfalfa reduce fertilizer nitrogen input by symbiotic nitrogen fixation (Zentner et al., 2001; Mohr et al., 1999). In addition, the year-round crop stands of these perennial crops may prevent the development of soil salinity (Agriculture Canada, 1991). Forage legume also improve the physical properties (Blackwell et al., 1990) and organic matter of soil (Campbell et al., 1990) and reduce soil erosion. Alfalfa, because of its frequent cuttings and large biomass production may suffer more in its growth under Zn deficiency.

The effect of zinc fertilization on growth and yield of many plants such as wheat, maize-mungbean-rice potato were investigated (Ceylan et al., 1998; Oktay et al., 1998, Hossain et al., 2008). In addition numerous researches were conducted on Zn in Alfalfa. Stout et al., (1987), Reid et al., (1987), Grewal and Williams (2000), Grewal (2001), observed increase in yield with Zn application. Bernnan, 1992 determined that effectiveness of zinc fertilizer as measured by dry matter production and zinc content of clover was found to vary markedly among the soil types. Adequate Zn nutrition of Alfalfa is essential for good seedling vigour and zinc sufficient plants have better tolerance to water stress and excessive soil moisture content than Zn – deficient plants (Grewal and Williams, 2000).

Ödemiş is one of the major alfalfa production areas of the Aegean region. However, zinc deficiency is widespread in the soils of this region because of sandy texture (Aşkın et al., 1997).

The present study was conducted to investigate the effect of increasing Zn doses on herbage, hay, dry matter and crude protein yields of alfalfa under field condition.

MATERIALS AND METHODS

The research was conducted at the experimental fields of Ödemiş Vocational High School in Turkey during three growing seasons (2003 to 2005). Pionner variety which is most favourable to ecological conditions of area was used. The soil characteristics of the experimental area are given in table 1.

Table 1. Some physical and chemical properties of soil in the experimental field.

Characteristics	Unit	Value
pH		6.97
Soluble salt	%	<0.03
$CaCO_3$	%	0.52
Sand	%	75.94
Clay	%	3.42
Loam	%	20.64
Texture		Loamy-sand
Organic Matter	%	1.30
Total N	%	0.07
Available P	mg kg^{-1}	17
Available K	mg kg^{-1}	155
Available Ca	mg kg^{-1}	615
Available Mg	mg kg^{-1}	167
Available Na	mg kg^{-1}	10
Available Fe	mg kg^{-1}	9
Available Cu	mg kg^{-1}	1.3
Available Zn	mg kg^{-1}	0.8
Available Mn	mg kg^{-1}	3.1

Field trials were arranged in a randomized block design with three replications. Each plot area was 5.4 m^2 and consisted of 12 rows. The plots were seeded on 4 April 2003. Seeding rate was 30 kg ha^{-1}. The treatments were four different Zn fertilizer rates at 0, 40, 80, 120 kg ha^{-1} in the form of Zn SO_4. $7H_2O$ at sowing and following years. Additionally, at the sowing 50 kg N ha^{-1}, 120 kg P_2O_5 ha^{-1} and 200 kg K_2O ha^{-1} were also applied to all plots in the form of urea, triple super phosphate and potassium sulphate, respectively.

All plots were irrigated uniformly. Alfalfa yield was determined by harvesting whole plot. Five cuttings were practiced each year at 25% blooming stage.

500 g fresh sample of herbage was collected from each plot at second harvests of each year for dry matter, dry matter ratio determination, crude protein and zinc analysis. Crude protein contents were analyzed in ground hay samples by Kjeldahl method (Bremner, 1965). Plant samples were wet digested (HNO_3: $HClO_4$; 4:1) and in the extracts zinc concentration was measured by atomic absorption spectroscopy (Munoz, 1968). All data were analyzed statistically by Tarist programme (Açıkgöz et al., 1993).

RESULTS

Herbage, hay and dry matter yields of Alfalfa as 3 years average were significantly increased by zinc treatments ($p<0.05$). Highest herbage, hay and dry matter yields were obtained at 80 kg ha^{-1} Zn treatment as 94.7, 23.2, 19.3 t ha^{-1}, respectively (Figure 1). Yield increases were 30.9% in herbage, 34.7% in hay and 32.1% in dry matter yields compared to controls in 80 kg ha^{-1} zinc treatment.

Although the effect of Zn applications were not significant statistically on dry matter ratio. Dry matter ratios were changed between 20.19 - 20.50%.

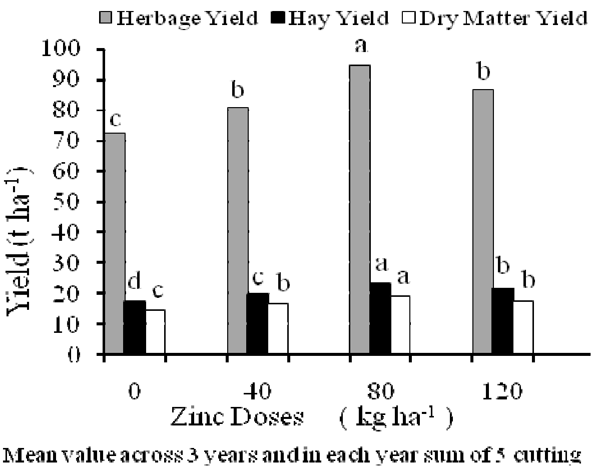

Figure 1. Effects of zinc treatment on herbage, hay and dry matter yield of alfalfa.

Zinc application had a significant effect on crude protein yield ($p<0.05$). Average crude protein yield of alfalfa increased from 2.9 to 4.1 t ha^{-1} (42.2 %) when zinc doses increased from 0 and 80 kg ha^{-1}. However 120 kg ha^{-1} zinc application decreased crude protein yield (Figure 2).

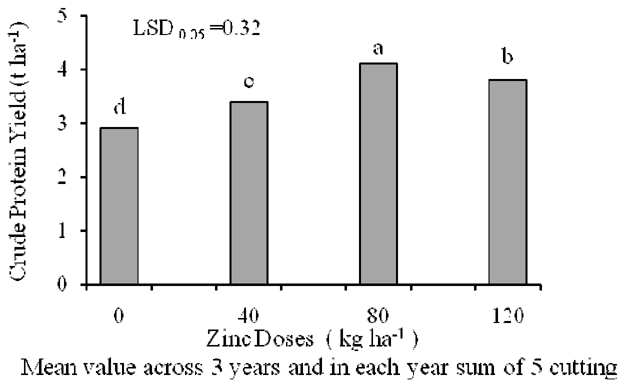

Figure 2. Effects of zinc treatment on crude protein yield in alfalfa.

Zinc concentrations in alfalfa were significantly influenced by Zn supply ($p<0.05$) (Figure 3). In the control treatment (no zinc application), lowest Zn concentration (28.9 mg Kg^{-1} DM) was determined while highest Zn concentration in alfalfa (34.3 mg Kg^{-1} DM) was found at maximum Zn doses (120 Kg^{-1} Zn ha^{-1}).

Yields of herbage, hay, dry matter, crude protein and zinc concentration were significantly effected by years ($p<0.05$), (Figure 4, 5, 6). Average yield values were highest in the second experimental year. However highest zinc concentrations of plant were determined in the first year.

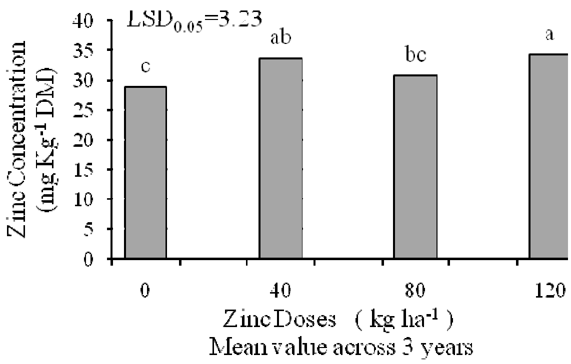

Figure 3. Effects of Zinc treatment on Zinc concentration in alfalfa.

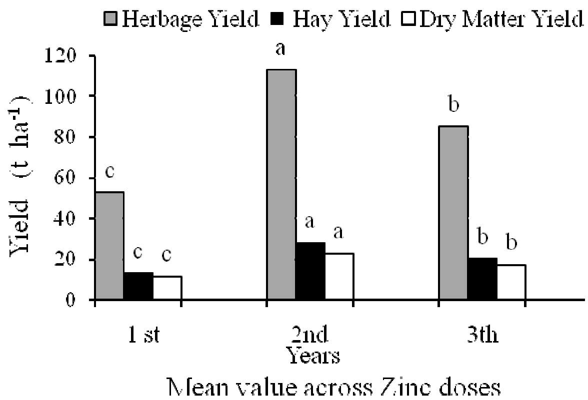

Figure 4. Effects of years on herbage, hay and dry matter yields of alfalfa.

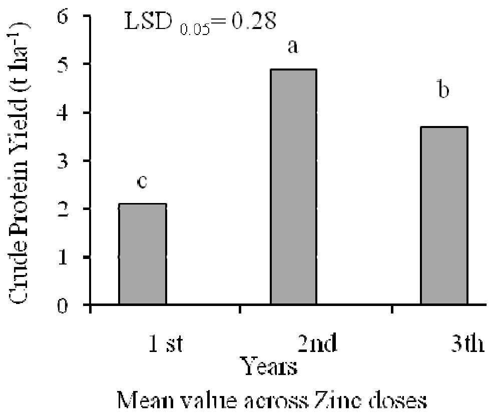

Figure 5. Effects of years on crude protein yield of alfalfa.

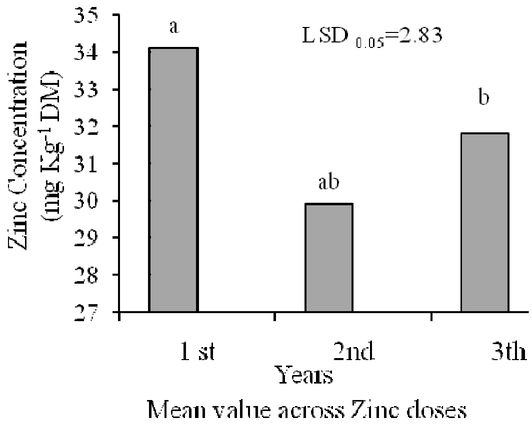

Figure 6. Effects of years on zinc concentration of alfalfa.

DISCUSSION

The results of present study indicated that Zn fertilization of alfalfa increased herbage, hay, dry matter crude protein yields and zinc concentration of alfalfa. 80 kg ha^{-1} zinc treatment provided highest yields. Confirming our findings, Grewal (2001) indicated that herbage yield of alfalfa cultivars were improved by Zn application. He determined that total herbage yield of seven cuttings increased from 7.3 t ha^{-1} to 13.6 t ha^{-1}. Reid et al., (1987) reported mean concentrations of Zn across five cuttings of Alfalfa in 2 year were 18, 27, 41 and 21 mg kg^{-1} dry matter for control, low foliar, high foliar and soil treatments, respectively. Zinc treated crops were more vigorous than others and had better growth. Zinc plays key role in stabilizing RNA and DNA structure (Brown et al., 1993; Çakmak, 2000) and involves in biosynthesis of growth promoting hormones such as indole -3- acetic acid (IAA) (Çakmak, 2000; Garg et al., 1986) and Gibberellin (Suge et al., 1986). Additionally, zinc is an activator of many enzymes involved in photosynthesis, cell elongation and cell division (Çakmak, 2000; Yu et al., 1999). Thus, Zn fertilization effected significantly yield, crude protein and Zn concentration of Alfalfa.

However, the highest dose of Zinc applications (120 kg ha^{-1}), decreased herbage, hay and dry matter yields in the study. This result may be originated from excess zinc dose which blocks physiological responses of Mg and Fe. Similar results were defined by Boawn and Rasmussen (1971) reported that excessive zinc fertilization decreased by almost 20 to 40% dry matter yield of Alfalfa. In another study Saigusa et al., (1999), also suggested that excessive zinc application might cause soil pollution.

Zinc fertilization increased significantly zinc contents of alfalfa plants. As a similar, Reid et al., (1987) noted foliar and soil applications of Zn increased Zn concentration of alfalfa and degree of increase varied with cutting.

Yield properties of alfalfa varied significantly throughout the experimental years and in the second year of the experiment, herbage, hay, dry matter and crude protein yields were higher than the first year, but in the first year zinc concentration of plant were higher than other year.

In conclusion, 80 kg ha^{-1} $year^{-1}$ $ZnSO_4$ application significantly promoted both qualitative and quantitative properties of alfalfa, except 120 kg ha^{-1} zinc dose decreased almost all yield performances of alfalfa in the experiment.

ACKNOWLEDGEMENT

This research study is partially supported by Comission of Ege University, Contract No. 2005-OMY-01.

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