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Zinc, iron and manganese fertilizers application and Zn, Fe, and Mn concentration in roots and shoots of soybean plants in pot experiment

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Abstract

In order to study the effects of zinc, iron, and manganese fertilizers on the micronutrients in roots and shoots of soybean, a pot experiment was done at 2010. The experimental design was a 3×3×3 factorial experiment based on Randomized Complete Block with three replicates. Treatments included of three rates of Zinc, iron, and manganese. After eight weeks, plants were lifted, dried, incinerated and were used to measure the micronutrients. The results were shown that Zinc application significant effects on Zn, Fe concentration in roots ($P<0.01$), and Zn, Fe and Mn concentration in shoots ($P<0.01$). Fe concentration in roots and shoots increased in 4 mgkg-1 soil application of iron, and in excess amounts, concentration of this element was decreased. Mn concentration in roots was not affected by zinc application. Iron application had no significantly effect on Zn concentration in shoots. In our study, antagonistic effects of iron and zinc were observed.

Key words : Iron, Manganese, Micronutrients, Soybean, Zinc.

INTRODUCTION

Besides industrial uses, oilseeds are important sources for human and animal nutrition. Adequate and timely supplies of macro and micronutrients are important factors in increasing the yield and quality of crops production. Micronutrients are elements that are required in small quantities but have a special role in the normal growth and development of plants [1]. Uptake of micronutrients from the soil and transfer to the edible parts of plant plays a vital role in human health [2]. In the other side, the ranges between deficient and toxic levels of micronutrients are narrow; in addition there are the interaction and antagonistic effects among elements in soil and plant. Among these elements, zinc, iron and manganese have a special significance [3]. Deficiencies of zinc, iron and manganese were observed in calcareous soils with high pH and low organic matter. Soils in many arid and semi-arid regions of Iran due to high pH are faced with Zn, Fe, and Mn deficiencies. Change in pH may influence uptake of micronutrient from soil solution [4]. Furthermore, nutrient transport from the soil to plant roots, uptake by roots and transfer to edible parts of plants are vary from region to region and spice to spice and even within the same region and among genotypes of the same species [5]. The concentration of micronutrients in plant tissues is stated on a dry-matter basis as either parts per million or milligrams per kilogram. Averagely, zinc and manganese concentrations in plant dry matter that were considered sufficient for adequate growth are 20 to100 and 5 to 100 mg/kg, respectively [6, 7]. The levels of deficient and sufficient of iron concentration in soybean seed are ranged by 42 to 45 and 70 to 77 mg/kg seed dry weight [8]. In addition, there are interaction, antagonistic and synergistic effects among micronutrients in soil and plant [9]. For example, there is antagonistic effect between iron and manganese in soybean plant [10]. Thus, this study was conducted in order to determination of the effects of zinc, iron, and manganese fertilization on Zn, Fe, and Mn concentrations in soybean shoots and roots in a pot experiment.

MATERIALS AND METHODS

A pot experiment was done at the research field of the Islamic Azad University of Kermanshah province, Iran (34 23' N, 47 8' E; 1351 m elevation) in 2010. The experimental design was a 3×3×3 factorial experiment based on Randomized Complete Block Design (RCBD) with three replicates in 81 pots. Surface soil was collected from an agricultural field and passed through a 2-mm mesh screen. The texture of the soil based on silty clay with pH 7.6 , total organic matter 1.8%, electrical conductivity (ECe) 0.46 dsm^{-1}, total nitrogen 0.09%, available phosphorus 7.4 mg kg^{-1}, available potassium 435 mg kg^{-1}, zinc, iron and manganese 0.56, 5.1 and 3.2 mg kg^{-1}, respectively. The experiment consist of 27 treatments included of three rates of Zinc (0, 4, and 8 mg Zn kg^{-1} as $ZnSO_4.7H_2O$), three rates of iron (0, 4, and 8 mg Fe kg^{-1} as $FeSO_4$), and three rates of manganese (0, 15, and 30 mg Mn kg^{-1} as $MnSO_4.4H_2O$). All pots were fertilized with 20 mg N kg^{-1} as NH_4NO_3, 40 mg P kg^{-1} as Ca (H_2PO_4). $2H_2O$. Six seeds of soybean (cv. Williams) inoculated with *BradyRhizobium japonicum* and were sown directly in plastic pots containing 4 kg of the soil. After 48 days, plants were lifted and samples were washed in deionized water, then shoot and root were separated. For measure of dry weight samples was dried at 70˚C and 48 hours, weighed, and incinerated at 550˚C. For micronutrients determination, dry ash samples soluble in concentrated HNO_3 and $HCLO_4$. Zn, Fe and Mn contents were determined by Atomic Absorption Spectrometry (AAS) according to [11]. Excel software was used to draw figures.

RESULTS

The impact of zinc fertilization on Zn, Fe, and Mn concentrations in soybean shoots and roots were shown in Figure (1). Based on results obtained, Zinc application led to increased in Zn concentration in soybean shoots and roots. Fe concentration in soybean shoots and roots were affected by zinc fertilization. Zinc application increased Mn concentration by 7.73% in soybean shoots, but had not significantly effect on Mn roots concentration

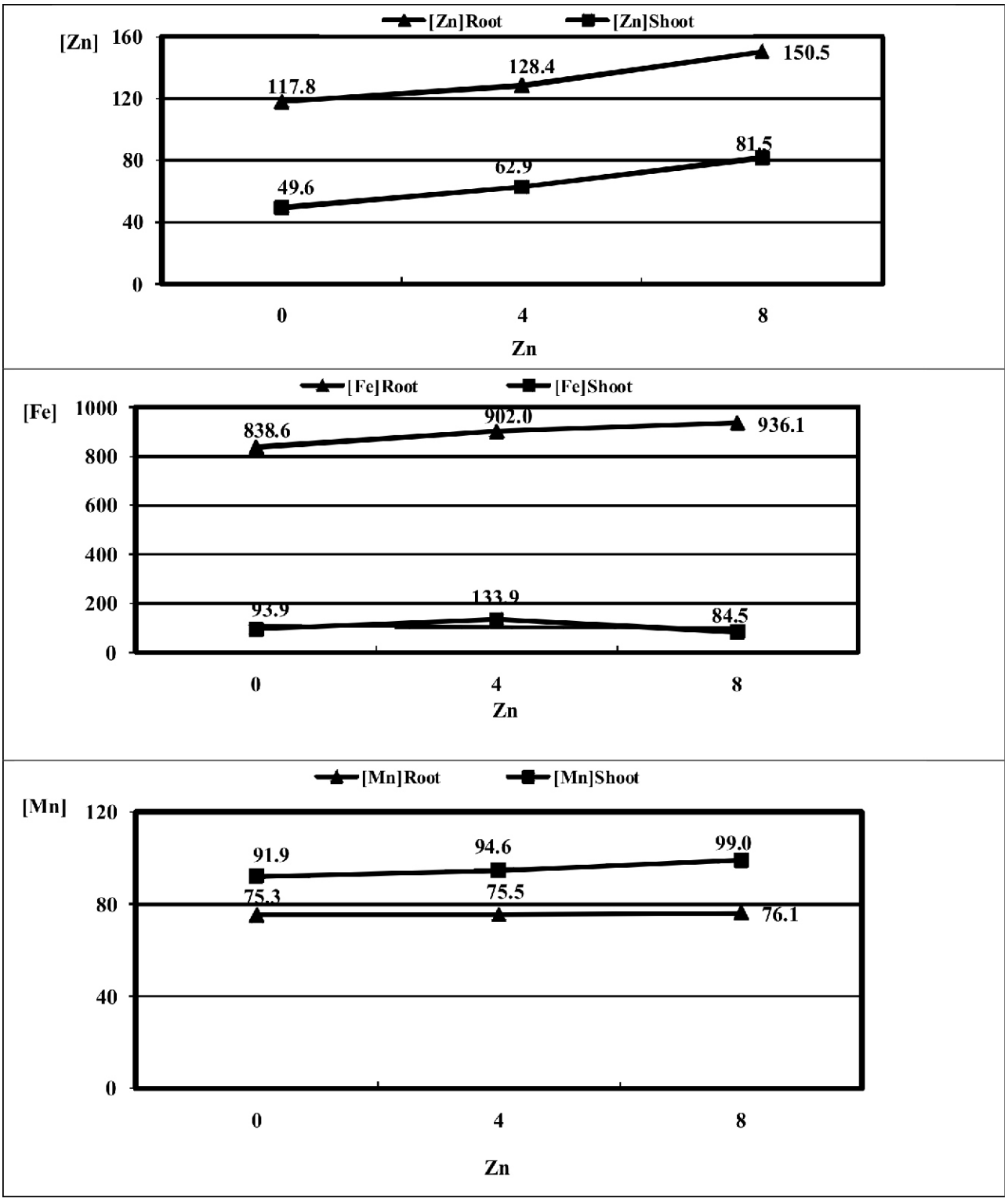

Figure 1: The impact of zinc fertilization (mg.kg^{-1} soil) on Zn, Fe, and Mn concentrations (mg.kg^{-1} dry weight) in soybean shoots and roots

(Fig 1). The impact of iron fertilization on Zn, Fe, and Mn concentrations in soybean shoots and roots were shown in Figure (2). Iron application up to 4 mg Fe per kg^{-1} soil made significant effect on Fe concentration in soybean shoots and roots by 205.99% and 36.34%, respectively, but in excess amount of iron fertilization up to 8 mg Fe per kg^{-}1 soil, decreased its. Iron application up to 4 mg Fe per kg^{-1} soil was reduced Mn concentration in soybean shoots by 18.71% (compared check treatment), while excess amounts of this element had no significantly effect on Mn concentration in soybean shoots and roots (Fig 2). The impact of manganese fertilization on Zn, Fe, and Mn concentrations in soybean shoots and roots were shown in Figure (3). Manganese application could increase concentration of Mn in soybean shoots and roots, severely. Furthermore, the

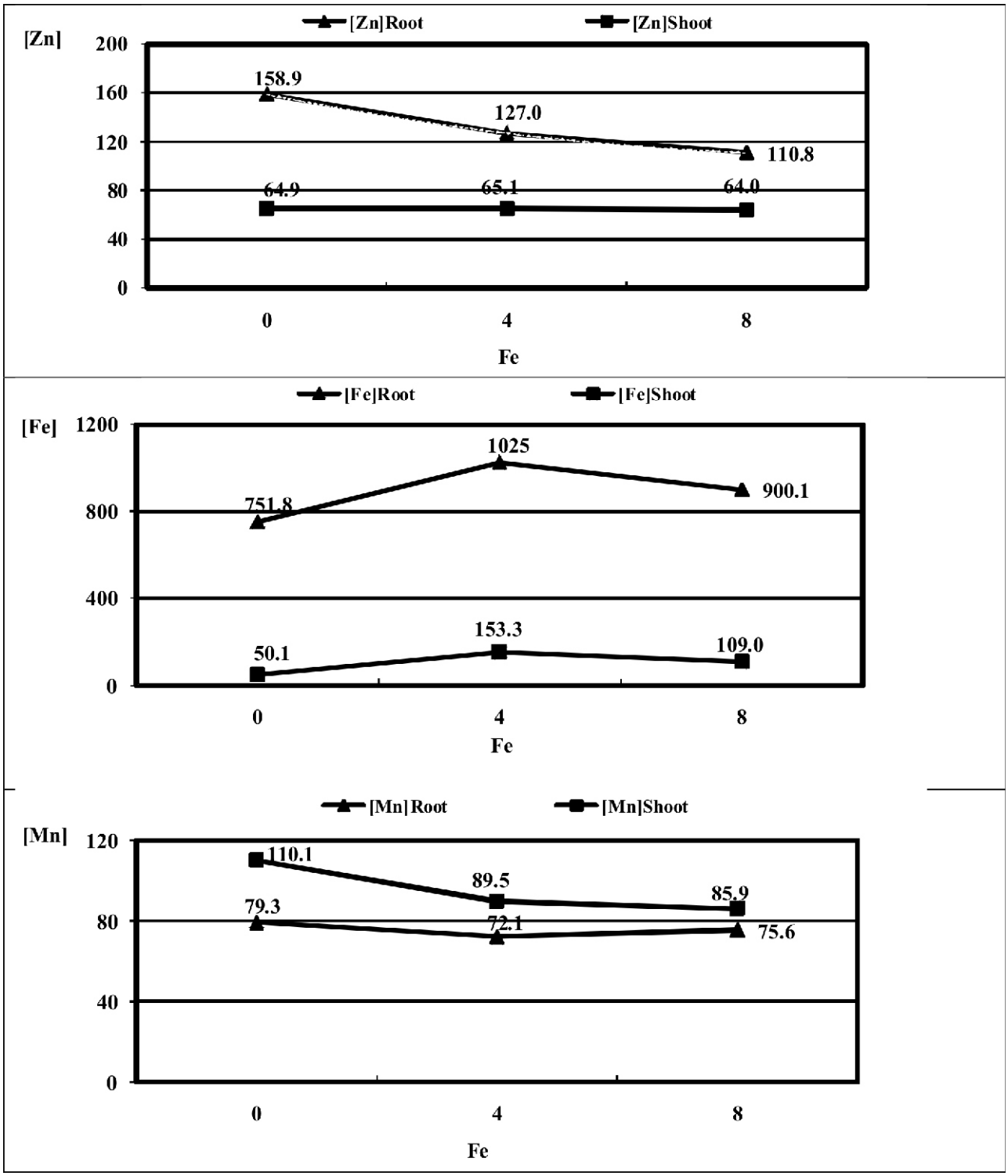

Figure 2: The impact of iron fertilization (mg.kg^{-1} soil) on Zn, Fe, and Mn concentrations (mg.kg^{-1} dry weight) in soybean shoots and roots

maximum of Mn concentration in shoots and roots was observed in 30 mg Mn per kg^{-1} soil treatment. Compared check treatment, manganese application up to 15 and 30 mg Mn per kg^{-1} soil increased Mn concentration in shoots by 214.17%, and in roots by 197.81%. These results were shown that there was positive relationship between Mn concentrations in roots and shoots of soybean (Fig 3). A similar trend was observed in Zn concentration in soybean shoots and roots (Fig 1).

DISCUSSION

In our experiment root Zn concentration was ranged between 117.8 mg/kg in check treatment to 150.5 mg/kg in 8 mg Zn kg^{-1} (+27.76%). Increase in zinc concentration in the shoot with 8 mg Zn kg^{-1} compared control treatment was recorded between 49.6 to 81.5 mg per kg dry weight (+64.31%). In the other hand, Zn concentration in shoots and roots were lower in 0 mg Zn kg^{-1} soil treatment compared with 4 and 8 mg Zn kg^{-1} soil treatments. The

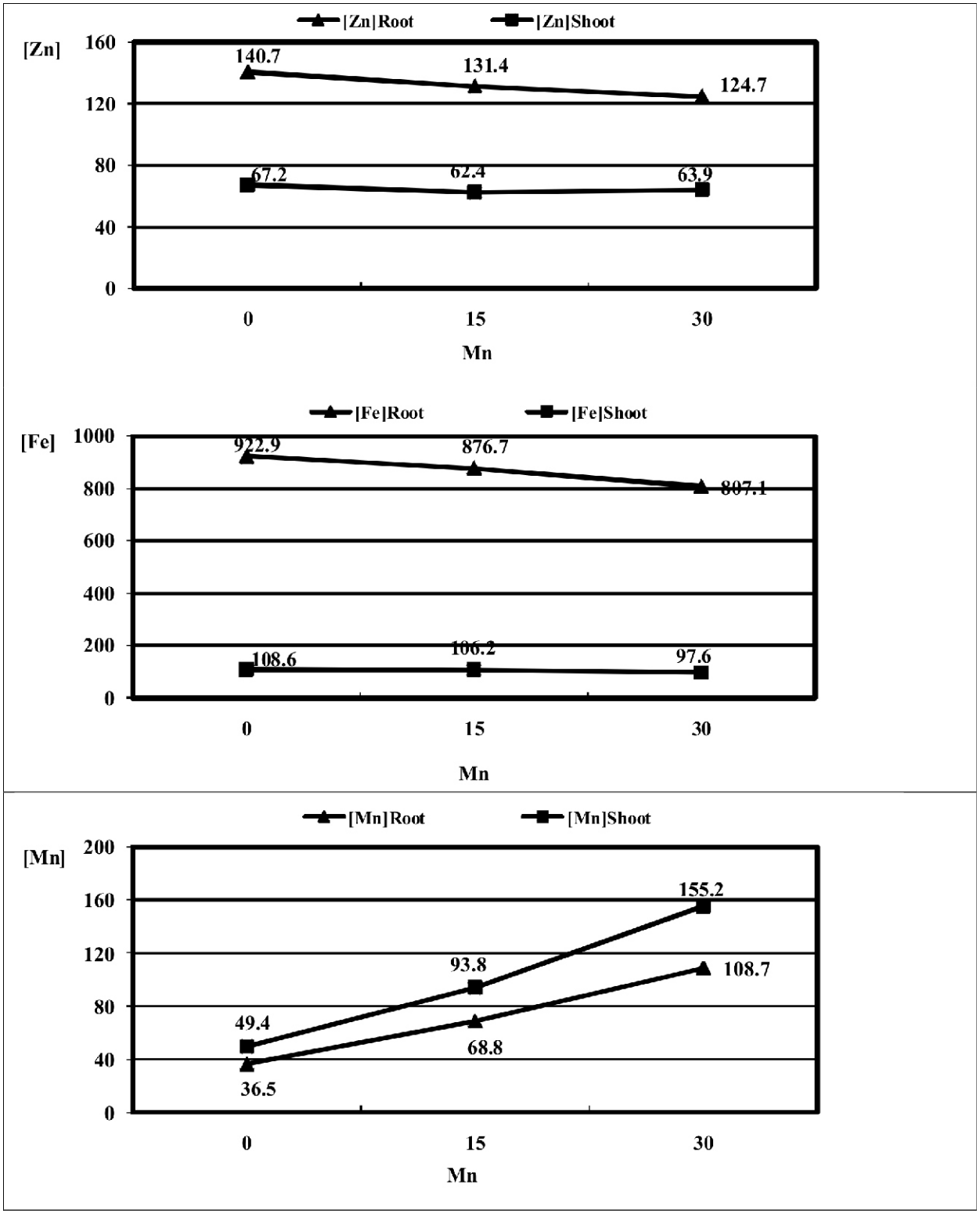

Figure 3: The impact of manganese fertilization (mg.kg^{-1} soil) on Zn, Fe, and Mn concentrations (mg.kg^{-1} dry weight) in soybean shoots and roots

effects of zinc fertilization on Zn concentration in tissues of plant were emphasized by [12, 13]. Zinc fertilization increase Shoots Fe concentration by 11.62% (838.6 mg/kg in check treatment to 936.1 mg/kg in 8 mg Zn kg^{-1}). Furthermore, Fe concentration in roots increased in 4 mg Zn kg^{-1} (133.9 mg/kg), and in excess amounts, concentration of this element was decreased (84.5 mg/kg). In previous study, zinc application not only increased Zn concentration in plant tissues but also changed the other micronutrients content [14]. In the other side, Excessive zinc fertilization in soybean is a preventer for iron uptake by plant roots [15]. Manganese concentration in soybean shoots increased by zinc application, but [Mn] roots no affected. A similar result was obtained by [16]. Based on results obtained iron application had no significantly effect on Zn concentration in soybean shoots,

while decreased Zn roots concentration by 30.27%. Zinc uptake was reduced by iron fertilization in excess amount [17]. Compared control treatment (non manganese fertilization) manganese fertilization up to 30 mg Mn per kg^{-1} soil were reduced Zn and Fe concentrations in soybean roots by 11.37% and 12.55%, respectively, while the effect of manganese applied on Zn and Fe concentrations in soybean shoots was very slightly. There was a negative relationship between manganese and iron [18]. In contrast, if manganese was used in little amount, it would increase absorption of iron by plant roots [19]. Reduction in Fe concentration, resulting manganese fertilization was observed in our study. A similar result was observed by [20].

CONCLUSION

These results indicated that by applications of zinc, iron, and manganese increased their concentration in soybean shoots and roots. In generally, except Mn, Zn and Fe concentrations were higher in roots compared with shoots, while Mn concentration in roots was lower than that of soybean shoots.

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REFERENCES

1. Fageria NK. *The use of nutrients in crop plants*. CRC Press, Taylor & Francis Group. 2009.

2. Tsui KH, Chang PL, Juang HH. Manganese antagonizes iron blocking mitochondrial aconitase expression in human prostate carcinoma cells. *Asian J Androl*. 2006; 8(3): 307-315.

3. Hu-lin H, You-zhang W, Xiao-e Y, Ying F, Chun-yong W. Effects of different nitrogen fertilizer levels on Fe, Mn, Cu and Zn concentrations in shoot and grain quality in rice (*Oryza sativa*). *Rice Sci*. 2007; 14(4): 289-294.

4. Barrow NJ. Testing a mechanistic model: IV. Describing the effects of pH on zinc retention by soils. *J. Soil Sci*. 1986; 37: 295-302.

5. Yang XE, Ye ZQ, Shi CH, Zhu ML, Graham RD. Genotypic differences in concentrations of iron, manganese, copper, and zinc in polished rice grains. *J Plant Nutr*. 1998; 21(7): 14531462.

6. Fox TC, Guerinot ML. Molecular biology of cation transport in plant. Annual. Review. Plant Physiology. *Plant Mol Biology*. 1998; 49: 669-696.

7. Kirkby EA, Romheld V. Micronutrients in Plant Physiology: Functions, Uptake, and Mobility. Proceedings No. 543, International Fertilizer Society, Cambridge, U.K., December 9, 2004; pp. 154.

8. Wiersma JV. High rates of Fe-EDDHA and seed iron concentration suggest partial solutions to iron deficiency in soybeans. *Agron J*. 2005; 97: 924934.

9. Paschke MW, Valdecantos A, Redente EF. Manganese toxicity thresholds for restoration grass species. *Environ Pollut*. 2005; 135: 313-322.

10. Ghasemi-Fasaei R, Ronaghi A, Maftoun M, Karimian N, Soltanpour PN. Influence of Fe-EDDHA on iron- manganese interaction in soybean genotypes in a calcareous soil. *J Plant Nutr*. 2003; 26: 1815-1823.

11. Kacar B. *Plant nutrition practice guide*. Ankara Univ. Agricultural Fac. Pub: 900, Practice Guides: 214. Ankara, Turkey. 1984.

12. Gangloff WJ, Westfall DG, Peterson GA, Morvedt JJ. *Availability of organic and inorganic Zn fertilizers*. Colorado State University Agriculture Experiment Station Technical Bulletin TB00-1. 2000.

13. Salton NA, Gbur EE, Wilson CE, Norman RJ. Rice response to granular zinc sources varying in water-soluble zinc. *Soil Sci. Soc. Am. J*. 2005; 69: 443-452.

14. Kaya C, Higgs D. Response of tomato (*Lycopersicon esculentum* L.) cultivars to foliar application of zinc when grown in sand culture at low zinc. Sci. Hortic. 2002; 93, 5364.

15. Bernal M, Cases R, Picorel R, Yruela I. Foliar and root Zn supply affect differently Fe- and Zn-uptake and photosynthetic activity in soybean plants. *Environ Exp Bot*. 2007; 60: 145150.

16. Lopez MAF, Ellis DR, Grusak MA. Effect of zinc, and manganese supply on the activity of superoxidase dismutase and carbonic anhydrase in *Medicago truncatula* wild type and *raz* mutant plants. *Plant Sci*. 2005; 168: 1015-1022.

17. Mandal B, Hazra GC, Mandal LN. Soil management influence on zinc desorption for rice and maize nutrition. *Soil Sci Soc Am J*. 2000; 64: 1699-1705.

18. Ming C, Yin CR. *Effect of Mn and Zn fertilizers on nutrient balance and deficiency diagnosis of winter eheat crop in pot experiment*. International Symposium on the role of Sulphur, Magnesium, and Micronutrients in Balance Plant Nutrition (edited by: S. Portch): 369-379, Sulphur Institute, Washington, DC. 1992.

19. Alloway BJ. Zinc in soils and crop nutrition. Brussels, Belgium: International Zinc Association. 2004.

20. Ronaghi, A, Ghasemi-Fasaei R. Field evaluations of yield, iron-manganese relationship, and chlorophyll meter readings in soybean genotypes as affected by iron-ethylenediamine di-o-hydroxyphenylacetic acid in a calcareous soil. *J Plant Nutr*. 2008; 31: 81-89. DOI: 10.1080/01904160701741925.