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Agriculture and Environment

The effect of zinc application on the yield and zinc uptake of maize in Xerochrept and Haploxeralf soils

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Abstract. *The aim of this study is to determine the effect of increasing the amount of zinc applied to soil on the yield and zinc uptake of corn plant in Xerochrept and Haploxeralf soils. For this purpose, a research was carried out under greenhouse condition by growing corn plant in soils taken from different areas of Tekirdag region. In the experiment, the zinc was applied at an amount of 0, 2.5, 5, 10 and 20 ppm Zn levels in the form of ZnSO4.7H2O. Dry matter yield and zinc content of corn plant were evaluated in the experiment. According to the obtained results, soil samples were found to be insufficient in organic matter and zinc content. According to the analysis results, zinc and dry-matter content of maize plant increased with the increase of Zn application. The optimum zinc content is obtained from 20 ppm Zn application (Zn4). With 20 ppm zinc application, the dry-matter content of maize in Xerochrept and Haploxeralf soils is increased 124,6 % and 148,28 % on average, respectively, and zinc content of maize in Xerochrept and Haploxeralf soils is increased 292.73 % and 270.48 %, respectively. It is found that there are increases in the amounts of dry-matter content and zinc uptake of maize with the application of different levels of zinc to the soils in subject. Determining the maximum yield of maize which has a wide planting area among cereals after wheat and barley in Turkey has a great importance.*

Keywords: zinc, maize, yield, Xerochrept, Haploxeralf.

Introduction

One of the most important factors in agricultural production is the conditions of the amounts and availabilities of plant nutrients in soils. Availability of plant nutrients is closely related to the soil properties. To pay attention to the factors that negatively affect the availability in plant production and soil management is compulsory for a balanced nutrition (Aydin et al, 1997). Modern agricultural development is predicated upon favorable ecological conditions with adapted high-yielding varieties and chemical inputs, particularly fertilizers, together with good soil and crop management (Stewart et al., 2005).

Plant nutrition elements are necessary for the plant for its growth and normal development and the roles of the nutrition elements cannot be substituted by other chemical elements. Zinc is a required element for plants, animals and humans. It is usually found in low concentrations in the soils.

The availability of micro nutrition elements is within the limit level in Turkey, especially in crop plantation areas because of the negative soil properties such as high values of $CaCO_3$, pH and clay and low levels of organic matter. Zinc has an important place among these micro nutrition elements. It is known that half of the agricultural areas in Turkey are deficient in zinc and this deficiency is increasing especially in the soils of some areas. Tekirdag is also one of the places where zinc deficiency is seen. Plants take zinc as Zn2+. The amount of zinc for the plants to grow normally is very low. The amount of zinc in the plant is 25-150 mg kg-1 however it is determined that when this amount decreases to under 20 mg kg-1, this element becomes insufficient (Yilmaz et al., 1997). Maize and rice are the most sensitive plants to zinc deficiency among the field crops (Selimoglu, 1995).

In a study where the effect of fertilizers with phosphorus and zinc applied in different doses to hybrid maize in Campus area of Konya is researched, it is seen that there are significant increases in the amount of phosphorus uptaken by grain with the increase in zinc level and these increases are found to be significant at the level of $p<0.05$ (Akay, 1997). Maize is in the third rank after wheat and barley among the crops according to plantation area and production and in the first rank according to the average yield of crops with 800 thousand hectare plantation area, 3.5 million tones production and average yield of 4375 kg/ha in our country (Anonymous, 2006). Although maize is a plant whose physiology and morphology is well known, the production of new types with high yield every year, requires determination of suitable production techniques oriented researches.

The aim of this research is to determine the effect of the application of increasing levels of zinc in greenhouse conditions on dry-matter yield and zinc content of maize grown in two different soils which are zinc deficient and commonly found in the Thrace region.

Material and methods

Two different soils commonly found in Tekirdag which are in Xerochrept (Soil No 1) and Haploxeralf (soil N: 2) major groups of Soil Taxonomy are chosen for the research. One of the soil samples

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(Soil No 1) is taken from Altinova district of Tekirdag and the other sample (Soil No 2) is taken from Koseilyas village. Both of the soil samples used in the research are taken from 0-30 cm depth of the Tekirdag province (Jackson, 1965). Textures of the soil samples were determined by Bouyoucos Hydrometer method (Tuzuner, 1990), pH (1:2.5 soil: distilled water) was measured by pH meter with glass electrodes (Bayrakli, 1987). Organic matter of the soil samples was analyzed by Walkley-Black method (Greweling and Peech, 1960), salinity was measured (1:2.5 soil: distilled water) by electrical conductivity instrument, exchangeable cations (Ca2+, Mg2+, K+) by flame photometer and lime with Scheibler calcimeter method, vapor distillation (Kjeldahl) method is used to determine the amounts of total N as stated and available phosphorus with blue color method in spectrophotometer (Saglam, 2008) and available Fe, Mn, Zn and Cu content of the soil samples are determined with ICP-OES instrument by Kacar (2009).

This study is conducted in greenhouse conditions in 40 plastic pots with 2 soils, 5 different zinc doses (Zn0= Control, Zn1= 2.5 ppm Zn, Zn2= 5 ppm Zn, Zn3= 10 ppm Zn and Zn4= 20 ppm Zn) and with 4 repetitions according to factorial experiment design. 2 kg of soil according to air-dry weight principle are put into every pot after sifted from 4 mm sieves. In order to supply normal development of the plants, fertilizers are given to every pot before the plantation as 100 ppm N (in the form of NH4NO3), 80 ppm P and 100 ppm K (in the form of KH2PO4). In the experiment, Kermess hybrid seed is used and 5 maize seeds are planted in every pot and then, 3 plants are left after the germination. Plants are harvested after 50 days from germination by cutting at 2 cm above the soil and are prepared for analysis by cleaning with pure water. The harvested plants are washed with tap water first, then two times with pure water, and then dried at 65 oC and their dry-matter weights are determined. Total nitrogen in dried maize plant samples burned dry and wet are determined with vapor distillation (Kjeldahl) method, available phosphorus with yellow color method in spectrophotometer (Saglam, 2008) and other available Ca, Mg, K, Fe, Mn, Zn, Cu contents with ICP-OES instrument (Kacar, 2009).

The experimental data were analyzed by ANOVA and the differences were compared by Least Significant Difference (LSD) test ($p<0.01$). For all investigated parameters, analysis of variance was performed using the MSTAT-C computer software program.

Results and discussions

When pH value of the soil samples are analyzed (Table 1), soil sample with soil No 1 is in slightly acidic class, soil sample with soil No 2 is in neutral class (Kacar, 2009). All the soils are in “unsalted” class when the salt values of the soil samples are examined (Saglam, 2008). $CaCO_3$ values of the soil No 1 and soil No 2 samples were found 3.21% and 1.20%. For lime content the soils are in the “little limy” class and this is in the quality for maize (Kacar, 2009). The organic material content of the soil No 1 and soil No 2 samples were found 1.49 % and 1.17 %. It appeared that the soil samples are in “poor” class when organic material and total nitrogen amounts are examined (Ulgen and Yurtsever, 1995). Organic matter and nitrogen results resemble the previous studies carried out in the soils of the region (Belliturk et al., 2007). It is determined that the soil No 1 and soil No 2 samples are in “sand loam (SL) and loam (L)” class when

Table 1. Some physical and chemical properties of the soils.

Soil No	pH (1/2.5 H_2O)	Salt (dS/m)	$CaCO_3$ (%)	Organic Matter (%)	Texture			
					Clay (%)	Silt (%)	Sand (%)	Class
1	7.16	0.145	3.21	1.49	14.27	24.58	61.15	SL
2	6.25	0.122	1.20	1.17	16.32	33.37	50.31	L

Table 2. Some available macro nutrition elements (ppm).

Soil No	N	P	K	Ca	Mg
1	720	4.49	228.77	6747.28	308.97
2	572	10.43	189.16	3421.92	717.14

Table 3. Some available micro nutrition elements (ppm).

Soil No	Fe	Mn	Zn	Cu
1	7.82	11.79	0.31	1.83
2	31.05	65.90	0.29	1.90

the texture classes of the soil samples are examined.

Total N content is found to be inadequate, K content adequate and Ca content in excess for both of the soils when Table 2 is examined. P content of the soil with No1 is found to be low, P content of the soil with No2 is found to be adequate. The soil with No1 is found to be adequate in terms of Mg content whereas the soil with No2 is found to be in excess. When available micro nutrition element contents of the soils in Table 3 are examined, Fe, Mn and Cu contents are found to be in excess, Zn content is found to be low for both of the soils (Gunes et al., 2007).

It is declared that there is a significant relation between phosphorus content and available zinc in soils. Former studies state that generally the plants grown in phosphorus rich soils show zinc deficiency. The zinc deficiency seen in maize grown in phosphorus rich soils can be removed by giving zinc to the soil (Kacar, 2009)

Table 4. Amount of dry-matter of maize with different levels of zinc application (g/pot) and significance groups.

Soil No	Amount of Dry-Matter (g/pot)*					
	ZnO	Zn1	Zn2	Zn3	Zn4	Aver.**
1	1.83 d	1.86 d	2.07 b	2.22 a	2.28 a	2.05 a
2	1.45 f	1.47 f	1.66 e	1.92 c	2.15 ab	1.73 b
Aver.***	1.64 d	1.67 d	1.87 c	2.07 b	2.22 a	1.89

*The values are the average of 4 repetitions of 3 maize in the pots.
** $LSD_{0.01}$: 0.24; *** $LSD_{0.01}$: 0.07; **** $LSD_{0.01(interaction)}$: 0.09

The results show that the maximum amount of dry-matter of Zn4 (2.22 g/pot) was observed in maize. The lowest amount of dry-matter of Zn0 and Zn1 (1.64 and 1.67 g/pot) were obtained in maize (Table 4). Dry matter content of maize is increased from 1.83 grams to 2.28 grams (124.6 %) in Xerochrept soil and it is increased from 1.45 g to 2.15 g (148.28 %) in Haploxeralf soil with 20 ppm Zn (Zn4) application in comparison with control (Zn0). The researchers Ozguven and Katkat (1997) state that dry matter content has been increased 37 % with 10 ppm zinc application in comparison with control.

Table 5. Zinc content of maize with different levels of zinc application (ppm)

Soil No	Zinc Content of Maize (ppm)*				
	ZnO	Zn1	Zn2	Zn3	Zn4
1	11.0	13.8	17.0	19.7	32.2
2	10.5	13.0	16.0	18.8	28.4

* The values are the average of 4 repetitions of 3 maizes in the pots

Zinc content of maize is increased to 32.2 ppm from 11 ppm (292.73 %) in Xerochrept soil and it is increased from 10.5 ppm to 28.4 ppm (270.48 %) in Haploxeralf soil with 20 ppm Zn (Zn4) application in comparison with control (Zn0). The researchers Ozguven and Katkat (1997) state that zinc content has been increased 51 % with 10 ppm zinc application in comparison with control and zinc uptaken from the soil is increased 110 %.

When Table 4 and Table 5 are examined, the lowest Zn content is obtained by Zn0 application and the highest Zn content is obtained by Zn4 application in maize grown in both soils. It is determined that Zn content of maize grown in Xerochrept soil (soil no: 1) is higher than that of grown in Haploxeralf soil (soil no: 2). According to Table 4 and Table 5, increase in dry matter and zinc content of the plant is seen with the increase of added zinc to the soils. It is stated that if the Zn content of maize is under 20 ppm, then it is inadequate and if Zn content of maize is between 20 and 60 ppm then it is adequate (Kacar and Inal, 2008). According to this, the adequate Zn content for maize is obtained from Zn_4 (20 ppm Zn) application. The importance of Zn element for maize is introduced once again by such studies. Similar results are obtained in former studies (Yalcin and Usta, 1992; Selimoglu, 1995).

Conclusion

As a result, it is determined that there are significant increases in dry matter and zinc content of maize depending on different levels

of zinc application when compared with control (Zn0). These results obtained related with zinc content of maize are very important. There has been a cultivation turn as sunflower-wheat in the Thrace region for years. This cultivation turn damages the nutrition balance in soils and it causes especially phosphorus accumulation in soil and causes increases in micro element deficiencies. It turned out that fertilization containing zinc in zinc deficient agricultural areas is necessary for balanced plant nutrition and fertilization as cited in this study. Such studies in which making up zinc deficiency, which is a great problem for Turkey, is handled should be increased. Otherwise, the amount and quality of the product is negatively affected.

The studies in recent years show that nutrition problems relative to micro nutrition elements in World and Turkey soils are very common. Agriculture is getting narrow while population is increasing. Therefore, it is necessary to fertilize soils in a balanced and controlled manner considering soil types in the light of science and technology in order to meet food demand of the rapidly increasing World population.

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