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# The Effect of Increasing Nitrogen and Zinc Doses on the Iron, Copper and Manganese Contents of Maize Plant in Calcareous and Zinc Deficient Soils

Sevinç Adiloglu
Trakya University Tekirdağ Agricultural Faculty 59030, Tekirdağ, Turkey

**Abstract:** This research was carried out in order to determine the effects of increasing nitrogen and zinc fertilizers on the iron, copper and manganese content of maize plant in calcareous and zinc deficient soils. For this purpose sandy calcareous and clay calcareous soils were used in this research. The experiment was done greenhouse conditions with three replications and maize was grown. Three different doses of N ($N_0$: 0; $N_1$: 50 and $N_2$: 100 kg N $ha^{-1}$) were applied to each pot as $NH_4NO_3$. Four different doses of Zn ($Zn_0$ 0; $Zn_1$: 5; $Zn_2$:10 and $Zn_3$: 20 mg $kg^{-1}$) were applied to each pot as $ZnSO_4.7H_2O$. According to the results, dry matter amount of maize plant increased with increasing of N and Zn doses. Iron, Cu and Mn contents of maize plant decreased with increasing of N and Zn application doses. Increasing of dry matter amount and decreasing of Fe, Cu and Mn contents of maize plant were determined significant at the level of 1%, statistically.

**Key words:** Nitrogen, zinc, iron, copper, manganese, maize, calcareous soil

## INTRODUCTION

The aim of the agriculture is to produce maximum yield from a unit area and purpose, more and more fertilizer has been applied to soil and plant.

Zinc and other trace elements deficiency is a major problem in the world, particularly in the recent years. Generally, deficiency of these elements is seen in calcareous soils (Brady and Weil, 1999).

Iron, Cu and Mn deficiency in plant and soil have been occurred with more N fertilizer application to low organic matter amount soils (Peralta-Videa *et al*., 2002).

Nitrogen application to the soil accelerates vegetative growing of plant and this may lead Zn, Fe, Cu and Mn deficiency in soil. This adverse effect is more severe in the soil with low available Zn and low organic matter amount (Ozanne, 1955; Loneragan & Webb, 1993).

The effect of increasing rates Zn application to rice was investigated by Alpaslan and Taban (1996). Iron, Cu and Mn contents of plant decreased with increasing zinc application.

Aydın (1995) investigated the changes of nutrient element contents of rice plant under paddy soil conditions with clay-calcareous and clay-non calcareous soils in greenhouse. According to the results, N fertilizer application increased dry matter yield, N and Zn contents of rice plant while these increases were found statistically significant for dry matter yield and N content of plant; it was not significant for Zn content of plant.

According to Kalbasi *et al*. (1988), Fe, Cu and Mn are not uptake sufficiently level by plants in calcareous soils, therefore, these elements deficiency is seen frequently and commonly in plants. Because, these elements precipitates in these soil conditions.

Iron, Cu and Mn contents of plant decreased with increasing Zn application to Zn deficient and calcareous soils (Arrieche and Ramirez, 1999; Öncel *et al*., 2000; Katkat and Özgüven, 2001; El-Nagar, 2002).

Nitrogen and Zn fertilizers increasing rates application to Zn deficient, low organic matter amount and calcareous soils decreased Fe, Cu and Mn contents of plants (Güneş *et al*., 2000).

The effect of increasing rates of N and Zn application to Zn deficient, low organic matter amount and calcareous soils on Fe, Cu and Mn contents of maize plant was investigated in this research.

## MATERIALS AND METHODS

Sandy-calcareous (Calcixeroll) and clay-calcareous (Xerochrept) (Ekinci, 1990) soil samples were used this research. Soil samples were analysed for pH (Thomas, 1996), lime (Loeppert and Suarez, 1996), organic matter (Nelson and Sommers, 1996), available phosphorus (Kuo, 1996), available Fe, Cu, Zn and Mn (Lindsay and Norvell, 1978) and texture (Gee and Bauder, 1986). Also Fe, Cu, Zn and Mn contents of plants were analysed with Atomic Absorption Spectrophotometer (Kaçar, 1972).

This research was conducted in Tekirdağ province of Turkey during May and June 2003. Pot experiment was carried out under greenhouse conditions. For this purpose, soil samples were sieved through 4 mm and then

packed into 2 kg pots. Experiment was done 3 nitrogen doses×4 zinc doses×2 soils×3 replications: 72 pot according to factorial experiment design. Nitrogen doses were 0, 50, 100 kg $ha^{-1}$ (as $NH_4NO_3$), Zn doses were 0, 5, 10, 20 mg $kg^{-1}$ (as $ZnSO_4$ $7H_2O$) in solution forms and zinc only once, nitrogen two times applied to the pots. Additionally, 70 kg $P_2O_5$ $ha^{-1}$ phosphorus were applied to each pot. Pioneer 3377 MF hybrid maize seed was used in this experiment. Two plants were left on each pot after the germination. Then plants were harvested after 50 days and prepared for analysis. Necessary analyses of plants were carried out and results were evaluated statistically (Soysal, 2000).

## RESULTS AND DISCUSSION

Some physical and chemical properties of soil samples are given in Table 1, showing that the organic matter amounts are low while Zn contents are deficient in calcareous soils.

According to Table 2, dry matter amount of maize plant increased with increasing rates of N and Zn application. Increasing of dry matter amount was higher in clay- calcareous soil than in sandy- calcareous soil. These increases were significant statistically at 1% confidence level. Average dry matter amount for clay-calcareous and sandy- calcareous soils were determined 5.14 and 3.70 g $pot^{-1}$, respectively, with increasing nitrogen application. These values for increasing zinc application were determined 5.13 and 3.67 g $pot^{-1}$, respectively. Previous researchers also found that increasing rates N and Zn application to the soils increased dry matter amount of plants (Karimian, 1995; Arrieche and Ramirez, 1999; Peralta-Videa *et al*., 2002).

Table 3 shows that Fe content of maize plant decreased with N and Zn applications. The effect of Z and Zn application on Fe content of maize plant was found to be statistically significant at the level of 1%. The effect of decreasing with N application was found to be higher than with Zn application for both soil samples (Table 3).

Iron content of plants decreased with increasing rates of nitrogen and zinc application to zinc deficient and low organic matter containing soils (Alpaslan and Taban, 1996; Kacar, 1997; Katkat and Özgüven, 2001; Peralta-Videa *et al*., 2002). This was interpreted by these researchers that plant vegetative growth increased with N application and Fe transportation was negatively affected by this result. Furthermore, it was attributable to antagonist effect between Zn and Fe.

Copper content of maize plant decreased with N and Zn application (Table 4). This decrease was found to be significant statistically at the level of 1%. Decreasing rate of Cu content was determined higher in clay soil than in sandy soil.

Copper uptake of plants decreased with zinc application to zinc deficient soils (Haldar and Mandal, 1981; Peralta-Videa *et al*., 2002).

Plant vegetative growth increased with N application to soil. This situation is hindering Cu transportation in plant; consequently, Cu deficiency is seen (Gartrell, 1981; Lou and Rimner, 1995; Katkat and Özgüven, 2001).

According to Table 5, Mn content of maize plant decreased with increasing rates of N and Zn application to calcareous soils. The effect of N and Zn applications

Table 1: Some physical and chemical properties of soils

| | | | | | Available (mg $kg^{-1}$) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Soil | pH(1: 2.5 $H_2O$) | Org. matter (%) | $CaCO_3$ (%) | Available,$P_2O_5$ kg $ha^{-1}$ | Fe | Cu | Zn | Mn | Texture |
| Sandy- calcareous | 7.77 | 1.06 | 12.10 | 94.0 | 2.85 | 0.21 | 0.37 | 1.03 | SL |
| Clay- calcareous | 8.31 | 1.92 | 7.56 | 76.2 | 3.47 | 1.23 | 0.28 | 8.26 | C |

Table 2: The effect of increasing rates N and Zn application on dry matter amount of maize plant*

| | | Dry matter (g $pot^{-1}$) | | | | | |
|---|---|---|---|---|---|---|---|
| Soil | N Doses | $Zn_0$ | $Zn_1$ | $Zn_2$ | $Zn_3$ | Average | |
| Sandy-calcareous | $N_0$ | 2.68a | 2.78ab | 2.86ab | 2.96b | 2.82a | 3.70a |
| | $N_1$ | 3.20a | 3.54b | 3.74b | 4.02c | 3.63b | |
| | $N_2$ | 4.31a | 4.47a | 4.77b | 5.10e | 4.66c | |
| | Average | 3.39a | 3.59b | 3.79c | 4.02d | | |
| | | 3.69a | | | | | |
| Clay-calcareous | $N_0$ | 4.05a | 4.31b | 4.40b | 4.52b | 4.32a | 5.14b |
| | $N_1$ | 4.88a | 5.04a | 5.32b | 5.60c | 5.21b | |
| | $N_2$ | 5.70a | 5.84ab | 5.99b | 6.04b | 5.89c | |
| | Average | 4.87a | 5.06b | 5.23c | 5.38d | | |
| | | 5.13b | | | | | |

*: Soils, N doses and Zn doses are evaluated individually and the same letter signs no statistically significant differences between them at the confidence level of 0.01

Table 3: The effect of increasing rates N and Zn application on Fe content of maize plant*

| | | Fe (mg kg$^{-1}$) | | | | | |
|---|---|---|---|---|---|---|---|
| Soil | N Doses | $Zn_0$ | $Zn_1$ | $Zn_2$ | $Zn_3$ | Average | |
| Sandy-calcareous | $N_0$ | 196.4c | 172.5b | 160.2a | 151.9a | 170.2c | 151.5a |
| | $N_1$ | 170.2d | 158.6c | 145.4b | 120.9a | 148.7b | |
| | $N_2$ | 148.3c | 132.5b | 145.2c | 117.3a | 135.8a | |
| | Average | 171.6c | 154.5b | 150.2b | 130.0a | | |
| | | 151.5a | | | | | |
| Clay-calcareous | $N_0$ | 218.4c | 209.2b | 188.7a | 180.8a | 199.3c | 182. 0 b |
| | $N_1$ | 199.3c | 186.7b | 170.3a | 167.6a | 180.9b | |
| | $N_2$ | 176.5b | 164.2a | 164.5a | 158.6a | 165.9a | |
| | Average | 193.8b | 186.7b | 174.5a | 169.0a | | |
| | | 181.0b | | | | | |

*: Soils, N doses and Zn doses are evaluated individually and the same letter signs no statistically significant differences between them at the confidence level of 0.01

Table 4: The effect of increasing rates N and Zn application on Cu content of maize plant*

| | | Cu (mg kg$^{-1}$) | | | | | |
|---|---|---|---|---|---|---|---|
| Soil | N Doses | $Zn_0$ | $Zn_1$ | $Zn_2$ | $Zn_3$ | Average | |
| Sandy-calcareous | $N_0$ | 12.0c | 9.8b | 8.2a | 7.0a | 9.2c | 8.1a |
| | $N_1$ | 11.4c | 8.7b | 6.5a | 6.1a | 8.1b | |
| | $N_2$ | 10.6b | 6.3a | 5.9a | 5.5a | 7.0a | |
| | Average | 11.3c | 8.2b | 6.8a | 6.2a | | |
| | | 8.1a | | | | | |
| Clay-calcareous | $N_0$ | 17.6d | 13.6c | 12.1b | 10.0a | 13.3b | 11.8b |
| | $N_1$ | 15.9c | 12.4b | 11.4ab | 10.6a | 12.6b | |
| | $N_2$ | 14.6c | 8.9b | 8.3b | 6.6a | 9.6a | |
| | Average | 16.0e | 11.6b | 10.6b | 9.0a | | |
| | | 11.8b | | | | | |

*: Soils, N doses and Zn doses are evaluated individually and the same letter signs no statistically significant differences between them at the confidence level of 0.01

Table 5: The effect of increasing rates N and Zn application on Mn content of maize plant*

| | | Mn (mg kg$^{-1}$) | | | | | |
|---|---|---|---|---|---|---|---|
| Soil | N doses | $Zn_0$ | $Zn_1$ | $Zn_2$ | $Zn_3$ | Average | |
| Sandy-calcareous | $N_o$ | 63.1b | 55.3a | 56.4a | 55.2a | 57.5c | 53.4a |
| | $N_1$ | 59.1c | 53.0b | 52.2b | 47.7a | 53.2b | |
| | $N_2$ | 53.5c | 54.5c | 48.6b | 41.8a | 49.6a | |
| | Average | 58.7c | 54.2b | 52.4b | 48.2a | | |
| | | 53.3a | | | | | |
| Clay-calcareous | $N_0$ | 79.8c | 69.7b | 63.5a | 60.8a | 68.4b | 63.2b |
| | $N_1$ | 76.8c | 63.1 b | 63.5b | 56.0a | 64.8b | |
| | $N_2$ | 63.7c | 56.4b | 57.1 b | 48.6a | 56.4a | |
| | Average | 73.4c | 63.0b | 61.3b | 55.1a | | |
| | | 63.2b | | | | | |

*: Soils, N doses and Zn doses are evaluated individually and the same letter signs no statistically significant differences between them at the confidence level of 0.01

on Mn content of maize plant was found to be statistically significant at the confidence level of 1%. Decreasing rate of Mn content of maize plant with N and Zn application was determined higher in clay soil than in sandy soil.

Manganese content of plants decreased with increasing N application to low organic matter content soils (Güneş and Aktaş, 1996; Brady and Weil, 1999). On the other hand, Mn content of plants also decreased with Zn application to Zn deficient soils (Baker *et al.*, 2000; Peralta *et al.*, 2001).

According to the results of this experiment, dry matter amount of maize plant increased with increasing rates of N and Zn application to calcareous soils. Iron, Cu and Mn contents of maize plant decreased, which was statistically significant at the level of 1% with increasing rates of N and Zn application to zinc deficient, low organic matter content and calcareous soils. Iron, Cu and Mn deficiency are seen frequently in these soils with increasing N and Zn applications. Therefore, care should be taken in the interaction and dynamic equilibrium between nutrient elements in zinc deficient and low organic matter content calcareous soil conditions. Otherwise, quality and quantity of yield may decrease in these soils.

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