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The Effect of Increasing Nitrogen Doses on the Zinc Content of Maize Plant in the Soils of Different Properties

Sevinç Adiloglu and M. Turgut Saglam
Department of Soil Science, Faculty of Agriculture, Trakya University Tekirdağ, 59030-Tekirdağ, Turkey

Abstract: This research was carried out in order to determine the effect of increasing nitrogen fertilizer doses on the zinc uptake of maize plant in the soils of different physical and chemical properties. For this purpose sandy acid, clay acid, sandy calcareous, clay calcareous and loam neutral soils were used in this research. According to the results pH values of the soil samples were between 4.99 and 8.31; organic matter amounts were between 0.80 and 1.92%; $CaCO_3$ contents were between 0.00 and 12.10% ; CEC values were between 17.66 and 28.74 cmol kg^{-1}; available phosphorus were between 51.8 and 123.7 kg P_2O_5 ha^{-1} available zinc content were between 0.28 and 0.62 mg kg^{-1}; textures were Loamy-Sand (LS), Sandy-Loam (SL), Loam (L) and Clay (C) determined. The experiment was done greenhouse conditions with three replications and maize was grown. Three different doses of N (No: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. N content of maize plant increased with increasing of N application doses and Zn content of maize plant increased with increasing of Zn application doses. Zn content of maize plant decreased with increasing of N application doses and N content of maize plant decreased increasing of Zn application doses. These increases and decreases result were important determined at the level of 1%, statistically.

Key words: Nitrogen, zinc, maize, clay soil, acid soil, calcareous soil

INTRODUCTION

Zn deficiency is a major problem in the world, which is determined 50% in Turkey's soils and 30% in the world[1].

Previous studies show that the nutrient elements are effective Zn availability in the soils. Nitrogen takes the first place among them. According to Ozanne[2] Zn-protein complex occurred between Zn and N in plant root with N fertilizer application to soil, which hindered Zn transportion from roots to the other parts. Consequently, Zn deficiency occurred with N application to soils.

N contents of plants decreased with increasing rates of Zn application to the soil. This is because a competition occurs between Zn and NH_4 with increasing Zn doses, therefore, NH_4 uptake by the plants is hindered[3].

N application to the soil accelerates vegetative growing of plant and this may lead Zn deficiency in soil. This negative effective is more severe in the soil with low available Zn[2,4,5].

The kind and N form of N fertilizer applied to soil also directly affect Zn availability. Zn content of bean plant was investigated by Marschner[6] in initial pH value 6.8 soil. pH value of soil raised to 7.3 with $NaNO_3$ application and Zn content of bean plant was determined as 34 mg kg^{-1}. On the other hand, pH value of soil reduced to 5.4 with $(NH_4)_2SO_4$ application and Zn content of plant was determined as 49 mg kg^{-1}. Marschner[6] attributed this to the increase in the uptake rate of cation/anion and increase in Zn availability with the decrease in pH value.

The changes of nutrient element contents of rice plant under paddy soil conditions investigated[7] 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, it was not significant for Zn content of plant.

A pot experiment was carried out with 0, 5, 10, 15 mg kg^{-1} Zn application to acid soils in Venezuela. Dry matter yield and Zn content of plant increased whereas N and P content of plant decreased with Zn application[8].

The effect of increasing rates of N and Zn application to maize plant was investigated in Brazil. For this purpose, four N doses (0, 70, 140 and 210 kg N ha^{-1}) and two Zn

Corresponding Author: Sevinç Adiloglu, Department of Soil Science, Faculty of Agriculture, Trakya University Tekirdağ, 59030-Tekirdağ, Turkey Tel: 90 282 2931442 Fax: 90 282 2931454

doses (0 and 3 kg Zn ha^{-1}) were applied to maize plant in pot experiment. 25, 45 and 63 days after the germination, analysis of N and Zn contents were done on the leaf samples of plant. According to the results, N content of plant increased and Zn content of plant decreased with increasing rates of N application. But Zn content of plant increased and N content decreased with increasing rates of Zn application[9].

The effect of increasing rates of N and Zn application to the soils having different physical and chemical properties on N and Zn content of maize plant was investigated.

MATERIALS AND METHODS

Sandy-acid (Xerochrept), clay-acid (Haploxeralf), sandy-calcareous (Calcixeroll), clay-calcareous (Xerochrept) and loam-neutral (Xerochrept)[10] soil samples were used this research. Soil samples were analysed for pH[11], lime[12], organic matter[13], available phosphorus[14], exchangeable potassium[15], CEC[16], available Zn[17] and texture[18].

Total N contents of the plants were analysed according to Kjeldahl[19]. Also zinc contents of plants were analysed with Atomic Absorbtion Spectrophotometer[19].

Pot experiment was carried out under greenhouse conditions. For this purpose, soil samples were sieved through 4mm mesh, then packed into 2 kg pots. Experiment was done 3 nitrogen doses x 4 zinc doses x 5 soils x 3 replications: 180 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 according to average phosphorus dose for maize plant. 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[20].

RESULTS AND DISCUSSION

Some physical and chemical properties of soil samples shows significant differences among them (Table 1).

According to Table 2, dry matter amount of maize plant increased with increasing rates of N and Zn application. These increases were significant statistically at 0.01 confidence level. The effect of N and Zn applications to the soils were found different. The highest average dry matter amount was determined in clay-acid soil (5.44 g pot^{-1}). These values for clay-calcareous, loam-neutral, sandy-acid and sandy-calcareous soils were 5.14, 5.01, 4.96 and 3.70 g pot^{-1}, respectively. Previous researchers[8,21-26] found that increasing rates N and Zn application to the soils increased dry matter amount of maize plants.

Table 1: Some physical and chemical properties of soils

Soil No.	pH (1:25 water)	Org. matter (%)	$CaCO_3$ (%)	CEC (cmol kg^{-1})	Available (kg ha^{-1}) P_2O_5	Available (kg ha^{-1}) K_2O	Avail. Zn (mg kg^{-1})	Texture
1	5.01	0.80	0.00	17.66	106.6	287.2	0.44	LS
2	4.99	1.01	0.00	22.70	51.8	292.3	0.62	C
3	7.77	1.06	12.10	19.62	940.0	343.4	0.37	SL
4	8.31	1.92	7.56	28.74	76.2	384.8	0.28	C
5	7.09	1.64	0.40	23.58	123.7	354.0	0.54	L
Min.	4.99	0.80	0.00	17.66	51.8	287.2	0.28	
Max.	8.31	1.92	12.10	28.74	123.7	384.8	0.62	

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

Soil No.	N Doses	Dry matter (g pot^{-1}) Zn_0	Zn_1	Zn_2	Zn_3	Average	
1	N_0	2.89a	3.00ab	3.16c	3.25c	3.07a	4.96a
Sandy-acid	N_1	4.64a	5.23b	5.42b	5.94c	5.31b	
	N_2	5.83a	6.29b	6.76c	7.13d	6.50c	
2	N_0	3.63a	3.83a	4.37b	4.50b	4.08a	5.44b
Clay-acid	N_1	5.00a	5.52b	5.91c	6.09c	5.63b	
	N_2	5.86a	6.42b	6.86c	7.27d	6.60c	
3	N_0	2.68a	2.78ab	2.86ab	2.96b	2.82a	3.70c
Sandy-calcareous	N_1	3.20a	3.54b	3.74b	4.02c	3.63b	
	N_2	4.31a	4.47a	4.77b	5.10c	4.66c	
4	N_0	4.05a	4.31b	4.40b	4.52b	4.32a	5.14d
Clay-calcareous	N_1	4.88a	5.04a	5.32b	5.60c	5.21b	
	N_2	5.70a	5.84ab	5.99b	6.04b	5.89c	
5	N_0	3.74a	4.14b	4.16b	4.37b	4.10a	5.01a
Loam-neutral	N_1	4.56a	4.71ab	4.94b	5.20c	4.85b	
	N_2	5.85a	5.93a	6.20b	6.28b	6.06c	

*: 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

According to Table 3, N content of maize plant were increased with N applications. But N contents of maize plant decreased with Zn applications. The effect of N and Zn applications on N content of maize plants found statistically significant at the level of 1%.

In general, the highest N content was determined in clay-acid soil (3.27% N). These values for clay-calcareous, loam-neutral, sandy-acid and sandy-calcareous soils were 3.08, 2.99, 2.88 and 2.81%, respectively.

The highest increase in comparison to the control (N_0Zn_0) was found for sandy calcareous soil with 47%. These increases for sandy-acid, clay-calcareous, clay-acid and loam-neutral soils were 45, 25, 20 and 19%, respectively. The reason of these differences may be attributable to some different physical and chemical properties of soils[27-29].

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

		N (%)					
Soil No.	N Doses	Zn_0	Zn_1	Zn_2	Zn_3	Average	
1	N_0	2.50a	2.35ab	2.24ab	2.15b	2.31a	2.88a
Sandy-acid	N_1	3.25a	3.13ab	2.85bc	2.67c	2.97b	
	N_2	3.94a	3.61b	3.24c	2.61d	3.35c	
2	N_0	3.21a	3.01a	3.07a	2.53b	2.96a	3.27b
Clay-acid	N_1	3.77a	3.42b	3.20b	2.83c	3.30b	
	N_2	4.07a	3.90a	3.33b	2.93c	3.56c	
3	N_0	2.52a	2.35ab	2.28ab	2.09b	2.31a	2.81a
Sandy-	N_1	3.01a	2.75ab	2.59bc	2.48c	2.71b	
calcareous	N_2	3.91a	3.54b	3.34b	2.87c	3.41c	
4	N_0	2.87a	2.78a	2.66ab	2.45b	2.69a	3.08c
Clay-	N_1	3.44a	3.34ab	3.14b	2.81c	3.18b	
calcareous	N_2	3.83a	3.42b	3.20bc	2.99c	3.36c	
5	N_0	2.84a	2.79ab	2.65ab	2.52b	2.70a	2.99d
Loam-	N_1	3.37a	3.13ab	3.06bc	2.78c	3.08b	
neutral	N_2	3.37a	3.28a	3.16ab	2.94b	3.19b	

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

		Zn (mg kg^{-1})					
Soil No	N Doses	Zn_0	Zn_1	Zn_2	Zn_3	Average	
1	N_0	23.98a	31.71b	38.48b	55.06c	37.31c	34.05b
Sandy-acid	N_1	21.10a	28.74b	34.36b	51.84c	34.01b	
	N_2	20.64a	27.64b	31.98b	43.03c	30.82a	
2	N_0	33.13a	41.11b	55.83c	70.65d	50.18c	44.05e
Clay-acid	N_1	25.75a	38.28b	49.23c	59.31d	43.14b	
	N_2	23.51a	32.85b	45.75c	53.16d	38.82a	
3	N_0	24.59a	31.45b	34.95b	43.42c	33.60b	30.18a
Sandy-	N_1	22.38a	26.05ab	30.81b	41.94c	30.29b	
calcareous	N_2	20.52a	23.80ab	28.65bc	33.66c	26.65a	
4	N_0	28.70a	36.66b	43.36b	54.13c	40.71b	37.06c
Clay-	N_1	24.72a	31.89b	41.65c	45.24c	35.87a	
calcareous	N_2	22.56a	31.55b	40.70b	43.59c	34.60a	
5	N_0	31.24a	37.84a	50.75b	62.55c	45.59c	40.32d
Loam-	N_1	29.22a	35.20a	43.63b	57.72c	41.44b	
neutral	N_2	24.68a	30.31ab	31.60b	49.17c	33.94	

*: 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

Some previous researchers found different effect with increasing N and Zn application to maize plant. Increasing N doses increased N content of plants. But increasing Zn doses decreased N content of plants. According to authors, explained this with decreasing effect of Zn application was antagonism between Zn^{+2} and $NH_4^+$and increasing Zn applications hindered NH_4^+ uptake by plant also this situation had negative effect on N nutrition of plant. This negative effect of Zn increases with decreasing organic matter amount of soil[3,9,21,26,30,31].

Zn content of maize plant increased with Zn application while it decreased with N application (Table 4). These increases and decreases were found to be significant statistically at the level of 1%.

In general, the highest Zn content was determined in clay-acid soil (44.05 mg kg^{-1}) with N and Zn application. These values for loam-neutral, clay-calcareous, sandy-acid and sandy-calcareous soils were 40.32, 37.06, 34.05 and 30.18 mg kg^{-1}, respectively.

Zn content of maize plant decreased with increasing rates of N application and this decrease was found statistically significant. Zn content of maize plant was found to be 37.31 mg kg^{-1} for N_0 dose and 30.82 mg kg^{-1} for N_2 dose in sandy-acid soil. These values for clay-acid, sandy-calcareous, clay-calcareous and loam-neutral soils were 50.18-38.82; 33.60-26.65; 40.71-34.60 and 45.59-33.94 mg kg^{-1}, respectively (Table 4). These decreasing rates were found 25, 22, 21, 18 and 15% for loam-neutral, clay-acid, sandy-calcareous, sandy-acid, clay-calcareous soils, respectively. Zn content of plants and available Zn content of soils were consistent. The highest Zn content of plant was determined in clay-acid soil. Same way, the highest available Zn content was determined in clay-acid soil (Table 1). Available Zn content of soils increased with the increase in acidity. On the other hand, available Zn content of clay soils was higher than that of sandy soils. It implies that there is a relationship between available Zn content and some physical and chemical properties of soils[5].

Decrease in Zn content of plants with increasing rates of N application was directly related with the available Zn content of soils. Vegetative growth was accelerated with increasing rates of N application and this may cause Zn deficiency problem in Zn deficient or under critical level of Zn in soils[2,5]. Available Zn contents of 1, 3, 4 number soils were low, around the critical level (0.5 mg kg^{-1})[17]. Therefore Zn deficiency was not in great extent in these soils, consequently, Zn content of plants were not obtained below the critical level of in all soils 20 mg kg^{-1}[32]. According to some researchers, Zn-protein complex formed in plant root and transportion of Zn to vegetative part of plant was hindered with N application to soil. This situation is more important in Zn deficient soils[2,4,5,26]. Some previous researchers[30,33-35] determined statistically significant increases in Zn content of plants with Zn application.

Many researchers determined decreases in Zn content of plants with increasing rates N application to the soils. These decreases were found to be significant according to some researchers while not for others. The reason for not significant statistically, the available is because Zn content of soil is sufficient or high[9,21,30,36-39].

Zn content of maize plant was decreased statistically significant at the level of 1% with increasing rates N application to the soil having different some physical and chemical properties.

Increasing rates of N application with no Zn application reduced the plant Zn contents to the critical levels (20 mg kg^{-1}) in the all soils [32].

Zn deficiency may be increased with same farming system and same fertilization programme for a log time. Zn deficiency is a important nutrition problem in the

world. On the other hand, excess N fertilizers are applied to low organic matter content soils. This situation adversely affect Zn nutrition of plants as proven in this research.

N and Zn requirements should be determined with increasing rates application of N and Zn for different plants. In addition, soil and plant analysis results should be evaluated together. Otherwise, Zn deficiency will increase with excess N application, consequently quantity and quality of yield will decrease.

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