Asian Journal of Chemistry Vol. 21, No. 2 (2009), 1475-1482

Effect of Nitrogen and Zinc Application on Nickel, Lead and Cadmium Contents of Maize Plant in Typic Xerochrept and Calcixeroll Soils

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This research was carried out in order to determine the effects of nitrogen and zinc fertilizers on the nickel, lead and cadmium contents of maize plant in typic xerochrept and typic calcixeroll soils. The experiment was done in greenhouse conditions with three replications and maize plant 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 $ZnSO_4\cdot 7H_2O$. According to the results, dry matter amount and Ni content of maize plant increased with increasing of N and Zn doses. Lead and Cd contents of maize plant decreased with increasing of N and Zn application doses. Increasing of dry matter amount and Ni content and decreasing of Pb and Cd contents of maize plant were determined significant at the level of 1 %, statistically.

Key Words: Nitrogen, Zinc, Nickel, Lead, Cadmium, Maize, Xerochrept, Calcixeroll.

INTRODUCTION

There is growing concern worldwide surrounding issues of soil contamination from a large range of pollutants including heavy metals. On the other hand, more and more fertilizer has been applied to soil and plant for maximum yield production. 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[1].

Nitrogen application to the soil accelerates vegetative grow of plant and this may lead Zn and Ni deficiency in soil. This adverse effect is more severe in the soil with low available Zn and low organic matter amount[2,3]. The effect of increasing rates of Zn application to maize plant was investigated by Adiloglu[4]. Cadmium contents of plant decreased with increasing Zn application.

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Adiloglu[5] investigated the changes of nutrient element contents of maize plant in calcareous and zinc deficient soils under greenhouse conditions. According to the results, N fertilizer application increased dry matter amount and N content of maize plant. While these increases were found statistically significant for dry matter amount and N content of plant. Gray and McLaren[6] reported that Ni, Pb and Cd were not uptaken in sufficient levels by plants in calcareous soils, because these elements precipitated in these soil conditions. Therefore, these elements deficiency may be seen in plants. Lead and Cd contents of plant decreased with increasing Zn application to Zn deficient and calcareous soils[7-9]. Application of N and Zn fertilizers in the increasing rates to Zn deficient, low organic matter containing and calcareous soils decreased Pb and Cd contents and increased Ni contents of plants[10].

In this research, the effect of N and Zn application to typic xerochrept and typic calcixeroll soils, which contain low organic matter, Zn deficient and high calcareous, on Ni, Pb and Cd contents of maize plant was investigated.

EXPERIMENTAL

Typic xerochrept and typic calcixeroll[11] soil samples were used in this research. Soil samples were analyzed for pH[12], lime[13], organic matter[14], extractable Ni, Pb and Cd[15] and texture[16]. Nickel, lead and cadmium contents of plants were also analyzed with ICP-OES[17].

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 N doses × 4 Zn 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 $ZnSO_4 \cdot 7H_2O$) in solution forms and Zn only once, N 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 45 d and prepared for analysis. Required analyses of plants were carried out and results were evaluated statistically[18].

RESULTS AND DISCUSSION

Physical and chemical properties of soils: The physical and chemical properties of soil samples are given in Table-1, showing that the organic matter contents are low and Zn contents are deficient in xerochrept and cacixeroll soils.

Effect of nitrogen and zinc application on dry matter amount of maize plant: The effect of increasing rates of N and Zn application on dry matter amount of maize plant are given in Table-2. 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 typic xerochrept soil than in typic calcixeroll soil. These increases were significant statistically at 1 % confidence level. Average dry matter amount for xerochrept and calcixeroll soils were determined 3.43 and 2.94 g

TABLE-1
SOME CHARACTERISTICS OF THE SOIL SAMPLES

Soil	pH (1:2.5 H_2O)	Organic matter (%)	$CaCO_3$ (%)	Available Zn (mg kg^{-1})	Extractable (mg kg^{-1})			Texture
					Ni	Pb	Cd	
Xerochrept	7.60	1.02	9.16	0.34	1.17	0.67	0.038	C
Calcixeroll	7.90	1.25	14.05	0.22	0.52	0.63	0.032	LS

TABLE-2
EFFECT OF INCREASING RATES OF N AND Zn APPLICATION ON DRY MATTER AMOUNT OF MAIZE PLANT*

Soil	N doses	Dry matter (g pot^{-1})				Average	
		Zn_0	Zn_1	Zn_2	Zn_3		
Xerochrept	N_0	2.65a	2.76a	2.91b	2.95b	2.81a	3.43b
	N_1	3.10a	3.18a	3.30b	3.42c	3.25b	
	N_2	3.90a	4.10b	4.32c	4.54d	4.21c	
	Average	3.21a	3.34b	3.51c	3.63d		
		3.42b					
Calcixeroll	N_0	2.26a	2.44b	2.78c	3.10d	4.32a	2.94a
	N_1	2.52a	2.80b	2.97c	3.26d	5.21b	
	N_2	2.90a	3.15b	3.42c	3.64d	5.89c	
	Average	2.56a	2.79b	3.05c	3.34d		
		2.93a					

*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.

pot^{-1}, respectively, with increasing N application. As for the increasing Zn application, average dry matter amount were determined 3.42 and 2.93 g pot^{-1} for xerochrept and calcixeroll soils, respectively. The similar results were also found by Fayiga *et al.*[3], Adiloglu[5], Peralta-Videa *et al.*[19] and Agyarko *et al.*[20].

Effect of nitrogen and zinc application on nickel content of maize plant: The effect of increasing rates of N and Zn application on Ni content of maize plant are given in Table-3. Table-3 shows that Ni contents of maize plant increased with N and Zn applications. The effect of Zn and Zn application on Ni content of maize plant was found to be statistically significant at the level of 1 %. The N fertilizer was more effective on increasing Ni content of the plant when compared to Zn fertilizer for xerochrept and calcixeroll soils (Table-3).

Same results were found by Gray *et al.*[6], Wang *et al.*[7], Reeves and Adigüzel[21], Montagne *et al.*[22] in Zn deficient and low organic matter containing soils. They attributed this to the increase in vegetative growth with N and Zn application and therefore increase of Ni transportation to plant.

Effect of nitrogen and zinc application on lead content of maize plant: Lead content of maize plant decreased with N and Zn application (Table-4), which is significant statistically at the level of 1 %. Decreasing rate of Pb content was determined higher in xerochrept than calcixeroll soil.

TABLE-3
EFFECT OF INCREASING RATES OF N AND Zn APPLICATION ON
Ni CONTENT OF MAIZE PLANT*

Soil	N doses	Ni (mg kg^{-1})				Average	
		Zn_0	Zn_1	Zn_2	Zn_3		
Xerochrept	N_0	1.10a	1.18b	1.30c	1.52d	1.27a	2.58b
	N_1	2.80a	2.92b	3.01b	3.19c	2.98b	
	N_2	3.30a	3.41b	3.52c	3.68d	3.47c	
	Average	2.40a	2.50a	2.61b	2.79c		
		2.57b					
Calcixeroll	N_0	1.12a	1.19b	1.32c	1.48d	1.27a	2.54a
	N_1	2.76a	2.92b	3.03c	3.14d	2.96b	
	N_2	3.14a	3.28b	3.46c	5.59d	3.36c	
	Average	2.34a	2.46b	2.60c	2.73d		
		2.53a					

*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
EFFECT OF INCREASING RATES OF N AND Zn APPLICATION ON
Pb CONTENT OF MAIZE PLANT*

Soil	N doses	Pb (mg kg^{-1})				Average	
		Zn_0	Zn_1	Zn_2	Zn_3		
Xerochrept	N_0	0.35c	0.22b	0.19b	0.10a	0.21c	0.16b
	N_1	0.26c	0.20b	0.11a	0.07a	0.16b	
	N_2	0.19c	0.13b	0.09b	0.04a	0.11a	
	Average	0.26d	0.18c	0.13b	0.07a		
		0.15b					
Calcixeroll	N_0	0.23c	0.20bc	0.17ab	0.13a	0.18b	0.15a
	N_1	0.20b	0.19b	0.12a	0.09a	0.15b	
	N_2	0.14c	0.11bc	0.08ab	0.05a	0.09a	
	Average	0.21b	0.17b	0.12a	0.09a		
		0.14a					

*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.

It was also stated that Pb uptake of plants decreased with Zn application to Zn deficient soils[19,23-25].

Plant vegetative growth increased with N application to soil. This situation is hindering Pb transportation in plant; consequently, Pb uptake decreased by plant[6,9,26].

Effect of nitrogen and zinc application on cadmium content of maize plant: Table-5 shows the effect of increasing N and Zn application on Cd content of maize plant in xerochrept and calcixeroll soils. A statistically significant (at 1 % confident level) decrease was obtained for Cd content of maize plant with increasing rates of N and Zn application to the soils. The rate of this decrease was higher in xerochrept than calcixeroll soil.

TABLE-5
EFFECT OF INCREASING RATES OF N AND Zn APPLICATION ON Cd CONTENT OF MAIZE PLANT*

Soil	N doses	Cd (mg kg^{-1})				Average	
		Zn_0	Zn_1	Zn_2	Zn_3		
Xerochrept	N_0	0.98d	0.82c	0.69b	0.52a	0.75c	
	N_1	0.86d	0.71c	0.62b	0.48a	0.66b	0.65b
	N_2	0.71d	0.60c	0.51b	0.42a	0.56a	
	Average	0.85d	0.71c	0.60b	0.47a		
		0.66b					
Calcixeroll	N_0	0.89d	0.72c	0.60b	0.48a	0.67c	
	N_1	0.76d	0.63c	0.51b	0.40a	0.57b	0.56a
	N_2	0.61d	0.49c	0.38b	0.31a	0.44a	
	Average	0.75d	0.61c	0.49b	0.39a		
		0.56a					

*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.

Cadmium content of plants decreased with increasing N application to low organic matter content soils[4,27,28]. Similarly, Cd content of plants also decreased with Zn application to Zn deficient soils[5,6,8,29,30].

Conclusion

According to the results of this experiment, dry matter amount of maize plant increased with increasing rates of N and Zn application to xerochrept and calcixeroll soils. Nickel content of maize plant increased, but Pb and Cd contents of maize plant decreased, with increasing rates of N and Zn application to zinc deficient, low organic matter containing and xerochrept and calcixeroll soils. These increases and decreases were statistically significant at the level of 1 %. Increasing of Ni uptake is seen frequently in these soils with increasing N and Zn applications. This situation is very important of plant nutrition, food quality, human health and the environment pollution. Therefore, care should be taken in the interaction and dynamic equilibrium between nutrient elements and heavy metals in Zn deficient and low organic matter containing xerochrept and calcixeroll conditions.

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(*Received*: 28 February 2008; *Accepted*: 8 October 2008) AJC-6933