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Interaction of between Cd and Zn in Barley (*Hordeum vulgare* L.) Plant for Phytoextraction Method

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***Abstract*—**The aim of this research is to remediation of the cadmium (Cd) pollution in agricultural soils by using barley (*Hordeum vulgare* L.) plant. For this purpose, a pot experiment was done in greenhouse conditions. Cadmium (100 mg/kg) as $CdSO_4.8H_2O$ forms was applied to each pot and incubated during 30 days. Then Ethylenediamine tetraacetic acid (EDTA) chelate was applied to each pot at five doses (0, 3, 6, 8 and 10 mmol/kg) 20 days before harvesting time of the barley plants. The plants were harvested after two months planting. According to the pot experiment results, Cd and Zn amounts of barley plant increased with increasing EDTA application and Zn and Cd contents of barley 20,13 and 1,35 mg/kg for 0 mmol /kg EDTA; 58,61 and 113,24 mg/kg for 10 mmol/kg EDTA doses, respectively. On the other hand, Cd and Zn concentrations of experiment soil increased with EDTA application to the soil samples. Zinc and Cd concentrations of soil 0,31 and 0,021 mg/kg for 0 mmol /kg EDTA; 2,39 and 67,40 mg/kg for 10 mmol/kg EDTA doses, respectively. These increases were found to be statistically significant at the level of 1 %. According to the results of the pot experiment, some heavy metal especially Cd pollution of barley (*Hordeum vulgare* L.) plant province can be remediated by the phytoextraction method.

***Keywords*—**Barley (*Hordeum vulgare* L.), Cadmium and Zinc, phytoextraction, soil pollution.

I. Introductİon

NOWADAYS, modern agricultural technologies are using for plant growth and production. But many applications such as excess chemical and inorganic fertilizers, some hormones, soil regulators, excess pesticides, and using treatment sludge and waste water in irrigation are preferred to gain maximum yield from per unit area in agriculture [1]. The increase in the amount of some heavy metals as a result of advancing industry and urbanization has become a threat for the ecosystem in the world. In many industries, some heavy metals such as cadmium, lead, chrome, cobalt, nickel, mercury, and copper are released outside and natural sources, especially agricultural soils, in high levels. While investigating the soil pollution, it should never be forgotten that the soil cannot be reproduced, and its replacement is impossible [2]-[5].

Phytoextraction method is applicative widely, to the soils, which is polluted of heavy metal. Because using of this method is very important for sustainable soil fertility.

The aim of this research is to identify the applicability of Phytoextraction method in the region as one of the solutions of heavy metal pollution problem by using field experiment, which is one of the cheapest and most efficient biological formulas to eliminate some heavy metals, especially Cd, pollution which affects the agricultural soils in the country and in Trakya region, specifically.

II. Materials and Methods

This pot experiment was done greenhouse conditions in Namık Kemal University, Agricultural Faculty, Department of Soil Science and Plant Nutrition. Experiment was conducted according to Randomized Block experiment design with three replicates. Barley (*Hordeum vulgare* L.) plant was used in this research for test plant. Cadmium (100 mg/kg) was applied as $CdSO_4.8H_2O$ forms to each pot and pots incubated during 30 days. Ethylenediaminetetraacetic acid (EDTA) chelate was applied to each pot at five doses (0, 3, 6, 8 and 10 mmol/kg) 20 days before harvesting time. Plants were harvested after two months planting. A general view of pot experiment in Fig. 1. Then plant samples were prepared for analysis and Cd and Zn concentration of plant samples were determined ICP- OES instruments [6]. Variance analyses were done between Cd and Zn concentration of plant green part. Also, pH, EC, organic matter amount, available phosphorus, exchangeable potassium, lime [7], available some trace elements (Fe, Zn, Cu and Mn), exchangeable Cd contents and texture class [8] of soil sample were analysed. Some physical and chemical properties of soil samples are given in Table I.

Fig. 1 A general view of pot experiment

III. Results and Discussion

The pot experiment results and statistically relations between Cd and Zn of barley plant are given in Tables II and

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III. Besides Zn and Cd concentrations of barley plant are given in Fig. 2.

TABLE I
PHYSICAL AND CHEMICAL COMPOSITION OF THE SOIL USED IN THE EXPERIMENTS

Parameter	Unit	Value
pH	(1: 2.5)	7.40
EC	dS/m	0.150
Texture class	-	Clay
Organic matter	(%)	1.08
Available P_2O_5	(kg da^{-1})	9.90
Exchangeable K_2O	(mg kg^{-1})	51.20
$CaCO_3$	(%)	4.82
Available Fe	(mg kg^{-1})	2.60
Available Zn	(mg kg^{-1})	0.40
Available Cu	(mg kg^{-1})	0.60
Available Mn	(mg kg^{-1})	3.05
Exchangeable Cd	(mg kg^{-1})	0.02

TABLE II
AVERAGE CONCENTRATIONS OF ZN AND CD IN THE GREEN PARTS OF THE BARLEY PLANT (P<1%)*

EDTA doses (mmol/kg)	Cd (mg/kg^{-1})	Zn (mg kg^{-1})
Control	1.35 ± 0.30**a**	15.05 ± 0.23 **a**
0	22.55 ± 3.25**b**	17.26 ± 1.02**ab**
3	56.27 ± 3.20**c**	21.12 ± 1.55a**b**
6	89.85 ± 2.54**d**	24.85 ± 0.69b**c**
9	108.56 ± 2.49**e**	29.64 ± 0.77**cd**
10	116.50 ± 2.11**e**	37.08 ± 4.13**d**

a,b,c,d: Values in the same column with different letters are statistically different at the 1 % significance level, *: average values of tri replicates in experiments.

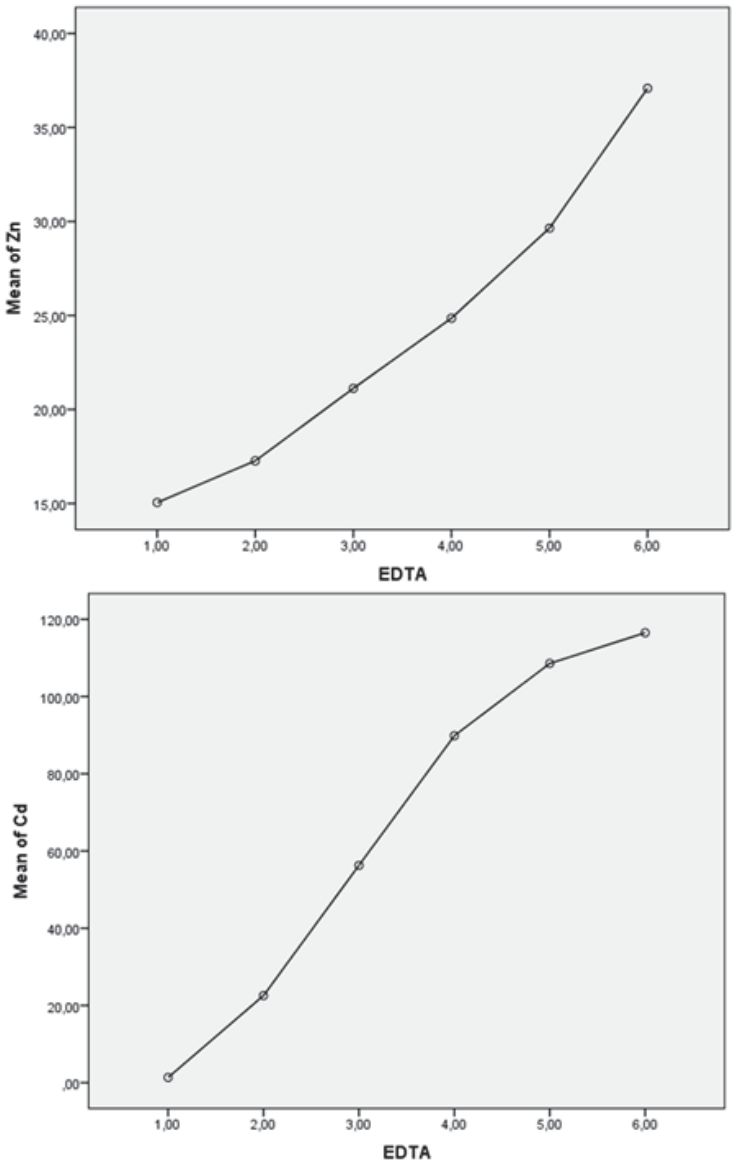

Fig. 2 The effect of EDTA application on Zn and Cd concentrations of Barley

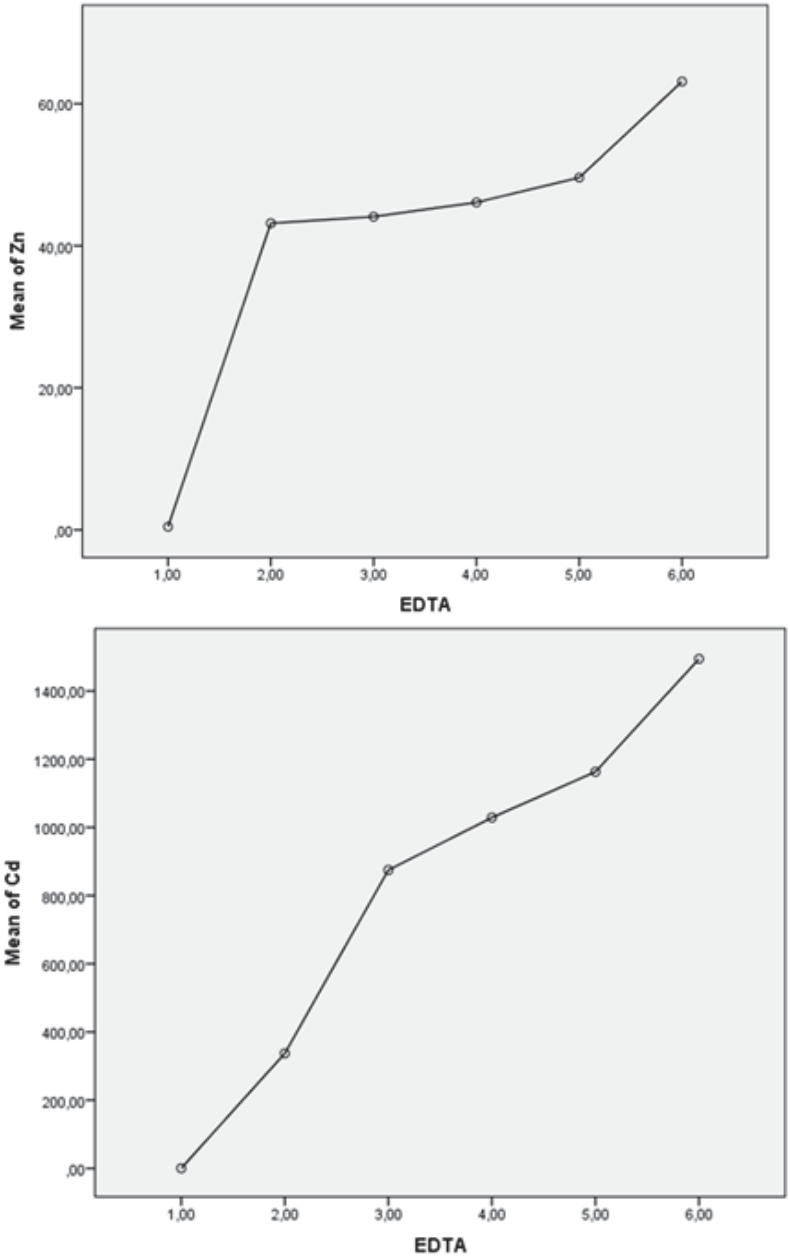

Fig. 3 The effects of increasing EDTA applications on Zn and Cd content of the soil

TABLE III
VARIANCE ANALYSIS FOR CD VE ZN CONCENTRATIONS MEASURED IN THE GREEN PARTS OF THE BARLEY PLANT AFTER HARVESTING

SV	(df)	Cd		Zn	
		Total of squares	F value	Total of squares	F value
General	17	1127.84			
Doses	5	1011.93	391.30**	202.38	20.95**
Error	12	115.907		9.65	

*: P≤0.01; SV: source of variance

According to the results of experiment (Tables II and III), Zn and Cd contents of barley plant increased with increasing doses EDTA application to the plants. These increases were found to be significant at the level of 1 %, statistically. Same results were obtained earlier researchers [9], [10].

TABLE IV
AVERAGE CONCENTRATIONS OF CD AND ZN IN THE SOIL SAMPLES AFTER HARVESTING +

EDTA doses (mmol/kg)	Cd (mg kg $^{-1}$)	Zn (mg kg $^{-1}$)
Control	0.25 ± 0.02 **a**	0.42 ± 0.01 **a**
0	33.73 ± 6.30**b**	43.17 ± 0.36 **b**
3	87.49 ± 6. 80 **c**	44.09 ± 0.25 **b**
6	102.87 ± 7.23**cd**	46.10 ± 0.99 **b**
9	116.31 ± 9.60 **d**	49.60 ± 0.61 **b**
10	118.67 ± 10.44 **e**	63.12 ± 3.95 **c**

a,b,c,d,e: Values in the same column with different letters are statistically different at the 1% significance level, +: tri replicates experiments, *: % 1 significant

Extractable Cadmium and Zn contents of soil samples after pot experiment are given in Table IV. According to Table IV, extractable Cd and Zn contents of soil samples increased with increasing EDTA application. These increases were found to be significant at the level of 1 %, statistically (Table V). Same results were obtained earlier researchers [9], [10]. The reason of this result, solubility of Zn and Cd increased with EDTA application (Fig. 3).

TABLE V
VARIANCE ANALYSIS FOR CD VE ZN CONCENTRATIONS MEASURED IN THE SOIL SAMPLES AFTER HARVESTING

SV	(df)	Cd		Zn	
		Total of squares	F value	Total of squares	F value
General	17	33482,18		1127.84	
Doses	5	33278.07	85.58**	1011.93	156.81**
Error	12	204.10		115.90	

*: P≤0.01; SV: source of variance

IV. CONCLUSION

This pot experiment result is predictable; because the application of chelates such as EDTA increases the dissolubility of some heavy metals, especially Cd in soil and their uptake by hyperaccumulator plants i.e. barley. Increasing some heavy metal uptake by plants hinders the use of some basic nutrient elements. As a result, the dry matter yield and nutrient absorption of some plants decreases dramatically. At the end of the pot experiment, the amount of Cd heavy metal which is removed from soil by the plant increase with the increasing EDTA doses application to the soil. On the other hand, Cd, and Zn contents of barley plant increased with EDTA application to the soils. Interactions between Zn and Cd, contents of plant were found statistically significant at the level of 1 %.

As a result, simple and cheap methods (Phytoremediation method) which help the remove of Cd from agricultural soils by increasing their mobility are gaining more significance day by day on the agricultural lands of agricultural soils [11].

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