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Study on the Cd uptake by lettuce plants in liming experiment

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Cadmium belongs to toxic heavy metals. Toxicity is a term specific to soil, plant, animal and human being, determined by, beside the total quantity of the element concerned, its solubility, mobility and availability. Solubility depends, partly, on the chemical properties of the compound in question and partly on the physical and chemical characteristics of the environment, in this case, of the soil, especially on the buffer capacity and chemical reaction, and, in function of them, can change within a quite wide range (Várallyay 1993).

Cadmium has an outstanding importance among toxic heavy metals because of its mobility in the plant-soil system and in this way it can get into the nutrition chain. Cadmium is especially dangerous because the plant can accumulate it in large quantities without any visible signs. (Lehoczky et al. 1996, 1997).

In the previous years in our experiments with different plants (maize, garlic, spinach, lettuce) we came to the conclusion that lettuce can accumulate Cd in its leaves in high concentrations (Lehoczky et al. 1998) therefore we chose lettuce (*Lactuca sativa* L.) as a test plant. In our experiments with local soil of two different Cd contents and acidity our aim was to examine how much liming of the soil can influence Cd accumulation in the plant.

Materials and Methods

For our pot experiments we collected soil from areas where the Cd content, pH and hydrolytic acidity of the soil was different and liming can be reasonable. The soil type of T1 experimental soil was an Eutric Fluvisol with a slightly acidic pH, while soil type of T2 experimental soil was a Mollic Fluvisol and strongly acidic.

Pots were filled with 5 kg air dry soil. To examine the influence of liming we applied the following treatments, in four replication: (T1 soil) $CaCO_3$ g/kg soil: control=0, M1=4.5; M2=9.0; (T2 soil) $CaCO_3$ g/kg soil: control=0, M1=5.0 M2=10.0. Two hundred lettuce seeds were sown into each pot. Plants were grown for 28 days then we finished the experiments. The fresh weight was measured and then after drying the dry matter weight of each pot. Cd concentration in plant samples was determined by ICP-AES spectrometry after digestion in cc. nitric acid. The calculation of total Cd uptake was based on plant dry matter weight and Cd concentration. The mathematical-statistical analyses of the experimental data and measurement results were carried out by SPSS computer programme.

The most important physical and chemical properties of the selected soils can be seen in Table 1.

Results and Conclusions

On T1 experimental soil liming did not cause any changes in the fresh and dry weight of the plants comparing them to the control. On T2 soil after liming the biomass production of the lettuce was smaller.

On T1 soil after liming treatments (M1, M2), the Cd content of the leaves of lettuce was significantly lower by 38% than that of the control. There was not difference between the effects of the two lime doses, when we applied double lime dose the Cd concentration of the plants did not decrease further on.

During M1 treatment, Cd uptake by plants was 32% less than the control group. M2 treatment decreased the Cd content slightly but statistically this difference could not be justified.

On T2 soil liming decreased the Cd content of the leaves of lettuce by 58% comparing it to the control. The application of double dose of lime (M2) did not decrease the Cd concentration of lettuce significantly. On this soil the Cd uptake by plants was 70% less during lime treatment.

The cadmium concentration in lettuce was higher on both soils in the dry matter than the total Cd concentration of air dry soil. On T2 soil it meant a sixteen-fold difference. Lettuce accumulated cadmium in its leaves significantly.

Our results call the attention to the fact that the Cd concentration of lettuce can be high even on soils with low Cd content, which can be explained by the rate of acidity and hydrolytic acidity of soils among other soil properties.

To sum up we made the following important statements. Our results justify that the liming of soil can influence the Cd uptake by plants significantly. It can be explained by the changes of the pH of experimental soil and of the values of

Table 1. The characteristics of the experimental soils.

Soil Type	Eutric Fluvisol		Mollic Fluvisol	
Cd mg/kg soil	total* 3.88	available** 2.57	total* 0.53	available** 0.29
pH_{H2O}	6.9		5.4	
pH_{KCl}	6.3		4.6	
y_1	5.6		14.9	
Clay %	21.7		47.6	
Silt %	18.7		38.7	
C %	2.1		2.5	

*in cc.$HNO_3H_2O_2$,**determined by Lakanen-Erviö method

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Table 2. Biomass production of lettuce, Cd concentration and Cd uptake by plants on T1 soil, (Eutric Fluvisol).

Treatments	fresh weight g / pot^{-1}	dry weight g / pot^{-1}	Cd mg / kg d.w.$^{-1}$	Cd mg / pot^{-1}
control	47.1 a	2.64 a	5.12 a	13.5 a
M 1	50.8 a	2.92 a	3.14 b	9.2 b
M 2	47.8 a	2.77 a	3.19 b	8.9 b
$LSD_{5\%}$	6.35	0.35	0.69	2.4

Table 3. Biomass production of lettuce, Cd concentration and Cd uptake by plants on T2 soil, (Mollic Fluvisol).

Treatments	fresh weight g / pot^{-1}	dry weight g / pot^{-1}	Cd mg / kg d.w.$^{-1}$	Cd mg / pot^{-1}
control	97.6 b	5.1 b	8.59 b	43.99 b
M 1	51.8 a	3.7 ab	3.62 a	13.38 a
M 2	61.9 a	3.4 a	3.72 a	12.67 a
$LSD_{5\%}$	26.1	1.7	0.63	10.23

hydrolytic acidity as these properties are determinants regarding the solubility of Cd. The importance of the differences in the pH and hydrolytic acidity is justified by our results. The Cd concentration in lettuce was much higher on the strongly acidic T2 soil, than on the T1 soil despite the fact that the Cd content of T2 soil was much lower (about one seventh) than that of T1 soil with neutral pH. On T2 soil the influence of liming was more expressed and during lime treatments the Cd concentration in the leaves of plants decreased at a greater extent (by 58%) than on T1 experimental soil with smaller hydrolytic acidity (by 32%). As an influence of liming, the pH value of both soils increased significantly while hydrolytic acidity (y1) decreased but we could not show difference between the influence of the two lime doses.

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