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Influence of Cadmium Contamination of Soil to Quality of Carrot (*Daucus carota* L.)

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Abstract

In South Slovakia there are the most productive agricultural soils for intensive vegetable production. The research results show that from cadmium (Cd), lead (Pb) and mercury (Hg) elements, the cadmium (Cd) poses the greatest danger in the field vegetables growing. We studied in our pot experiments the effect of cadmium doses of 1.0 and 2·0 mg·kg^{-1} cadmium to the pots on cadmium content in the roots of carrots. The results prove that the carrot root was two times more Cd cumulative (87%) than the foliage. Based on the results of the soil 1 and 2 mg·kg^{-1} Cd contamination caused four, or seven times the soil loads, Resulting in the carrot root Cd content significantly exceeded (7 times and 10 times) the threshold limit value (0.1 mg·kg^{-1}). Compromising the quality of the root is proportional to the soil Cd contamination. Cultivation is closely related to soil quality.

Keywords

Cd contamination, productive soil, carrot, cumulation

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Introduction

Current knowledge demonstrates the need for a comprehensive approach to addressing soil contamination and accessibility of heavy metals to plants. The relationship between heavy metal content in soil and their transport to the plant parts can not be generalized. It can characterize the level of risk of a particular type of pollution for specific soil and climatic conditions and crop species.

An important knowledge is that due to different soil and climatic factors are hardly ever found a linear relationship between the content of heavy metals in soil and their transport from soil to plants (Queirolo et al., 2010). Entry of heavy metals from soil and their negative effect to plants in various growing conditions depends largely on the efficiency of the root system as a barrier. Based on our results of monitoring soils of southern Slovakia, cadmium of the three monitored heavy metals (Cd, Pb, Hg) was shown to be relatively worst element in field vegetables growing. Therefore, following his transfer from the soil and characterized its accumulation in the underground and above-ground parts of carrots.

Material and Method

Experiments were established under the foil cover in the form of model experiments in the years 2012 - 2013. The seeds of carrots - *Daucus carota sativus* (Kaerka) were seeded directly into containers of PVC containing 11 kg of black soil in three variants and ten repetitions. To the soil substrate were applied the nutrients N, P, K in the form of salt solutions of NH_4NO_3, KH_2PO_4 and K_2SO_4. Cadmium as monitored contaminants was applied in the form of Cd $(NO_3)_2.4H_2O$ in two doses.

Variants of the experiment

C: NPK - Control;
A: NPK + 1 mg Cd·kg^{-1} soil;
B: NPK + 2 mg Cd·kg^{-1} soil

For each option, after the emergence of the carrots were reduced to ten plants per container. During the growing season, the plants watered to 75% of the maximum water capacity of the substrate. Further treatment of carrots was carried out in accordance with conventional cultivation methods.

The total Cd content in dry matter of the above-ground and underground parts of carrot was determined after mineralization in a muffle furnace at a controlled temperature regime (250 °C for 1 h, 350 °C for 1 hour, 450°C for 6 hours). Ash were washed and dissolve in HNO_3, c = 2 mol·dm^{-3}. Analytical determination was done by AAS for instrument SPECTRAA-200 after completing mineralizates to 25 cm^3 graphite furnace pair in the graphite furnace. Wholesomeness of carrots consumerism part was evaluated according to the maximum level under the Bulletin of the Ministry of Health no. 981/1996.

Results and Discussion

In model terms of pot experiment was followed the transfer of Cd (1 mg and 2 mg·kg-1 soil) from soil substrate to ground and above-ground part of carrots. Agrochemical indicators of used loamy-sandy soil were determined before the establishment of the experiment.

Table 1. Cd content in the dry matter of roots and leaves of carrots and statistical evaluation of the results (years 2012-2013)

Variant	Part of plant	Cd (mg·kg^{-1})				Statistical significance	
		min.	x	max.	s		
C	**roots**	0.014	0.063	0.125	0.0681	**C : A**	+ +
	leaves	0.001	0.043	0.047	0.0191		+
A	**roots**	0.126	0.596	1.308	0.4037	**C : B**	+ +
	leaves	0.001	0.322	0.856	0.1229		+
B	**roots**	0.365	1.155	2.680	0.6343	**A : B**	-
	leaves	0.002	0.491	1.565	0.2940		-

Legend: x - arithmetic mean; s - standard deviation

Results of soil analysis showed that the soil had alkaline reaction, pH = 7.5 with high available phosphorus, potassium and magnesium. The doses of Cd (1 mg respectively. 2 mg Cd·kg^{-1} of soil) accounted the increased load of soil with cadmium (3.6 resp. 6 times). Changes of Cs content in soil had an impact on the change of its contents in roots and above ground portions carrots. Concentration levels of Cd in the dry matter of carrot and statistical evaluation are listed in Table 1.

The risk of Cd increased content in the carrot roots compared to the control variant is statistically significant and highly significant. In contrast to the control, applied dose of Cd triggered in fresh crop of carrots roots increased risk in accordance with the increase of applied dose d (Fig. 1).

The addition of 1 mg Cd per kg soil caused an average 6.4-fold increase, while 2 mg Cd per kg soil induced 11-fold the increase of Cd content in the carrot roots. Results confirmed the knowledge that there is no linear relationship between Cd content in the soil and its transport from soil to plants.

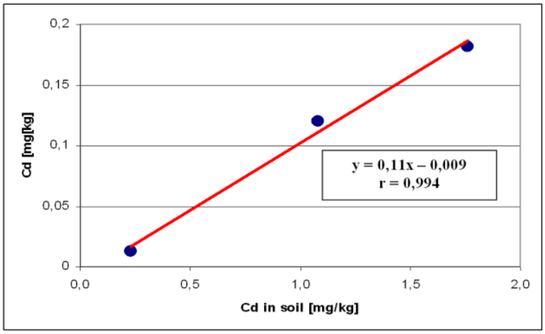

Fig. 1 Change of Cd content in fresh carrot roots, depending on soil Cd content (average 2012-2013)

Wholesomeness of consumerist carrot part was evaluated according to the standard of maximum Cd level in fresh vegetables.

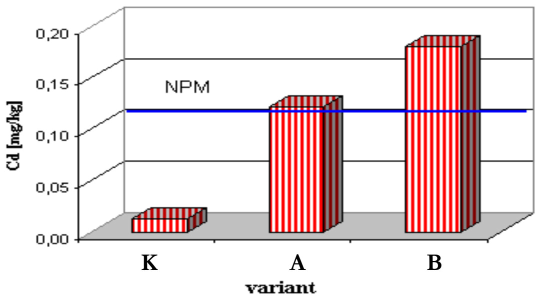

Fig. 2 Cd content in fresh carrot root (average 2012-2013)
NPM - maximally acceptable limit

In the conditions of Cd doses (1 mg, 2 mg·kg^{-1} of soil), the content of Cd in the roots of carrot binding exceeded the maximally acceptable limit (0.1 mg·kg^{-1}) (Fig. 2).

Our findings are consistent with the authors. who watched root uptake of Cd and its distribution in plants (Abbas et. al., 2010; Koffi et al., 2013).

The significance of the mobile forms Cd transfer in roots and aerial parts was also confirmed in non-phytotoxic conditions. The braking function of the root system was reflected, depending on the plant species specificity.

Therefore, in carrots. such as root vegetables. was probably blocked transport of Cd. The results are consistent with published results, where the most intensive Cd accumulators are leafy and root vegetables (carrots, salads) and least the fruiting vegetables (tomato, pepper, eggplant).

Assessing withdrawn microgram quantities of Cd by harvest from the substrate, the maximum level to account for the roots of carrots (87%) and the minimum for leaves of carrot (13%) (Fig. 3).

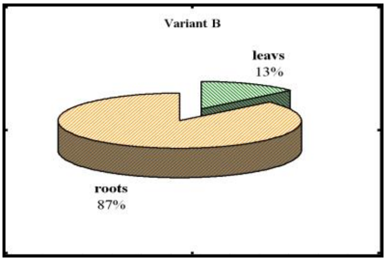

Fig. 3 Microgram quantities of Cd depleted by harvest from the soil substrate

Conclusion

The results of cadmium transfer rate monitoring from soil into plants is clear. Multiple increase of reference levels of Cd in the soil results increased intake to root portions. Result is hygienic failure rate in culinary parts of vegetables. Knowledge of the Cd income to ware portions of vegetables are important for agricultural practices and recommending of productive land area use to provide nutrition, vegetables without risking its hygienic defects (Lisiewska et al., 2001 Hegedűsová et al., 2002).

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