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Reseach on Heavy Metal Accumulation of Cu, Pb, Cd and Zn of the Carrot

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Abstract The researching results of Cu, Pb, Zn and Cd accumulation ability of the carrot (*Daucus carota subsp. Sativus*) showing that these metals are accumulated mainly in the leaves accounting for 66-91% of the total metal accumulated content. The highest accumulating concentrations of Cu in roots is 0.532 mg/kg, in leaves is 1.342 mg/kg in the condition that the soil is affected at 100 mg/kg. The highest accumulation of Pb concentrations in the roots is 0.274 mg/kg, in leaves is 0.853 mg/kg at the Pb concentration in experimental soil of 140 mg/kg. The highest accumulation of Zn concentrations in roots is 14.35 mg/kg, in leaves is 22.136 mg / kg at the experimental concentrations of 400 mg/kg. The highest accumulation of Cd in roots is 0.0293 mg/kg and in leaves is 0.085 mg/kg at the Cd concentrations in the soil of 4 mg/kg. In general, the highest accumulating concentrations of heavy metals in plants grown on soil which gets heavy metals infection 02 times higher than QCVN 03: 2008 / BTNMT. At higher experimental concentrations, plants have the signs of retardation, the accumulating concentration in plants is decreased.

Keywords: Heavy metals, carrot, accumulation

Introduction

After being accumulated in the soil, the heavey metals will penetrate the plants via capillarity. In case the accumulating concentration is at low level, it will become the trace elements helping to increase the productivity and the quality of agricultural products. However, at high accumulating concentration in soil, the metals will probably penetrate the plants and accumulate in the roots (rhizofiltration) or is fixed in the plant biomass (phytostabilization). In some cases, the heavy metals are transported to the plant branches and leaves and stored in the vacuole or probably eliminated into the environment via stoma in the form of salt under the leaf surface (phytoextraction) [4].

Among the popular vegetables, the carrot (Daucus carota subsp. Sativus) is being consumed very popularly. In the world there have been some studies on the heavy metal accumulating ability of the carrots. G.A. Boamponsem, M.Kumi, I.Debrah make the research about the metal accumulating ability including Cu, Pb, Cd and Zn on the carrot (Daucus

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carota subsp. Sativus) by planting on clean soil and irrigating by wastewater contaminated with heavy metals, the analysis results of heavy metals in the plant shows that there is a Cd uniform accumulation in both the leaves, roots and stem of respectively 0.071mg / kg, 0.058 mg / kg and 0.082 mg / kg, Cu accumulation mainly in roots of 0.221 mg/kg, in leaves of 0.143 mg/kg and in stem of 0.092 mg/kg. The remaining elements of the research are not clearly presented [1]. When studying some vegetables including carrots (Daucus carota subsp. Sativus) grown in the soil contaminated with heavy metals, the research result made by S. Singh (2012) showed that the heavy metal accumulating ability of carrots (Daucus carota subsp. Sativus) of each element are different, Zn accumulation in roots is 28 mg / kg, in leaves is 52 mg/kg; Cu accumulation in roots is 13 mg / kg, in leaves is 16 mg / kg; Pb accumulation in roots is 15 mg / kg, in leaves 22 mg / kg; Cd in roots is 2 mg / kg, in leaves is 3 mg / kg [2].

In Vietnam, there are some researches on the heavy metal accumulation ability in some vegetables such as: watercress (Nasturtium officinale), spinach (Ipomoea aquatica), small colza (Brassica juncea), ... but there has not been any research on the heavy metal accumulation in the carrots (Daucus carota subsp. Sativus).

Materials and methods

- Researched soil: the alluvial soil is taken from the Red River, then is dried naturally and is crushed into small sieves of 2mm to remove stones and gravel. After that the soil is incubated at the humidity of 60-70%.
- Heavy metals: Cu, Pb, Zn and Cd from the salt of Cu (NO3) 2; Pb (NO3) 2; Zn (NO3) 2; Cd (NO3) 2

Contamination method

Step 1: Determining the concentration of Cu, Pb, Zn and Cd in the soil after being crushed (control samples in Table 1)

Step 2: Dividing the soil into small piles and then spraying the metal salts blending together with water on such soil. The metals concentration is contaminated following QCVN 03: 2008 / BTNMT [3]. Accordingly, control samples keep the initial concentration, CT1 is supplemented by a concentration of the standard, the remaining formula including CT2, CT3 and CT4 are supplemented by the standards and higher standards of 1.5, 2, 2.5 and triple the specific concentration given in the table 1. Each metal concentration is sprayed 3 times, after each spray the soil is turned over to increasing identity. After being added the heavy metals, the soil is incubated in 15 days at the room temperature, and the humidity is kept at saturation.

Step 3: after being incubated, the soil is sifted through a sieve of 2mm and moved to the foam container sized 40 cm x 45 cm x 60 cm.

Table 1. Heavy metal concentration in the experiment

Formula	Cu	Pb	Cd	Zn
Control	40	55	1	110
CT1	50	70	2	200
CT2	75	105	3	300
CT3	100	140	4	400
CT4	150	210	6	600

- Plants: Plant 6 small carrots in each foam basin. Each planting formula is repeated 03 times and the plants are harvested after 4 months. All the plant samples are slowly taken out of the ground, then soaked in the glass jar containing distilled water from 30 to 45 minutes. Using soft brush and rinse out the outside soil layer, then separating the roots and leaves and putting in nylon bags (with holes for fresh).

- Method of specimen preservation: The specimen is chopped into small and put into the paper bags and dried at the temperatures of 800

degree from 12 - 24 hours (until weight keeps constant). After being dried, the sample will be crushed and stored in sealed plastic bags.

- Method of analysis: For the specimens, weight 1 (g) of crushed specimen into porcelain cup, then heat at 5500 degree Celsius within 4-8 hours (until the specimen completely turn into the white milk color). The specimen is cooled and mixed with a mixture of HNO3: HCl (1: 3 ratio), volume up to 50ml then filtering and measuring on the AAS machine. For soil specimen using destructive methods using acid mixture of HNO3 and H_2SO_4 then measuring on AAS machine.

Conclusion and Discussion

The analysis result of heavy metal concentrations in plants is transferred to mg/kg of dry biomass. Accumulating concentration of each heavy metal is shown in Table 2.

Table 2. Heavy metal accumulation concentration in the carrots (mg/kg of dry biomass)

Formula	Cu		Pb		Zn		Cd	
	In roots	**In leaves**	**In roots**	**In leaves**	**In roots**	**In leaves**	**In roots**	**In leaves**
Control	0,389	0,761	0,16	0,366	3,65	8,1	0,0022	0,0213
CT1	0,406	1,053	0,195	0,488	5,98	13,549	0,0064	0,0322
CT2	0,421	1,469	0,228	0,711	6,567	17,907	0,0074	0,0753
CT3	0,532	1,342	0,274	0,853	14,351	22,136	0,0293	0,0853
CT4	0,277	1,316	0,279	0,751	9,371	20,908	0,0156	0,0654

The heavy metals are accumulated mainly in the leaves and stems. The accumulation amount in the biomass is from 66 (%) to 91 (%) of the total metal content accumulated by the plant. Thus the mechanism of carrots (Daucus carota subsp. Sativus) for heavy metals is using the extraction mechanism (phytoextraction). The acceptable heavy metals adsorbed by the plants are moved to the top parts of the plant (branches, leaves) via the xylem cell [4]. The highest concentrations accumulated in the plant is Zn, then Cu, Pb and Cd. Cd has low accumulating concentration in the plant due to the concentration used in the experiment is low. At CT4 the metal accumulating concentrations in the plant is low because the salt concentration in the soil is too high, that affects the plant growth and development. The experiment shows that samples at CT4 and some at CT3 have a slower growth rate, the collected biomass is lower than the control sample and sample at CT1. The slow growth rate causes to reduce the

heavy metal accumulation in plants. It is probably due to the self-defense mechanism of the plant. When the heavy metal concentration is high, the plant will secrete enzymes with the essential components of proteins in the root zone. These substances become the heavy metal retention in the root zone preventing from penetrating the plant. This mechanism is called the phytolignification (a type of fixed mechanism (phytostabilization)) [4]

Evaluation on the accumulation of Cu and Pb

Concentration of Cu accumulated in the roots is from 0.277 to 0.532 mg / kg, in leaves is from 0.761 to 1.469 mg / kg. Cu concentrations are accumulated in the roots at a very low level accounting for 17-33% of the total amount of Cu absorbed by the plant. Control sample shows that the concentrations of Cu is at the lowest accumulation (total accumulating concentration is 1.15 mg / kg), the highest accumulating concentration of Cu is at CT2 (1.89 mg / kg), followed by the CT3 (1.874 mg / kg). Although CT4 uses the highest infection concentration (150 mg / kg), the accumulation of Cu is lower than that in CT2 and CT3. The results showed that the linear is correct to CT2 when the Cu concentration in soil increases, the Cu concentrations in plants accordingly increases. The formula after CT3 and CT4 are no longer linear.

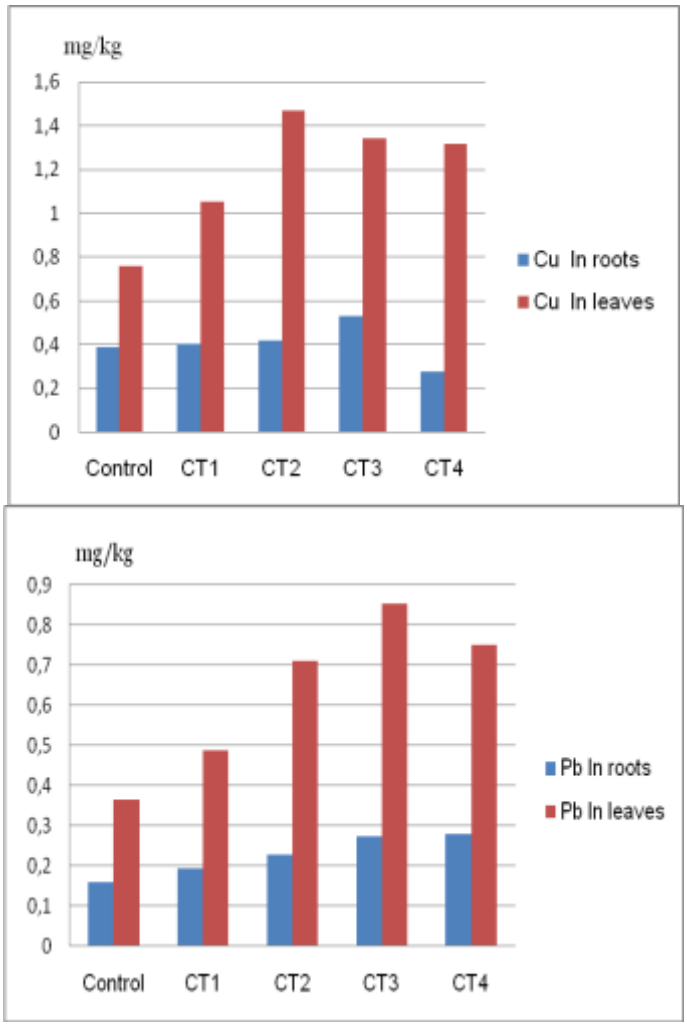

Figure 1. Accumulating concentration of Cu (left) and Pb (right) in the carrot roots and leaves

For the Pb element, the accumulating content in the root ranges from 0.16 to 0.279 mg / kg, in the leaves from 0.366 to 0.853 mg / kg. Pb concentration accumulated in the root accounts for 24.2 to 30.4% of the total Pb absorbed in the plant. Although concentrations of Pb is higher than the concentration of Cu at the same formula, the content accumulated in the plant of Pb is lower than Cu. Perhaps this is because the Pb element is less flexible, higher precipitating and the toxic competing for priority of Pb in the ion exchange is lower than that of Cu. Besides unlike Cu, the highest accumulating concentration of Pb is at CT3 (1,132 mg / kg), followed by respectively CT4 (1.025 mg / kg), CT2 (0.939 mg / kg), CT1 (0.683 mg / kg), the lowest is control sample (0.526 mg / kg). The linear process of the correlating relation between the Pb in soil and in plant is right to CT3. CT4 has the signs of reducing accumulation ability in the plant.

Evaluation on the accumulation of Zn and Cd

Zn and Cd are the 02 isomorphs. In the fact, the plant has no demand of using Cd, however in the case that the environment lacks of Zn meanwhile the Cd concentrations at or above the average level, the plant often has the phenomenon of "wrong sucking" .

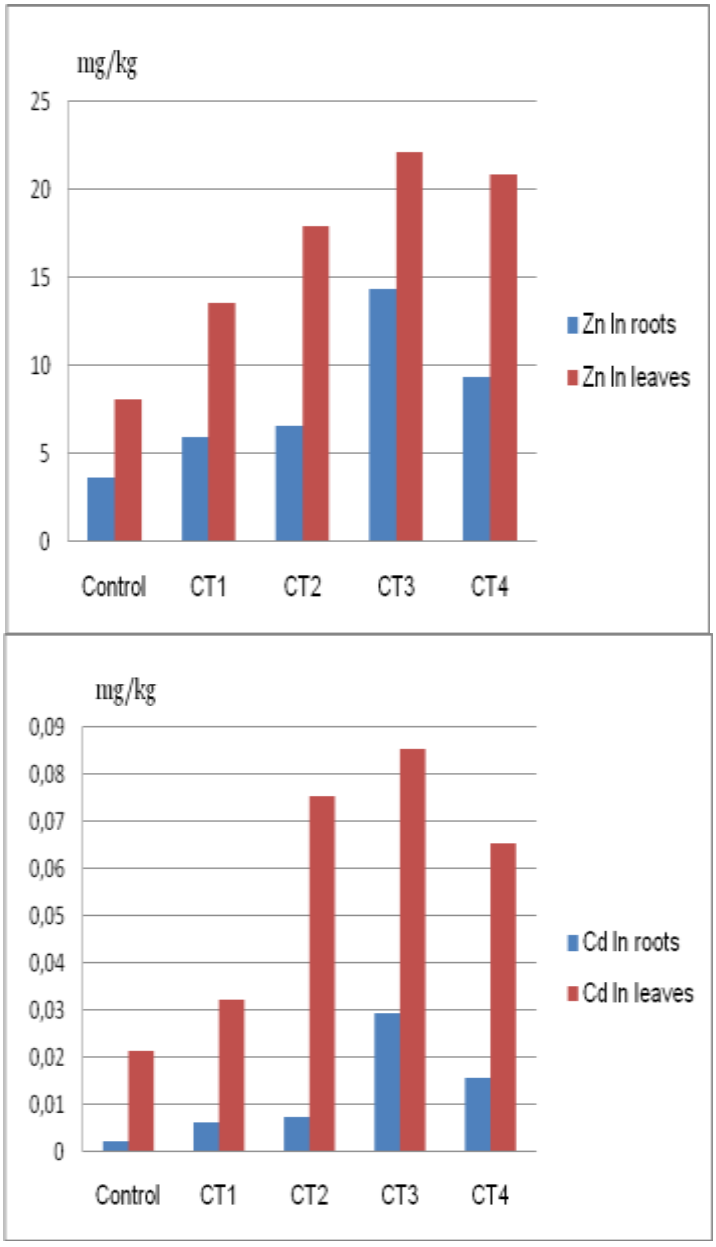

Figure 1. Accumulating concentration of Zn (left) and Cd (right) in the carrot roots and leaves

The study showed that the Zn concentration accumulated in the roots ranges from 3.65 to 14.35 mg/kg, in leaves from 8.1 to 22.136 mg/kg. Zn accumulating content ranges from 26.8% - 39.3% of the total Zn content absorbed in the tree. Like the Pb element, Zn accumulating content has the linear on the experiment concentration in the soils and the accumulating concentration in the plants to CT3. The highest accumulating concentration recorded is at CT3 (36.478 mg / kg) followed by CT4 (30.279 mg / kg), CT2 (24.47 mg / kg), the lowest is control sample (11.75 mg / kg).

Unlike the above metals, Cd concentration accumulated in the roots at the lowest when ranging from 9.4% - 25.57% of the total Cd content accumulated in the plants. The accumulating concentration in the roots is from 0.0022 to 0.0293 mg / kg, in leaves is from 0.021 to 0.085 mg / kg. Like the Zn element, Cd accumulating content has the linear on the experiment concentration in the soils and the accumulating concentration in the plants to CT3. The highest accumulating concentration recorded is at CT3 (0.115 mg / kg), followed by CT2 (0.0827 mg / kg), CT4 (0.081 mg/kg), the lowest is control sample (0.0235 mg / kg).

Conclusion

The carrot (Daucus carota subsp. Sativus) is able to accumulate the heavy metals (Cu, Pb, Cd and Zn), the heavy metals are mainly accumulated in the branches and leaves of the plants. The heavy metals accumulating content in the plants is correlated with the heavy metals content in the soils to the experiment concentration at CT3 (the metal concentrations exceeding QCVN 03: 2008 / BTNMT 1.5 times). At CT2, the accumulating concentration of Cu is considered to be optimal in the carrots (Daucus carota subsp. Sativus). The optimal accumulating concentration of the remaining elements is CT3 (the metal concentrations exceeding QCVN: 2008 / BTNMT 2 times). At the concentration 3 times higher than QCVN 03: 2008 / BTNMT (CT4), the plants have the signs of reducing accumulation ability.

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