



Research Article

Effect of heavy metal contamination on tomato plant growth, vegetative qualities and accumulation

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Abstract

Current study was done in the greenhouse at the Department of Biology/ College of Science/ University of Tikrit. This study designed to revealed the effect of different doses of heavy elements (Cd, Pb and Zn) on the growth of tomato plant *Lycopersicon esculentum* and vegetative qualities of the plant. The results of the study showed significantly decreased of vegetative qualities of the tomato plant decreases increases was increased with the increasing in concentrations of heavy metals, results revealed a large variation in the absorption of heavy elements by roots of tomato plant. Such as lead element was showed high of absorbents, than the other elements. On the other hands the biosynthesis of lead in the tomato plant record high values than the other heavy elements, finally the root system examination of tomato plant was showed high concentration of heavy elements than its vegetable parts.

Keywords: Cadmium, Lead, Zinc, Vegetative Total, Root System, Tomato.

Introduction

Heavy elements are one of the most dangerous materials that pollute the soil and their danger is represented by their longer period of availability within soil without any recycling or undergoing chemical changes, as a result of their availability in agricultural soils, they not only affect the growth of plants but they pollution of grains and fruits which may leads to harmful effects on humans and other organisms (Shteivi, 2005).

The discharge of heavy metals into the biosphere is causing growing concern because of their cumulative effects on plants, animals, and humans (Salman et al., 2010). Heavy elements are found in the plant in the form of coated elements (Chelated) and the coated material is an organic molecule that contains two or more atoms capable of binding to the atom of heavy metal forming a ring structure the coated metals are characterized by high solubility point in water and stability for a wide range of pH and molecules that are capable of coated heavy metals are mainly produced by microorganisms which present in the soil around plants roots, and this mechanism was facilitates absorbing of Heavy elements (Faizan et al., 2017).

Many techniques prevail in treatment, including phytoremediation, and is a sustainable and less expensive way

to remove pollutants at the same time is environmentally friendly, and it does not affect people who live and work in the surrounding areas as it uses plants to clean nature. Thus leading to the development of a low-cost treatment technique (Jateng, 2015).

Phytoremediation is defined as the use of plants to remove some pollutants in the environment from contaminated soil and water (Joan et al., 2018). Plants play a vital role in creating an environment suitable for the presence of other living organisms and an essential link in the food chain (Hussein and Younis, 2012). Some plants have been used as biological indicators to detect contamination with some minerals, but the content of plants of heavy elements varies according to the type, variety and plant part (Zurayk et al., 2002). The distribution of heavy metals in plant parts such as roots, stems, leaves and fruits is different due to the difference of the element and its behavior in the process of absorption and transport within the plant. However, the roots are filters for heavy metal elements that accumulate in them slowly, especially if they are found at high levels, thus partially

inhibiting the transfer of these minerals to the visible parts above the soil surface (Shaltout, 1992).

Aim of study

The aim of current research to study the effect of (cadmium, lead, and zinc) on the vegetative qualities and physiological changes of the tomato plant *Lycopersicon esculentum* planting in a greenhouse and to identify the parts of plants in which heavy elements accumulate.

Material and Methods

Soil samples analysis

Soil samples analyzed in the laboratories of the Biology Dep./ College of Education for Pure Sciences and the laboratories of the Geology Dep. / Faculty of Agriculture / University of Tikrit, where soil texture was measured (Blake and Hartge 1986), the quantity estimate of soil organic matter, the soil electrical conductivity (EC) (Richard, 1954) estimated of pH soil, the concentrations of heavy elements (Cd, Pb and Zn) in soil samples (Jackson, 1958). Table 1 shows the results of the physical and chemical analyses of the soil sample used in the research.

Table 1. Physical and Chemical Characteristics of Study Soil

No.	Types	Estimated
1	Soil Texture	sandy loam
2	organic matter %	1.61
3	Electrical conductivity (EC) Desi Siemens/M	230
4	pH	7.3
5	Cadmium (Cd) Mg/g	0.01<
6	Lead (Pb) Mg/g	0.1<
7	Zinc (Zn) Mg/g	2.3

Greenhouse Experience

The (15-25 cm) of soils were taken from the uncultivated land and placed in the greenhouse to dry and sieved with a sieve with a size of 2 mm holes and then added the elements of heavy elements (Cd, Pb, Zn) in four concentrations and three repeaters, soil samples were put in plastic pots (20 cm and a height of 20 cm) The capacity of each pot is 4 kg soil.

Heavy metals concentrations

1. Addition of cadmium in the form of Cd(NO₃)₂.4H₂O to the soil at concentrations (15,40, 65) mg of cadmium/kg soil.
2. Addition of lead in the form of Pb(NO₃)₂ to the soil at concentrations of (15,40, 65) mg of lead/kg soil.
3. Adding zinc in the form of (ZnSO₄.7H₂O) to the soil at concentrations (15,40,65) mg of zinc/kg soil.

Seeds were planted in June 2022 by 5 seeds/pot, and it was taken into account that the distances between the seeds were equal, the pots were randomly placed under the conditions of

the greenhouse. The pots were watered by tap water at (75%) of the field capacity of soils. Estimate the amount of water used daily by using balance, after 10 days of planting, the number of seedlings was reduced to 3 seedlings in each pot and the measurements of plants (plant height, phalanx length, and the number of shoots (branches) The percentage of germination was calculated. The surface leaves area was estimated (Saieed,1990) where the plant leaf was photographed by the scanning device, and then the coped paper was fully weighed b sensitive elec. balance and then papers cut to leaves edges and weighed with sensitive scales, according to the law

Papered area to leaves of plant = (weigh of coped paper X area of coped aper) / weigh of coped paper

Tomato planting

After 120 days of planting, tomato plants of each pot were harvested, and the plants were collected after washing the roots and separating it from vegetative parts and samples were left to dry and both dry root and vegetative parts were weight and estimated post-oven 70°C/48 hours and then grinded. 0.5 g of dry matter was taken in Baker and digested by adding H₂SO₄, HNO₃ and HClO₄ in proportions 2:1:1/ (2-4) hours, by converging of the baker with hourglass, and then the Baker and the An hourglass were washed with distilled water and filtered digested samples, then the complete the volume to (50) ml by distill water (APHA, 1998). The concentrations of each of (Cd, Pb, Zn) were estimated by the atomic absorption spectrometer and the celebration curve for each element can estimated.

Statistical analysis

The results were analyzed statistically according to the randomized complete block design (R.C.B.D) and by using the Statistical analysis system (SAS) using the Dunkin' polynomial test (Daoud and Waliyas, 1990).

Results and Discussion

Table 3, 2 showed that the addition of cadmium and zinc in different concentrations to the soil lead to a significant decrease in the height of the plant, number of shoots, length of the phalange, the leaf area, and the weight of the dry organic matter of the vegetative and root parts. this results was agreed with some studies which revealed the treatment of the soil with cadmium and zinc lead to a significant decrease in the growth qualities of the tomato plant (Dudka et al., 1994) increasing concentrations of these heavy metals have toxic effects that lead to a significant reduction in growth of leaves and roots of the plant (Youssef et al., 1993).

Since zinc is a slow-moving heavy metal in plants and accumulates within root parts, the moving zinc from the roots to the upper parts of the plant was unknown (Al-Nuaimi, 2000). so as t does not move from post-mature tissues to pre-mature tissues after the depletion of zinc from the soil. The results are shown in Table 3, there was no significant defects appeared in the characteristics of tomatoes due to the

accumulation of zinc in plants, and these were agreed with results which pointed to the accumulated zinc within tomato

plants at minimum concentrations, which doesn't effect on metabolic activities of the plant (Barlog et al., 2016).

Table 2. Effect of Cd Concentrations (mg/kg) on Vegetative Qualities of Tomato Plant

Study Characteristics	Elements Concentrations			
	0	15	40	65
Plant height Cm	66.34 a	42.03 ab	32.04 b	28.357 c
Numbers of Tiller	6.34 a	5.35 a	4.28 b	4.02 b
Pharyngeal length	12.04 a	9.68 a	4.03 b	6.35 c
Leaves area Cm ²	254.37 a	168.65 a	115.72 b	75.63 b
Dry matter weight of vegetative parts	4.08 a	1.29 b	1.79 c	1.56 c
Dry matter weight of root parts	4.95 a	3.32 b	2.23 b	2.09 c

*Rates with similar letters do not differ significantly at the probability level (5%) according to the Dunkin' polynomial test.

Table 3. Effect of Zinc Zn Concentrations (mg/kg) on Vegetative Qualities of Tomato Plant

Study Characteristics	Elements Concentrations			
	0	15	40	65
Plant height Cm	52.31 a	34.00 ab	28.00 b	19.35 c
Numbers of Tiller	2.31 a	2.01 a	1.25 b	1.00 b
Pharyngeal length	9.00 a	6.65 a	3.00 b	1.31 c
Leaves area Cm ²	250.35 a	164.61 a	111.68 b	70.58 b
Dry matter weight of vegetative parts	1.27 a	1.91 b	0.76 c	0.52 c
Dry matter weight of root parts	2.02 a	1.28 b	0.48 b	0.8 c

*Rates with similar letters do not differ significantly at the probability level (5%) according to the Dunkin' polynomial test.

Table 4 shows that the treatment of soil with lead led to a significant decrease in the growth of plants such as (height, number of shoots, and the length of the phalanx) which increased with increasing concentrations of heavy metal compared with the control group with a no significant

decrease of leaf area, these results due to the effect of heavy elements on photosynthesis and macromolecule biosynthesis (proteins and carbohydrates), and finally effect on height of the plant, shoots and the length of the phalanx of the plant (Wu, 2004).

Table 4. Effect of Pb (Lead) Concentrations (mg/kg) on Vegetative Qualities of Tomato Plant

Study Characteristics	Elements Concentrations			
	0	15	40	65
Plant height Cm	62.48 a	51.00 a	42.00 b	38.31 b
Numbers of Tiller	7.74 a	6.19 a	5.85 b	5.05 c
Pharyngeal length	14.65 a	11.65 ab	11.00 ab	10.00 b
Leaves area Cm ²	316.71 a	304.85 a	274.75 a	236.1 a
Dry matter weight of vegetative parts	4.30 a	3.89 b	3.44 b	2.30 c
Dry matter weight of root parts	4.46 a	4.35 a	4.00 b	3.32 c

*Rates with similar letters do not differ significantly at the probability level (5%) according to the Dunkin' polynomial test.

Conclusion

This greenhouse study conducted at the Department of Biology, College of Science, University of Tikrit, aimed to investigate the impact of different doses of heavy elements (Cd, Pb, and Zn) on the growth and vegetative qualities of *Lycopersicon esculentum* (tomato plants). The findings revealed a significant decrease in vegetative qualities as the concentrations of heavy metals increased, underscoring the adverse effects of heavy metal exposure on tomato plant development. Notably, the study observed substantial variations in the absorption of heavy elements by the tomato

plant roots, with lead (Pb) exhibiting particularly high absorbance compared to the other elements.

Furthermore, the study highlighted a higher biosynthesis of lead within the tomato plant compared to the other heavy elements, suggesting a potential mechanism by which the plant responds to heavy metal stress. Lastly, the examination of the tomato plant's root system revealed that heavy elements were concentrated at higher levels in the roots than in the vegetable parts, indicating the plant's ability to sequester these toxic elements in its root system as a defense mechanism.

Overall, these findings emphasize the sensitivity of tomato plants to heavy metal contamination and their capacity to absorb and accumulate these elements, with lead being of particular concern. This research underscores the importance of monitoring and mitigating heavy metal pollution in agricultural environments to safeguard plant health and the safety of food crops.

Conflict of Interest

The author hereby declares no conflict of interest.

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