



Research Article

Effect of treating *Vigna radiata* L with cadmium and lead on yield characteristics

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Abstract

This study was carried out in the gardens of the College of Education for Women University of Tikrit for the season 2022 for the period from 20/7/2022 to 1/10/2022 to study the effect of treating the soil with cadmium at a concentration of 0, 3, and 6 mg.kg⁻¹. soil and lead at a concentration of 0 and 400 600 mg.kg⁻¹ soil in yield values and its components (number of pods. plant-1, number of seeds.pod-1, weight of 100 seeds g, seed yield. plant-1, harvest index %, biological yield g. mung bean. Spraying with a mixture of cadmium and lead, a concentration of (600+6) mg.kg⁻¹. soil, led to a decrease in yield values and its components, giving the lowest values (4.00, 4.00, 7.80, 12.85, 50.32, 25.52, and 6.57), respectively.

Keywords: Cadmium, Lead, Yield characteristics, *Vigna radiata* L.

Introduction

Heavy metals in the soil cause great danger and harm to the environment and organisms through their presence in the ecosystem above certain levels that differ according to the type of metal, the nature of the soil, and the type of organism affected by these minerals (Duffus, 2002). Heavy metals are among the most dangerous pollutants on the environment (Mudgal et al., 2010). Through its accumulation in water, soil, and within the tissues of living beings, being one of the transitional elements that have the ability to form complex compounds of a stable nature with many organic and inorganic compounds that are found in the bodies of living organisms, and this leads to their accumulation within living tissues (Al-Gharawi et al., 2014). Heavy metals differ in their readiness and toxicity according to their chemical state, so they are either dissolved metal ions, dissolved complexes, organic or inorganic complexes, or are in the form of suspended particles (Al-Gharawi et al., 2014).

Heavy metals are among the most dangerous substances that are introduced into the soil, and their danger comes from remaining in the soil for a long period of time without decomposing or undergoing any chemical changes. Human (Shteivi, 2005).

The toxicity of the heavy metal for plants depends on its availability and ability to be absorbed by the plant. When these elements are present in high absorbable quantities, they

compete with the necessary elements for plants and absorb them in excessive quantities and replace them in plastids or enzymes, thus impeding or inhibiting their function. Heavy elements also have harmful effects. It affects the growth of both the terrestrial and aerial organs of plants and prevents the activity of the photosynthesis process and sometimes leads to the death of the plant (Shah et al., 2009). Soil contamination with heavy elements such as Cd and Pb is considered one of the most dangerous environmental pollutants in the world (Zhang et al., 2011 and Savci, 2012).

It is symbolized by the symbol (Cd), its atomic number is 48, with a bright white color that has high resistance to corrosion and a low melting point, and it has chemical properties similar to those of calcium and cadmium, an element present in the aquatic environment in different physical and chemical forms (Bocharde, 1985). It is considered one of the most toxic heavy metals to the environment as it shows adverse effects on soil viability, plant metabolism, biological activity and health of animals and humans (Kabata-Pendias, 2007). High levels of cadmium have been recorded in soils that have been irrigated with sewage water or that are located in areas with a high density of vehicle traffic, or lands that witness excessive use of agricultural chemicals or that are located near industrial areas (Bhatti, et al., 2016, Ebong and Ekong 2015).

A metallic element with a bluish-gray color, atomic number 26, it is found little or rarely in the original state, but it is found in three basic forms: dissolved lead, colloidal lead, and

particulate lead (Belabed, 2010). In agriculture, lead reduces crop yields (Yin et al., 2017). It can increase the production of reactive oxygen (RO), which causes oxidative stress in plants (Nigam et al., 2019). It also has the ability to bind with enzymes, which leads to a change in their effectiveness, such as inhibiting or stimulating them (Van and Clijstres, 1990). It also has the ability to accumulate on the surfaces of the roots, and cause disturbances in the structure and functions of the plasma membrane, and this in turn leads to the entry of lead into the tissues of the plant, and causes various damages therein (Kannedy and Gonsalves, 1987).

Vigna radiata L. is one of the most important leguminous crops in the world, and it is one of the most common crops in most tropical and subtropical regions. It belongs to the legume family Leguminisae, the genus *Vigna*, and the type *radiata*. There are 80 species of mung, all belonging to the genus *Vigna*. The English name for the mung be Mungbean, Greengram, Blackgram (Allahmoradi et al., 2011). Cultivation of the mung bean plant is good in different types of lands, provided that the drainage is good. The best soil types are deep, well-drained loamy soils, and mash plants are tolerant to salinity and alkalinity to a small degree. Mash is considered one of the short-day plants, and it is a fast-ripening crop that is drought-resistant and does not need a high percentage of moisture (Khalil, 2020). The mung plant has been known as a staple food among the Indians and Chinese for more than 2000 years, after boiling its grains and using it as a soup or eating it fresh as a salad. In Pakistan, its seeds are used in the manufacture of bread, pasta, sweets and spices, while its leaves and stems are used as food for animals, especially poultry (Rafiq et al., 2012). Mung bean is an effective and excellent source of amino acids (Gupta et al., 2018). Moreover, polyphenols, polysaccharides and peptides present in mung bean all exert antioxidant activity, which contributes to disease prevention (Xie et al., 2019). The mung bean is harvested within 75-90 days when the pods have darkened or are half to one third ripe. Ripe pods are usually picked by hand. The moisture content present in the pods at the time of harvest is 13-15%. To enhance the shelf life, the moisture content should be reduced to 12% by drying. Or the whole plant is harvested and dried in the sun and then the seeds are separated from the pods by beating or many agricultural mechanisms may be available for harvesting (Naik, 2020).

Materials and methods

This study was conducted during the agricultural season 2021-2022 in the canopy located in the gardens of the scientific departments - College of Education for Girls, using plastic water bottles for the period from 20/7/2022 to 1/10/2022. The soil was taken from the Tigris River basin and sifted using a sieve with a diameter of (2) mm after it was air-dried. Then the soil was placed in plastic bottles with a height of (40) cm and a diameter of (30) cm with an amount of 15 kg.

Experimental Design

The experiment was designed according to the overlaid complete block design (CRD) with three two-factor replicates.

The first factor: the cadmium element with concentrations of (0, 3, 6) mg kg⁻¹ soil and added it directly to the bottles. The second factor is lead, with concentrations of (0, 400, 600) mg.kg⁻¹soil. Thus, the number of factors has reached (9) treatments and with three replications, so that the number of experimental units is (27), distributed randomly.

The seeds of the local mash, the Khadrawi variety, were sown after obtaining them from the approved agricultural offices on 20/7/2022 by placing 5 seeds in each vial. The seeds were irrigated regularly from the first day of planting until the maturity of the crop. After two weeks of cultivation, the plants were diluted to one plant in each flask. The plants were fertilized with (40) kg N.h⁻¹ (17.66) g. A bottle and P fertilizer of (75) kg. (33.11) gm. Flask (Al-Tamimi, 2017) An analysis of the soil used in the laboratories of the College of Agriculture and the College of Engineering - University of Tikrit was carried out.

Studied characteristics

Number of pods

Plant⁻¹

Calculated as an average of the number of pods present in the harvested plants (Al-Jumaili, 2007).

Number of seeds

Pod⁻¹

Calculated from dividing the average number of seeds per plant by the average number of pods per plant (Al-Qaisi, 2013).

Weight of 100 seeds (g)

After mixing the seeds of the harvested plants, 100 seeds were randomly taken from them and then weighed.

Seed yield

Plant⁻¹

Grim

The plants of the experimental unit were harvested and their seed yield was weighed.

Harvest Index (%): Calculated according to the following formula:

$$\text{Harvest Index (\%)} = (\text{Seed Yield/Biological Yield}) \%$$

Statistical analysis

The data were analyzed for the design used according to Dunkin's multiple range test at the probability level (0.05).

Results and discussion

Table 1. We notice a significant decrease in the characteristic of the number of pods per plant contaminated with a mixture of cadmium and lead at a concentration of (6,600) mg, respectively. contaminated, which gave (8.00) pod plant⁻¹.

Table 1. The effect of different concentrations of cadmium and lead (mg.kg⁻¹) on the number of pods. plant⁻¹

Pb	Cd	0	3	6	Pb Mean
0		8.00a	7.00b	4.66de	6.55a
400		6.00c	6.00c	4.50de	5.50ab
600		7.00b	5.00d	4.00e	5.33b
Cd Mean		7.00a	6.00b	4.38c	

***There are no significant differences between the numbers that have the same or similar letters in the same column, according to Dunkin's multiple range test at the level of probability of 5%.**

The treatment with a mixture of cadmium and lead at a concentration of (6 and 600) mg.kg⁻¹. soil, respectively, showed a significant effect on the number of seeds. Pod⁻¹, as it gave the lowest value was (4.00) seeds, with a decrease of (42.85%) compared to plants. grown in uncontaminated soil that gave (7.00) pod. plant⁻¹ **Table 2.**

Table 2. The effect of different concentrations of cadmium and lead (mg.kg⁻¹) on the number of seeds. Pod⁻¹.

Pb	Cd	0	3	6	Pb Mean
0		7.00a	7.00a	4.66d	6.22a
400		6.00b	6.00b	4.66d	5.55ab
600		5.33c	5.00cd	4.00e	4.77b
Cd Mean		6.11a	6.00a	4.44b	

***There are no significant differences between the numbers that have the same or similar letters in the same column, according to Dunkin's multiple range test at the level of probability of 5%.**

From **Table 3.** it is noted that plants grown in soil contaminated with a mixture of cadmium and lead, concentration of 6 and 600 (mg.kg⁻¹ soil), respectively, gave the lowest value in the weight of 100 seeds amounted to 7.80 (gm), with a decrease of (16.48%). Compared to plants grown in uncontaminated soil, which gave the highest value of 9.34 (gm).

The results of **Table 4.** indicate that plants grown in soil contaminated with cadmium and lead, concentrations of 6 and 600 (mg.kg⁻¹ soil), respectively, gave the lowest value for the seed yield characteristic of 12.85 g, with a decrease of (52.40%) compared to plants grown in uncontaminated soil. Which gave the highest value amounted to 27.0 g.

Table 3. Effect of different concentrations of cadmium and lead (mg.kg⁻¹) on the weight of 100 seeds (gm).

Pb	Cd	0	3	6	Pb Mean
0		9.43a	9.00b	8.91c	9.11a
400		8.70d	8.59e	8.09g	8.46b
600		8.00h	8.25f	7.80i	8.01bc
Cd Mean		8.71a	8.61ab	8.26b	

***There are no significant differences between the numbers that have the same or similar letters in the same column, according to Dunkin's multiple range test at the level of probability of 5%.**

Table 4. Effect of different concentrations of cadmium and lead (mg.kg⁻¹) on seed yield. plant⁻¹ (gm).

Pb	Cd	0	3	6	Pb Mean
0		27.00a	25.14b	19.89e	24.01a
400		25.03b	24.00c	16.72f	21.91b
600		24.00c	22.66d	12.85g	19.83c
Cd Mean		25.34a	23.93b	16.49c	

***There are no significant differences between the numbers that have the same or similar letters in the same column, according to Dunkin's multiple range test at the level of probability of 5%.**

Treating the soil with a mixture of cadmium and lead elements, concentrations of 6 and 600 (mg.kg⁻¹ soil), respectively, resulted in a significant decrease in the harvest index characteristic of mung bean plant, giving the least value of (50.32%) and a decrease of (9.96%) compared to the plants that were grown. with uncontaminated soil, which gave the highest yield index (55.89%) **Table 5.**

Table 5. The effect of different concentrations of cadmium and lead (mg.kg⁻¹ soil) on the yield index (%).

Pb	Cd	0	3	6	Pb Mean
0		55.89c	59.12a	55.40c	56.80a
400		57.47b	58.40a	53.17c	56.35a
600		57.48b	58.39a	50.32d	55.40c
Cd Mean		56.94a	58.64b	52.96c	

***There are no significant differences between the numbers that have the same or similar letters in the same column, according to Dunkin's multiple range test at the level of probability of 5%.**

From **Table 6.** we note that plants grown in soil contaminated with cadmium and lead, concentrations of 6 and 600 (mg.kg⁻¹ soil), respectively, had a biological yield decreased to 25.52 (g), with a decrease rate of (47.18%) compared to plants grown in uncontaminated soil, which gave Biological yield reached 48.32g.

Table 6. The effect of different concentrations of cadmium and lead (mg.kg⁻¹ soil) on the biological yield (gm).

Pb	Cd	0	3	6	Pb Mean
0		48.32a	42.50c	35.90g	42.24a
400		43.55b	41.11e	31.46h	38.70b
600		41.75d	38.79f	25.52i	35.35c
Cd Mean		44.54a	40.80b	30.96c	

***There are no significant differences between the numbers that have the same or similar letters in the same column, according to Dunkin's multiple range test at the level of probability of 5%.**

Heavy metal pollution inhibits plant growth through its effects on the processes of cell division and expansion and hormonal regulation of plant growth (Burzynski and Jacob, 1983; Wierzbicka, 1987). Therefore, various metabolic activities are disturbed, such as photosynthesis, respiration, building nucleic acids, protein, enzyme activity, and other vital processes that lead to a decline in the growth and productivity of different plants (Flower et al., 1977).

Several studies, including the study of (Van and Clijsters, 1990; Ouzounidou, 1995), showed that increased levels of heavy metals negatively affect the growth of chloroplasts, as it leads to significant inhibition of the process of building chlorophyll as a result of the reduction of photosynthetic pigments in particular and the inhibition of a number of enzymes, which It causes a decrease in the outputs of this process, including carbohydrates.

The heavy metals have the ability to inhibit the biosynthesis of chlorophyll at the protochlorophyllide stage (Strobert et al., 1985). As the decrease in the mechanism of action of the enzymes related to the construction of chlorophyll leads to the inhibition of the chlorophyll content in plants treated with cadmium and its decrease (Keshan and Mukherji, 1992). This in turn negatively affects the process of photosynthesis and thus negatively affects the growth and yield characteristics of the plant. The results were in line with (Padmaja et al., 1990) that chlorophyll concentrations were reduced by treating bean seedlings with different levels of cadmium.

As for lead, its accumulation at toxic levels leads to a weakness in the chlorophyll production process (Wrischer and Meglaj, 1980). Increasing lead levels led to a change in the microstructure of chloroplasts, which in turn inhibited the biosynthesis of chlorophyll as a result of cell disruption and chromosomal division, thus directly negatively affecting growth and yield characteristics (Fargasova, 1994; Xiong, 1997). These results are consistent with (Kastori et al., 1998) who observed a decrease in the ratio of chlorophyll a: b in sunflower plants treated with different concentrations of lead.

Conclusion

The objective of the study was to investigate the influence of soil treatment with cadmium and lead at specified

concentrations on the yield values and its components for mung bean cultivation.

The research found that soil application of a combined cadmium and lead mixture at a concentration of (600+6) mg.kg⁻¹ soil resulted in a significant decrease in yield values and its components. The lowest values recorded were (4.00, 4.00, 7.80, 12.85, 50.32, 25.52, and 6.57) respectively.

The key terms in this study are Cadmium, Lead, and Yield characteristics.

In conclusion, the research provides evidence that cadmium and lead, when applied at specific concentrations, can negatively impact mung bean yield. This presents a significant area of concern that warrants further investigation in order to understand how to mitigate these adverse effects and handle soil contaminants effectively.

Conflict of Interest

The author hereby declares no conflict of interest.

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References

- Al-Ghazzawi, G. J., & Al-Shammari, A. J. S. (2014). Ability some types of bacteria Isolated from the Shatt al-Arab and water and marine bioadsorption For some heavy metals. *J Basra Res Sci*, 40, 1817-2695.
- Al-Jumaili, J. M. (2007). The effect of planting dates on the growth and yield of soybean max mirre L., *Anbar Journal of Agricultural Sciences*, 5(2): 141-148.
- Allahmoradi, P., Ghobadi, M., Taherabadi, S., & Taherabadi, S. (2011, May). Physiological aspects of mungbean (*Vigna radiata* L.) in response to drought stress. In *International conference on food engineering and biotechnology* (Vol. 9, pp. 272-275).
- Al-Qaisi, W. A. and Helal, H. M. (2013). Effect of Fenugreek Seed Extract and Vitamin C on the Growth and Yield of Broad Bean *Vicia faba* L. Dept. of Life Sciences. Faculty of Education. *Baghdad University. Journal of Agricultural Sciences*, 5(1). 105-117.
- Al-Tamimi, A. H. (2017). The effect of irrigation periods and vitamin E and C spraying on the growth and yield of cattle *Vigna radiata* L. *Al-Furat Journal of Agricultural Sciences*, 9(4): 1201-1219.
- Belabed, B. E. (2010). La pollution par les métaux lourds dans la région d'Annaba «Sources de contamination des écosystèmes aquatiques» pp:7-20.
- Bhatti, S. S., Kumar, V., Singh, N., Sambyal, V., Singh, J., Katnoria, J. K. and Nagpal, A. K. (2016). Physico-chemical properties and heavy metals contents of soils and Kharif crops of Punjab, India. *Procedia Environmental Sciences*. 35: 801-808.
- Borchardt, T. (1985). Relation ship between carbon and cadmium uptake in *Mytilus edulis*. *Mar. Biol* 85: 233-244.
- Burzyński, M., & Jakób, M. (1983). Influence of lead on auxin-induced cell elongation. *Acta Societatis Botanicorum Poloniae*, 52(3-4), 231-239.
- Duffus, J. H. (2002). " Heavy metals" a meaningless term?(IUPAC Technical Report). *Pure and applied chemistry*, 74(5), 793-807.
- Ebong, G. A., & Ekong, C. I. (2015). Pollution status of trace metals in waste impacted soils within Borokiri town, Port Harcourt metropolis, Rivers state, Nigeria. *Int. J. Sci. Res. Environ. Sci*, 3(2), 436-444.
- Fargasova, A. (1994). Effect of Pb, Cd, Hg, As, and Cr on germination and root growth of *Sinapis alba* seeds. *Bulletin of Environmental Contamination and Toxicology*, 52(3), 452-456.
- Flowers, T. J., Troke, P. F., & Yeo, A. R. (1977). The mechanism of salt tolerance in halophytes. *Annual review of plant physiology*, 28(1), 89-121.
- Gupta, N., Srivastava, N., & Bhagyawant, S. S. (2018). Vicilin—A major storage protein of mungbean exhibits antioxidative potential,

- antiproliferative effects and ACE inhibitory activity. *PLoS One*, 13(2), e0191265.
- Kabata-Pendias, A. (2007). Trace elements in soils and plants. 3rd ed. CRC Press. Boca Rotan. USA.
- Kennedy, C. D., & Gonsalves, F. A. N. (1987). The action of divalent zinc, cadmium, mercury, copper and lead on the trans-root potential and H⁺ efflux of excised roots. *Journal of Experimental Botany*, 38(5), 800-817.
- Kastori, R., Plesničar, M., Sakač, Z., Panković, D., & Arsenjević-Maksimović, I. (1998). Effect of excess lead on sunflower growth and photosynthesis. *Journal of Plant Nutrition*, 21(1), 75-85.
- Keshan, U., & Mukherji, S. (1992). Effect of cadmium toxicity on chlorophyll content, Hill activity and chlorophyllase activity in *Vigna radiata* L. leaves. *Indian Journal of Plant Physiology (India)*.
- Khalil, N. A., Al-Mutwali, Abdullah Al-Mutwali, S., Magdy Mohamed, Al-Murshidi, Wajih, A. A. (2020). Cereal crops and legumes. Faculty of Agriculture - Cairo University. pp 255-265.
- Mudgal, V., Nidhi, M., & Anurag, M. (2010). Heavy metals in plants: phytoremediation: plants used to remediate heavy metal pollution. *Agriculture and Biology Journal of North America*, 1(1), 40-46.
- Naik, M. G., Panoth, A., Ven, K. N. (2020). Mung bean .Springer Nature switzer land A.G.pp.213-228.
- Nigam, N., Khare, P., Yadav, V., Mishra, D., Jain, S., Karak, T., ... & Tandon, S. (2019). Biochar-mediated sequestration of Pb and Cd leads to enhanced productivity in *Mentha arvensis*. *Ecotoxicology and Environmental Safety*, 172, 411-422.
- Ouzounidou, G. (1995). Effect of copper on germination and seedling growth of *Minuartia*, *Silene*, *Alyssum* and *Thlaspi*. *Biologia plantarum*, 37, 411-416.
- Padmaja, K., Prasad, D. D. K., & Prasad, A. R. K. (1990). Inhibition of chlorophyll synthesis in *Phaseolus vulgaris* L. seedlings by cadmium acetate. *Photosynthetica*, 24(3), 399-405.
- Rafiq, M., Mali, M., Naqvi, S. A., Dahot, M. U., Faiza, H., & Khatari, A. (2012). Regeneration of plants in EMS treated local mung bean (*Vigna radiata* L. Wilczek) under salt stress. *Pakistan Journal of Biotechnology*, 9(2), 75-88.
- Savsi, S. (2012). An agricultural pollution . chemical fertilizers . *Int. J. of Environ. Sci and Develop*. 3(1):77-80.
- Shah, S. F. R. (2009). *Effect of mixed industrial wastewater on soil, tree biomass production and trace metal uptake* (Doctoral dissertation, MSc. Thesis. p: 29-31. University of Punjab. Lahore).
- Shteivi, M. (2005). The effect of toxins on human health and safety. Faculty of Agricultural Sciences in Arish, Suez Canal University.
- Stobart, A. K., Griffiths, W. T., Ameen-Bukhari, I., & Sherwood, R. P. (1985). The effect of Cd²⁺ on the biosynthesis of chlorophyll in leaves of barley. *Physiologia plantarum*, 63(3), 293-298.
- Van, A. F. and Clijstres, H. (1990). *Plant cell Environ*, 13:195-906.
- Wierzbicka, M. (1987). Lead accumulation and its translocation barriers in roots of *Allium cepa* L.—autoradiographic and ultrastructural studies. *Plant, Cell & Environment*, 10(1), 17-26.
- Wrischer, M., & Meglaj, D. (1980). The effect of lead on the structure and function of wheat plastids. *Acta Botanica Croatica*, 39(1), 33-40.
- Xie, J., Du, M., Shen, M., Wu, T., & Lin, L. (2019). Physico-chemical properties, antioxidant activities and angiotensin-I converting enzyme inhibitory of protein hydrolysates from Mung bean (*Vigna radiata*). *Food chemistry*, 270, 243-250.
- Xiong, Z. T. (1997). Bioaccumulation and physiological effects of excess lead in a roadside pioneer species *Sonchus oleraceus* L. *Environmental pollution*, 97(3), 275-279.
- Yin, J., Wang, A. P., Li, W. F., Shi, R., Jin, H. T., & Wei, J. F. (2017). Sensitive biomarkers identification for differentiating Cd and Pb induced toxicity on zebrafish embryos. *Environmental Toxicology and Pharmacology*, 56, 340-349.
- Zhang, M., & Pu, J. (2011). Mineral materials as feasible amendments to stabilize heavy metals in polluted urban soils. *Journal of Environmental Sciences*, 23(4), 607-615.

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