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EFFECTS OF LEAD AND CADMIUM ON SHOOT LENGTH AND ROOT LENGTH OF CASCABELA THEVETIA (L.) LIPPOLD.

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ABSTRACT

Agricultural sustainability and civilization of society enormously depend on land. However, contamination of soil due to heavy metals is a major threat to mankind. Cadmium is one of the most toxic metals in the environment and has noxious effects on vegetative growth. Lead is the second ranked of most widely distributed hazardous substances in the environment and can cause morphological, physiological, and biological dysfunctions in plants. This study investigates the effect of various concentrations of lead and cadmium, i.e. 400mg, 800mg, 1200mg, 1600mg Pb kg^{-1} and 5mg, 10mg, 15mg, 20mg Cd kg^{-1}, on root length and shoot length of Cascabela thevetia (L.) Lippold. The results states lead treatments have decreased the length of shoot by 19 cm and 11.99 cm of root. Cadmium treatments to the plants have decreased by 20 cm and 11 cm of shoot and root respectively. Higher concentrations of heavy metals in the soil can significantly reduce root lengths and shoot lengths.

Key words: Heavy metals, Lead, Cadmium, Soil contamination, Root length, Shoot length.

1. INTRODUCTION

Soil pollution is a very important environmental issue that has been attracting considerable public attention over the last few decades. Soil contamination is caused by the chemicals released by human activities in the normal soil environment. Heavy metal soil contamination is one of the raising critical concerns for both human health and the ecosystem (Singh et al., 2011). Heavy metal soil contamination is one of the world's major environmental problems (Bihola et al., 2018). Heavy metal concentration in upper horizon of soil is increasing with increased urbanization and industrialization. Heavy metals can be divided into essential and non-essential groups. Essential heavy metals include Co, Cu, Cr, Fe, Mn, Ni, and Zn. They are considered as essential micronutrients but are toxic if taken in excess quantities. Heavy metals are known to have harmful effects on plant growth and soil microflora leading to big losses in plant productivity (Roy et al., 2005).

Due to their extensive use and significant toxicity to plant functions, heavy metals including lead (Pb) and cadmium (Cd) have drawn much attention of researchers (Oncel et al., 2000). In comparison, Cd turns out to be more toxic than Pb (Sharifah Barlian Aidid et al., 1993). Cadmium toxicity is a major factor limiting plant growth (Fediue and Erdei, 2002). Many types of grains, vegetables, and fruits have been reported to accumulate Cd and humans absorb at least 90% of cadmium from plant foods (Clemens and Ma, 2016). Cadmium toxicity is 2 to 20 times greater than any other metals (Kabata-Pendias and Pendias, 2001) and as an initial defence against its delivery to the shoot, plants store Cd in their roots (Das et al., 1997). Lead is also one of the most wide-spread heavy metal contaminants in soils. Lead can be retained in the environment for 150-5000 years (Prasad et al., 1999). Although having no biological purpose, lead may disrupt a plant's morphology, physiology, and biochemistry (Fahr et al., 2013). It is extremely challenging to get lead out of the soil mixture once it has been mixed with soil. Lead inhibits germination of seeds and retards growth of seedling, decreases germination percentage, germination index, roots and shoots length tolerance index and dry mass of roots and shoots (Mishra et al., 2006). Hence the heavy metal contamination from the soil must be removed as well as breaking down this type of toxin into nontoxic form is not easy. Phytoextraction method has been used to develop approaches that facilitate the removal of heavy metals from soil into plants that are planted on it.

Phytoextraction is the use of vegetation for the ex-situ treatment of contaminated soils. Considering the fact that, limited studies have recently been conducted on the effects of lead and cadmium on root length and shoot length. Therefore, the present study addresses the effects of lead and cadmium on root lengths and shoot lengths of Cascabela thevetia (L.) Lippold.

2. MATERIALS AND METHODS

2.1 Plant Description

Cascabela thevetia (L.) Lippold. is an ornamental shrub. Leaves: alternate or sub opposite simple with reticulate venation. Inflorescence: cymose cluster. Flower: ebracteate, pedicelate complete, actinomorphic, bisexual, hypogynous, pentamerous, large, yellow. Calyx: 5, gamosapelous. Corolla: 5, gamopetalous, funnel shapes Androecium: 5, polyandrous, epipetalous, Gynoecium: bicarpellary, syncarpous, ovary superior. Fruit: drupe.

2.2 Collection of Plants and Soil Preparation

Cascabela thevetia (L.) Lippold. is an ornamental plant, which was purchased from the Govt. Plant Nursery, Gandhinagar, Gujarat. 30 plants of height ranging from 10 to 20cm were purchased and placed in the Botany laboratory, RR Mehta College of Science, Palanpur for identification with the help of flora of Gujarat state (Shah, 1978). All plants were propagated in 30 pots separately. Each pot (15cm diameter and 15cm height) contained a mixed soil composed of two-third soil and one-third fine sand. The soil was mixed thoroughly. Average of 3kg of soil was mixed with organic fertilizer and kept in the botanical garden of college.

2.3 Lead and Cadmium Treatment to the Plants

The plants were grown in 5 groups (control & all the four concentrations of lead and cadmium) of pots. Each group contained 3 pots. In total 15 pots were assigned to lead treatment and 15 pots were prepared for the cadmium treatment. Plants were irrigated for 10 days with tap water (without lead or cadmium treatment). All the plants were treated with sequential concentrations of lead and cadmium. Nitrates of lead and cadmium were used for the experiment, i.e. lead was used from lead nitrate and cadmium was used from cadmium nitrate. The potted soil was treated with cadmium nitrate Cd $(NO_3)_2$ at the rate of 0mg, 10mg, 15mg and 20mg Cd Kg^{-1} soil and Pb $(NO_3)_2$ at the rate of 0mg, 400mg, 800mg, 1200mg and 1600mg Pb Kg^{-1} soil respectively. Pots containing untreated soil are used as a control group. The series of concentrated solution of heavy metals is given to the rhizospheric regions of the plants (Fig.1). The pots were labelled according to their solutions. The plants were treated with lead and cadmium in different concentrations and growth parameters such as root length and shoot length were determined after 50 days. To this end, the root length and shoot length was accurately measured by scale in cm. The average of the three replicates were calculated and standard deviation (SD) was determined. Results of shoot length and root length were expressed in the form of mean ± SD.

Fig.1 Rhizospheric treatment of the plant

3. RESULTS AND DISCUSSION

The concentration of lead and cadmium were found in the parts of plant (Cascabela thevetia (L.) Lippold.) during the experimental period (50 days) as a result in the form of changes in root lengths and shoot lengths is shown in tables 1 and 2.

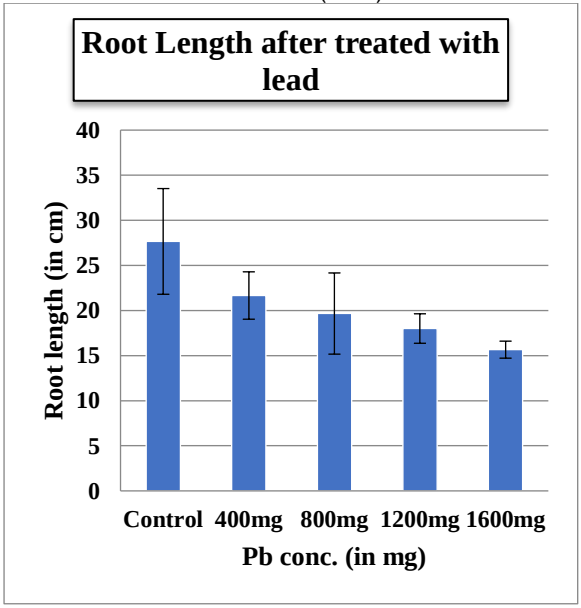
3.1 Root Lengths of the plants treated with lead and cadmium

In Cascabela thevetia (L.) Lippold. 27.66cm root length is reported in control medium of cadmium while concentration of 5mg, 10mg, 15mg and 20mg Cd Kg^{-1} soil, the root length is 26.66cm, 23.33cm, 20.33cm and 16.66cm respectively (Table-1). This result indicates that with the increasing concentrations of cadmium, the root length decreases, whereas 27.66cm root length was reported in control medium of lead. The concentrations of 400mg, 800mg, 1200mg and 1600mg Pb Kg^{-1} soil, the root lengths observed in plants were 21.66cm, 19.66cm, 18.0cm, and 15.66cm respectively (Table-1, Fig. 6 & 7). These results manifest that when the concentration increases, the root length decreases. Shanying, et al., 2017 also reported a similar outcome. As Nas and Ali, 2018 stated that the root development of several plants was quickly inhibited by lead poisoning. Lead inhibits root length as mentioned by Mishra et al., 2006 in Ceratophyllum demersum L. Arias et al., 2010 reported significantly inhibited root elongation in Proposis sp. by lead. Weigel and Jager, 1980 support this study that the excessive amount of cadmium in soil causes toxic symptoms in plants, especially root growth.

Table 1: Root length of Cascabela thevetia (L.) Lippold. after the treatment of lead and cadmium.

Concentration		Lead (Pb) (mean ± SD) (I)	Cadmium (Cd) (mean ± SD) (II)
I	II		
Control	**Control**	27.66 cm ±5.85	27.66cm ±4.78
400mg	**5mg**	21.66 cm ±2.62	26.66 cm ±1.24
800mg	**10mg**	19.66 cm ±4.49	23.33 cm ±2.35
1200mg	**15mg**	18.00cm ±1.63	20.33 cm ±1.24
1600mg	**20mg**	15.66 cm ±0.94	16.66 cm ±0.47

Values are mean ± S.D. (n=3)



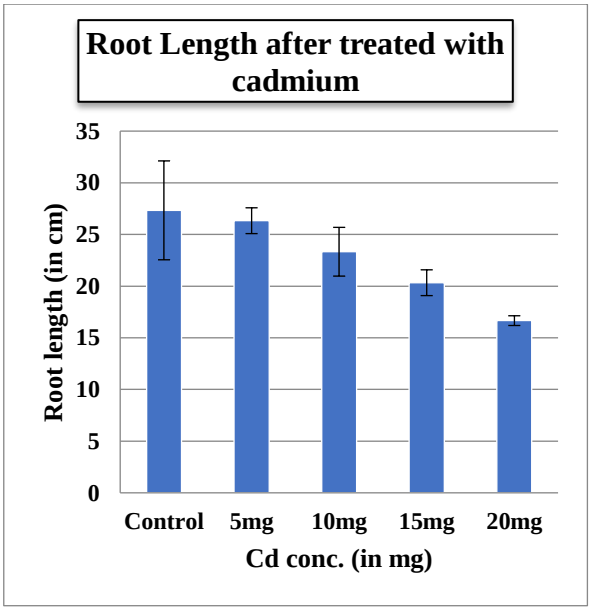


Fig. 2 Lead effects on root length Fig. 3 Cadmium effects on root length

3.2 Shoot lengths of the plants treated with lead and cadmium

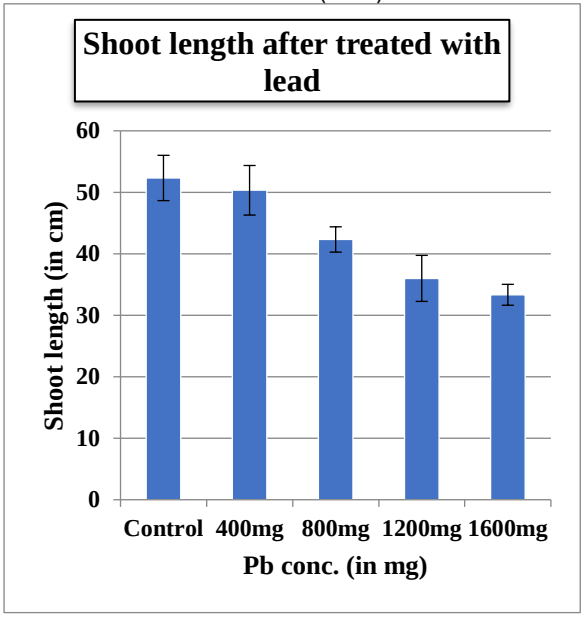
In Cascabela thevetia (L.) Lippold., 52.33cm, 50.33cm, 42.33cm, 36.0cm and 33.33cm shoot lengths were observed in various concentrations of lead viz. 0mg, 400mg, 800mg, 1200mg and 1600mg Pb Kg-1 soil respectively. Moreover, 47.0cm, 44.33cm, 42.0cm and 32.33cm shoot lengths were observed in 5mg, 10mg, 15mg and 20mg Cd Kg^{-1} soil respectively while 52.33cm in control medium. (Table 2, Fig. 6 & 7). Like root length, shoot length diminishes as lead and cadmium concentration increases (Fig. 3) Mishra et al., 2006 observed similar results i.e., decreased shoot length in Ceratophyllum demersum in various concentrations of lead. Various concentrations of lead inhibit shoot length in Pisum sativum (Kervesan et al.,

2001), Zea mays (Cimrin et al., 2007), Paspalum distichum and Cynodon dactylon (Shua et al., 2002), Lycopersicon esculentum (Jaja et al., 2004), Ipomoea aquatic (Gothberg et al., 2004), and Lens culinaris (Haider, 2006).

Table 2: Shoot lengths of Cascabela thevetia (L.) Lippold. after the treatment of lead and cadmium.

Concentration		Lead (Pb) (mean ± SD) (I)	Cadmium (Cd) (mean ± SD) (II)
I	II		
Control	**Control**	52.33 cm±3.68	52.33 cm±3.68
400 mg	**5 mg**	50.33 cm±4.02	47.0 cm±4.32
800 mg	**10 mg**	42.33 cm±2.05	44.33 cm±5.24
1200 mg	**15 mg**	36.0 cm±3.74	42.0 cm±8.16
1600 mg	**20 mg**	33.33 cm±1.69	32.33 cm±3.29

Values are mean ± S.D. (n=3)



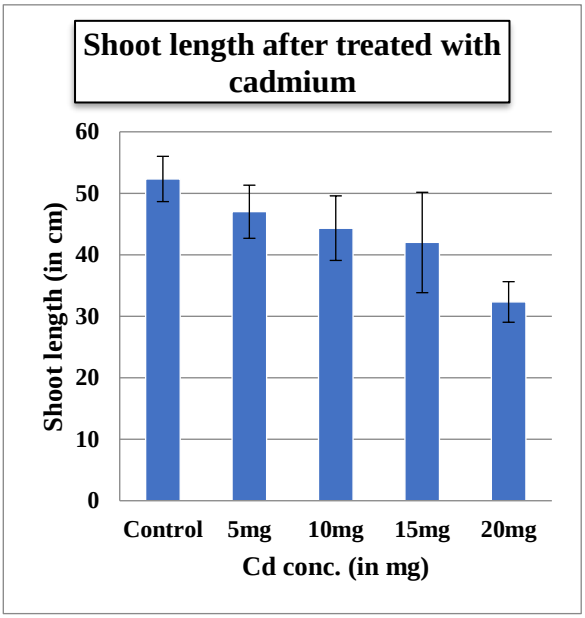


Fig. 4 Lead effects on shoot length Fig. 5 Cadmium effects on shoot length

Fig. 6 Effects of various concentration of lead on root length and shoot length

Fig. 7 Effects of various concentration of cadmium on root length and shoot length

4. CONCLUSION

Results conclude that on increasing the concentration of lead and cadmium, significantly reduced root length and shoot length is observed as compared to control. Thus, heavy metals showed harmful effects on root lengths and shoot lengths of Cascabela thevetia (L.) Lippold. The aim of this research was to determine the ability of Cascabela thevetia (L.) Lippold. to phytoextraction of cadmium and lead from soil and determine the effectiveness of this plant on removal of these metals from the environment in future.

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6. CONFLICT OF INTEREST

The authors states that there was no conflict of interest in this research.

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