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TOXIC EFFECTS OF LEAD AND CADMIUM ON GERMINATION AND SEEDLING GROWTH OF *ALBIZIA LEBBECK* (L.) BENTH

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Abstract

The effects of lead and cadmium on seed germination, seedling, root, shoot length and seedling dry biomass of *Albizia lebbeck* was evaluated under laboratory conditions with and without lead and cadmium treatments. Lead and cadmium treatments at 10, 30, 50, 70 and 90 µmol/L affected seed germination and seedling growth of *A. lebbeck* as compared to control. Lead treatments at 10, 30, 50, 70 and 90 µmol/L concentrations produced significant ($p<0.05$) effects on seed germination and seedling length of *A. lebbeck* while lead treatment at 50 µmol/L significantly affected root growth and seedling dry biomass as compared to control. Similarly, cadmium treatments from 10 to 90 µmol/L affected the seed germination, root, shoot length and seedling dry biomass of *A. lebbeck* as compared to control. Seedlings vigor index of *A. lebbeck* showed gradual decrease with increase in concentration of lead and cadmium. Cadmium treatments showed adverse effects on seedlings of *A. lebbeck* as compared to lead. Lead and cadmium treatments at 90 µmol/L exhibited lowest percentage of tolerance in seedlings of *A. lebbeck* as compared to control.

Introduction

The toxicity of heavy metals is a problem for ecological, evolutionary and environmental reasons (Nagajyoti *et al.,* 2008). Heavy metals such as lead and cadmium are highly toxic pollutants as they are added in the environment through automobile exhausts (Lagerwerff & Specht, 1970). Inhibition of germination and retardation of plant growth are commonly observed due to lead toxicity (Morzeck & Funicelli, 1982; Wierzbicka & Obidzinsca, 1998; Lerda, 1992; Antosiewicz & Wierzbicka, 1999; Shaukat *et al.*, 1999; Iqbal & Shazia, 2004). Negative effects of lead toxicity on seed germination and seedling growth of some tree species were examined (Iqbal & Siddiqui, 1992; Shafiq & Iqbal, 2005). Lead contents in soil and wheat tissues along with the roads were decreased with increase in distance from the roads (Lone *et al.*, 2006). Foliar application of lead affected growth and yield of wheat (Rashid & Mukhirji, 1993). Lead produced highly significant effects on shoot, root lengths and seedling dry biomass of *Lythrum salicaria* (Juseph *et al.,* 2002). Dense traffic releases detrimental exhaust gases and toxic pollutants like unburnt and partially burnt hydrocarbons, lead compounds and other elements that are contained in petrol polluting the city environment (Iqbal *et al.,* 2001).

The increasing influx of heavy metals into water bodies from industrial, agricultural, and domestic activities is of global concern because of their well documented negative effects on human and ecosystem (Mataka *et al.,* 2006). Cadmium is a heavy metal with high toxicity and has an elimination half-life of 10-30 years (Jan, *et al.,* 1999). People are exposed to cadmium by intake of contaminated food or by inhalation of tobacco smoke or polluted air (Järup *et al.,* 1998). High concentrations of cadmium in soils represent a potential threat to human health because it is incorporated in the food chain mainly by plant uptake (Alvarez-Ayuso, 2008). Influence of cadmium toxicity on germination and growth of some common trees were investigated by Iqbal & Mehmood (1991).

The aim of the present research was to investigate the effects of lead and cadmium on seed germination and seedling growth of *Albizia lebbeck* (L.) Benth.

Materials and Methods

The healthy seeds of *Albizia lebbeck* were collected randomly from the Karachi University Campus. The top ends of seeds were slightly cut with a clean scissor to remove any possible dormancy. The seeds were surface sterilized with dilute solution of Sodium-hypo chloride to prevent any fungal contamination. Ten seeds were placed in Petri dishes (90 mm diameter) on filter paper (Whatman No. 42). Metal treatments of Pb and Cd were prepared using lead nitrate and cadmium nitrate with concentrations of 10, 30, 50, 70 and 90 µmol/L respectively. At the start of experiment, 3 ml of respective treatment was added to each set of Petri dish and at every 3rd day, the old solution was sucked out and replaced with 2 ml of new solution. The control received only 2 ml of distilled water. There were five replicates per treatment and the Petri dishes were kept at room temperature (20±2°C) with 3 hourly light period provided by 200 watt bulb and the experiment lasted for 12 days. The experiment was completely randomized. Germination was recorded and seedling dry biomass was determined by placing the seedling in oven at 80°C for 24 hours. The number of germinated seeds were counted after 12 days of treatment. Seedling dry biomass was measured with electrical balance. Maximum root, shoot and seedling length were also obtained. Seedling vigor index (S.V.I) was determined as per the formula given by Bewly & Black (1982) and Tolerance indices (TI) were determined by the use of the formula given by Iqbal & Rahmati (1992). The seed germination and seedling growth data were statistically analyzed by Analysis of Variance (ANOVA) (Steel & Torrie, 1984) and Duncan's Multiple Range Test (DMRT) (Duncan, 1955) to determine the level of significance at $p<0.05$.

Results

Seed germination, root, shoot and seedling length, root shoot ratio and dry biomass of *Albizia lebbeck* L., were highly decreased with the treatment of Pb and Cd at 10, 30, 50, 70 and 90 µmol/L as compared to control (Tables 1&2, Fig. 1). Lead treatments at 10 µmol/L concentration produced significant ($p<0.05$) effects on seed germination and seedling length as compared to control. Increase in concentration of lead to 30µmol/L significantly affected seedling dry biomass of *A. lebbeck* as compared to control. Further increase in the concentration of lead upto 50 µmol/L produced toxic effects on root growth. Similarly, cadmium treatment at low concentration of 10 µmol/L significantly ($p<0.05$) decreased seed germination, seedling and root length as compared to control (Table 2). Cadmium treatment at 30 µmol/L produced significant ($p<0.05$) effects on root length of *A. lebbeck* as compared with control (Table 2). Seedling vigor index for *A. lebbeck* was highest in control seedling and gradually declined with the increase in concentration of lead and cadmium treatment from 10 to 90 µmol/L. The tolerance of *A. lebbeck* seedlings to lead and cadmium gradually decreased with the increasing concentrations of lead and cadmium as compared to control (Fig. 2). Lead treatments at 10, 30, 50, 70 and 90 µmol/L produced 94.12, 82.35, 74.51, 72.56 and 27.45% of tolerance in *A. lebbeck*, respectively. Cadmium treatment at similar range of treatments produced 92.15, 80.39, 64.7, 41.18 and 11.76% of tolerance in *A. lebbeck* respectively. According to tolerance indices, lead and cadmium treatments at 90 µmol/L showed lowest percentage of tolerance in *A. lebbeck* seedlings as compared to control. Cadmium treatment produced more toxic effects on *A. lebbeck* seedlings than lead treatment at all concentrations.

Table 1. Effects of different concentrations of lead on seed germination, root, shoot length, seedling length, dry biomass, root/shoot ratio and Seedling Vigor Index of *Abizia lebbeck*.

Treatment lead (Pb) µmol/L	Seed germination (%)	Root length (cm)	Shoot length (cm)	Seedling length (cm)	Seedling dry biomass (mg)	Root/shoot ratio	Seedling vigor index S.V.I.
00 µmol/L	96 ± 5.47a	5.1 ± 0.07a	8.8 ± 0.24a	13.8 ± 0.03a	39.58 ± 0.31a	0.63 ± 0.08a	1324.80
10 µmol/L	88 ± 5.47b	4.8 ± 0.24a	8.6 ± 0.08ab	13.4 ± 0.18b	38.13 ± 0.03a	0.56 ± 0.004b	1179.20
30 µmol/L	76 ± 5.47c	4.2 ± 0.04a	8.4 ± 0.08bc	12.6 ± 0.08b	36.84 ± 0.11b	0.51 ± 0.004b	957.60
50 µmol/L	74 ± 5.47c	3.8 ± 0.13b	8.1 ± 0.20bc	11.9 ± 0.11c	35.13 ± 0.07c	0.47 ± 0.004b	880.60
70 µmol/L	66 ± 5.47d	3.7 ± 0.15c	7.9 ± 0.21c	11.0 ± 0.17d	33.33 ± 0.09d	0.47 ± 0.004b	726.00
90 µmol/L	54 ± 5.47e	1.4 ± 0.14d	6.4 ± 0.16d	7.9 ± 0.31e	29.62 ± 0.07e	0.22 ± 0.004c	426.00
L.S.D.	7.149	0.439	0.528	0.496	0.326	0.022	

Number followed by the same letter in the same column are not significantly different at $p<0.05$ level.
± Standard Error.

Table 2. Effects of different concentrations of cadmium on seed germination, root, shoot length, seedling length, dry biomass, root/shoot ratio and Seedling Vigor Index of *Abizia lebbeck*.

Treatment cadmium (Cd) µmol/L	Seed germination (%)	Root length (cm)	Shoot length (cm)	Seedling length (cm)	Seedling dry biomass (mg)	Root/shoot ratio	Seedling vigor index S.V.I.
00 µmol/L	96 ± 2.44a	5.1 ± 0.07a	8.8 ± 0.24a	13.8 ± 0.03a	39.58 ± 0.31a	0.63 ± 0.009a	1324.80
10 µmol/L	84 ± 2.44b	4.7 ± 0.14b	7.6 ± 0.07b	12.3 ± 0.14b	38.13 ± 0.23a	0.62 ± 0.006a	1033.20
30 µmol/L	66 ± 5.08c	4.1 ± 0.07c	7.4 ± 0.14b	11.5 ± 0.15c	36.17 ± 1.36b	0.55 ± 0.01b	759.00
50 µmol/L	54 ± 5.08d	3.3 ± 0.14d	6.5 ± 0.14c	9.8 ± 0.12d	34.11 ± 0.36c	0.51 ± 0.013c	592.20
70 µmol/L	38 ± 3.73e	2.1 ± 0.15e	5.1 ± 0.14d	7.2 ± 0.15e	30.36 ± 0.12d	0.41 ± 0.011d	273.60
90 µmol/L	22 ± 3.73f	0.6 ± 0.07f	4.7 ± 0.07e	5.3 ± 0.21f	22.60 ± 0.09e	0.13 ± 0.006e	116.60
L.S.D.	11.429	0.337	0.425	0.429	0.401	0.030	

Number followed by the same letter in the same column are not significantly different at $p<0.05$ level.
± Standard Error.

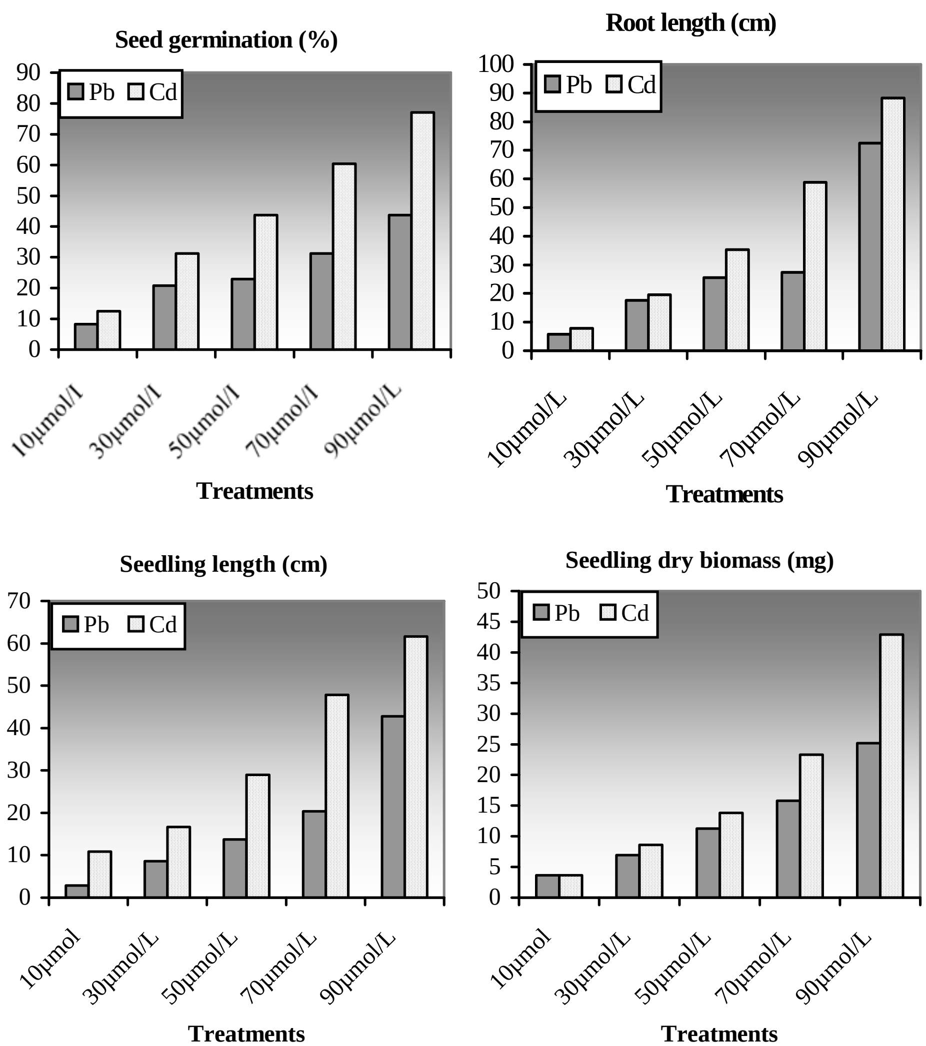

Fig. 1. Percentage decrease in seed germination, seedling length, root length and seedling dry biomass of *Albizia lebbeck* at different concentrations of lead and cadmium as compared to control.

Discussion

Siris (A. *lebbeck* (L.) Benth) belonging to family Mimosaceae is a multipurpose tree for semi-arid regions. Siris has been widely distributed around the tropics and mainly planted as a shade tree. Siris is found on a wide range of soil types including those that are alkaline and saline (Prinsen, 1986) but not subject to water logging. Heavy metals have been widely recognized as highly toxic to plants. Plants can be affected directly by air pollutants, as well as indirectly through the contamination of soil and water. At the same time, plant is a part of food chain and may create a risk for man and animals through contamination of food supplies (Farga Šová, 1994).

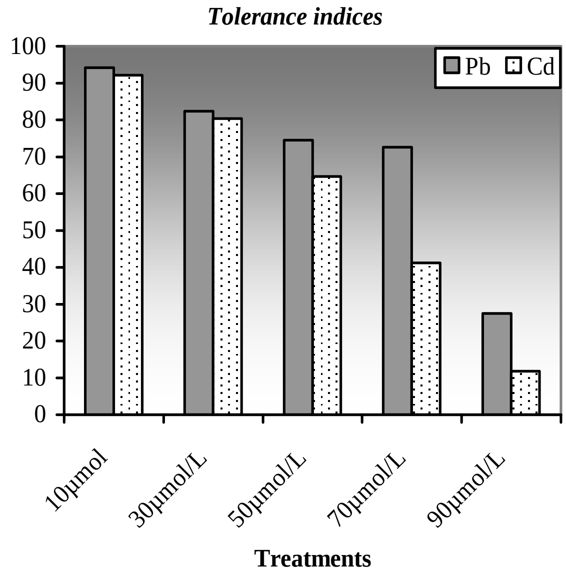

Fig. 2. Tolerance indices of *Albizia lebbeck* at different concentrations of lead and cadmium as compared to control.

Lead and cadmium toxicity have become an important issue due to their constant increase in the environment. In the present investigation, seed germination and seedling vigor index of *A. lebbeck* gradually decreased with the increase in concentration of lead and cadmium. Lead and cadmium treatments significantly ($p<0.05$) decreased seed germination as compared to control. Seed germination and seedling growth inhibition by heavy metals has also been reported by many other workers (Morzek & Funicelli, 1982; Al-Helal, 1995; Azmat *et al.*, 2005; Shafiq & Iqbal, 2005). The decrease in seed germination of *A. lebbeck* can be attributed to the accelerated breakdown of stored food material in seed by the application of lead and cadmium. (Kalimuthu & Siva, 1990) found reduction in seed germination in maize treated with 20, 50, 100 and 200 µg/ml lead acetate and mercuric chloride. Excessive amounts of toxic elements usually caused reduction in plant growth (Prodgers & Inskeep, 1981). Some elements such as Cu, Co, Fe, Mo, Mn, Ni and Zn are essential mineral nutrients. Others, such as Cd and Pb, however have no known physiological activity (Lasat, 2002). Significant reduction in root growth of *A. lebbeck* with the increase in concentration of cadmium treatment was also observed as compared to control. Cadmium is a highly toxic contaminant that affects many plant metabolic processes (Li *et al.*, 2008). Cadmium can also affect root metabolism, which shows sensitivity to Cd^{2+} toxicity by a reduction in lateral root size (Wójcik &Tukendorf, 1999). This is due to reductions in both new cell formation and cell elongation in the extension region of the root (Prasad, 1995; Liu, *et al.*, 2004).

The effects of heavy metals on plant depend on the amount of toxic substance taken up from a given environment. The seedlings of *A. lebbeck* also showed a gradual decrease in seedling vigor and dry biomass as concentrations of lead and cadmium increased. Similar observations in crops had been observed by Hailing *et al.*, (1991). The toxicity of some metals may be so severe that plant growth is reduced before large quantities of the element can be translocated (Haghiri, 1973).

According to the tolerance test, tolerance to lead and cadmium treatments in *A. lebbeck* was lower as compared with control. This information can be considered a contributing step in exploring and finding of the tolerance limit of *A. lebbeck* at different concentrations of treated metal. Cadmium is found highly toxic to seedling growth of *A. lebbeck* as compared to lead. Results of the findings can be useful indicator of metal tolerance to some extent for plantation of this species in metal contaminated area. How fairly low amounts of lead and cadmium absorbed over many years could lead to extinction of such an important plants species is unknown. In the metal contaminated areas, further research is needed to determine different levels of metals in the environment and various parts of the plants.

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