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Effect of lead and cadmium on germination and seedling growth of *Leucaena leucocephala*

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ABSTRACT: A study was conducted to determine the effect of different concentrations of lead and cadmium on seed germination and seedling growth of *Leucaena leucocephala*. Seed were grown under laboratory conditions at 25, 50, 75 and 100 ppm of metal ions of lead and cadmium. Both lead and cadmium treatments showed toxic effects on various growth indices of *L. leucocephala*. Increasing the concentration of lead to 75 ppm, significantly ($p<0.05$) decreased seed germination as compared to control. Seedling and root growth was significantly ($p<0.05$) reduced at 50 ppm treatment of lead. Seed germination and root length significantly ($p<0.05$) decreased at 50 ppm treatment of cadmium as compared to control. The seedling dry weight also significantly ($p<0.05$) reduced at 25 ppm treatment of lead and cadmium. Cadmium treatment at 100 ppm showed comparatively pronounced effects in *L. leucocephala* seedlings as compared to lead. The results of the study suggest that due to better metal tolerance indices there is a possibility of growing *L. leucocephala* in areas contaminated with lead and cadmium. @ JASEM

Unmanaged human activities such as livestock grazing, logging, and intentional fire can result in environmental degradation. Burning of fossil fuel, flooding, mining and eutrophication further deteriorate the environment. Degradation of environment adversely affects germination, growth and biodiversity of plants. The environment of the city of Karachi is deteriorating rapidly since the last couple of decade due to various types of pollutants emitted from various types of anthropogenic activities affecting the growth of plants. Metals are of special interest with respect to the toxicological importance to human health, plants and animals (Azevedo and Lea, 2005, Jarup, 2003). Lead and cadmium are the toxic elements of primary importance (Breckle and Kahile, 1992). Lead is one of the best known heavy trace elements, with a long history of toxicity. Its exposure is becoming a great concern because of its toxic nature, wide spread occurrence and long life in biological system. The major sources of lead in soil are usually derived from weathered bedrock, parents material from lead mine, smelting operations, use of lead arsenate, use of tetramethyl lead as antiknocking additive to petrol (Foy et al., 1978). Lead is common heavy metal and can be found in batteries, ceramics, chemicals and fertilizers. It is also used in a number of products including gasoline, hair dyes, leaded glass, newsprint, paints, pesticides, pottery and rubber toys. Inhibition to germination and retardation of plant growth has been reported due to lead toxicity (Jaffer et al., 1999; Morzeck and Funicelli, 1982; Wierzbicka and Obidzinska, 1998). Cadmium is a common and transitional metal and available in the form of cadmium sulfate is in the environment. Geochemically it is quite mobile element in soil, water and thus freely taken up by plants. Cadmium is one of highly dispersed metals by human activities (Kabata-Pendias and Dudka, 1990). Cadmium has many uses in industry and consumer products, like batteries, pigments, metal coatings, and plastics. Many research workers have drawn their attention on the toxic effects of cadmium on plant growth (Breckle and Kahile, 1992; Iqbal and Mehmood, 1991; Kabata-Pendias and Dudka, 1990; Mathur et al., 1987). *Leucaena leucocephala* is economically an important leguminous plant with its ability to grow in different environment in the tropics. *L. leucocephala* has a great potential as a pastures species providing sources of crude protein and other important nutrients for livestock production (Aganga and Tshwenyane, 2003). Little information is available on the effects of heavy metals on seed germination and seedling growth of *L. leucocephala*. The present research was carried out to investigate the effects of lead and cadmium on different growth indices of *L. leucocephala*.

MATERIALS AND METHODS

Healthy seeds of *L. leucocephala* (Lam.) de-Wit. were collected from plants growing at Karachi University Campus. Seeds were rubbed by sand paper to break the seed dormancy. Seeds were placed in petri dishes (90-mm diameter) on filter paper (Whatman # 42) and were treated separately with 2 mL solution of 25, 50, 75 and 100 ppm lead nitrate and cadmium sulfate. Control treatments were supplied with distilled water. The experiment was completely randomized and consisted of five treatments replicated three times. The petri dishes were kept at room temperature ($28 \pm 2^{\circ}$ C) under four 40-Watt tube lights. Experiment was concluded after 10 days and various growth indices such as seed germination, root and seedling length were measured. Dry weight was determined after drying the seedlings in an oven at 72 ^{0}C for 48 hours. Tolerance indices were determined by the following formula as given by Iqbal and Rahmati (1992). Data for various

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growth indices were subjected to analysis of variance and Duncan's Multiple Range Test.

RESULTS

Lead and cadmium treatment showed toxic effect on seed germination, seedling growth, root growth and dry biomass in *L. leucocephala* as compared to control (Fig. 1-4). Seed germination, seedling length, root length and seedling dry weight of *L. leucocephala* significantly ($p<0.05$) decreased at 100 ppm of lead and cadmium treatment as compared to control (Fig. 1). The effect of various treatments of lead was significantly less ($p<0.05$) on seed germination, root and seedling growth and dry matter accumulation of *L. leucocephala* than various treatments of cadmium showing some degree of tolerance to lead than cadmium. Percentage of seed germination of *L. leucocephala* was significantly ($p<0.05$) decreased by lead at 75 ppm (Fig. 1). It was observed that 50 ppm lead treatment produced significant ($p<0.05$) effects on seedling and root length of *L. leucocephala* as compared to control (Fig. 2). The seedling dry weight of *L. leucocephala* was significantly ($p<0.05$) reduced at 25 ppm treatment of lead as compared to control. Similarly, 50 ppm cadmium treatment produced significant ($p<0.05$) effects on seed germination and seedling length of *L. leucocephala* as compared to control (Fig. 3). The root length was also significantly ($p<0.05$) decreased at 50 ppm treatment of cadmium. The seedling dry weight of *L. leucocephala* was significantly ($p<0.05$) affected at 25 ppm cadmium treatments as compared to control.

The seedlings of *L. leucocephala* were tested for tolerance to heavy metals, using different concentrations of lead and cadmium (Fig. 4). *L. leucocephala* showed high percentage of tolerance at 25 ppm of lead as compared to control. Increase in concentration of lead (50-75 ppm) gradually decreased the tolerance of *L. leucocephala*. The treatment of lead at 100 ppm showed the lowest percentage of tolerance in *L. leucocephala*. It was observed that cadmium treatment also produced low percentage of tolerance in *L. leucocephala*. A high percentage of tolerance was found in *L. leucocephala* at 25 ppm cadmium treatment. Increased in concentration of cadmium treatment at 50 ppm reduced the percentage of tolerance. Lowest percentage of tolerance was found in *L. leucocephala* at 100 ppm cadmium treatment. According to tolerance test it was observed that tolerance in *L. leucocephala* at 100 ppm of cadmium was lower than lead. Cadmium treatment showed comparatively more toxic effects on *L. leucocephala* seedlings as compared to lead.

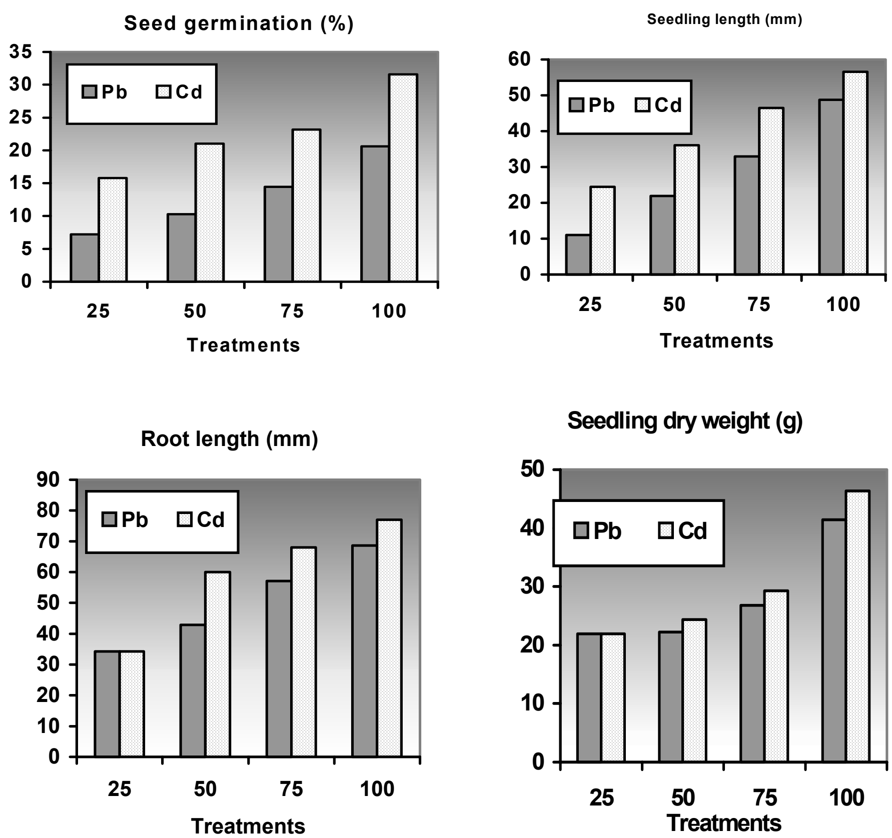

Fig.1. Percentage decrease in seed germination (%), seedling length (mm), root length (mm) and seedling dry weight (g) at different concentration of lead and cadmium as compared to control.

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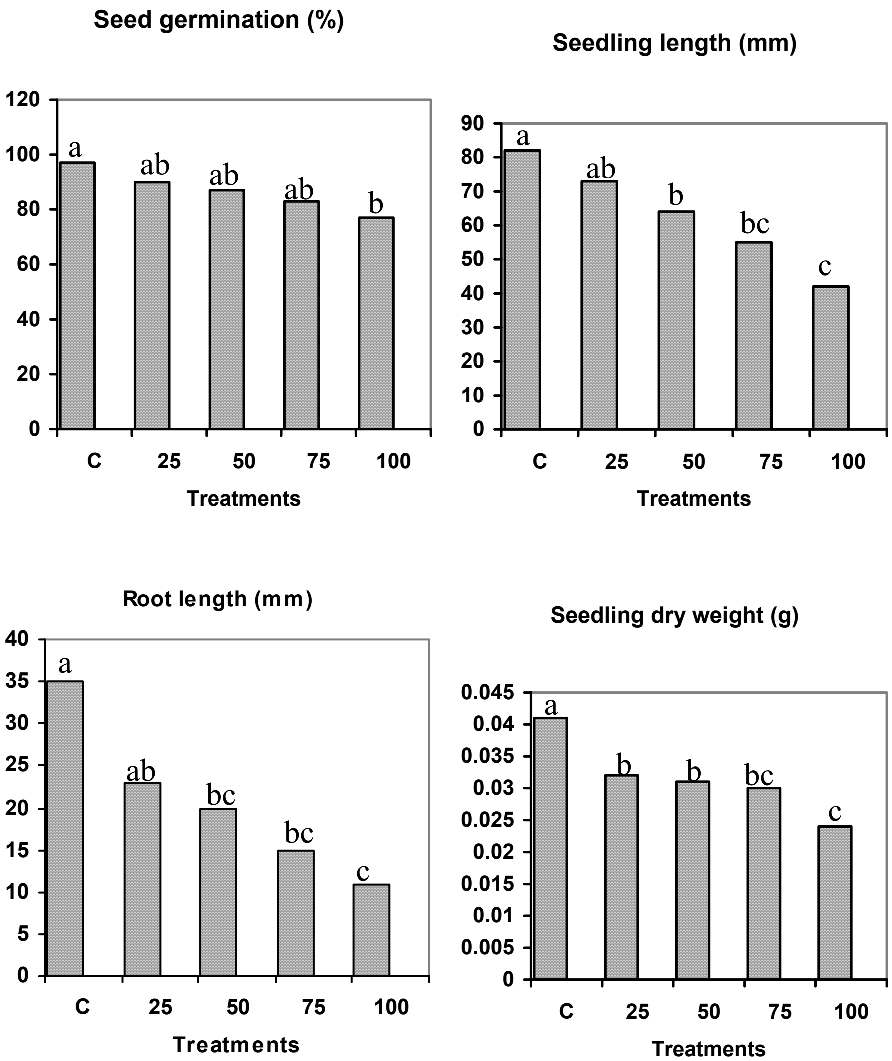
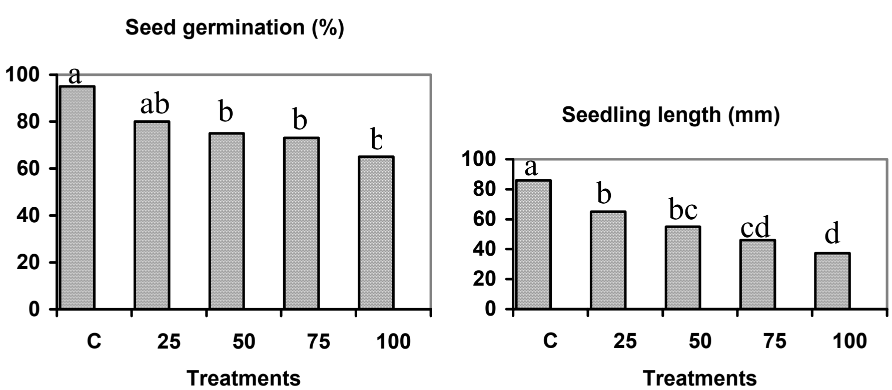


Fig.2. Effect of different concentration of lead on seed germination, seedling length, root length and seedling dry weight of *Leucaena leucocephala.* Values followed by the same letters are not significantly different at $p<0.05$.



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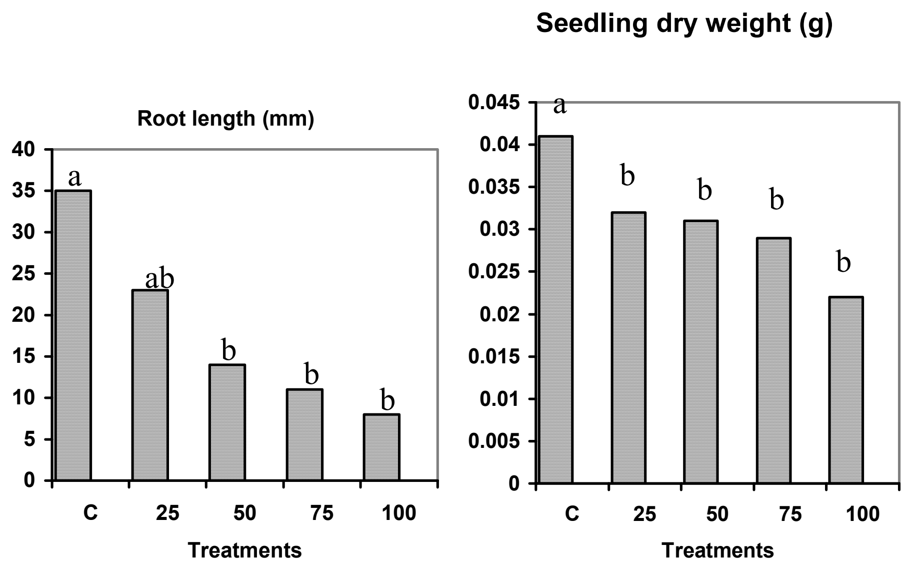

Fig.3. Effect of different concentration of cadmium on seed germination, seedling length, root length and seedling dry weight of *Leucaena leucocephala.* Values followed by the same letters are not significantly different at $p<0.05$.

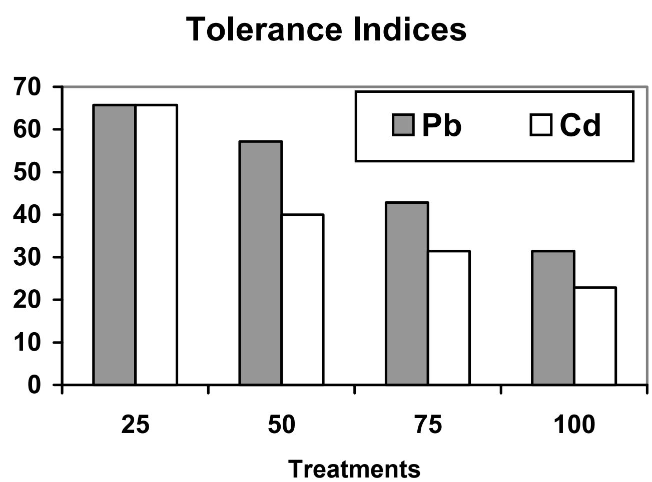

Fig.4. Indices of tolerance for *Leucaena leucocephala* at different treatments of lead and cadmium.

DISCUSSION

The plants under stress conditions are most likely to be adversely affected by high concentration of heavy metals. Lead and cadmium toxicity has become important due to their constant increase in the environment. In the present investigation, lead and cadmium treatment decreased seed germination and seedling growth of *L. leucocephala*. The decrease in seed germination of *L. leucocephala* can be attributed to the accelerated breakdown of stored food materials in seed by the application of lead and cadmium. Reduction in seed germination can also be attributed to alterations of selection permeability properties of cell membrane. The decrease in seed germination of *L. leucocephala* due to heavy metal treatment is in conformity with the findings of other workers (Ayaz and Kadioglu, 1997; Hasnain et al., 1995; Iqbal and Mehmood, 1991; Jamal et al., 2006a, b; Kalimuthu and Siva, 1990; Mahmood et al., 2005). Kalimuthu and Siva (1990) found reduced in seed germination in corn treated with 20, 50, 100 and 200 $\mu g\ mL^{-1}$ lead acetate. Treatment of wheat with lead at 1, 2, 5, 10 and 20 mM reduced the germination process showing gradual reduction in germination with increase in concentration (Hasnain et al., 1995).

Excessive amount of toxic element usually caused reduction in plant growth (Prodgers and Inskeep, 1981). The wide spread use of cadmium in a large number of products and industrial process has resulted in severe environmental contamination. Our

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knowledge is still insufficient to explain the mechanism of cadmium toxicity and more especially the interaction of cadmium with important biochemical processes in plant growth. An attempt has been made to evaluate the effect of increasing levels of cadmium toxicity on germination and seedling vigor of *L. leucocephala.* Iqbal and Mehmood (1991) reported gradual decrease in plant growth of *Dalbergia sissoo* with increasing of cadmium level. Mathur et al. (1987) found that higher concentration of cadmium and chromium (100-250 ppm) affected germination and early growth performance of *Allium cepa.* The reason of reduced seedling length in metal treatments could be the reduction in meristematic cells present in this region and some enzymes contained in the cotyledon and endosperms. Cells become active and begin to digest and store food which is converted into soluble form and transported to the radicle and plumule tips for enzyme amylase which converts starch into sugar and protease act on protein. So when activities of hydrolytic enzyme are affected, the food does not reach to the radicle and plumule affecting the seedling length.

Lead and cadmium treatment showed greater toxic effects on root growth of *L. leucocephala*. The reduction in root length in metal treatments could be due to reduced mitotic cells in meristematic zone of root. Lerda (1992) made similar observations in roots of on *Allium cepa*. These findings confirm that metal treatment reduced the frequency of mitotic cell in meristematic zone and are responsible for inhibition in root growth. The reason for different response of seedling and root growth to heavy metals is not known but might be due to rapid accumulation of heavy metals in root than shoot or to faster rate of detoxification in shoot than root. Renjini and Janardhanan (1989) observed that the growth rate of root, shoot and formation of lateral root were retarded with increase in the concentration of cadmium acetate in peanut. Breckle and Kahile (1992) reported that a combined treatment of 20 ppm lead and 1 ppm cadmium greatly reduced the growth of young roots of *Fagus sylvatica* than in treatment where metals were applied separately.

The effects of toxic substances on plants are dependent on the amount of toxic substance taken up from the given environment. The toxicity of some of the metals may be large enough that plant growth is retarded before large quantities of the element can be translocated (Haghiri, 1973). *L. leucocephala* seedlings showed gradual decrease in dry weight with increase in concentration of lead and cadmium. Lead and cadmium treatment showed significant effect on seedling dry weight, which was evident in the poor growth of roots and aerial parts. Cadmium treatment at 25ppm concentration showed reduction in dry weight of *L. leucocephala* seedlings. Reduction in growth parameters also leads to decreased dry biomass.

Tolerance test showed that tolerance to lead and cadmium in *L. leucocephala* was low at 100 ppm as compared to control. The reason for low tolerance against both metals might be due to changes in the physiological mechanism in seed germination and seedling growth of plant. Shafiq and Iqbal (2005) reported similar results for low tolerance in *Cassia siamea* seedlings at 100 ppm of lead and cadmium treatment as compared to control. *L. leucocephala* was found comparatively tolerant species to lead than cadmium treatment. The results of the study suggest that due to better metal tolerance indices there is a possibility of growing *L. leucocephala* in areas contaminated with lead and cadmium.

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