Pak. J. Bot., 43(1): 445-452, 2011.

TOLERANCE OF *ALBIZIA LEBBECK* (L) BENTH TO DIFFERENT LEVELS OF LEAD IN NATURAL FIELD CONDITIONS

ZIA-UR-REHMAN FAROOQI, MUHAMMAD ZAFAR IQBAL, MUHAMMAD KABIR AND MUHAMMAD SHAFIQ

Department of Botany, University of Karachi, Karachi, 75270, Pakistan.
E-mail: farooqi_bot@yahoo.com; shafiqeco@yahoo.com

Abstract

Lead produced significant effects on different growth parameters of *Albizia lebbeck* (L.) Benth such as root, shoot, seedling length, leaf area, plant circumference and seedling dry biomass in natural field conditions. Seedling growth performance of *A. lebbeck* showed low level of tolerance with increasing concentrations of lead treatments from 25 to 125µmol/L. Lead treatments at 25 to 125µmol/L produced significant effect on shoot, root and seedling length of *A. lebbeck*. Number of leaves, leaf area and circumference were significantly ($p<0.05$) reduced at all concentrations of lead treatments. Seedling dry biomass was significantly reduced at 100 and 125µmol/L treatment of lead. Lead treatment at 25µmol/L showed high percentage of tolerance indices while by increasing lead levels to 125µmol/L, percentage of tolerance indices was low.

Introduction

All compartments of the biosphere are polluted by a variety of inorganic and organic pollutants by anthropogenic activities which alter the normal biogeochemical cycling (Prasad & Freitas, 2003). Most of the toxic pollutants are discharged in the air by man made activities (Nriagu & Pacyna, 1988). The continuous discharge of various types of toxic materials, such as carbon particles, unburned and partially burned hydrocarbons, fuels, tar materials, heavy metals and other elements in the environment, produced toxic effects on plants (Qadir & Iqbal, 1991).

Lead is a common heavy-metal pollutant, released from leaded gasoline and industrial processes (Xiong, 1998). Lead is a toxic element that is being releasing into the atmosphere for the last 70 years by human economic activity (Antosiewicz & Wierzbicka, 1999). Lead is generally added in the environment through automobile exhaust (Lagerwerff & Specht, 1970) and industrial effluents (Campbell, 1976). 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). Lead and cadmium are the toxic elements of primary importance in ecotoxicology (Breckle & Kahile, 1992). Exposure to lead (Pb) as well as other heavy metals in the environment is still a matter of public health concern (Rinderknecht *et al*., 2005). Lead and cadmium treatments at 10, 30, 50, 70 and 90µmol/L inhibited the seed germination and seedling growth of *Thespesia populnea* L. (Kabir *et al*., 2008). Lead and cadmium produced significant effects on germination, root, shoot, seedling lengths and seedling dry biomass of *Albizia lebbeck* (L.) Benth in lab conditions at 10, 30, 50, 70 and 90µmol/L (Farooqi *et al*., 2009).

Emission of Pb from petrol driven motor vehicles is an environmental problem. Yousafzai (1991) found the level of Pb (810-4527 ppm) and Cd (0.2-4.5 ppm) in the street dust of metropolitan city of Karachi and concluded that Pb in roadside dust of Karachi city was mostly attributed by leaded gasoline from vehicular traffic. Inhibition of germination and retardation of plant growth are commonly observed due to lead toxicity (Morzeck & Funicelli, 1982; Wierzbicka & Obidzinsca, 1998; Lerda, 1992; Shaukat *et al.,* 1999). Lead produced highly significant effects on shoot, root lengths and seedling dry biomass of *Lythrum salicaria* (Juseph *et al*., 2002). Foliar application of lead affected growth and yield parameters of wheat was studied by Rashid & Mukhirji (1993). Effects of lead toxicity on seed germination and seedling growth of some tree species were carried out (Iqbal & Sidiqui, 1992; Shafiq & Iqbal, 2005). Germination of two rice *(Oryza sativa* L.) cultivars (Ratna and IR36) in the presence of 10 µM Pb decreased germination percentage, germination index, shoot/root length, tolerance index and dry mass of shoots and roots (Mishra & Choudhuri, 1998).

Siris (*A. lebbeck* (L.) Benth) belongs to a family Mimosaceae is a multipurpose tree for semiarid regions. *A. lebbeck* has been widely distributed around the tropics and mainly planted as a shade tree. This tree is found on a wide range of soil types including those that are alkaline and saline (Prinsen, 1986) but not subject to water logging.

The aim of the present investigation was to determine the tolerance of *Albizia lebbeck* (L.) Benth., seedlings to lead treatments in the natural field conditions.

Materials and Methods

The healthy seeds of *Albizia lebbeck* (L.) Benth were collected randomly from the Karachi University campus. The experiment was conducted in natural field conditions at Department of Botany, University of Karachi. The top ends of the seeds were slightly cut with a clean scissor to remove any possible dormancy. The seeds were sown in large earthen pots having garden soil at 1 cm depth and watered regularly. After two weeks of their germination, uniform size seedlings were transplanted in plastic pots of 7.0 cm in diameter and 9.8 cm in depth containing garden soil. One seedling was transplanted in each pot and was treated with a solution of lead nitrate having 25, 50, 75, 100 and 125 µmol/L concentrations. There were five replicates for each treatment and the experiment was completely randomized. The seedlings were treated with 5 ml of their respective treatment after two days intervals. Pots were reshuffled weekly to avoid light/ shade or any other environmental effect. After 8 weeks seedlings were removed from pots and washed their roots with water. Data on seedling length, root and shoot length, leaf area was obtained. Seedling dry biomass was determined by drying the plant material in an oven at 80^{o}C for 24 hours. Tolerance indices (TI) were determined using the formula given by Iqbal & Rahmati (1992).

$$TI = \frac{\text{Mean root length in metal solution}}{\text{Mean root length in distilled water}} \times 100$$

The data obtained was statistically analyzed by analysis of variance (ANOVA) (Steel & Torrie, 1984) and Duncan's Multiple Range Test (Duncan, 1955) at $p<0.05$ level.

Results

Lead treatments showed prominent effects on seedling growth performance of *Albizia lebbeck* (L.) Benth in natural field conditions. Reduction in root, shoot and seedling lengths, leaf number, leaf area and dry biomass was observed for *A. lebbeck* in all concentrations (25, 50, 75, 100 & 125µmol/L) of lead treatment as compared to control (Table 1). Shoot length of *A. lebbeck* was gradually reduced (14.80, 14.60, 14.40, 13.40 & 13.40 cm) with increase in concentration of lead (25, 50, 75, 100 & 125µmol/L).

Table1. Effects of lead on growth parameters of *Albizia lebbeck* at different concentrations.

Treatment lead (Pb) µmol/L	Shoot length (cm)	Root length (cm)	Seedling length (cm)	Number of leaves	Leaf area (cm^2)	Circumference (cm)	Seedling dry biomass (g)
00	15.20 ± 0.49a	7.80 ± 0.37a	23.00 ± 0.83a	16.60 ± 1.08a	16.87 ± 0.83a	34.00 ± 1.18a	1.30 ± 0.10a
25	14.80 ± 0.58b	7.20 ± 0.58b	22.00 ± 1.14b	14.60 ± 1.33b	11.80 ± 0.43b	31.20 ± 0.92b	1.28 ± 0.11a
50	14.60 ± 1.12b	7.00 ± 0.55b	21.60 ± 1.63b	14.20 ± 1.15b	9.78 ± 0.53c	31.20 ± 0.92b	1.24 ± 0.12a
75	14.40 ± 0.60b	6.80 ± 0.37c	21.20 ± 0.86b	14.20 ± 0.58b	7.89 ± 0.47d	29.60 ± 1.03c	1.22 ± 0.14a
100	13.40 ± 0.40c	6.80 ± 0.37c	20.20 ± 0.74c	14.00 ± 0.54b	6.97 ± 0.61d	28.20 ± 1.28c	1.14 ± 0.08b
125	13.40 ± 0.24c	6.20 ± 0.37d	19.60 ± 0.51c	13.60 ± 0.68b	6.25 ± 0.74d	26.20 ± 0.58d	1.05 ± 0.09b

Number followed by the same letter in the same column are not significantly different according to Duncan Multiple Range Test at $p>0.05$ level.

± Standard error

Root length of *A. lebbeck* was suppressed (7.20, 7.00. 6.80. 6.80 & 6.20 cm) at 25, 50, 75, 100 and 125 µmol/L concentrations respectively and control showed (7.80 cm) better root growth. Lead treatments at 25 to 125µmol/L concentrations significantly ($p<0.05$) affected seedling length. A significant ($p<0.05$) reduction was also found in number of leaves at all treatments of lead. Leaf area showed a prominent decrease (11.80, 9.78, 7.89, 6.97 and 6.25 cm^2) at 25, 50, 75 100, and 125 µmol/L concentrations of lead. Plant circumference of *A. lebbeck* was also determined and showed significant reduction (31.20, 31.20, 29.60, 28.20 and 26.20 cm) at 25, 50, 75, 100 and 125 µmol/L concentrations of lead as compared to control which showed 34.00 cm circumference. A significant reduction (1.14 and 1.05 g) in seedling dry biomass was found at 100 and 125 µmol/L of lead treatments, respectively. Reduction in percentage of different growth variables was increased by increasing concentrations of lead (Fig. 1).

The seedlings of *A. lebbeck* were tested for tolerance to different concentrations of lead (Fig. 2). It is shown that tolerance of *A. lebbeck* was gradually decreased by increasing concentrations of lead treatments. Lead treatment at 25 µmol/L showed high percentage (92.31%) of tolerance in seedlings of *A. lebbeck* while lead treatments at 50, 75 and 100µmol/L showed 89.74, 87.18 and 87.18% of tolerance, respectively. Lead treatment at 125µmol/L showed lowest percentage of tolerance (79.49%) in *A. lebbeck* seedlings as compared to control.

Discussion

Albizia lebbeck (L.) Benth showed inhibition in all growth variables at different levels of lead treatments. Root, shoot and seedling length were highly affected with increasing concentrations of lead. A significant reduction was observed in root, shoot and seedling length as compared to control. This might be due to reductions in both new cell formation and cell elongation in the extension region of the root and these findings were similar to the results of Haussling *et al*., (1988). Excessive amounts of toxic elements usually caused reduction in plant growth (Prodgers & Inskeep, 1981). Seedling growth inhibition by heavy metals has also been reported by many other workers (Morzek & Funicelli, 1982; Azmat *et al*., 2005; Shafiq & Iqbal, 2005). 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 (Fargasova, 1994).

Lead is a toxic element that is harmful to growth of *A. lebbeck* and it showed a significant reduction in leaf area and seedling dry biomass. This reduction might be due to accumulation of lead in soil which physically blocks water uptakes from root to shoot and is related with the rate of photosynthesis, mainly associated with the water content and CO_2 absorption. These results were supported by Jaja & Odoemena (2004) as they found that leaf area, fresh and dry biomass of wheat (Roma VF) variety was highly inhibited with increase in lead levels. In the present investigation, seedling growth performance of *A. lebbeck* gradually decreased with the increase in concentration of lead as compared to control. Similar results were found by applying lead treatments in the lab conditions at 10, 30, 50, 70 and 90 µmol/L concentrations which produced significant ($p<0.05$) effects on seed germination and seedling length of *A. lebbeck* while lead treatment at 50, 70 and 90 µmol/L significantly affected root growth and seedling dry biomass as compared to control (Farooqi *et al*., 2009). The circumference of *A. lebbeck* was also reduced with increase in lead which entered into plant system through stomates and disturbed physiological activities of plants. It has been shown that the metals induce chromosomal abnormalities and also decrease the rate of cell division. In general, effects

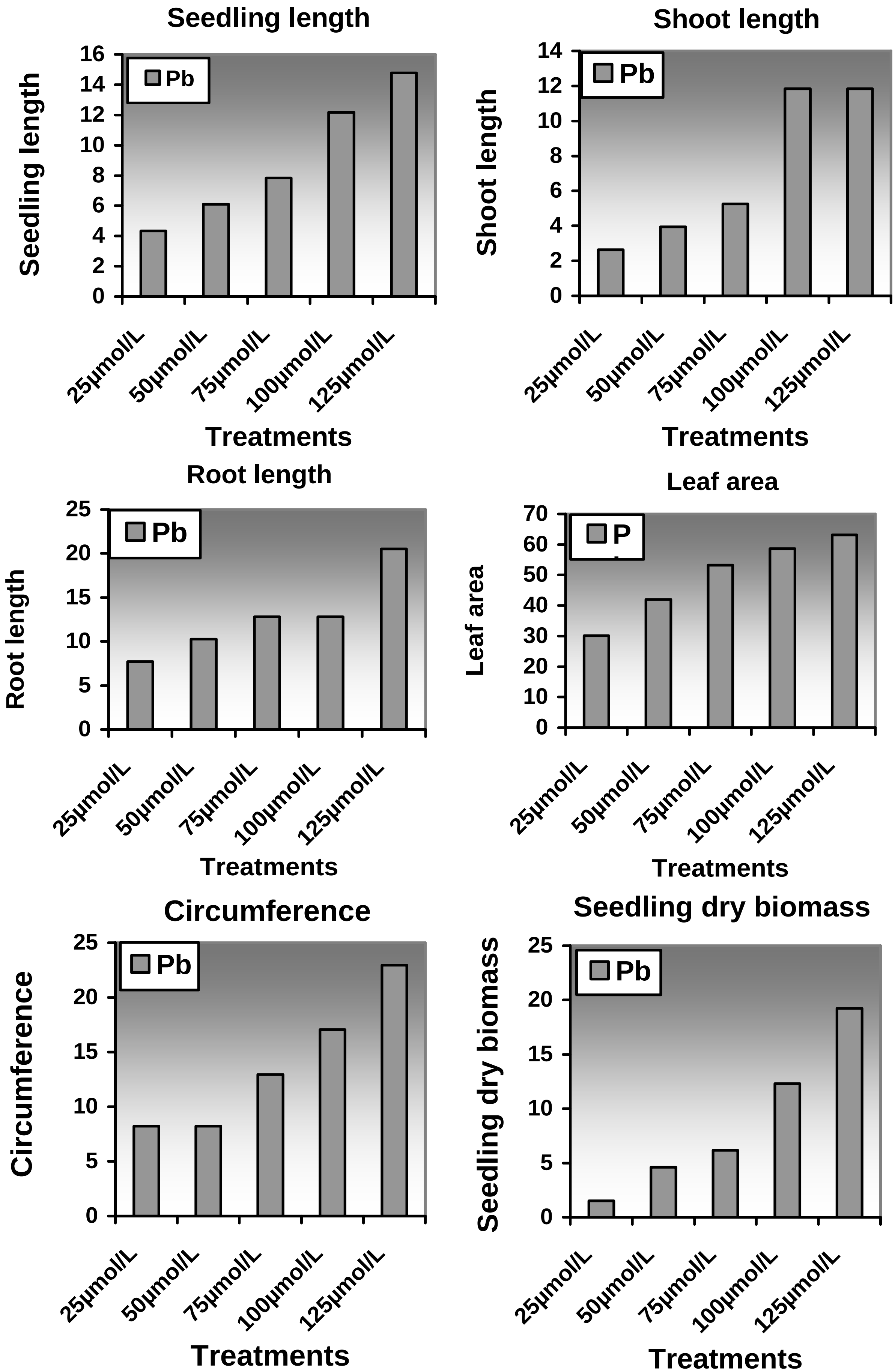

Fig. 1. Percentage increase in reduction of seedling, root and shoot lengths, leaf area, circumference and seedling dry biomass at increasing concentrations of lead.

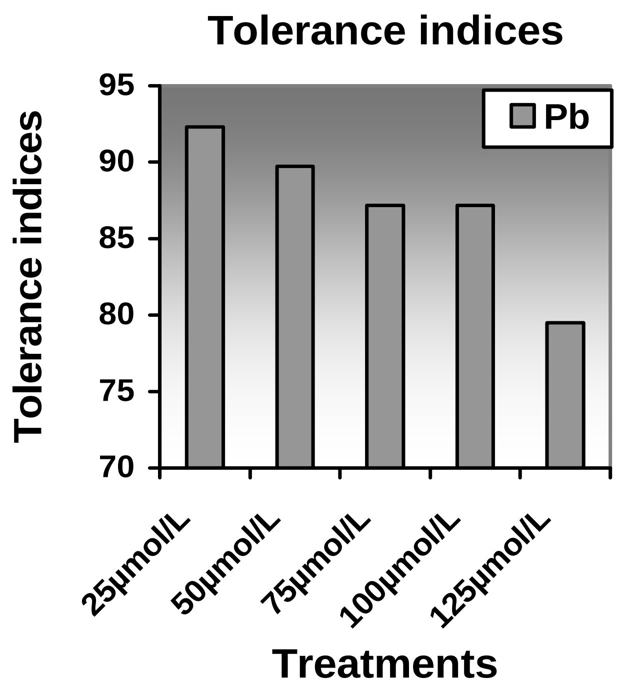

Fig. 2. Tolerance indices of *Albizia lebbeck* at different concentrations of lead as compared to control.

are more pronounced at higher concentration and at longer duration of exposure (Monn *et al*., 1995). Plants have a range of potential mechanisms at the cellular level that might be involved in the detoxification and thus tolerance to heavy metal stress. These all appear to be involved primarily in avoiding the build-up of toxic concentrations at sensitive sites within the cell and thus preventing the damaging effects described above, rather than developing proteins that can resist the heavy metal effects (Hall, 2002). The effects of heavy metals on plants depend on the amount of toxic substance taken up from the environment. The seedlings of *A. lebbeck* also showed a gradual decrease in seedling dry biomass as concentrations of lead increased. 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). Seedling growth of *Arabidopsis thaliana* was found sensitive to Pb^{2+} treatment at 1 mM (Li *et al*., 2005).

Tolerance to lead treatments in *A. lebbeck* was lower as compared to control. This information can be considered a contributing step in exploring and finding of tolerance limit of *A. lebbeck* at different levels of treated metal. These findings were similar to the results of Kabir *et al*., (2008). According to them the tolerance limit of *Thespesia populnea* L. gradually decreased with increasing lead levels. Tolerance to heavy metals in plants may be defined as the ability to survive in a soil that is manifested by an interaction between a genotype and its environment (Macnair *et al*., 2000). Metal hyperaccumulating plants are thus not only useful in phytoremediation, but also play a significant role in biogeochemical prospecting and have implications on human health through food chain and possibly exhibit elemental allelopathy (metallic compounds leached through plant parts of the hyperaccumulator would supress the growth of other plants growing in the neighbourhood) and resistance against fungal pathogens (Boyd *et al*., 1994). Further studies on the morphological attributes of the root characteristic such as root length, root diameter and root hairs are required. These characters could play a key role in understanding the transport of metal from soil to aerial parts of the plants which is possible due to presence of the specialized epidermal cells found in the roots and stem.

References

Antosiewicz, D. and M. Wierzbicka. 1999. Localization of lead in *Allium cepa* L. cell by electron microscopy. *Journal of Microscopy,* 195: 139-146.

Azmat, R, Z. Huma, A. Hayat, T. Khanum and R. Talat. 2005. The inhibition of bean plant metabolism by cadmium metal: Effects of cadmium metal on physiological process of bean plant and *Rhizobium* species. *Pakistan Journal of Biological Science,* 8(3): 401-404.

Boyd, R.S., J.J. Shaw and S.N. Martens. 1994. Nickel hyperaccumulation in *S. Polygaloids* (Brassicaceae) as a defense against pathogens. *American Journal of Botany,* 81(3): 294-300.

Breckle, S.W. and H. Kahile. 1992. Effects of toxic heavy metals, Cd, Pb on growth and mineral nutrition of beech (*Fagus sylvatica* L). *Vegetatio,* 101: 43-53.

Campbell, J.A. 1976. A mathematical treatment of variation of heavy metal content of lichen with distance from a source. *Lichnologist,* 8: 83-86.

Duncan, D.B. 1955. Multiple range and multiple F-test. *Biometrics,* 11: 1-42.

Fargasova, A. 1994. Effects 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.

Farooqi, Z.R., M.Z. Iqbal, M. Kabir and M. Shafiq. 2009. Toxic effects of lead and cadmium on germination and growth of *Albizia lebbeck* (L.) Benth. *Pakistan Journal of Botany,* 41(1):27-33

Haghiri, F. 1973. Cadmium uptake by plants. *Journal of Environmental Quality*, 2: 93-96.

Hall, J.L. 2002. Cellular mechanisms for heavy metal detoxification and tolerance. *Journal of Experimental Botany,* 53(366): 1-11.

Haussling, M., C.A. Jorns, G. Lehmbecker, C. Hercht-Bucholz and H. Marschner. 1988. Ion and water uptake in relation to root development of Norway spruce (*Picea abies* (L.) Karst). *Journal of Plant Physiology*, 133: 486-491.

http://www.ej biotechnology. info/content/vo16/issue3/fuIl/3/index.htmI.

Iqbal, M.Z. and D.A. Siddiqui. 1992. Effect of lead toxicity on seed germination and seedling growth of some tree species. *Pakistan Journal of Scientific and Industrial Research*, 35: 139-141.

Iqbal, M.Z. and K. Rahmati. 1992. Tolerance of *Albizia lebbeck* to Cu and Fe application. *Ecologia*, 11: 427-430

Iqbal, M.Z., M. Shafiq and A.S. Kausar. 2001. Toxic effects of lead and cadmium individually and in combination on germination and growth of *Leucaena leucocephala*. *Pakistan Journal of Botany,* 33: 551-557.

Jaja, E.T. and C.S.I. Odoemena. 2004. Effect of Pb, Cu and Fe compounds on the germination and early seedling growth of tomato varieties. *Journal of Applied Science and Environmental Management,* 8(2): 51-53.

Juseph, L.u., L.C. Andrea and T.K. Mal. 2002. Effects of lead contamination on the growth of *Lythrum salicaria. Environmental Pollution,* 120(2): 319-323.

Kabir, M., M.Z. Iqbal, M. Shafiq and Z.R. Farooqi. 2008. Reduction in germination and seedling growth of *Thespesia populnea* L., caused by lead and cadmium treatments. *Pakistan Journal of Botany,* 40(6): 2419-2426.

Lagerwerff, J.W. and A.W. Specht. 1970. Contamination of roadside and vegetation with cadmium, nickel, lead and zinc. *Environmental Science and Technology,* 4: 583-586.

Lerda, D. 1992. The effect of lead on *Alium cepa* L. *Mutation Research*, 231: 80-92.

Li, M., L.J. Zhang., L. Tao and W. Li. 2005. Ecophysiological responses of *Jussiaea rapens* to cadmium exposure, *Aquatic Botany,* 88(4): 347-352.

Macnair, M.R., G.H. Tilstone and S.E. Smith. 2000. The genetics of metal tolerance and accumulation in higher plants. In: *Phytoremediation of contaminated soil and water*. (Eds.): N. Terry, G. Banuelos. CRC Press LLC, 235-250.

Mishra, A and M.A. Choudhuri, 1998. Amelioration of lead and mercury effects on germination and rice seedling growth by antioxidants. *Biologia Plantarum,* 41(3): 469-473.

Monn, C.H., O. Braendli, G. Schaeppi, C.H. Schindler, U. Ackermann-Liebrich and P.H. Leuenberger. 1995. Particulate matter accumulation<10μm (PM10) and total suspended particulates (TSP) in urban, rural and alpine air in Switzerland. *Atmospheric Environment*, 29: 2565-2573.

Morzeck, J.R.E. and N.A. Funicelli. 1982. Effect of zinc and lead on germination of *Spartma alterniflora* Loisel seeds at various salinities. *Environmental and Experimental Botany,* 22: 23-32.

Nriagu, J.O. and J.M. Pacyna. 1988. Quantitative assessment of world wide contamination of air, water and soil by trace metals. *Nature*, 333: 134-139.

Prasad, M.N.V. and H.M.D. Freitas. 2003. Metal hyperaccumulation in plants – Biodiversity prospecting for phytoremediation technology. *Electronic Journal of Biotechnology,* 6(3). [online]. December 15, 2003. [Visited on November 21,2008]

Prinson, J .H. 1986. Potential of *Albizia lebbeck* as a tropical fodder tree- a review of literature. *Tropical Grasslands*, 29: 78-83.

Prodgers, R.A. and W.P. Inskeep. 1981. Heavy metals tolerance of inland salt grass *Distichlis spicata. Great Basin Naturalist,* 51: 271-278.

Qadir, N. and M.Z. Iqbal. 1991. Growth of some plants raised from polluted and unpolluted seeds. *International Journal of Environmental Studies,* 39: 95-99.

Rashid, P. and S. Mukhirji. 1993. Effect of foliar application of lead on the growth and yield parameters of wheat. *Pakistan Journal of Scientific and Industrial Research,* 36: 473-475.

Rinderknecht, A.L., M.T. Kleinman and J.E. Ericson. 2005. Pb enamel biomarker: deposition of pre- and postnatal Pb isotope injection in reconstructed time points along rat enamel transect. *Environmental Research,* 99: 169-176.

Shafiq, M. and M.Z. Iqbal. 2005. The toxicity effects of heavy metals on germination and seedling growth of *Cassia siamea* Lamark. *Journal of New Seeds,* 7: 95-105.

Shaukat, S.S., M. Mushtaq and Z.S. Siddiqui. 1999. Effects of cadmium, chromium and lead on seed germination, early seedling growth and phenolic contents of *Parkinsonia aculeate* L., and *Pennisatum americanum* (L.) Schumann. *Pakistan Journal of Biological Sciences,* 2: 1307-1313.

Steel, R.G.D. and J.H. Torrie. 1984. Principles and procedures of statistics. Mc Graw Hill Book C., Inc., Singapore, 172-177.

Wierzbicka, M. and J.Obidzinska. 1998. The effect of lead on seed imbibition and germination in different plant species. *Plant Science,* 137: 155-171.

Xiong, Z.T. 1998. Lead uptake and effects on seed germination and plant growth in a Pb hyperaccumulator *Brassica pekinensis* Rupr. *Bulletin of Environmental Contamination and Toxicology,* 60(2): 285-291.

Yousufzai, A.H.K. 1991. Lead and heavy metals in the street dust of Metropolitan city of Karachi. *Pakistan Journal of Scientific and Industrial Research,* 34: 167-172.

(Received for publication 22 July 2009)