International Journal of Innovative Research and Advanced Studies (IJIRAS)
Volume 4 Issue 5, May 2017

ISSN: 2394-4404

Phytoremedial Effect Of Lead (Pb) And Cadmiuim (Cd) On The Root And Shoot Length Of Wheat And Barley

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Abstract: Contamination by heavy metals can be considered as one of the most critical threat to the soil and water resources as well as human being. Physical, chemical and biological can be used for remediation of contaminated sites but phytoremediation gained much attention due to low cost, cheap, easily applicable and eco friendly clean up technology. To evaluate the effect of lead and cadmium on germination and root, shoot length of wheat and barley, the experiment was conducted under greenhouse condition for their fast germination rate. Use of wheat and barley does not have the destructive impact on the soil fertility and structure. The presence of plant is likely to improve the overall condition of the soil, regardless of the degree of contamination reduction. Lead (50 and 100 mg kg^{-1}) and cadmium (25 and 50 mg kg^{-1}) concentration were used to evaluate the potential of wheat and barley as bioassay for the assessment of changes in the levels of lead and cadmium. After 10 DAT, germination percentage and root, shoot length of wheat and barley decreased with the increasing concentrations of both the metals. Similar picture was seen after 20 DAT but at 30 DAT, seedling growth in all the treatments of lead and cadmium were comparable to control. A significant reduction in the level of metal present in the soil, seed germination and seedling growth of wheat and barley were seen. Overall differences in the germination percentage and root, shoot length of wheat and barley indicate their potential as a phytoremediator.

I. INTRODUCTION

Pollution by heavy metals is one of the most serious environmental problems which have been subjected as extensive research in recent years (Jayakumar et al., 2007). As a result of the continuous civilization progress and the increasing human population, rapid and unorganized urbanization and industrialization have contributed the levels of heavy metals in the urban environment of the developing countries such as China (Wong et al., 2003) and India (Tripathi et al., 1997; Khillare et al., 2004; Sharma et al., 2008).

Contamination of soil with heavy metals such as Pb, Cd, Zn, Cu, Cr and Ni has increased fastly within past few years due to rapid increased in the industrialization (Ahmadpour et al., 2006). Excess use of pesticides in agriculture, wastes from de-acidifying soils are the other factors leading to soil pollution (Szczyglowska et al., 2011). These metals are dominantly found in almost all kinds of industrial and sewage wastes (Jaleel et al., 2009).

Soils can be contaminated as a result of spills or direct contact with contaminated wastes, streams such as airborne emissions processes, solid wastes, sludges or leachate from waste materials. The solubility of metals in the soil is influenced by the chemistry of the soil and ground water (Sposito, 1989; Evans, 1989).

Some heavy metals such as Fe, Mo and Mn are essential micronutrient for plants al low concentration, but in higher doses they may cause metabolic disorders and growth inhibition for most of the plant species (Fernandes and

Henriques, 1989; Claire et al., 1991). Heavy metals may enter in the food chain as result of their uptake by edible plants, thus the determination of heavy metals in the environmental samples is very important (Kachenko et al., 2004; Alirzayeva et al., 2006).

Lead causes inhibition of germination and retardation of plant growth (Morzeck and Funicelli, 1982; Lerda, 1992; Antosiewicz and Wierzbicka, 1999; Shaukat et al., 1999).. Negative effects of lead toxicity on seed germination and seedling growth of some tree species were examined (Iqbal and Siddiqui 1992; Iqbal and Shazia 2004).

High concentration of cadmium in soils represents 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 some common trees were investigated.

Human and ecosystem may be exposed to chemical hazards through the direct ingestion of contaminated lands or drinking water that has percolated through such soil (Mclaughlin et al., 2000). These heavy metals are toxic because they cause DNA damage and their carcinogenic effects in animals and humans are probably caused by their mutagenic ability (Knasmuller et al., 1998; Baudouin et al., 2002). Heavy metals have adverse effect on plants and their productivity, although some metals are essential for plant growth in small quantities (Lehokzky et al., 2000).

The cleanup of the contaminated sites is important in order to reclaim the areas and minimize the entry of toxic element in the food chain. Remediation of heavy metals contaminated sites is particularly challenging because unlike organic contaminants, metals do not undergo microbial or chemical degradation. They are toxic and their total concentration in the soil persists for a long time after their introduction (Adriano, 2003; Kirpichtchikova et al., 2006).

Certain plant species of higher plants can accumulate very high concentration of metals in their tissue without showing toxicity (Klassen et al., 2003). Such plant can be used successfully to clean up heavy metals polluted soils, if their biomass and metal contents are large enough to complete remediation within a reasonable period (Ebbs and Kochain, 1998).

Since last decade phytoremediation has emerged as a low cost effective technology that uses plants and their associated microbial flora for environmental cleanup (Raskin et al., 1994; Salt et al., 1995; 1998).

II. BENEFITS OF PHYTOREMEDIATION

- ✓ Phytoremediation is a lower-cost technology
- ✓ It has been perceived to be a more environmental friendly "green" and low-tech alternative to more active and instructive remedial methods.
- ✓ It can be applied in situ to remediate shallow soil and ground water and can be used in surface water bodies.
- ✓ It does not have the destructive impact on soil fertility and structure. The presence of plant is likely to improve the overall condition of the soil, regardless of the degree of contaminant reduction.
- ✓ Vegetation can also reduce or prevent erosion and fugitive dust emissions.
- ✓ It can be used on a large range of contaminants.
- ✓ The top soil is left in a usable condition and may be used in agriculture.
- ✓ The soil can remain at a site after the removal of the contaminant rather than being disposed of or isolated.
- ✓ The uptake of contaminated groundwater can prevent the migration of contaminants.
- ✓ The generation of secondary wastes is minimal.
- ✓ Organic pollutants may be converted to carbon dioxide and water instead of transferring toxicity.

III. MATERIALS AND METHODS

SELECTION OF TEST PLANTS

WHEAT (T. AESTIVUM)

It is annual cultivated herb belonging to the family Poaceae reaching upto a height of 60 cm-108 m. It has adventitious fibrous root. Stem is herbaceous, aerial, erect, branched, branching by tillers, cylindrical, internodes hollow, nodes solid and swollen, glabrous, green. Leaf cauline alternate, sessile, simple, exstipulate, leaf-base sheathing, leaf blade linear. Flower is sessile, bracteates, bracteolate, complete, hermaphrodite, zygomorphic, heteromerous, cyclic, hypogynous. Fruit is caryopsis.

BARLEY (H. VULGARE)

It is an annual grass belonging to the family Poaceae reaching upto height of 60 to 120 cm. The Barley plant has several cylindrical culms (tillers) with hollow internodes separated by solid nodes. There are 5-7 internodes in a culm which increase in length and are progressively smaller in diameter towards the tip. Single leaf, consisting of a tubular sheath and blade, are borne alternately on the opposite sides at each internode. The leaf sheath encases the culm and extends from the node to which it is attached to almost the whole length of the next internode. Barley's flower, commonly called 'ear' is distinguished into two morphological types-six rowed and two rowed. Fruit is caryopsis.

EXPERIMENTAL DESIGN

Pots were prepared with soil from the botanical garden. Each pot could hold 5 kg soil and was prepared with a layer of crocks and gravel of about 1.5 inches depth at bottom. The whole experiment was conducted upto a period of 30 days containing Pb (50 and 100 mg kg^{-1}) and Cd (25 and 50 mg kg^{-1}) in increasing concentrations. Each treatment was set up with six replicates. Metals were applied to the pots in aqueous solution as Pb(NO3)2 and Cd(NO3)2. Control pots were set up with test plant without any treatment. The pots were kept in a random block design and watering was done as and when necessary with precaution so that soil remains moist without flooding in order to prevent leaching of metals. The whole experiment was conducted in green house for 30 days. Seeds of wheat and barley were allowed to germinate upto 10 DAT. The percentage of wheat and barley seed along with root, shoot lengths and dry biomass of the seedling were recorded for 10 days in each case separately. Similar procedure was repeated at regular interval of 10 day after treatment, i.e., (10, 20, and 30).

IV. RESULT AND DISCUSSION

GERMINATION PERCENTAGE

At 10 DAT, the germination percentage of wheat and barley seeds was lower than that of control (Fig. 1). In case of Pb 50 mg kg-1 concentration, the germination percentage was similar in both wheat and barley. In case of Pb 100 mg kg^{-1}, germination percentage was higher in wheat as compared to barley. At Cd 25 mg^{-1} concentration germination was higher in wheat and at Cd 50 mg kg^{-1} concentration; it was just reverse of Cd 25 mg kg^{-1}. At Pb 50 mg kg^{-1} concentration, the germination percentage was similar with control in both wheat and barley. Overall, it was seen that seeds were slow to geminate in the treated pots. Reduction in germination percentage was seen to increase as the study progressed. Cd was reported more phytotoxic at both 25 mg kg^{-1} and 50 mg kg^{-1} concentration. Maximum reduction in germination percentage was seen at Cd 50 mg kg^{-1} concentration respectively.

At 20 DAT, germination percentage was again lower in treated plants as compared to control. In case of Pb 50 and Pb 100 mg kg^{-1} concentrations, the barley showed better germination in comparison to wheat. Similar results were seen in case of Cd at both the concentrations.

At 30 DAT, the germination percentage in all treated plants better as compared to the previous germination percentage at 10 DAT and 20 DAT. At Pb 50 mg kg^{-1} and 100 mg kg^{-1}, germination percentage was almost similar with controls in both wheat and barley seedlings. At Cd 50 mg kg^{-1} concentration, the germination percentage was little bit lower in comparison to controls. The germination percentage was in the order controls > Pb 50 > Cd 25 > Pb 100 > Cd 50 respectively.

The presence of excessive amount of Cd in soil may causes reduction of growth. Growth inhibition caused by Cd could be ascribed mainly to inhibited cell division or cell enlargement (Davies et al., 1991). Metals such as chromium and aluminium have also been reported not to inhibit germination but impair growth and seedling establishment. Suppression of the germination of the spinach seeds manifested in delay in germination with increase in concentrations of lead, cadmium, and nickel salts **(**Lawal et al., 2011). The decrease in germination percentage of barley seeds may be related to negative effect of Cadmium on water uptake and water movement (Barcelo et. al 1990). The reduction in seed germination may be due to the presence of enzyme inside seed which degraded β-amylase and acid phosphatase leads to decreased or delayed seed germination (Bansal et al. 2002) results in decrease of ATP production.

V. ROOT AND SHOOT LENGTHS

At 10 DAT, root and shoot lengths were lower than that of controls and it goes on increasing with increasing concentrations, At Pb 50 mg kg^{-1}, the root lengths of wheat was almost similar with control as compared to barley but shoot length of barley was similar with the control as compared to wheat. Similar results were seen at Pb 100 mg kg^{-1} concentrations. In case of Cd, at Cd 25 mg kg^{-1}, shoot lengths of wheat and root lengths of barley were most affected. At Cd 50 mg kg^{-1}, maximum reduction was reported in both root and shoot lengths of barley.

At 20 DAT, root and shoot lengths were better in comparison to previous observations. At Pb 50 mg kg^{-1}, root lengths were most affected in case of wheat and shoot lengths in case of barley. At Pb 100 mg kg^{-1}, the results were just opposite of Pb 50 mg kg^{-1} concentrations. In case of Cd, maximum reduction in root and shoot length was seen at Cd 50 mg kg^{-1}.

At 30 DAT, root length and shoot lengths were similar with control except Cd 50 mg kg^{-1} concentrations. Pb was seen to cause maximum reduction in root in both wheat and barley while Cd was seen to cause maximum reduction in shoot length in both wheat and barley at both the concentrations. Overall, it is reported that Cd was more phytotoxic at 10, 20 and 30 DAT.

Exposure of Pb causes inhibition of root growth in maize as compared to shoot (Ghani, 2010). Plant treated with Cd showed a significant reduction in shoot length and it goes on increasing with increasing concentrations. Cd caused more inhibition of root than Pb. Cd and Ni reduced the shoot lengths in *Oryza sativa*. Cadmium Chloride treated seedlings showed significantly lowered values for Shoot and root length.

VI. DRY BIOMASS

At 10 DAT, the root and shoot dry weight of wheat was most affected at Pb 50 and Pb 100 mg kg^{-1} concentrations in comparison to barley and it was maximum at higher concentrations. In case of Cd, root dry weight was most affected in case of both wheat and barley. Maximum reduction in dry weight of root and shoot was reported at higher concentration.

At 20 and 30 DAT, the effects on root and shoot length was lesser. Again it was seen that Pb caused maximum reduction in root dry biomass in both wheat and barley even at 10, 20 and 30 DAT. In case of Cd, maximum reduction was seen in case of shoot dry biomass in both wheat and barley. This reduction was higher at Cd 50 mg kg^{-1} concentration. Overall, it is reported that maximum reduction in both root and shoot length was caused by Cd in both wheat and barley respectively.

Cd accumulated plants showed decrease dry biomass. The inhibiting effect of Cd at the first harvest was maximum. Reduction in total biomass and dry weight of seedling of plants treated with Cd was reported (Bhardwaj et al., 2009). The seedlings of *A. lebbeck* also showed a gradual decrease in seedling vigor and dry biomass as concentrations of lead and

ISSN: 2394-4404

cadmium increased. Similar observations in crops had been observed (Hailing et al., 1991).

VII. CONCLUSION

In the study, the use of wheat and barley plants can remediate the pollutants from the contaminated soil. A significant reduction in germination percentage, root and shoot lengths and dry biomass was seen. According to the tolerant potential, wheat and barley could be widely used for bioassays along with their tolerance of metals to some extent in the contaminated area.

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