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Cadmium Contamination Affects Leaf Biomass in Sandy Loam and Sewage Water Irrigated Soil

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ABSTRACT

Industrial waste materials disposal have been contaminating hectares of productive agricultural land globally. Metal concentrations increase in the soil is mainly due to this. Cd Phytoextraction is a promising and environment friendly approach for soil decontamination. Plant potential for Cd extracting generally depends on biomass yield. In present experiments, this technology has been tested by six plant species in pot experiments. During this study, different Cd concentrations were given to different pots. The results indicated that there was increase in the biomass yield in the sewage water irrigated soil, over the sandy loam soil. In this study, the response of different plant species, in the sandy loam soil and sewage water irrigated soil has been observed.

Keywords: Phytoremediation, Contaminated Soils, Chlorosis, Cadmium, Heavy Metals

I INTRODUCTION

Phytoextraction is an environmental cleanup effort depends to a large degree on the identification of suitable plants. This study provides a promising start for biomass based phytoextraction as it includes high biomass producing species. Growing these species is practically easier than producing hyper accumulators (Mahler *et al.* 1978, Huang *et al.* 1997). The apparent complexing and slow release of Cd to root system alleviates its toxicity even though the absolute amount may be greater *(Yanai et al., 2006).* This is probably a result of dilution of the absorbed Cd in a larger biomass of plant tissues (Strickland *et al.*, 1979). Organic compounds can be degraded while metals remediation requires physically removal or immobilization.

Therefore, Remediation of metal-contaminated soil faces a particular challenge. Disposal of Industrial waste materials have been estimated to contaminate hectares of productive agricultural land. It causes an increase in metal concentrations in the soil (Blaylock *et al.*, 1997). As metals cannot be degraded so it requires removal. Remediation of metal compounds presents a different set of problems when compared to organics (Blaylock *et al* 1997). Phytoremediation is often referred to botanical bioremediation or green remediation (Chaney *et al.*, 1997; and Turgut *et al.*, 2004). Phytoremediation is a new emerging technology employed for removing toxic metals, contaminants and pollutants from soil (Blaylock *et al.*, 1997). The successive additions of Cd in soils affect the yield of different plant parts (viz., Stem, Leaf and Seed) of different species.

Cadmium being toxic to plant, its increased concentration in soil reduces growth and impairs metabolism (Foy *et al.*, 1978; Aery and Sarkar, 1991, Clijsters and Van-Assche, 1985). The beneficial effect of sewage waste water irrigation and adverse effect of Cd on different crops have also been reported by several workers (Narwal *et al.*, 1983). Generally, the background cadmium (Cd) concentration in agricultural soils remains less than 1 mg per kg (Chaney *et al*., 1997). Increased Cd levels were also found in the surface soils near the metal processing industries. The main objectives of the present study were to study the seed and dry matter yield of the Raya (*Brassica juncea*), Toria *(B. campastris)*, Oat *(Avena sativa)*, Barley *(Hordeum vulgare)*, Bathua *(Chenopodiun murale*) and Rijhka *(Medicago sativa)* in to two different soils.

II MATERIALS AND METHODS

The pot experiments were conducted in Cd spiked soils to examine the effect of different Cd concentration on the plant growth. The present investigation was done to fulfill the objectives of the present study. Two experiment sets have been used for both types of soil i.e. sandy loam and sewage water irrigated soil. To evaluate the relative efficiencies regarding growth plant species were grown in Cd enriched sandy loam soil and sewage water irrigated soil. The experiments were conducted using 5 kg capacity earthen pots.

1.1. Physico-Chemical Properties Of Soils

Before starting the experiment, the soils were characterized. The soils were characterized for background concentration of Cd and different chemical parameters and they are shown in Table 1 and 2. The Physico-Chemical properties of both soils are given in table 1 and 2 respectively. The sewage water irrigated soil was collected from the fields. These were irrigated with sewage water since 1998. The sewage water irrigated soil was taken to study the effects of sewage water with comparable levels of added Cd. The yield of different plant parts viz., stem, leaves and seed of all the six species is show in figures respectively.

1.2. Treatments and Cd levels:

The pot experiments were given five treatments (0, 20, 40, 60 and 80 mg Cd Kg^{-1} soil) to examine the effect of different Cd concentration on the plant growth. The experiments were conducted in earthen pots.

1.3. Plant Species

Raya (*Brassica juncea*), Toria *(B. campastris)*, Oat *(Avena sativa)*, Barley *(Hordeum vulgare)*, Bathua *(Chenopodiun murale*) and Rijhka *(Medicago sativa)* were chosen for this work. To observe the seed and dry matter yields these six plant species were grown in to two different soils. All the plants were grown with three replicates.

1.4. Dry Matter Yield

Visual toxicity symptoms of Cd were recorded of all six-plant species. In the controlled (Cd_0) treatment, there were no distinct Cd toxicity symptoms throughout the growing period of crops. At 40 mg Cd kg^{-1}, some light chlorotic symptoms, resembling to Fe-chlorosis, appeared after about 2 weeks of germination. The chlorotic symptoms became more conspicuous with the increasing levels of Cd, and Chlorosis was most conspicuous in Oat followed by Barley, Toria, Bathua, Rijhka and Raya. At 60 and 80 mg Cd kg^{-1} soil treatments, the leaves were considerably narrow and small as compared to Cd control in all the species tested. The data showed that dry matter yield varied widely with all the plant species in sandy loam soil and sewage water irrigated soil.

1.5. Yield in Plants Grown in Sandy Loam Soil

Leaf dry matter yield was also affected by application of different treatments of Cd. There was a 3, 11, 17 and 25 percent decrease in dry matter yield in the 20, 40, 60 and 80 mg Cd kg^{-1} soil, respectively as compared to control. The highest yield was observed in Raya and lowest was in Rijhka. All the species show variability with the application of different treatments of Cd. Application of Cd has not much effect up to 20 mg kg^{-1} soil in all the cases except Rijhka, but further increasing the dose of Cd resulted in the reduction of dry matter yield.

1.6. Yield in Plant Grown in Sewage Water Irrigated Soil

The data on the leaf dry mater yield of different species as affected by Cd treatments shows that the application of different levels of Cd has not much effect up to 40 mg kg^{-1} soil. Further increasing the dose of Cd resulted in the reduction of dry matter yield. Further, increase in Cd amount (after Cd 40 mg kg^{-1}) showed much adverse effect on dry matter yield of leaves. There were 2, 4, 19 and 29 percent decrease in dry matter yield of leaf with the application of 20, 40, 60 and 80 mg Cd kg^{-1} soil, respectively.

II RESULTS AND DISCUSSION

All the plants species were harvested at the maturity. The root, stem leaf and seeds were separated and weighed for the study of effect of different Cd concentration on the yield. After recording other observations, the harvested plants were put in paper bags and kept at 65±2°C for 48 hours till constant weight was obtained. The biomass was recorded as g $plant^{-1}$ after taking average. The results of the present study are shown in by graphical representation. It was necessary to observe the amount of cadmium initially in the soil.

III CONCLUSION

Experiments, in which soils used rather than solution, approximately are more closely to the natural conditions. The effect of soil buffering capacity influences nutrient availability to plants. The goal was to assess to develop the heavy metal removal technique in natural conditions of the soil. It was observed that Cd affects all the growth parameters. However, it could be used to remediate the Cd contaminated soil without the application of any chemical. The efficacy of Phytoextraction as a viable remediation technology is still being explored. This study provides a promising start for biomass-based Phytoextraction as it includes high biomass producing species and growing these species is practically easier than producing hyper accumulators. Phytoextraction as well as agronomic practices for sustaining environment should be further explored.

The response of different plant species, in the sandy loam soil and sewage water irrigated soil has been observed. The results indicated that there was increase in the biomass yield in the sewage water irrigated soil, over the sandy loam soil. The highest leaf dry matter yield of Raya was also recorded in sewage water irrigated soil. Similar trend was observed in Toriya, Oat, Bathua, Rijhka and Barley. The maximum decrease in the mean dry matter yield was at Cd_{80} treatment in both soils. As compared to Cd_0 the overall reduction in the mean stem and leaf dry matter yields was more in sewage water irrigated soil over the sandy loam soil.

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Table 1: Physico-Chemical Characteristic of the sandy loam soil

Characteristics	Contents
*pH	7.67
*EC (dSm^{-1})	0.39
Mechanical Composition (%)	
i) Sand	76.3
ii) Silt	12.3
iii) Clay	1.4
Organic carbon (%)	0.36
Olsen's P ($mg\ kg^{-1}$)	12.0
CEC (m.e/100 g)	7.2
Metal contents ($mg\ kg^{-1}$)	
i) Lead	2.78
ii) Cadmium	0.80
iii) Nickel	0.25
iv) Zinc	3.1
v) Iron	14.4
vi) Manganese	5.1
vii) Copper	3.4

*1:2 Soil: Water suspension

Characteristics	Contents
*pH	7.35
*EC (dSm^{-1})	0.84
Mechanical Composition (%)	
i) Sand	74.4
ii) Silt	12.6
iii) Clay	13.2
Organic carbon (%)	0.82
Olsen's P ($mg\ kg^{-1}$)	22.7
CEC (m.e/100 g)	8.5
Metal contents ($mg\ kg^{-1}$)	
i) Lead	2.97
ii) Cadmium	13.4
iii) Nickel	0.32
iv) Zinc	16.1
v) Iron	36.4
vi) Manganese	3.3
vii) Copper	11.8

Table 2: Physico-Chemical Characteristic of the sewage water irrigated soil

*1:2 Soil: Water suspension

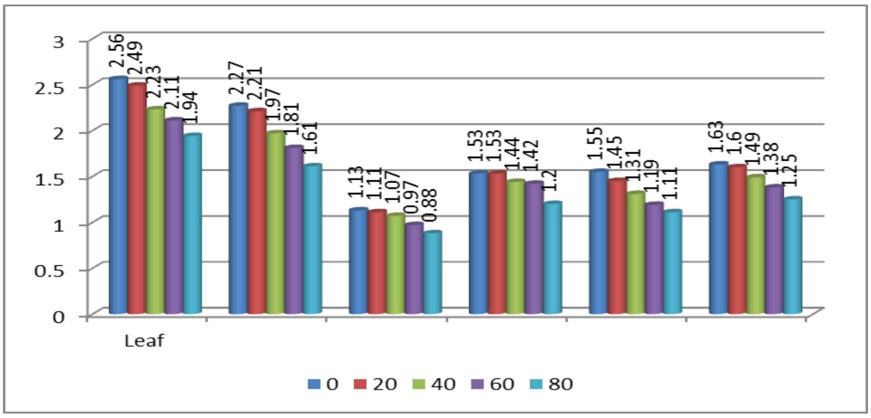

Fig 1: Yield of Different Species (g $Plant^{-1}$) influenced by Cd Application in Sandy Loam Soil

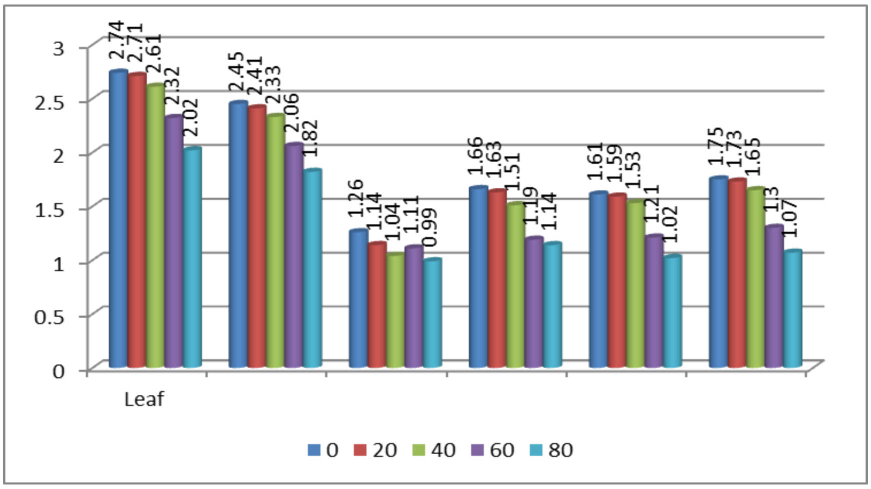

Fig 2. Yield of Different Species (g Plant^{-1}) influenced by Cd Application in Sewage Water Irrigated Soil