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Phytoremediation of Lead (Pb) using *Cassia Tora* (L) Plants

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ABSTRACT

Phytoremediation has been proposed as an environmentally friendly and cost-effective method of de-contamination of soils polluted with heavy metals including lead (Pb) as an alternative to conventional remediation techniques. In this research, a greenhouse hydroponic experiments were carried out to study the Pb phytoremediation potential of *cassia tora* plants. Three week old seedlings transplanted in hydroponic solutions were treated with different doses of Pb in the concentration range of 20, 50, 100, 200 and 500 mg/L supplied as $Pb(NO_3)_2$. After 15 day of culture, the plants were harvested, blotted to dryness and separated into roots and shoots. The root and shoot dry weights, Pb uptake, Translocation factor (TF) and Bioconcentration factor (BCF) were determined. The results indicate that the uptake and TF increased significantly ($P<0.05$) with increasing Pb concentrations. BCF and root/shoot dry weights were however decreased ($P<0.05$) with increased Pb dosage. The TF was less than one in all treatments indicating that *cassia tora (L)* was non-hyperaccumalator of Pb. However, BCF greater than one in all treatment is suggesting that *cassia tora (L)* could be used in phytoremediation of Pb contaminated environment at low level concentrations.

Keywords: Greenhouse, Hydroponic, Phytoremediation, *Cassia tora (L)*, Pb

I. INTRODUCTION

Industrial and anthropogenic activities has led to an increased release of various heavy metals including Pb into the environment. Pb is one of the most dangerous pollutants because of its long-time persistence in the environment [1]. It is not only affects plant growth and productivity, but also enters the food chain causing hazards to humans and animals [2]. Recently, over 10,000 people estimated to have been affected by Lead poisoning in Zamfara State, Northern Nigeria; which lead to hospitalization and even death especially among children [3, 4]. The possible negative impact of Pb on the environment and human health creates the need for remediation of contaminated areas. Phytoremediation has been proposed as an environmentally friendly and cost-effective alternative to traditional physico-chemical remediation techniques such as thermal desorption, soil washing, soil vapour extraction e.t.c. [5, 6]. Phytoremediation is the use of plants, including trees and grasses, to remove, destroy or sequester toxic contaminants from soil, water and air [7]. Phytoremediation involves three subsequent stages: (a) solubilization of metals in soil and their transfer to the root surface, (b) uptake into the roots, (c) translocation to the shoots [8].

Cassia tora (L) belongs to the family *Leguminaceae* and sub-family *Caesalpiniaceae*. It is widespread in the tropics and is commonly found in West Africa as weed on roadsides, grassland and cultivated grounds [9]. The seeds, roots and leaves from this plant have ethnomedicinal use to heal wounds, skin diseases, leprosy, bronchitis and fever [10]. *Cassia tora (L)* is very stress tolerant and easily grown plant [10]. Siringoringo [11] reported that *Cassia multijuga* was found to be highly capable of absorbing and accumulating Pb. Ghose and Singh [12] and Gupta and Sinha [13] reported that *Cassia tora (L)* accumulated high concentrations of heavy metals including Pb in their leaves and root, hence, reducing their negative effect on the ecosystem. Most relevant information from literature on *Cassia tora (L)* concern with the nutritive and chemotherapeutic values, there is however, little information on its use as bioaccumulator of heavy metals [14]. Therefore, this paper was aimed to study the potentials of *Cassia tora (L)* in the phytoremediation of Pb using hydroponic culture protocol.

II. METHODS AND MATERIAL

A. Plant Material and Experimental Design

The seeds of *Cassia tora* (L) were sown in experiment farm of Bayero University, Kano, Nigeria. After growing for 3 weeks, seedlings of similar sizes and vigor were transplanted to a modified Hoagland hydroponic solution in 1-L plastic vessels (three plants per vessels) containing the following compositions: NH_4NO_3 1.5 mM, $CaCl_2$ 1.00 mM, $MgSO_4$ 1.60 mM, K_2SO_4 1.00 mM, KH_2PO_4 0.30 mM H_3BO_3 2.0 µM, $MnSO_4$ 5.0 µM, $ZnSO_4$ 0.5 µM, $CuSO_4$ 0.2 µM and $(NH4)_6Mo_7O_{24}$ 0.05 µM. Iron was supplied as Fe-EDTA at 0.1 mM. The nutrient solutions were not aerated and replaced weekly. The plants were allowed to grow for 10 day in hydroponic culture in order to adapt to new hydroponic environment which served as control (CR). Pb was added as $Pb(NO_3)_2$ in the concentrations of 20, 50, 100, 200 and 500 mg/L. The plants were cultured for 21 day in treated solution under controlled conditions with a day/night temperature of 30 ± 3 ºC /25± 3 ºC, and a relative humidity of 75 ± 3% in a greenhouse. The pH of the nutrient solution was maintained at 5.3 and adjusted using NaOH or HCl. After treatments, the plants were harvested, separated into roots and shoots, soaked in 20 mM Na_2EDTA for 15 minutes to remove extracellular Pb [15] and then washed with tap water followed by deionized water. The plants were oven dried at 65 ºC to a constant weight and dry weights of root and shoot were determined.

B. Determination of Pb Concentration

The dried samples were ground, weighed on the basis of availability and ashed in a muffle furnace at 450 °C for 4 h. The ashed samples were dissolved in 0.10M HNO_3 and then filtered into 50 cm^3 volumetric flask. Pb content was analyzed using atomic absorption Spectrometer. The Pb concentrations in the samples were obtained from calibration curve prepared from the standard solution. Blank determination were carried out in the same way.

C. Estimation of Translocation Factor (TF)

TF was calculated using the following relation [15];

$$\text{TF} = \frac{Pb\ Content\ of\ the\ Shoot}{Pb\ Content\ of the\ \ Root}$$

D. Estimation of Biococentration factor (BCF)

BCF was calculated using the relation [16];

$$\text{BCF} = \frac{Pb\ Conc.\ in\ the\ Root}{Pb\ Conc.\ in\ the\ Hydroponic\ solution}$$

III. RESULTS AND DISCUSSION

A. Effects of Pb Level on Dry Weights

The root and shoot dry weights decreased gradually (P<0.05) with increasing Pb levels compared to control treatments (**Fig 1**). A maximum decrease of 0.32 mg was observed at highest concentration level (500 mg/L) and a minimum of 0.97 mg was recorded at the lowest level (20 mg/L) for roots. In case of shoot, however, a maximum reduction was 0.64 mg at 500 mg/L and minimum was 1.97 mg at 20 mg/L. Our results were in good agreement with Shahid *et al* [17] who observed similar pattern in *Vicia faba L.* when exposed to Pb treatments. The decreased might be due stimulation of free oxygen radical production, disruption of pigment function and alteration of membrane permeability [15, 20].

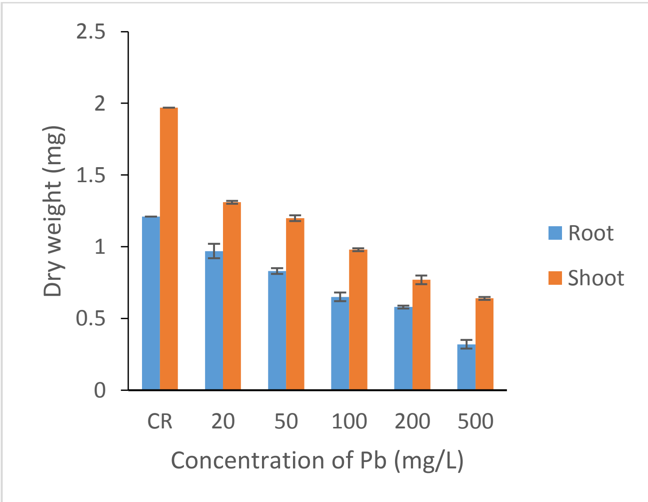

Figure 1. Effects of Pb Levels on root and shoot Dry weight. The vertical bars represent standard error of mean (n = 3).

B. Effects of Pb Levels on Pb Uptake

Fig. 2 shows the uptake of Pb in both roots and shoots of *Cassia tora* (L) plants. Both shoot and root Pb concentrations increased significantly (*P*<0.05) with increasing Pb levels, with a maximum uptakes of 700.84 at 500 mg/L and minimum uptake of 23.13 mg/kg at 20 mg/L for the roots. In case of shoots, a maximum uptake were noticed at 378.15 mg/kg at 500 mg/L while a minimum uptake of 15.18 mg/kg were observed at 20 mg/L Pb level. It has been documented by numerous authors that heavy metals uptakes in plants were concentration dependent [18, 19]. Roots accumulated more Pb than the shoots. The reason might be that the roots are organs in direct contact with Pb [20] and or because of Pb tolerance mechanisms by the plants [21].

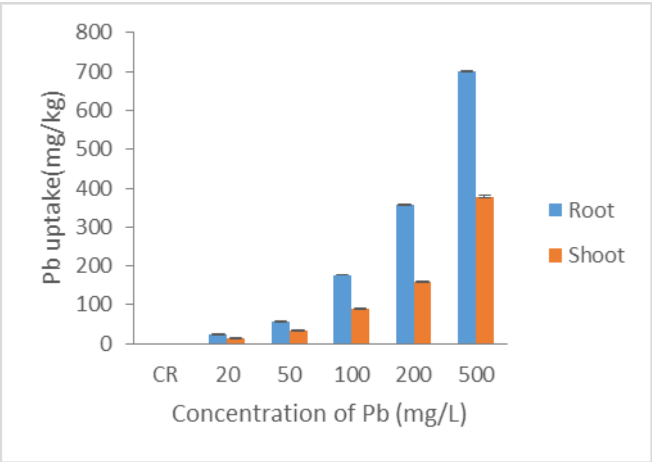

Figure 2. Effects of Pb Levels on Pb uptake. The vertical bars represent standard error of mean (n = 3).

C. Effects of Pb level on TF

TF, as a measure of hyper accumulation capacity of plant, depicts the ability of the plants to translocate the metal from roots to shoots [21]. TF>1 indicates that the plant translocate metals effectively from root to the shoot [22]. The TF increased steadily (P<0.05) with increasing Pb concentration until it reaches a maximum peak of 0.80 at highest concentration level (Fig. 3). The translocation factors were less than one (TF<1) in all treatments indicating non-hyperaccumulation capacity of cassia *tora (L)*. Similar findings were noted by [24].

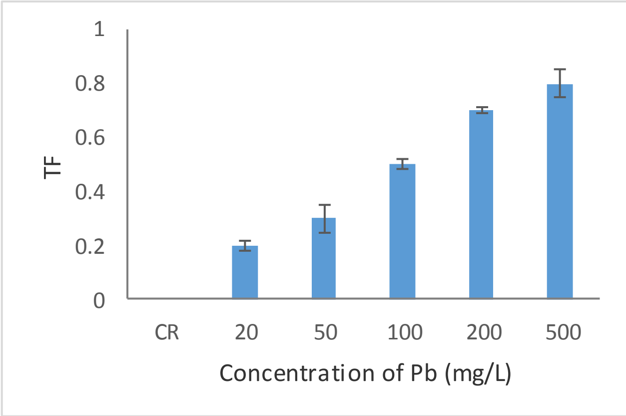

Figure 3. Effects of Pb Levels on TF. The vertical bars represent standard error of mean (n = 3).

D. Effects of Pb level on BCF

BCF is an index of the ability of plant to accumulate a particular metal with respect to its concentration in the medium [12, 23]. BCF was used to evaluate the phytoremediation potential *Cassia tora* (L) plants. BCF, decreased gradually with increasing Pb concentration from 57.40 to 11.55 at 20 and 500 mg/L Pb level respectively. Han *et al.,* [25] reported that BCF of Cd decreased with increasing metal concentration in soil. BCF was greater than one in all treatment, which suggests that *Cassia tora* (L) might be a potential candidate for phytoremediation of Pb contaminated environment [24].

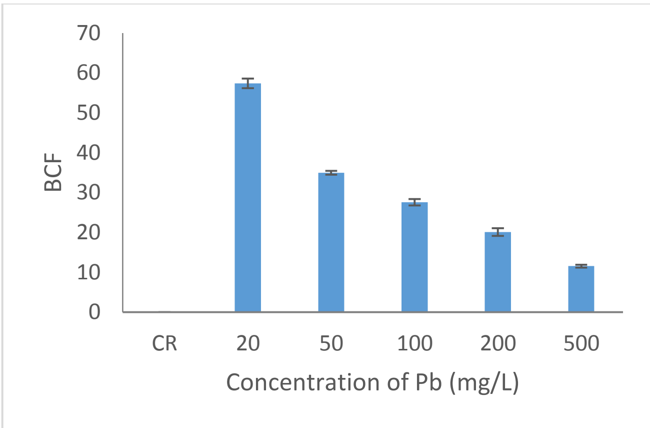

Figure 4. Effects of Pb Levels on BCF. The vertical bars represent standard error of mean (n = 3).

IV. CONCLUSION

It can be concluded based on the results of the study that Pb uptakes and accumulation in *cassia tora (L)* were concentration dependent. Higher concentrations of Pb brings about significant reduction of dry weight in both roots and shoots which led to toxicity symptoms. The translocation factor (TF) was less than one in all treatments indicating that *cassia tora (L)* was non-hyperaccumalator of Pb. However, BCF of greater than one in all treatment, is suggesting that *cassia tora (L)* could be used in the phytoremediation of Pb contaminated environment at low level concentrations.

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