Available online at www.journalijmrr.com

INTERNATIONAL JOURNAL OF MODERN RESEARCH AND REVIEWS

ISSN: 2347-8314

Int. J. Modn. Res. Revs.

Volume 2, Issue 4, pp157-160, April,2014

ORIGINAL ARTICLE

ACCUMULATION OF CADMIUM AND ITS EFFECT ON GROWTH OF *SESBANIA SESBAN* (L.) Merr.

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Article History: *Received 9 th March,2014, Accepted 26 th April, 2014*

ABSTRACT

The toxicity of the heavy metal cadmium affects growth and development of plants including inhibition of germination process and decrease the biomass of plant. The aim of this research is to study accumulation of Cd and its effect on the growth of *Sesbania sesban (*L.). Thus, *Sesbania* seedlings grown in pot culture undergoing, different concentration of Cadmium (Control, 0.10, 0.25, 0.50, 0.75 and 1.00 g kg^{-1}) after 120th days plants were removed and morphophysiological parameters like root length, shoot length and dry weight of plant, accumulation of cadmium in roots and shoots were determined. The results indicated that the concentrations more than 1.00 g kg^{-1} cadmium cause the reduction of morphophysiological parameters in treated plants rather than control plant. And cadmium addition in the cultures caused enhancement of cadmium content in roots and shoots of plant seedlings. It was also noted that accumulation of cadmium in the roots was much higher than in the shoots of the seedlings.

Keywords: Cadmium, accumulation, root length, shoot length, AAS, *Sesbania*

1.INTRODUCTION

Cadmium is a non-essential element that negatively affects plant growth and development. Cd (density 8.6 g cm^{-3}) is a widespread heavy metal, released into the environment by power stations, heating systems, metalworking industries, waste incinerators, cement factories and as a by-product of phosphate fertilizers. It is recognized as an extremely significant pollutant due to its high toxicity and large solubility in water. Clean-up of Cd-contaminated soil foams a challenge. Existing methods such as mechanical removal and chemical engineering are expensive, and are often incompatible with maintaining soil structure and fertility (Pulford, and Watson 2003). Phytoremediation, i.e., the use of plant systems to remove toxic elements from the polluted soil, has recently attracted a great deal of attention as an alternative means of soil decontamination because it is a cost-effective, environmentally friendly approach, applicable to large areas(Ha *et al* 2009 and Lin *et al*,2010). The plants with sufficient tolerance to metals are made use in phytoremediation. They are usually rare herbs with small biomass and little economic value (Linger 2001). Hence, phytoremediation is quite slow, taking several years, to halve the levels of metal contamination in soil (McGrath and Zhao 2003).

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Phytoremediation is the high concentration of heavy metals or certain combinations of heavy metals may adversely affects plant growth and biomass production by disrupting the physiology and morphology of plants. Some plant species have the ability to grow and develop in metalliferous (metal rich soils) soils such as near to mining sites. Such plants can be utilized to clean up heavy metal polluted sites. The general effects of various metals in plant are (Gardea-Torresdey *et al.*, 2005). The genus *Sesbania* consisting of about 500 species pantropically distributed is placed in the family *Leguminosae*, sub-family *Papilionoideae*. The majority of *Sesbania* species are annuals and some are relatively short-lived perennials. Because of the ability of *Sesbania* species to grow in heavy metal soils, withstand waterlogging, and tolerate soil salinity, they are often the preferred green manure crop for rice and wheat (Evans and Rotar, 1987).

So that the present study was conducted to evaluate the growth and Cd accumulation by *Sesbania sesban* plant exposed to various levels of Cd supplied as cadmium chloride at different growth periods, determine whether *S. sesban* plant can tolerate and translocate high concentrations of cadmium.

2.MATERIALS AND METHODS

Seed collection

The certified seeds of *Sesbania* were purchased from Local market Chidambaram, Cuddalore District, Tamil Nadu, India.

Methods of treatment

Seeds of *Sesbania* were sterilized with 1% $HgCl_2$ for 10 minutes, and then washed several times with distilled water and germination for 4 days in the green house condition. *Sesbania* were grown in unpored plastic pots in untreated soil (control) and in soil to which cadmium had been applied 0.10, 0.25, 0.50, 0.75 and 1.00 g kg^{-1}. Each pot contained 5 kg of air dried soil.

Pot experiment

The cadmium as finely powdered as (Cd_2Cl_2) and it was applied to the surface soil and thoroughly mixed with the soil. Twenty seeds were sown in each pot. All pots were watered. Plants were thinned to a maximum of 20 per pot, after a week of germination. Each treatment including the control was replicated three times. The plant samples were collected at 120^{th} day, the measurement of various morphological growth parameters like root length, shoot length, dry weight of root and shoot were determined.

Estimation of cadmium from *Sesbania sesban*(L.)

The powdered form of the roots and shoots were used to determine the cadmium accumulation. Plant material was taken in a 150 ml clean beaker and to that 10 ml concentrated nitric acid was added. It was covered with a watch glass and kept for an hour till the primary reactions subsided. It was then heated on a hot plate until all the material was completely dissolved. It was allowed to cool to room temperature and then 10 ml of perchloric acid (60%) was added to it and mixed thoroughly. It was then heated strongly on a hot plate until the solution became colourless and reduced to about 2-3 ml. While heating, the solution was not allowed to dry. After cooling, it was transferred quantitatively to 100 ml capacity volumetric flask, diluted to 100 ml with distilled water and kept overnight. Next day it was filtered through Whatmann no. 44 filter paper. The filtrate was stored properly and was analyzed for the estimation of cadmium using Atomic Absorption Spectrophotometer.

Statistical analysis

The experimental data were processed statistically by adapting the techniques of analysis of variance of standard deviation (Snedector and Cochran, 1967).

3.RESULTS AND DISCUSSION

Plant growth and biomass

The result indicate, that Cd treatment had significant effect on root, shoot length and root, shoot dry weight of *Sesbania*. As shown in (Fig.1) significant difference in root and shoot length was found between Cd treated plants and control. Increasing Cd concentration (up to 1.00 g kg^{-1}) in the soil induced a significant decline in this trait and the deleterious effect of Cd became more severe with increasing Cd level. Root and shoot length of *Sesbania* at 1g kg^{-1} Cd decreased compared to control plants. In addition, Plant biomass of *Sesbania* decreased significantly with increasing Cd level in the soil and the maximum decrease was found at 1.00 g kg^{-1} Cd compared to untreated plants (Fig. 2). Such a reduction in the growth of Cd stressed plants could be ascribed mainly to inhibited cell division and cell enlargement (Davies *et al*., 1991). Furthermore, the growth inhibition produced by Cd could be due mainly to the effect of this heavy metal on the photosynthesis rate and, as in other plant species, the degradation of chlorophyll or the inhibition of its biosynthesis being responsible for the photosynthesis and growth reduction produced by this metal. Our results showed that the increase of the Cd concentration diminishes the height of plants and their biomass. This result is in accordance with the Sandalio *et al*., (2001). Bhardwaj *et al*., (2009) in their investigation on the bean plant where they observed a reduction in total biomass and dry weight of seedling with increasing Cd concentration. Bahmani *et al*. (2012) reported that Cd treated bean plants showed significant decrease in growth and fresh weight in compared to control plant.

Fig.1 Effect of different concentration of cadmium on root & shoot length of *S.sesban*(L.)

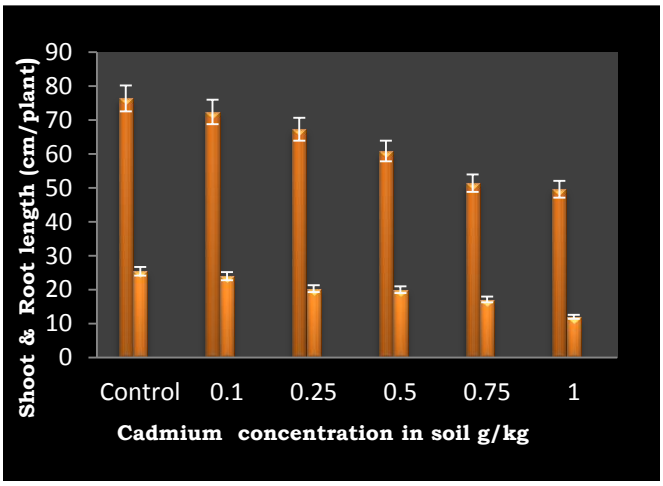
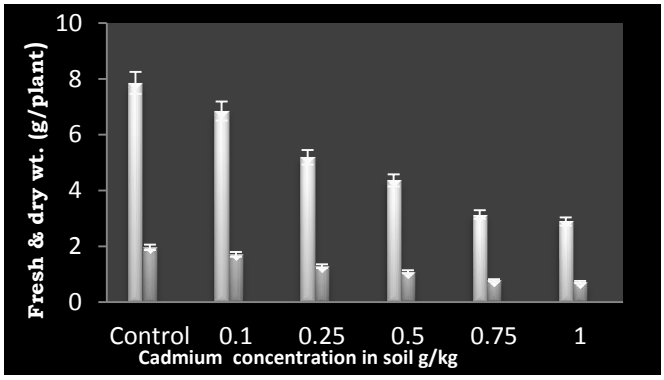


Fig.2 Effect of different concentration of cadmium on fresh & dry of *S. sesban*(L.)



Cd accumulation in root and shoot

In the present study, cadmium accumulation in root and shoot were significantly affected by Cd treatment. The accumulation of Cd in root and shoot of *Sesbania* was

increased with an increasing the concentration of Cd in the soils. The increase in Cd concentrations in plants with Cd treatment was previously reported in many studies (Koleli *et al.*, 2004; Ouzounıdou *et al*., 1997; Yildiz, 2005).

Fig.3 Effect of different concentration of cadmium on root & shoot accumulation of *S.sesban*(L.)

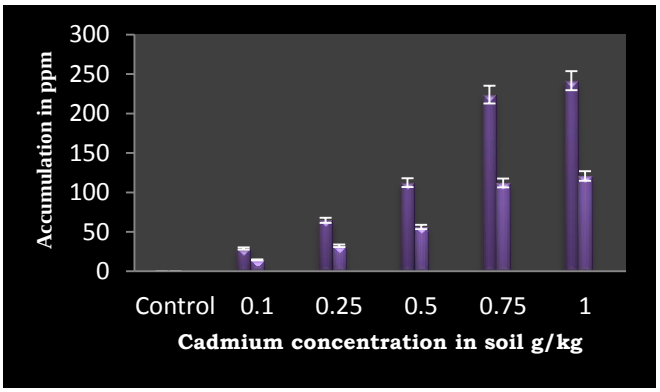
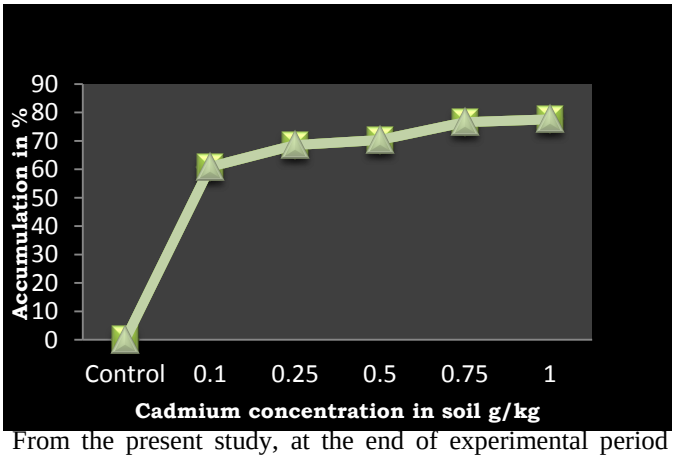


Fig.4 Effect of different concentration of cadmium on accumulation % of *S.sesban*(L.)



From the present study, at the end of experimental period (120 days), it was found that the cadmium accumulation was more (241.74 mg) in root when compared to stem of the experimental plants (fig. 3). This plant, showed maximum accumulation of cadmium in roots. The maximum accumulation percent found to be in 1.00g kg^{-1} soil (77.60 %, fig. 4). The uptake of metal in root and shoot parts indicate that the soluble metals can enter into the root symplast by crossing the plasma membrane of the root endodermal cells or they can enter the root apoplast through the space between the cells. The solutes travel up through the plants by apoplastic flow by xylem. To enter the xylem, metal must cross a membrane, probably through the action of a membrane pump or channel. Once loaded into the xylem, the flow of the xylem sap will transport the metal to the aerial parts, where it must be loaded into the cells of the leaf, again crossing a membrane. Cadmium uptake is likely mediated through transporters or channels for other divalent ions reported by Cosio *et al.*, (2004). Plants can contribute in many ways to enhance biodegradation in the soil. The present research study showed that during 120 days of exposure treatment, the heavy metal cadmium was depleted from the contaminated soil, suggesting absorption of cadmium metal by terrestrial plants. It has been noted that *Sesbania sesban* is the suitable plant for phytoremediation techniques, which has a lower biomass but accumulate a higher concentration of cadmium metal from the contaminated soil.

4.CONCLUSION

To conclude that, this results illustrated that cadmium had negative impact on growth of *Sesbania.* With increasing cadmium concentration in soil, root and shoot length, root and shoot dry weight of plant were decreased. The highest decrease was seen at 1.00 g kg^{-1} cadmium treatment. In addition, Cd accumulation in root and shoot of *Sesbania* increased by cadmium treatment. Meanwhile, the cadmium concentration in shoot was three times as much as root in all cadmium treated plants (0.10 to 1.00 g kg^{-1} cadmium). Based on results *Sesbania* is sensitive to cadmium concentration and it should be considered that in cadmium contaminated soil.

5.ACKNOWLEDGMENT

The authors are thankful to the University Grants Commission (UGC) New Delhi, India for providing financial support for the present investigation in the form of UGC-BSR fellowship to R. Bakiyaraj. The authors are grateful to Dr. K. Arumugam, Professor and Head, Department of Botany, Annamalai University for providing laboratory facilities for the study.

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