ABSTRACT

Some metals at lower concentration are essential for cells but all metals are toxic at higher concentrations. Heavy metal pollution of soil and water caused by mining, burning of fossils fuels, smelting of metalliferous ores, and agriculture waste, is a major environment problem and exposure to these metals can be toxic to living cells. Use of plants for decontamination/minimization of heavy metal pollutants has attracted attention because of the problems associated with pollutant removal using conventional methods such as soil replacement, solidification, electro-kinetic extraction and washing strategies. Phytoremediation is a cost effective emerging technology based on the use of green plants to clean up the polluted sites and is accepted publicly. Research efforts made towards understanding the mechanism of metal tolerance has generated a great deal of information but it remains ill understood. Thus, there is scope for research to understand the mechanism of metal tolerance by various plant species and to identify the site and form of metal accumulation within plant system. This thesis entitled “Studies on Metal Tolerance in Plants” was designed to study the metal stress on different plant species including a herb (Peanut), a shrub (Jojoba) and a tree (Pongamia).

Peanut (Arachis hypogaea L.) is a unique leguminous plant for its characteristic behavior to produce the pods underground in direct contact with soil. It has the double advantage for absorption of Cd from soil through roots and directly through the shells. Jojoba (Simmondsia chinensis) is an industrial crop – its seed wax is used in the cosmetic industry, as a lubricant, etc. The crop has considerable potential for cultivation in arid and semi-arid regions. In vitro nodal segments of jojoba respond to salinity in a similar way as the whole plant, so plant tissue culture technique could be used for preselection and evaluation of metal tolerance in this species.

Trees are ideal for remediation of heavy metals. They can withstand and accumulate higher concentration of pollutants owing to their large biomass and size. These can reach
a huge area and great depths for their extensive rooting. Trees prevent erosion, and the spread of the contaminant, because of their perennial presence. *Pongamia pinnata* (L.) Pierre is a medium sized, fast growing evergreen tree species. Its seed oil is a potential source of raw material in production of biodiesel. This tree can thrive in wide range of agroclimatic conditions and serve as rich source of flavonoids and oil for industrial applications. Pongamia was selected as a model system to study the effect of metal stress.

**Objectives of the study:**

“Studies on metal tolerance in plants” was taken up with the following objectives.

1. To study the influence of chromium, copper and cadmium induced stress on peanut seedlings cultured *in vitro*.

2. To study the influence of chromium, copper and cadmium on shoot cultures of jojoba (shrub).

3. To study effect of chromium, copper and cadmium on Pongamia (tree) seed germination, seedling growth and distribution of metal in different parts of plant.

The thesis is divided into five chapters followed by summary and list of references.

**CHAPTER 1: General Introduction**

This chapter covers the literature on metal tolerance and toxicity in plants. It includes the role of different antioxidative enzymes including superoxide dismutase (SOD), catalase (CAT) and guaiacol peroxidase (GPX), in stress induced by the metals. The importance and significance of the selected plants like peanut, jojoba, pongamia are emphasized. The significance and objectives of the study is included in this chapter.

**CHAPTER 2: Materials and Methods**

Materials and methods for tissue culture, metal analysis and biochemical analysis implemented during the course of work are described in this chapter. Methods specific to individual experiments have been dealt with in respective chapters.
CHAPTER 3: Effect of metals on *Arachis hypogaea*

This chapter describes the effect of different metals (Cr, Cu and Cd) on germination, seedling growth and metal accumulation in different organs of peanut after 4 weeks. Germination frequency was affected significantly in case of Cr and Cu. Cd was less effective. Seedling growth was severely affected by Cd followed by Cu and Cr. Metal content in different organs and enzymatic activities were assayed after 4 weeks of culture. Differential response was noted in metal accumulation, lipid peroxidation and antioxidative enzymes activities including superoxide dismutase, catalase and guaiacol peroxidase, in different organs of peanut seedling. Copper was more toxic to these antioxidative enzymes followed by Cd and Cr. Histological studies were conducted to study the changes in cellular distribution and morphoanatomy of root, stem and leaves confirming the adverse effect of these metals.

CHAPTER 4: Effect of metals on *in vitro* shoot cultures of Jojoba

Established shoot cultures of jojoba were used for this experiment. Shoot cultures were exposed to different concentration of Cr, Cu and Cd. Metal accumulation in stem and leaves was determined using Atomic Absorption Spectroscopy. Activity of enzymes including superoxide dismutase, catalase and guaiacol peroxidase and lipid peroxidation product level was estimated after 1 d, 7 d and 14 d of exposure. Differential response in enzyme activity and lipid peroxidation was noted. Cu was more inhibitory for these antioxidative enzymes followed by Cd and Cr. Jojoba was more tolerant towards Cr.

CHAPTER 5: Effect of metals on *Pongamia pinnata*

This chapter describes the effect of different metals (Cr, Cu and Cd) at various concentrations on *Pongamia* seed germination and seedling growth. Parameters including germination frequency, seedling growth and metal accumulation in different organs was tested. Germination frequency was not affected in any of the metals at the concentrations tested. Cd was more inhibitory for seedling growth followed by Cu and Cr. Chromium
used at higher concentration (600-800 μM) was not inhibitory for pongamia seedlings. Cu accumulation in pongamia seedling was optimum in seed coat followed by leaves, root, cotyledons and stem. In Cd and Cr seed coat accumulated optimum amount of metal followed by root, leaves, cotyledons and stem. Seed coat accumulated highest amount of metal as compared to other organs.

**SUMMARY**

The main findings of this research work conducted on different plant species are summarized in this section.