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Research Article

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Phytoremediation of aluminium and lead using *Raphanus sativus*, *Vigna radiata* and *Cicer arietinum*

James Raj and L. Jeyanthi Rebecca*

Department of Industrial Biotechnology, Bharath University, Chennai, Tamil Nadu, India

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ABSTRACT

Heavy metals are one of the most important environmental pollutants. Such heavy metal exposure is due to the industrial activities like mining, smelting, refining and manufacturing process. The aim of this study was to find the effect of phytoextraction of aluminium and lead in hydroponics culture by using Raphanus sativus, Vigna radiata and Cicer arietinum. The plants were allowed to grow in static hydroponic culture at 0, 5, 10, 15, 20 and 25 mM concentrations of aluminium chloride and lead acetate. The germination percentage was determined. It was found that the germination percentage of the seeds decreased with an increase in the concentration of the heavy metals. The maximum permissible limit of Al and Pb for Raphanus sativus was 15 mM whereas it was 25 mM and 35 mM, respectively for Vigna radiata. Finally the permissible limit was least for Cicer arietinum namely, 5 mM and 10 mM, respectively for Al and Pb.

Keywords: phytoextraction, radish, green gram, chick peas, hydroponics, lead, aluminium

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INTRODUCTION

Global development has raised new challenges in the field of environmental protection and conservation. Ironically, it is the economic, agricultural and industrial developments that are often linked to polluting the environments. One such example is the soil pollution by toxic metals which has shown a dramatic increase [1]. Heavy metals are one of the most important environmental pollutants [2, 3]. Such heavy metal exposure is due to the industrial activities like mining, smelting, refining and manufacturing process. Most of the effluents contain toxic substances such as heavy metals [1, 4]. The soil has been traditionally the site for disposal of most of the heavy metal wastes which needs to be treated. Unlike organic compounds, metals cannot degrade and therefore, effective cleanup requires their immobilization to reduce or remove toxicity. Phytoremediation describes the treatment of environmental pollutants using plants. These toxic substances are released into the environment causing disruption of natural aquatic and terrestrial ecosystems [5] and contribute to a variety of toxic effects on living organisms in the food chain [6] by bio-accumulation and bio-magnification [7]**.** Currently, conventional remediation methods of heavy metal contaminated soils are carried out but they are expensive and environmentally destructive [8-11].

Researchers have observed that some plant species are endemic to metalliferous soils and can tolerate greater than usual amounts of heavy metals or toxic compounds [12-14]. The identification of metal hyper accumulators capable of accumulating extraordinarily high metal levels, demonstrates that plants have the genetic potential to clean up contaminated soil [15-17]. For root to shoot transport, these elements are transported via the vascular system.

Different chelators may be involved in the translocation of metal cations through the xylem, such as organic acid chelators like malate, citrate, histidine [18].

The present study was carried out to find out the efficiency of three plants namely, *Raphanus sativus, Vigna radiata* and *Cicer arietinum* in the removal of aluminium and lead.

EXPERIMENTAL SECTION

The main aim of our experiment was to study the effect of aluminum and lead on the germination of seeds.

Plant Materials

The seeds of *Raphanus sativus*, *Vigna radiata* and *Cicer Arietinum* were procured from Sakthi Seeds, T.Nagar, Chennai and Susi Seeds, T.Nagar, Chennai respectively.

Nutrient Solution

The seeds were germinated in Hoagland solution. The seeds were allowed to germinate in the nutrient solution containing 0, 5, 10, 15, 20 and 25 mM concentrations of aluminium chloride and lead acetate in Petri dishes over a filter paper moistened with control solution (without heavy metal) or required heavy metal. For each experiment in the Petri dish ten seeds of each plant were taken. Observations were made at the end of each time interval. In each treatment, treated seeds were examined and the germination percentage of the seeds was found out.

RESULTS AND DISCUSSION

The effect of heavy metal salts of different concentrations of aluminium and lead on the seed germination of *Raphanus sativus, Vigna radiata* and *Cicer arietinum* was studied.

Effect of aluminium and lead on the germination percentage of Vigna radiata

On treatment of the seeds in hydroponics along with heavy metal salt solution of aluminium of different concentrations, it was seen that the germination percentage of the *V. radiata* seeds gradually decreased with increase in concentration of aluminium chloride or lead acetate. The seeds took 2 days to get cent percent germination. The germination percentage of the green gram seed was 50%, on day 7 even at 25 mM aluminium chloride (Fig 1). The maximum permissible limit for aluminium was 25 mM aluminium chloride.

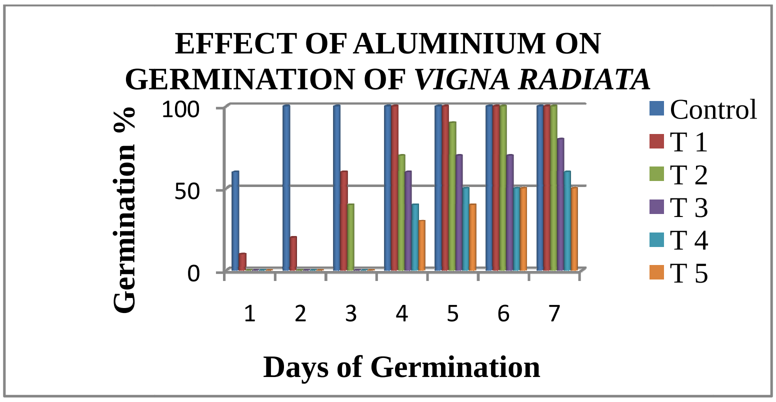

Fig 1- Effect of aluminium on germination of *Vigna radiata*

The germination percentage of the green gram seed was 100%, on day 7 even at 25 mM lead acetate (Fig 2). The maximum permissible limit for lead was 25 mM lead acetate.

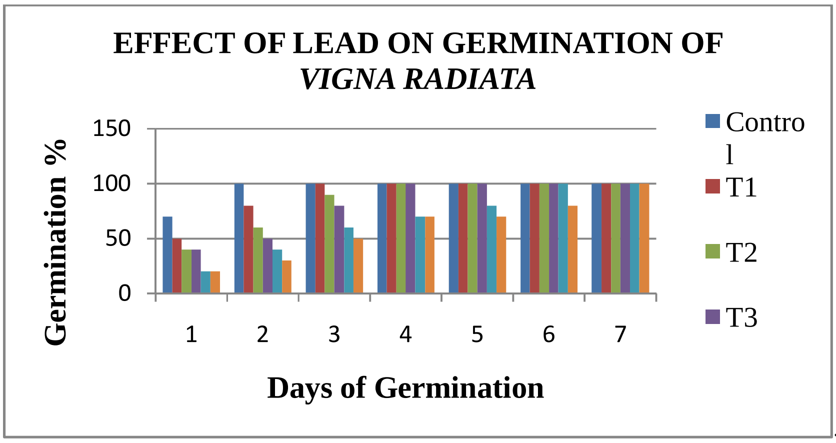

Fig 2- Effect of lead on germination of *Vigna radiata*

Effect of aluminium and lead on the germination percentage of Raphanus sativus

The germination percentage of the *R. sativus* seeds also gradually decreased with increase in concentration of aluminium chloride and lead acetate. The seeds took 7 days to get 80% germination in control. The germination percentage of the radish seed was 40%, on day 7 at 10 mM aluminium chloride (Fig 3). The maximum permissible limit for aluminium was 10 mM aluminium chloride.

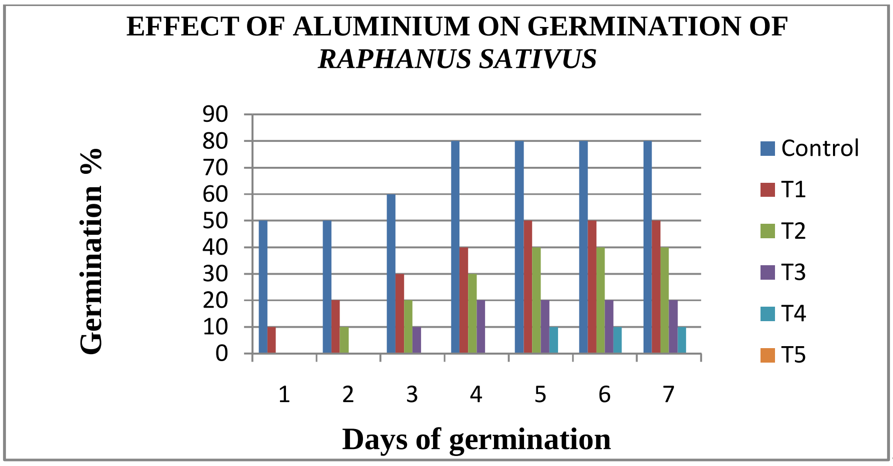

Fig 3- Effect of aluminium on germination of *Raphanus sativus*

The seeds took 4days to get 100% germination in control. The germination percentage of the radish seed was 40%, on day 7 at 10 mM lead acetate (Fig 4). The maximum permissible limit for lead was 10 mM lead acetate.

Effect of aluminium and lead on the germination percentage of Cicer arietinum

The seeds took 4 days to get 90% germination. The germination percentage of the black gram seed was 60%, on day 4 at 5 mM aluminium chloride (Fig 5). The maximum permissible limit for aluminium was 5 mM aluminium chloride.

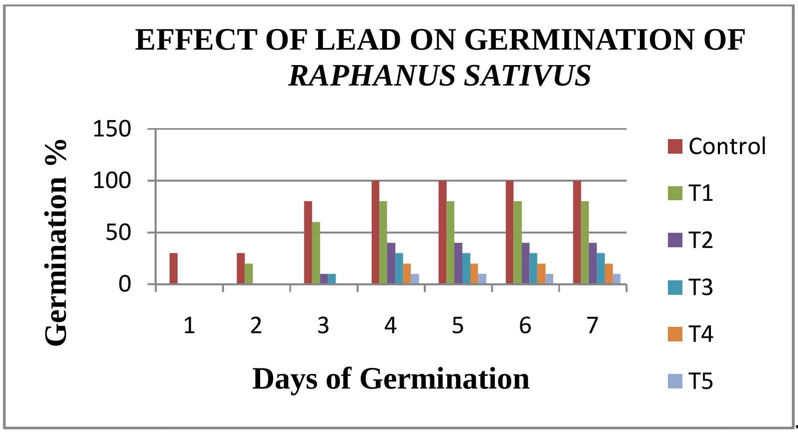

Fig 4- Effect of lead on germination of *Raphanus sativus*

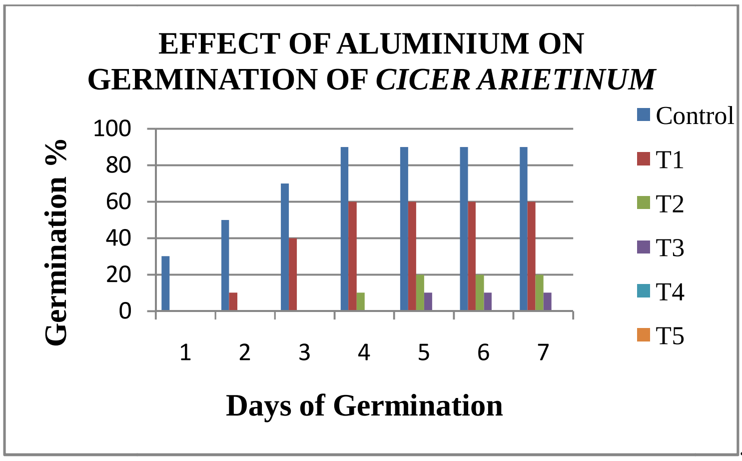

Fig 5- Effect of aluminium on germination of *Cicer arietinum*

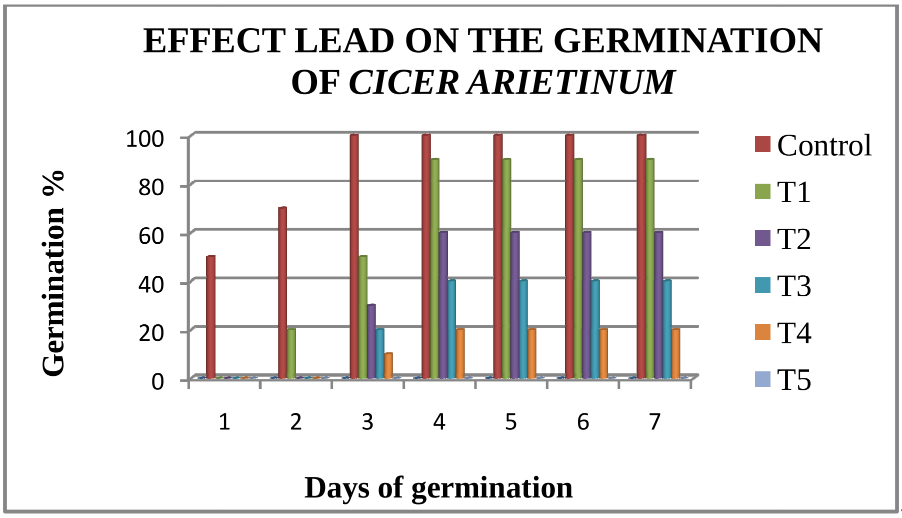

Fig 6- Effect of lead on germination of *Cicer arietinum*

The seeds took 3 days to get 100% germination. The germination percentage of the chick pea seed was 60%, on day 4 at 10 mM lead acetate (Fig 6). The maximum permissible limit for lead was 10 mM lead acetate.

Thus it was found that green gram was more tolerant to aluminium and lead than radish and chick pea. The effect of lead acetate on *Dolichos biflorus* had been studied and it was found that the seeds were able to germinate even at 100 ppm of lead acetate [19]. The maximum permissible limit of Hg, Al and Cr for radish was 500, 1500, 1000 ppm respectively while maize was comparatively tolerant to the treatment and the accumulation of heavy metal was more in root as compared to seed and shoot [20].

CONCLUSION

The result of this study showed that increased concentrations of aluminium inhibited seed germination. The maximum permissible limit of Al for *R. sativus* was 10 mM whereas it was 25 mM respectively for *V. radiata.* Finally the permissible limit was least for *C. arietinum* namely, 5 mM for Al. Among all the three plants in this study, *V. radiata* was more tolerable to aluminium which was followed by *R. sativus* and *C. arietinum*. The result of this study showed that increased concentrations of lead inhibited seed germination. The maximum permissible limit of lead for *R. sativus* was 10 mM whereas it was 25 mM respectively for *V. radiata.* Finally the permissible limit was least for *C.arietinum* namely, 5 mM for lead. Among all the three plants in this study, *V. radiata* was more tolerable to lead which was followed by *R. sativus* and *C. arietinum.*

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