Full Length Research Paper

Study on the effects of heavy metals on seed germination and plant growth on *Jatropha curcas*

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The individual effects of several doses of Cd, Cr, Zn, Cu, Pb and Hg on seed germination and growth of *Jatropha curcas* was studied. The doses used in this study were 1, 10, 20, and 30 mM. The seed germination and plant growth was significantly affected by Cd, Cr, Pb and Hg at 10 mM, as well as by Cu and Zn at 20 mM and higher concentrations (P<0.05). At lower concentration, Zn did not affect seed germination. The roots of the plants exposed to 1 mM-dose of Cd and Cu and 1 and 10 mM-dose of Zn grew more than the roots of the control treatment; on the other hand, for all the treatments of Cr, Pb and Hg, root length was significantly decreased. Exposures of 1 mM of Cd, Cr, Pb and Hg reduced the shoot length as compared to the control, while Cu and Zn increased the shoot length by 21.1 and 29.5% respectively.

**Key words:** Heavy metal, seed germination, *Jatropha curcas*.

INTRODUCTION

Heavy metal contamination affects the biosphere in many places worldwide (Meagher, 2000). Metal concentrations in soil range from less than 1 ppm to high as 100,000 ppm, whether due to the geological origin of the soil or as a result of human activity (Blaylock and Huang, 2000). Excess concentrations of some heavy metals in soils such as Cd, Cr, Cu, Ni and Zn have caused the disruption of natural aquatic and terrestrial ecosystems (Meagher, 2000). Some heavy metals at low doses are essential micronutrients for plants, but in higher doses they may cause metabolic disorders and growth inhibition for most of the plants species (Claire et al., 1991). Researchers have observed that some plants species are endemic to metalliferous soils and can tolerate greater than usual amounts of heavy metals or other toxic compounds (Blaylock and Huang, 2000). Several studies have been conducted to evaluate effects of different heavy metal concentrations on live plants and most of these studies have been conducted using seedlings or adult plants (Chatterjee and Chatterjee, 2000). Recently, effects of different heavy metal stress (namely: Cd, Cr, Cu, Zn, Hg and pb) on pollen germination and pollen tube length of *Jatropha* has been evaluated under *in vitro* condition (Acharya et al., 2011). In a few studies, the seeds have been exposed to see the effects of heavy metal contaminations (Claire et al., 1991). The present study reports data regarding the ability of *Jatropha curcas* seeds to germinate and grow in Petri dishes containing variable concentrations of heavy metal stress namely: Cd, Cr, Zn, Cu, Pb and Hg ions.

MATERIALS AND METHODS

*J. curcas* seeds were obtained from IARI experimental field. The seeds were immersed in 3% v/v formaldehyde solution for five minutes to avoid fungal contamination. Standard solutions of each heavy metal were prepared with distilled water as follows: Cd as Cd(NO\(_3\))\(_2\).4H\(_2\)O; Cr as K\(_2\)Cr\(_2\)O\(_7\); Zn as ZnSO\(_4\); Cu as CuSO\(_4\).5 H\(_2\)O, Pb as Pb(NO\(_3\))\(_2\) and Hg as HgCl\(_2\). For this experiment, blotting paper was placed into each sterile Petri dish and in each Petri dish 20 *Jatropha* seeds were taken. 20 ml solution of different metal concentrations was added in respective

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Figure 1. Seed germination of *Jatropha curcas* after ten days of exposure to heavy metals.

Petri dish. Controls were taken in three replicates where only 20 ml distilled water was added in each Petri dish. Each treatment was replicated three times. The seeds were set under a photoperiod of 12 h, and 25/18°C day/night temperature. The seedlings were harvested after 10 days and the germination rate, and root and shoot lengths were recorded. The data were analyzed through one-way analysis of variance (ANOVA) to determine the effect of treatments, and least significant difference (LSD) tests were performed to determine the statistical significance of the differences between means of treatments using SPSS statistical software (SPSS for Windows, Release 12).

**RESULTS AND DISCUSSION**

**Effects of heavy metals on seed germination**

Figure 1 shows the effects of the concentrations of Cd, Cr, Zn, Cu, Pb and Hg on seed germination of *J. curcas* grown on Petri dishes. The results were taken after 10 days of exposure of these metals with different concentrations (1.0, 10, 20 and 30 mM). In general, there was a reduction in seed germination as metal concentrations increased. 91% germination was observed in control seeds. The 20 and 30 mM dose of all the six metals significantly reduced the seed germination (P< 0.05). From the result obtained, it was observed that at a concentration of 30 mM, Hg inhibited seed germination markedly, followed by Pb and least was seen in the case of Zn treated seeds (Figure 1). However in this study, the lowest concentration of all the metals did not significantly reduced the seed germination, moreover at 1.0 mM concentration of Zn seed germination was increased by 4.4% (p< 0.05).

From the result, it was obtained that at a concentration of 20 and 30 mM Cd, Cr, Zn, Cu, Pb and Hg inhibited significantly seed germination by 31.9 and 40.7%; 39.6 and 54.9%; 19.8 and 25.3%; 28.6 and 34.1%; 42.9 and 61.5%; and 53.8 and 68.1% respectively. However at the lowest concentration of all metals, seed germination was not significantly inhibited. Claire et al. (1991) obtained similar results in a study using nickel and other heavy metals on cabbage, lettuce, millet, radish, turnip, and wheat. In an experiment on *Lens esculenta* L., seed germination decreased noticeably with the applications of Cu, Cd, Hg and Zn (Ayaz and KadYöOlu, 1996). But for Zn treatment, it acts as a stimulatory nutrient at lowest concentration and seed germination was promoted.

**Effects of heavy metals on root growth**

The data corresponding to the root growth of the *Jatropha* Vs. the dose of heavy metals is shown in Figure 2. The results were taken after 10 days exposure of metal stress. The mean control reading was obtained as 4.56 cm. It is clearly seen that root length was significantly reduced as metal concentration increased. But at the lowest concentration of Zn and Cu (1.0 mM) treatment, root length was significantly increased, but after that it was gradually decreased. For Cr treated seeds, it was drastically reduced from the lowest concentration and at 30 mM concentration, Pb and Hg treated seeds suffered most and no root length development was observed.

The results showed that the dose of 1 mM of Zn and Cu promoted the root growth by 50 and 29.2%
respectively as compared to the control treatments. However for the same doses, Cd, Cr, Pb and Hg reduced the root size. All the six metals demonstrated a concentration-dependent inhibition of root growth at higher doses and 97.8% reduction were obtained for 30 mM concentration of both Cd and Cr (Figure 2). Öncel et al. (2000) found similar effects using cadmium in wheat seedlings.

**Effects of heavy metals on shoot growth**

The effects of heavy metals over the shoot growth were different as compared to the effects on root growth (Figure 3). At the lowest concentration, only the Zn treated seeds showed significantly increased shoot growth (10.26 cm) as compared to control (7.92 cm); and for the rest of the metal treatment, it was reduced (Cd - 2.46 cm, Cr - 6.32 cm, Pb - 6.12 and Hg - 2.56 respectively). After that there was a significant decrease of shoot length with increasing concentration of all the six metals. Here also, just like the effect on root length, shoot length suffered mostly in the case of Pb and Hg treatment at the highest concentration, but in overall Hg treated seeds suffered most and Zn treated seeds suffered least (Figure 3). From the result, it was seen that at only 1 mM concentration of Zn and Cu, shoot growth was promoted.
by 29.6 and 4.2% respectively; for the rest of the cases, it was decreased significantly. Similar to the effect on root growth, Cd and Cr showed 98.2% reduction in shoot growth at 30 mM concentration.

Studies also indicate that heavy metals applied to seeds inhibit the growth of plumula and radicles. Other negatively affected characteristics include germination percentage, germination index, root and shoot lengths and root and shoot dry matter rates (Mishra and Choudhuri, 1999). Based on the results, it was concluded that the seed germination of J. curcas is seriously affected by a concentration of 10, 20 and 30 mM of Cr, Pb and Hg and by 20 and 30 mM of Zn. J. curcas did not show any significant capabilities to germinate and root and shoot growth at higher concentration of all the six metals (Figures 1, 2 and 3). However, Jatropha was able to germinate and grow efficiently at 1 mM Zn and Cu concentration evaluated in this study.

Based on the results, it can be concluded that all heavy metals have negative effects on seed characteristics of J. curcas; however, the damage to seed germination, root length and shoot length varies with the dose and type of metals. J. curcas may be grown directly in soils individually contaminated with moderate amounts of Zn and Cu. Further studies need to be performed in order to establish the maximum amount of Zn and Cu that the plant may tolerate, and the ability of the J. curcas to germinate and grow in media containing mixtures of these heavy metals.

REFERENCES


