J. Plantarum., 5(1): 1-8

ISSN PRINT 2710-4079
ISSN ONLINE 2710-4087

GERMINATION AND GROWTH RESPONSE OF *PARTHENIUM HYSTEROPHORUS* TO LEAD TOXICITY

ARSHAD JAVAID*, IQRA HAIDER KHAN AND AMNA SHOAIB

Department of Plant Pathology, Faculty of Agricultural Sciences, University of the Punjab, Quaid-e-Azam Campus, Lahore 54590, Pakistan

*Corresponding author's email: arshad.iags@pu.edu.pk, arshadjpk@yahoo.com

Abstract

Parthenium (*Parthenium hysterophorus* L.), a Mexican weed, entered in Pakistan during early 90s and now has established itself in various parts of the country due to its fast growth rate, high seed production potential, allelopathic nature, non-palatability and absence of natural enemies. The weed is considered highly competitive and tolerant to various stresses. This study was carried out to assess its tolerance to lead (Pb) toxicity *in vitro*. Seven concentrations of Pb (II) (20, 40, 60, …, 140 ppm) in the form of lead (II) nitrate were prepared and their effect was investigated on germination and growth of parthenium. The experiment was carried out in a completely randomized design with four replications. Different concentrations of Pb (II) reduced germination by 7–82%, shoot length by 4–86%, root length by 14–92%, fresh biomass by 27–95% and dry biomass by 33–98% over control. This study concludes that germination and growth of parthenium is very sensitive to 100 ppm concentration of Pb (II) while a concentration of 140 ppm is highly detrimental to parthenium causing up to 82% reduction in its germination.

Keywords: Alien weed, Germination, Heavy metal, Lead, Parthenium, Weed.

Introduction

Parthenium has spread to an alarming extent in different parts of Pakistan especially in Punjab, Khyber PhakhtunKhwa and Kashmir (Javaid and Riaz, 2012; Shabbir *et al.,* 2023). It entered in Pakistan during early 90s and now has occupied every open space along road sides, in grazing pastures, on undisturbed lands, and also in some crops (Riaz and Javaid, 2009, 2011; Javaid *et al.,* 2022a). With its origin in the Gulf of Mexico, now it has spread in over 50 countries of Africa, Asia and Australia, and is threatening to both agro as well as natural ecosystems (Al Ruheili *et al.,* 2022). It not only has negative effects on pastures and crops production (Shi and Adkins, 2020), but also has ill effects on human and animals (Kaur *et al.*, 2014). It also causes allergic problems in about all the regions where it has established itself (Allen *et al.,* 2018). Abundant seed production, release of allelochemicals, high competitiveness behavior, unpalatable for grazers and absence of natural enemies in the new entering regions are the major characteristics of parthenium responsible for its rapid spread (Javaid *et al.,* 2007; Chetty *et al.*, 2022). Parthenium can be controlled by using synthetic herbicides (Javaid, 2007), biocontrol agents (Strathie *et al.,* 2021), allelopathic plant extracts (Javaid *et al.,* 2006; 2011), and fungal metabolites (Khan *et al.*, 2022).

Lead is a bluish-gray noxious heavy metal that has toxic effects on both animals and plants. The major sources of Pb pollution include natural weathering process, Pb industry, fumes of automobiles, lead storage batteries, and mining of lead ores, lead plating process, fertilizers, pesticides, pigments and gasoline (Eick *et al.,* 1999). Organic lead compounds are more toxic to biological systems than inorganic forms (Kumar *et al.,* 2020). Mostly, plants absorb Pb ions from soil through roots and mostly the metal is accumulated in the roots (95%) while only a very small quantity is transferred to shoots (Gupta *et al.,* 2019). Pb toxicity interferes in production of chlorophyll (Chl a), root elongation, cell division, organization of lamellae in the chloroplast, transpiration and germination of seeds (Gupta *et al.,* 2010; Maestri *et al.,* 2010). Photosynthetic activity is badly affected by lead toxicity possibly due to restricted production of chlorophyll, carotenoids and plastoquinone, hindered electron transport, repressed activities of enzymes of Calvin cycle, and scarcity of CO_2 owing to closure of stomata (Stefanov *et al.,* 1995). A number of previous studies have shown that dry biomass, ash and activated carbon prepared from parthenium can adsorb many heavy metals like Ni (II) and Hg (II) (Kadirvelu *et al.,* 2002 a,b), Cd(II) ((Ajmal *et al.,* 2006), and Cr(VI) (Singh *et al.,* 2008) from aqueous solution or waste water. Ali and Hadi (2015) reported that *P. hysterophorus* has the phytoremidiation potential for cadmium. The objective of the present *in vitro* study was to investigate the germination and growth response of parthenium to Pb (II) toxicity. This study will help to use parthenium in future studies regarding phytoremediation of Pb (II).

Materials and Methods

Preparation of Pb (II) solutions: For preparation of a stock solution of 250 mL of distilled water. This stock solution was diluted by adding suitable qualities of distilled water to prepare 10 mL of different lower concentrations *viz.* 140, 120, 100, 80, 60, 40 and 20 ppm.

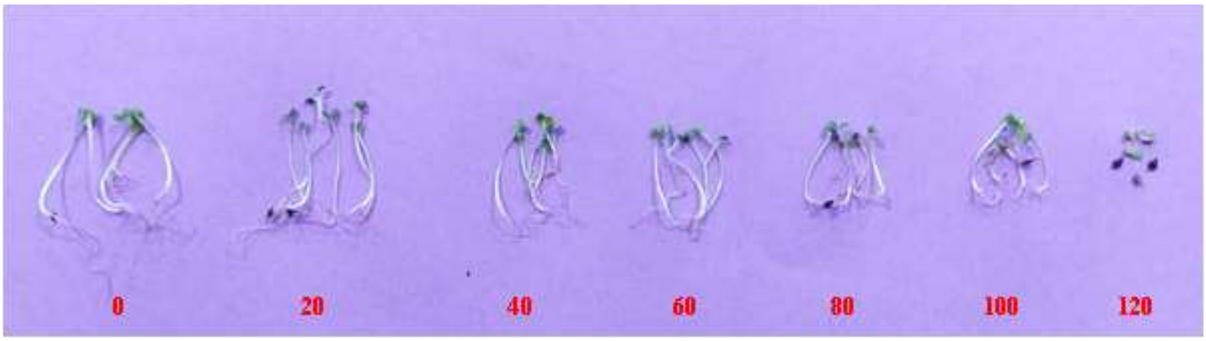
Laboratory bioassays: Parthenium seeds were collected from Lahore at the start of February 2022. After sun-drying, seeds were separated from husks and unhealthy seeds were discarded. Twenty-five parthenium seeds were arranged on a filter paper bed in Petri plates of 9-cm diameter. After that, 2.5 mL solution of lead (II) nitrate of 20, 40, 60, 80, 100, 120 and 140 ppm were poured in each plate. Control plates received the same quantity of distilled water. The experiment was done in a completely randomized design at room temperature with four replications. After 10 days, number of germinated seeds in each Petri plate was recorded. Germination data were transformed to percentage germination in each plate. Shoot and root lengths of seedlings were recorded with the help of a scale and mean values were calculated for each replicate plate. At the end, fresh and dry weights of all the seeding in each Petri plate were collectively recorded (Javaid *et al.,* 2020).

Statistical analysis: All the data concerning germination, shoot and root lengths, and seedling's biomass were analyzed by ANOVA. Thereafter, LSD test was applied to demarcate treatment means at $P \leq 0.05$ using Statistix 8.1 software.

Results and Discussion

Effect of lead on germination of parthenium:

In general, all the concentrations of Pb (II) solution had an adverse effect on germination of parthenium. In control, germination was 100%. On the other hand, germination in different concentration of Pb (II) solutios ranged from 18–93%. A gradual decrease in germination percentage was recorded with an increase in metallic ions concentration from 20 to 140 ppm. However, lower concentrations (20 to 80 ppm) were less inhibitory. The lowest concentration (20 ppm) reduced germination by 7% but the effect was nonsignificant over control. Concentrations ranging from 40 to 80 ppm had a significant adverse effect and reduced germination by 11–13% over control. A 100 ppm and higher concentrations had a drastic effect resulting in 26–82% reduction in germination over control (**figure 1** and **2A**). High lead concentrations (1 mM) reduced germination of rice seeds by 14–30% (Verma and Dubey, 2003). Gholinejad *et al.* (2020) demonstrated that 250–1000 ppm solution of lead ions reduced germination of *Lolium perenne* by 57–89%. It shows that parthenium is much more sensitive to lead toxicity as compared to this grass. The reduction in germination of parthenium seeds could be ascribed to the alteration in the root cell membranes and reduction in water absorbent surface due to metal toxicity (Kabir *et al.,* 2018). Germination is possibly inhibited due to lead interference with amylase and protease enzymes (Sengar *et al.*, 2008).



Concentration of Pb (ppm)

Figure 1 Effect of different concentrations of Pb (II) on germination and seedling growth of parthenium.

Effect of lead on growth of parthenium:

All the plant growth related parameters *viz.* shoot and root lengths, and seedling's biomass were negatively affected by Pb (II) solutions. The effect of 20 to 60 ppm was nonsignificant on shoot length. However, the concentrations beyond 60 ppm exhibited a severe effect on shoot length. The 80 and 100 ppm metallic ions reduced shoot length by 25% and 35%, respectively, over control. The two highest concentrations *viz.*

120 and 140 ppm had drastic effects where 78% and 86% reduction in shoot length was noted, respectively (**figure 1** and **2B**).

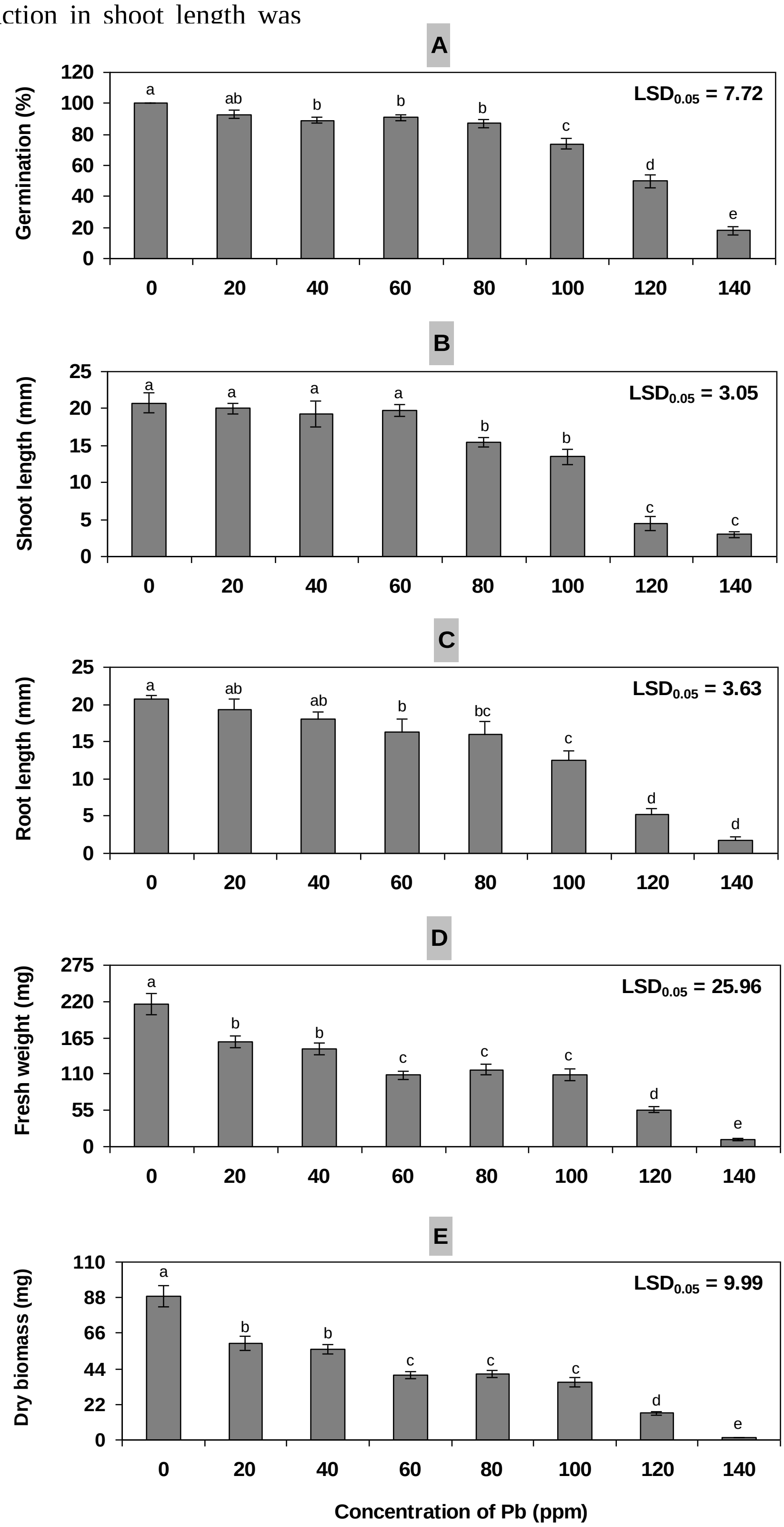


Figure 2 Effect of different concentrations of Pb (II) on germination and seedling growth of parthenium in laboratory bioassays. Vertical bars show standard errors of means of four replicates. Values with different letters at their top show significant difference ($P \leq 0.05$) as determined by LSD Test.

Root growth was more sensitive to exposure to Pb (II)solution than the shoot growth. Roots are the first, which absorb metal ions from the surrounding solution and thus show alteration and reduction in their growth. Similar severe effects have also been reported on root growth of parthenium due to Cr^{+6} (Javaid *et al.,* 2022b), plants extracts (Javaid *et al.,* 2011) and fungal metabolites (Khan *et al.,* 2022).

In the present study, there was a continuous decreasing trend in root length as the Pb (II) concentration was enhanced from 20 to 140 ppm. With an initial insignificant effect due to 20 and 40 ppm solutions, all the remaining concentrations significantly reduced root length. The effect was moderate up to 100 ppm where 14–40% reduction in root length was noted. However, 120 and 140 ppm solutions showed very severe effects resulting in 75% and 92% reduction in root length, respectively, over control (**figure 1** and **2C**). Many earlier researchers have reported the suppression of root growth at a concentration of 10^{-2} to 10^{-6} M Pb (II) (Sharma and Dubey, 2005). The reduction in root length under Pb toxicity stress could be attributed to the lowering of cell division at tips of root (Eun *et al.,* 2000). Lead nitrate caused mitotic irregularities and chromosome stickiness resulting in reduction in onion roots (Wierzbicka, 1994).

The effect of different concentrations of Pb (II) solution on fresh and dry biomass of seedlings is presented in **figure 2D** and **E**. All the concentrations of Pb (II) solution significantly ($P \leq 0.05$) reduced fresh and dry biomass of seedlings by 27–95% and 33–98%, respectively, over control. Similar reduction in plant biomass of pea (Kevresan *et al.,* 2001), *Phaseolus vulgaris* (Haider *et al.,* 2006) and maize (Çimrin *et al.,* 2007) have been reported due to Pb toxicity.

Conclusion

This study concludes that both germination and growth of parthenium are adversely affected by the presence of Pb (II). A 140 ppm concentration of Pb (II) can significantly reduce germination by 82%, shoot length by 86%, root length (92%) and dry biomass of parthenium by 98%.

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