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Lead stress and its effects on growth, antioxidant activity, and L-DOPA Production in Mucuna pruriens (L.) DC

The growing interest in herbal medicines has brought increased attention to medicinal plants, which are abundant in phytochemical compounds. However, concerns have arisen regarding the presence of heavy metals in some herbal formulations, likely due to the contamination of soil and water by industrial and agricultural activities in which these medicinal plants have grown. Lead, a toxic heavy metal, is known to induce the formation of reactive oxygen species, negatively impacting plant growth and overall productivity. This study explores the effects of lead on the growth and biochemical properties of Mucuna pruriens (L.) DC. To assess the impact, M. pruriens seeds were exposed to varying lead concentrations ranging from 200 to 2000 ppm over a 21-day period, for the determination of the LD50 value—the concentration at which 50% of the seeds successfully germinated. The LD50 for lead was identified as 1200 ppm, which then was used for the selection of lead concentrations for further polyhouse studies. Subsequently, the plants were cultivated in soil treated with lead concentrations ranging from 400 to 1600 ppm and were harvested after seed set formation, just before entering senescence, marking the completion of their life cycle. The findings revealed that lead exposure significantly affected both growth and various biochemical parameters, including levels of proteins, carbohydrates, chlorophyll, proline, total phenol and flavonoid content, malondialdehyde (MDA), L-DOPA, and antioxidant activity. Lead accumulation within the plants increased with higher concentrations, reaching a maximum of 947.47 mg kg−1 in plants treated with 1600 ppm of lead. Interestingly, L-DOPA content initially increased with increasing lead concentrations, peaking at 18.76 mg g−1 DW in the roots and 9.93 mg g−1 DW in the stems of plants treated with 1200 ppm, and 4.37 mg g−1 DW in the leaves at 400 ppm. The L-DOPA levels in the seeds of control plants and those treated with 800 ppm were similar, at 40.91 mg g−1 DW and 40.15 mg g−1 DW, respectively. Although lead accumulation followed a dose-dependent pattern, rendering the plants unsuitable for direct consumption, the increased L-DOPA content highlights the potential for its extraction and commercial application. The study also showed that lead-treated plants exhibited enhanced stress tolerance, evidenced by elevated proline levels, increased secondary metabolite production, and enhanced antioxidant activity.
Key words: Mucuna pruriens, L-DOPA, heavy metal stress, antioxidants, lead toxicity.

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