

铅胁迫下桤木幼树生长与抗性生理的变化及铅富集转移特性

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摘要:【目的】研究铅(Pb)胁迫下桤木幼树生长与抗性生理的变化以及对铅的富集与转移特性, 来评估桤木是否具有修复铅污染土壤的潜力。【方法】以1年生桤木幼树为实验材料, 在不同铅浓度(0、50、100、200和400 mg/kg)的土壤中进行为期6个月的盆栽实验。测定不同处理下桤木幼树的株高、基径、生物量、叶片过氧化标记物含量、渗透调节物质含量和抗氧化酶活性以及各器官(吸收根、运输根、主干、枝、叶)中氮(N)、磷(P)、钾(K)、铅含量, 计算各器官的铅富集系数和不同处理下的铅转运系数。【结果】①随着铅浓度增加, 植物的总生物量呈下降趋势, 铅浓度小于50 mg/kg时, 对桤木幼树的株高和基径有促进作用, 当铅浓度大于200 mg/kg时, 桤木幼树的株高、基径和总生物量均受到显著抑制。②随着铅浓度增加, SOD(超氧化物歧化酶)、POD(过氧化物酶)和CAT(过氧化氢酶)的活性呈先升高后降低的趋势, H₂O₂(过氧化氢)和MDA(丙二醛)的含量显著增加, Pro(脯氨酸)、SS(可溶性糖)和SP(可溶性蛋白质)的含量呈先升高后降低的趋势。铅浓度高于50 mg/kg时, 抗氧化酶(SOD、POD和CAT)的活性显著上升; 铅浓度低于50 mg/kg时, 对渗透调节含量(Pro、SS和SP)没有显著影响。③随着铅浓度增加, 桤木幼树运输根中的氮含量显著增加; 叶片中的磷、钾含量和吸收根中的磷含量显著减少, 而树枝和树干中的养分含量没有显著变化。④随着铅浓度增加, 桤木幼树各器官中的铅含量显著上升, 上升幅度为吸收根>运输根>主干>叶>枝。桤木幼树的转移系数(TF)随着铅浓度增加而显著下降, 桤木幼树根部的铅含量和生物富集系数(BCF)明显高于其他器官。【结论】桤木不属于铅富集植物, 对铅的转运能力也不突出, 但低浓度铅胁迫会促进桤木的生长发育。由于桤木分布广泛、生长迅速, 因此可将其作为低浓度铅污染地区的造林树种。

关键词: 桤木; 铅胁迫; 抗氧化酶; 铅富集系数; 铅转运系数

Abstract: 【Objective】 To evaluate the potential of *Alnus cremastogyne* for remediation of Pb-contaminated soils by studying the physiological changes in growth and resistance, and the enrichment and transfer of Pb in young *Alnus cremastogyne* trees under Pb stress. 【Method】 A six-month pot experiment was carried out in soil with different Pb concentrations (0, 50, 100, 200 and 400 mg/kg) using one-year-old *Alnus cremastogyne* trees as experimental materials. The plant height, basal diameter, biomass, leaf peroxide marker content, osmoregulatory substance content and antioxidant enzyme activity, as well as the contents of nitrogen (N), phosphorus (P), potassium (K) and lead (Pb) in each organ (absorbing root, transporting root, trunk, branch and leaf) were measured, and the Pb enrichment coefficient and Pb transport coefficient of each organ were calculated under the different treatment. 【Results】 ①With the increase of Pb concentration, the total biomass of the plant showed a decreasing trend. When the Pb concentration was less than 50 mg/kg, it promoted the plant height and basal diameter of young *Alnus cremastogyne* trees. When the Pb concentration was more than 200 mg/kg, the plant height, basal diameter and the total biomass of the young *Alnus cremastogyne* trees were all significantly suppressed. The activities of SOD (superoxide dismutase), POD (peroxidase) and CAT (catalase) tended to increase and then decrease with the increase of Pb concentration, the contents of H₂O₂ (hydrogen peroxide) and MDA (malondialdehyde) increased significantly, and the contents of Pro (proline), SS (soluble sugar) and SP (soluble protein)

tended to increase and then decrease. The activities of antioxidant enzymes (SOD, POD and CAT) increased significantly at Pb concentrations higher than 50 mg/kg, and there was no significant effect on osmolyte contents (Pro, SS and SP) at Pb concentrations lower than 50 mg/kg. (iii) Nitrogen content in transport roots of young *Alnus cremastogyne* trees increased significantly with increasing lead concentration; phosphorus and potassium content in leaves and phosphorus content in absorbing roots decreased significantly, while nutrient content in branches and trunks did not change significantly. ④With the increase of Pb concentration, the Pb content in each organ of young *Alnus cremastogyne* trees increased significantly, and the increase was absorbing root>transporting root>trunk>leaf>branch. The transfer factor (TF) of young *Alnus cremastogyne* trees decreased significantly with the increase in Pb concentration, and the Pb content and bioconcentration factor (BCF) in the roots of young *Alnus cremastogyne* trees were significantly higher than those in other organs. 【Conclusion】 *Alnus cremastogyne* is not a Pb-enriched plant and does not have outstanding Pb-transporting ability, but low concentrations of Pb stress will promote the growth and development of *Alnus cremastogyne*. Because of its wide distribution and rapid growth, *Alnus cremastogyne* can be used as a silvicultural species in areas with low concentrations of lead pollution.

Key words: *Alnus cremastogyne*; Lead stress; Antioxidant enzymes; Lead enrichment factor; Lead transport factor