镉和铅对长柔毛委陵菜体内锌的亚细胞分布和化学形态的影响

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中文摘要

通过营养液培养并采用差速离心技术和化学试剂逐步提取法，分析了Cd和Pb及不同Zn盐对长柔毛委陵菜(*Potentilla griffithii* var.*velutina*)叶片、叶柄和根中Zn的亚细胞分布和化学形态的影响.结果表明，除对照外，长柔毛委陵菜体内46%～74%和16%～33%的Zn分别分布在细胞壁和可溶部分中；在所有处理中，细胞壁和可溶部分的Zn含量占总量的74%～95%，这说明细胞壁和可溶部分是Zn在植物体内的2个主要分布位点.与对照相比，Zn、Cd和Pb的添加使Zn在细胞壁的分配比例显著增加9%～38%(p<0.05)，而可溶部分的分配比例则显著减少6%～40%(p<0.05).与单Zn处理相比，Cd和Pb虽然没有改变Zn亚细胞分布中“细胞壁>可溶部分>细胞核和叶绿体>线粒体”的格局，但增加了在细胞壁或可溶部分的分配比例，促进Zn向细胞壁或液泡中转移.Zn在长柔毛委陵菜体内以多种化学形态存在：在对照中植物各部位和单Zn处理的叶片中，Zn的乙醇提取态和水提取态所占比例达到61%～87%；在单Zn处理的叶柄和根中，Zn的氯化钠提取态和乙醇提取态占总量的62%～73%；在Zn/Cd和Zn/Pb复合处理中，氯化钠提取态、乙醇提取态和水提取态等3种化学形态占总量的70%～89%.Zn、Cd和Pb的添加大多提高了Zn的氯化钠提取态的分配比例，而降低乙醇提取态的分配比例，促进Zn向活性较弱的结合形态转移.这些结果表明细胞壁固持、液泡区隔化和活性较强化学形态的减少是长柔毛委陵菜在单Zn处理、Zn/Cd和Zn/Pb复合处理下耐Zn的主要机制.此外，不同Zn盐对长柔毛委陵菜的Zn亚细胞分布没有明显影响，而硝酸锌处理使Zn的乙醇提取态成为优势形态.

英文摘要

Using the differential centrifugation technique and sequential chemical extraction method,effects of Cd,Pb and different Zn salts on subcellular distribution and chemical form of Zn in Zn hyperaccumulator *Potentilla griffithii* var.*velutina* under nutrient solution culture were analyzed.Under all treatments except for the control,46%-74% and 16%-33% of total Zn in the plants are distributed in cell wall and in soluble fraction, respectively.Further,74%-95% of total Zn are localized in these two parts under all treatments,which suggest that cell wall and soluble fraction in the plant are major storage sites for Zn.Compared with the control,Zn percentage significantly increases by 9%-38% in the cell wall and decreases by 6%-40% in the soluble fraction with addition of Zn,Cd and Pb treatment (p<0.05).Although the addition of Cd and Pb has no influence on the pattern of Zn subcellular distribution presenting cell wall>soluble fraction>karyon and chloroplast>mitochondrion,it generally reduces Zn percentage in the chloroplast,karyon and mitochondrion and increases that in the cell wall or soluble fraction,suggesting that Cd and Pb promote the transferring processes of Zn from organelle to either cell wall or vacuole.As to the chemical forms,61%-87%of total Zn exist as ethanol- and water-extractable forms in plants under control and only leaves under Zn addition treatment;while 62%-73% of total Zn exist as NaCl- and ethanol-extractable forms in leafstalks and roots under Zn addition treatment.NaCl-,ethanol- and water-extractable forms are also the main chemical forms in the plants,occupied almost 70%-89% of total Zn under Zn/Cd and Zn/Pb compound treatments.The addition of Zn,Cd and Pb generally increases the percentage of NaCl-extractable Zn forms,but decreases that of ethanol-extractable Zn,which facilitates Zn chemical form transferring from relatively higher active forms to less active ones.These results mentioned above indicate that cell wall binding,vacuolar compartmentalization and reduction of total percentage in higher active chemical forms are main tolerance mechanisms for Zn in *Potentilla griffithii* var.*velutina* in response to Zn,Zn/Cd and Zn/Pb treatments.Additionally,different Zinc salts have no obvious influence on Zn subcellular distribution in the plant,whereas the treatment of Zinc nitrate turns Zn ethanol-extraction to a dominant chemical form.