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锰胁迫对垂序商陆叶片形态结构及叶绿体超微结构的影响

Manganese stress on morphological structures of leaf and ultrastructures of chloroplast of a manganese hyperaccumulator, *Phytolacca americana*

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中文摘要:

以超富集植物垂序商陆为实验材料,通过温室水培实验,研究不同锰处理条件下垂序商陆叶片受害症状、叶片形态结构和叶绿体超微结构的变化。当生长介质中锰供应水平为1 000 $\mu\text{mol/L}$ 时,垂序商陆生长良好,叶片未表现出受害症状,其形态结构和超微结构也没有明显的变化;当锰供应水平为5 000 $\mu\text{mol/L}$ 时,叶片开始出现褪绿现象,叶肉细胞排列疏松,栅栏组织细胞膨胀,叶绿体数量减少,外膜部分解体,类囊体膨胀,基质片层扭曲,淀粉粒颗粒变小;当锰供应水平为12 000 $\mu\text{mol/L}$ 时,叶片发生大量的褪绿现象,伤害率高达87.33%,并且伤害率随着锰胁迫时间的延长明显升高,叶肉细胞发生扭曲变形,叶绿体皱缩,外膜解体,类囊体空泡化加剧,基质片层严重扭曲,基粒排列紊乱甚至模糊成絮状,嗜饿颗粒增多。尽管在高锰浓度胁迫条件下植物叶肉细胞及叶绿体超微结构出现一定程度的毒害特征,但垂序商陆仍能完成部分功能,维持其个体的生长,这进一步表明超富集植物垂序商陆具有极强的锰耐性。

English Summary:

The toxicity symptoms, changes of leaf morphological structures and chloroplast ultrastructures of *Phytolacca americana* under manganese stress were investigated using hydroponic culture with different concentrations of manganese (Mn). The results indicated that this Mn hyperaccumulator species has a remarkable tolerance to Mn. Under nutrient culture conditions, *P. americana* could grow quite well with Mn supplied at a concentration of 1000 $\mu\text{mol/L}$. With the increase of Mn concentration in the culture solution, the leaf morphological structures and chloroplast ultrastructures of *P. americana* had some changes. At the Mn concentration reached 5000 $\mu\text{mol/L}$, the leaves showed chlorosis and injury symptoms with yellow-brown spots on the leaf surface. When Mn concentration exceeded 12000 $\mu\text{mol/L}$, the leaves showed purple spots on the surface during the 30-day Mn exposure, with an injury rate of 87.33%. Significant changes in leaf structure were noted, with swollen palisade cells which arranged loosely. When Mn concentration reached above 12000 $\mu\text{mol/L}$, the mesophyll and epidermal cells were distorted. With further increase of Mn concentration, the chloroplasts were shrunk with outer membrane disrupted, and the thylakoids swollen and became heavily hollowed. The stroma lamellae was distorted and grana disordered or blurred as floc, starch grains became smaller and less, and osmiophilic granules increased. Although the leaf morphological structures and chloroplast ultrastructures of *P. americana* had significant changes under heavy Mn stress, this species could still survive and grow. All these suggested that *P. americana* had an extraordinary tolerance to Mn.

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