生态学报 Acta Ecologica Sinica

罗毅,程显好,张聪聪,李维焕,于德洋.九州虫草菌丝体对Mn的耐性及富集.生态学报,2012,32(2):499~507

九州虫草菌丝体对Mn的耐性及富集

Manganese tolerance and accumulation in mycelia of *Cordyceps kyusyuensis*

投稿时间：2010-11-30 最后修改时间：2011-5-9

DOI：10.5846/stxb201011301704

中文关键词: 生物修复 抗氧化物酶 膜脂过氧化 离子交换量 超积累

English Keywords:bioremediation antioxidant enzymes lipid peroxidation cation exchange capacity hyperaccumulation

基金项目:山东省食用菌技术“泰山学者”建设工程专项经费资助;山东省自然科学基金联合专项资助(ZR2010CL005)

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中文摘要:

重金属耐性真菌的研究是生物修复的重要研究内容。研究了九州虫草(*Cordyceps kyusyuensis*)对于Mn的耐性及富集。在液体培养基中添加不同浓度(0-60 g/L)的Mn离子,测定其菌丝生物量、菌丝Mn含量、菌丝抗氧化酶活性和过氧化水平以及菌体细胞离子交换量、Mn在细胞中的分布的变化情况。实验结果表明九州虫草菌丝生物量与Mn浓度呈显著负相关,Mn浓度60 g/L为九州虫草菌丝生长极限浓度。菌丝中Mn含量随培养基中Mn浓度的增大而显著升高,10 g/L Mn时,菌丝细胞中Mn积累量达到细胞干重的1.0013%。九州虫草菌丝中过氧化产物丙二醛(MDA)、可溶性蛋白(SP)含量、可溶性糖浓度与培养基中Mn浓度呈负相关,实验组与对照组差异显著。抗氧化酶(过氧化氢酶(CAT)、过氧化物酶(POD)、超氧化物歧化酶(SOD))活性随着培养基中Mn浓度增大而显著升高,但变化趋势不同。九州虫草菌丝细胞不可溶性组分中Mn的量(91.51%-98.6%)显著高于可溶部分(1.40%-8.49%)。九州虫草菌丝细胞壁离子交换量(CEC)随着培养基中Mn浓度的升高变化不明显。说明在九州虫草菌丝对Mn的富集过程中,其细胞壁、细胞膜和细胞器对于Mn结合发挥了主要作用,细胞质中可溶性成分对Mn的结合发挥次要作用。在Mn的胁迫下,增强抗氧化酶系统的协同作用以清除大量自由基是细胞对锰耐性的重要机制。

English Summary:

The study of fungi resistance to heavy metals is a very important part in the bioremediation. In this paper we report the Mn resistance and hyperaccumulation in *Cordyceps kyusyuensis* in terms of mycelia biomass, manganese content in mycelia, antioxidant enzyme activities, peroxidation level, cation exchange capacity (CEC) of mycelia cells, and the distribution of manganese in cells in submerged culture supplemented with Mn^{2+} concentrations from 0 to 60 g/L. The results showed that the mycelia biomass of *C. kyusyuensis* was negatively correlated with manganese concentration, and the upper limit of Mn^{2+} concentration for mycelia growth was 60 g/L. At a Mn^{2+} concentration of 70 g/L or above, the mycelia growth was completely inhibited. The manganese content in mycelia increased significantly with the increase in Mn^{2+} concentration in the culture medium when the Mn^{2+} concentration in the culture medium was below 60 g/L, up to 1.0013% manganese content based on the dry weight of mycelia was approached when the manganese concentration in the culture medium was 10 g/L. The contents of malondialdehyde (MDA), soluble protein (SP) and soluble sugar in mycelia of *C.kyusyuensis* were negatively correlated with the Mn concentration in the culture media, which were significantly different between the control and the group treated with manganese in the culture medium. The activity of antioxidant enzymes including peroxidase (POD), catalase (CAT) and superoxide dismutase (SOD) in mycelia of *C. kyusyuensis* all increased with the increase in the initial Mn concentration in the culture media, but the mode of change in those indices varied greatly. The manganese content in the insoluble components (91.51%-98.6%) were much higher than that (1.4%-8.49%) in the soluble part of the mycelia cells. The cation exchange capacity (CEC) in *C. kyusyuensis* mycelia did not show significant change with the increase in Mn concentration in the media. The cell wall, cell membrane and organelles of *C. kyusyuensis* played major roles in binding the manganese ions in manganese accumulation, while the soluble components in cytoplasm played a minor role. Under manganese stress, the joint action of antioxidant enzyme in removing the great amount of free radicals due to peroxidation and maintaining the normal metabolism of cells is important in the mechanisms of manganese resistance in *C.kyusyuensis.* Compared with other fungi, the resistance to manganese stress in *C. kyusyuensis* is relatively high with a threshold of 60 g/L, and its ability to hyperaccumulate manganese is also very high. Our experiments showed that the manganese accumulated in the mycelia on dry weight basis was 1.0013%, just approached 1%, the threshold of hyperaccumulation, this makes the macrofungi *C. kyusyuensis* a potential hyperaccumulator for manganese. The high resistance to manganese stress and the high ability to accumulate manganese under submerged culture suggest that *C. kyusyuensis* may be applied to the bioremediation of contaminated water and soil. On the other hand, manganese content in the mycelia should be monitored and proven safe when *C. kyusyuensis* is used for medical purposes due to the ability to hyperaccumulate manganese in this fungus.

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