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Tolerance of lead by the fruiting body of *Oudemansiella radicata*

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ABSTRACT

This study focused on the tolerance responses of the fruiting body of *Oudemansiella radicata* towards different concentrations of lead (250–1000 mg kg^{-1}) for 2–6 d. To know about the lead tolerance and detoxification strategy, the lead content, thiol content and the activities of antioxidant enzymes were investigated. The maximum level for the lead concentration in *O. radicata* was recorded in the 6 d sample in each treatment, and for thiols, it was recorded in the 500 mg kg^{-1} Pb/2 d sample, while for superoxide dismutases (SOD) and catalases (CAT) activities, it was reached at 1000 mg kg^{-1} Pb after 2 d in the stipe and cap, respectively. Peroxidases (POD) activities showed a more complex trend and glutathione reductases (GR) reached the maximum at 500 mg kg^{-1} Pb after 2 d in the stipe. Overall, the results showed that low concentration lead stimulated the fruiting body of *O. radicata* to produce the thiols and activate the antioxidant enzymes after 2 d/4 d, while high concentration Pb resulted in the decline/decrease of the thiols and the activities of antioxidant enzymes after 4 d/6 d. Benefiting from the metal accumulation, detoxification potential and the short lifetime, mushroom have the potential for bioaccumulation of heavy metal in polluted farmland.

1. Introduction

Metals can be released to the environment through natural processes, but mainly through human activities, such as agriculture, mining, and industry. This kind of pollution constitutes a serious danger (Ayres, 1992). Metals can be essential, such as copper (Cu), zinc (Zn) and nickel (Ni), and nonessential, such as cadmium (Cd) and lead (Pb). However, above a critical concentration, both are known to be toxic, and that depends on the organism, the physicochemical properties of the metal, and the environmental factors (Gadd, 1993; Blaudez et al., 2000; Gimmler et al., 2001).

It is well documented that the fruiting body of mushrooms have the ability to bioaccumulate metal ions (Tüzen et al., 1998). However, many fungal species have developed defense mechanisms that alleviate the toxicity of metal stress. These mechanisms are generally based on metal immobilization through the production of intracellular and extracellular chelating compounds, such as thiol (SH) functional groups-containing compounds (Gadd, 1993), which are known to have high affinity for metal ions (Romero-Isart and Vašák, 2002) and capability to scavenge reactive oxygen species (ROS) (Bai et al., 2003). Generally, the sulphydryl compounds include cysteine, glutathione and metallothioneins of families 8–13 (fungi I–VI MTs; http://www.expasy.ch/cgi-bin/lists?metallo.txt).

The toxicity of metals in fungi can be due to the generation of ROS that may cause wide ranging damage to proteins, nucleic acids and lipids, and eventually lead to cell death (Bai et al., 2003; Collin-Hansen et al., 2005a,b; Baptista et al., 2009), so the tolerance of the fungi to heavy metals has been associated with its ability to clear away ROS (Fujs et al., 2007). Fungi display several antioxidant enzymes against ROS, including superoxide dismutases (SOD), catalases (CAT), peroxidases (POD) and glutathione reductases (GR), which are capable of removing oxygen radicals and their products and/or repairing oxidative damage (Jamieson, 1998; Bai et al., 2003).

Oudemansiella radicata, a deep root mushroom, wildly distribute in the tropics and subtropics of the Northern Hemisphere (McKnight et al., 1998). Nowadays, mature cultivation techniques have made it to a high yield. Some lead pollution occurred in China in the last decade, but no safe and effective way has been found to deal with it. In order to know the potential use of the *O. radicata* as bioaccumulator in Pb contaminated soil and the resistance/tolerance response of fruiting body of *O. radicata* to Pb, the Pb content and the thiol levels in the fruiting body of *O. radicata* were examined. Moreover, the activities of antioxidant enzymes (SOD, CAT, POD, GR) were also measured in this study.

2. Materials and methods

2.1. Soil treatments and mushroom sown

The mycelia (mixed with compost) of *O. radicata* were purchased from a mushroom production site in Chengdu of China. Mycelia used in the study were cultured at 25 ± 1 °C in the same

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Table 1
The physicochemical properties of the untreated and treated soil. Data shown are means of triplicates ± SD.

Parameter	Control	Pb 250	Pb 500	Pb 1000
pH	7.36 ± 0.02	7.21 ± 0.03	7.47 ± 0.02	7.36 ± 0.03
Water holding capacity (%)	12.43 ± 0.53	11.88 ± 0.77	11.97 ± 1.45	11.64 ± 2.01
CEC cmol kg^{-1}	12.13 ± 0.72	12.06 ± 1.18	12.33 ± 0.93	12.19 ± 1.34
OM g kg^{-1}	15.37 ± 0.16	15.77 ± 0.98	15.03 ± 1.47	15.93 ± 1.22
Pb (Total) mg kg^{-1}	44.05 ± 3.47	257.03 ± 10.12	497.38 ± 14.37	1012.33 ± 9.38
Pb (extracted) mg kg^{-1}	9.27 ± 0.57	86.34 ± 5.92	148.55 ± 9.57	265.74 ± 19.54

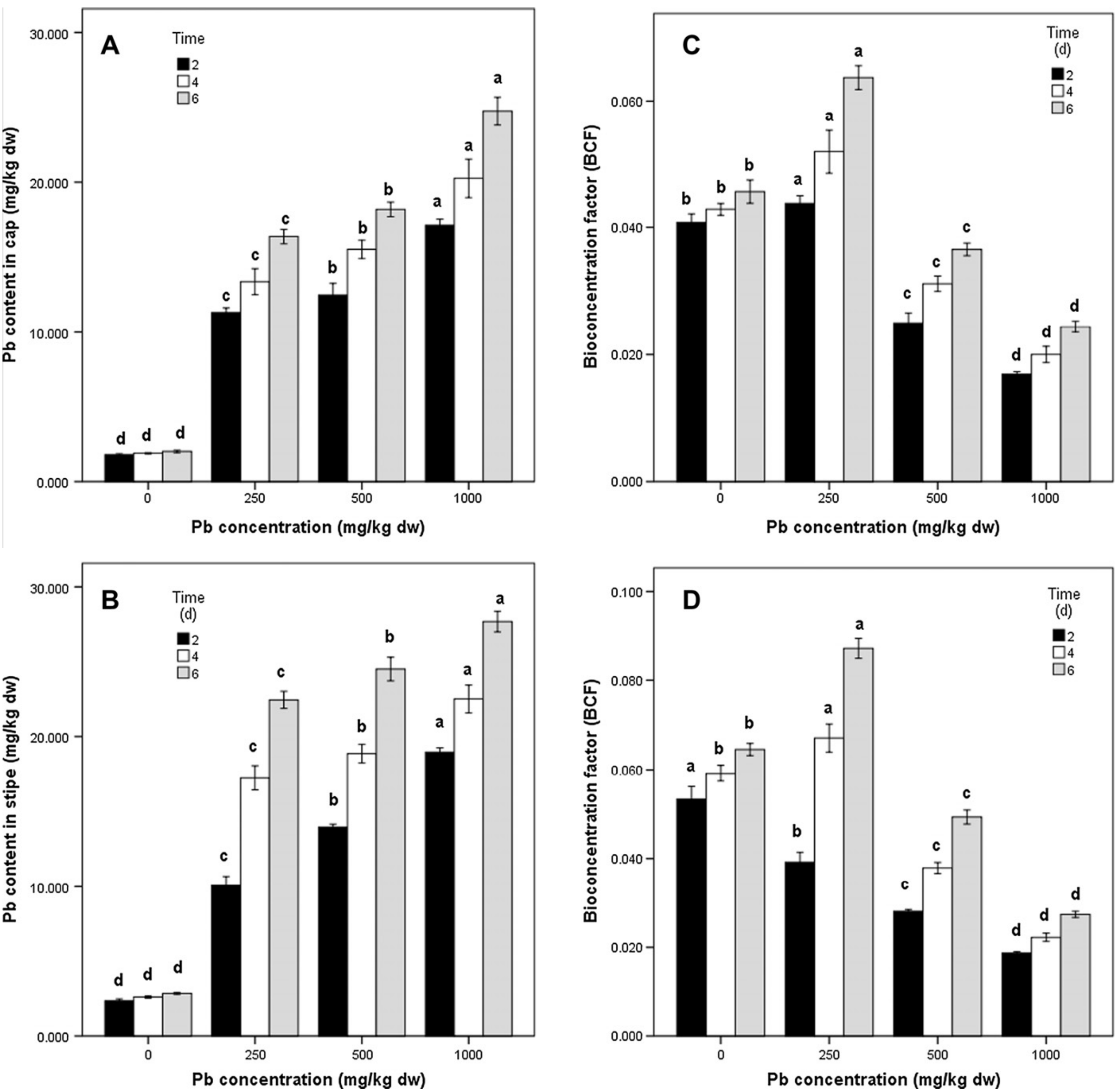

Fig. 1. Pb (II) accumulation by the fruiting body of *O. radicata* treated with different treatment, Pb content in cap (A), and in stipe (B), and the bioconcentration factor (BCF) of cap (C) and stipe (D). All the values are mean of triplicates ± SD. ANOVA significant at $p \leqslant 0.01$. Different letters indicate significantly different values at a particular growing time (DMRT, $p \leqslant 0.05$).