DOCTORAL THESIS

Interactions of arbuscular mycorrhizal fungi with an arsenic hyperaccumulator plant (pteris vittata) on the uptake of arsenic

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Interactions of Arbuscular Mycorrhizal Fungi with an Arsenic Hyperaccumulator Plant (*Pteris vittata*) on the Uptake of Arsenic

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ABSTRACT

The major objective of the project is to study the roles and effects of arbuscular mycorrhiza (AM) fungi on the growth, metal uptake and distribution in an arsenic (As) hyperaccumulator (*Pteris vittata*) and a non-hyperaccumulator (*Cynodon dactylon*) when grown in metal contaminated soil.

A field survey of metal concentrations and AM components of plants growing on five mining sites was conducted in Chenzhou City, Hunan Province, Southern China and a control site in Hong Kong. Significant differences were observed on the average total concentrations of four heavy metals [lead (Pb), zinc (Zn), copper (Cu), cadmium (Cd)] and one metalloid [arsenic (As)] in contaminated soils compared with the control site. Three components of mycorrhizal colonization (arbuscules, vesicles and coiled hyphae) were found in the roots of *C. dactylon* and *P. vittata* growing at Do Shun Long (DSL) mine site. Concentrations of As in fronds were 24-fold higher than in roots of *P. vittata* with the highest mycorrhizal colonization rate (73%) among all sampling sites. Extensive mycorrhizal colonization (85%) was also recorded in the roots of *C. dactylon* with As accumulation 57 times higher than in shoots.

A greenhouse trial was conducted to investigate the role of indigenous mycorrhiza (IM) isolated from As mine in aiding As uptake and tolerance by *P. vittata* (As hyperaccumulator) and *C. dactylon* (a multi-metal root accumulator). The infectious percentage of mycorrhiza (0mg/kg As: 26.4%, 50 mg/kg As: 30.3%, 100mg/kg As: 40.6%)

and the average biomass of shoots in infected *P. vittata* increased (0mg/kg As: 2.45g/pot, 50mg/kg As: 2.48g/pot, 100mg/kg As: 10.9g/pot) according to the increase of As levels when compared to control. IM also enhanced As accumulation (0mg/kg As: 3.70mg/kg, 50mg/kg As: 58.3mg/kg; 100mg/kg As: 88.1mg/kg) in the As mine populations of *P. vittata* and also sustained its growth by aiding P absorption. For *C. dactylon*, As was mainly accumulated in mycorrhizal roots and translocation to shoots was inhibited.

The effects of three types of single inoculum [IM, *Glomus mosseae* (GM) and *Glomus intraradices* (GI)] and two types of mixed inoculum (mixed with IM and either GM or GI) on the growth response of *P. vittata* and *C. dactylon* were studied. Mixed inoculum IM/GM promoted substantially higher mycorrhizal colonization and arsenate reductase (AR) activity in *P. vittata* than *C. dactylon* among all As levels. This may be attributed to IM/GM inoculum which could improve soil conditions and eventually favour AR formation and synthesis in plant root. The portion of *Paris* AM structure (observed in colonized roots) together with the highest As translocation factor of 10.2 in *P. vittata* inoculated with IM/GM was also noted.

The contributions of AM fungi and phosphate (P) amendment on the As uptake and accumulation of *P. vittata* and *C. dactylon* in As contaminated soil was investigated. It was found that the growth of mycorrhizal plants treated with P amendment was significantly improved when compared with non-amended plants. In addition, plant biomass, root surface area and chlorophyll concentrations in *P. vittata* inoculated with IM/GM were significantly higher when treated with P rock in 300 mg/kg As contaminated soil than the

other treatments. Henceforth, such combination seemed to play a potential role in enhancing phytoextraction efficiency of hyperaccumulating plants growing in As contaminated soil.

The effects of AM fungi and P rock on the phytoremediation efficiency of *P. vittata* and *C. dactylon* growing on As contaminated field soil were studied. Significant As reduction in soil, increased plant biomass and As accumulation were found for *P. vittata* treated with IM/GM and P rock at 100% water holding capacity (WHC) level. The overall results indicated that the synergistic effect of mycorrhiza and P rock affected As subcellular distribution of the hyperaccumulator and thereby altered its As removal efficiency under well-watered conditions.

The present study has proved that IM/GM combined with P rock would enhance the host plant in As accumulation when grown in As contaminated substrates. Therefore, mycorrhizal inoculation could be combined with other practices such as appropriate soil amendments to maximize re-vegetation success at field.

TABLE OF CONTENTS