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PGPR on heavy metal uptake by Lady's finger  
grown on sewage sludge amended soil  
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## Effect of arbuscular mycorrhizal fungi and PGPR on heavy metal uptake by Lady's finger grown on sewage sludge amended soil

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**Key words:** Lady's finger, arbuscular mycorrhiza, *Glomus mosseae*, PGPR, heavy metals, sewage sludge.

### Abstract

A pot experiment was conducted to determine the effect of arbuscular mycorrhizal fungi (AMF) and a plant growth-promoting rhizobacteria (PGPR) on the uptake of heavy metals by lady's fingers grown on soil amended with sewage sludge. Lady's finger seedlings were grown in soil amended with 5% (w/w) sewage sludge. *Glomus mosseae* and *Bacillus sphaericus* UPMB10 were inoculated individually or in combination to the respective pots. Plants inoculated with both mycorrhiza and bacteria had significantly higher shoot, root and fruit yields compared to the non-inoculated plants. Plant's uptake of N and P was subsequently increased with microbial inoculation. In general, the uptake of heavy metals (Cd, Pb, Cu and Zn) was higher in the plant shoots and roots than in the fruits. Microbial inoculation had no significant effect on heavy metals uptake except for Zn. Highest Zn content was observed in the fruits of plants inoculated with both AMF and PGPR. High mycorrhizal root infection was observed in plants inoculated with AMF individually or in combination with UPMB10.

### Introduction

Sewage sludge is increasingly being used as soil ameliorants, and presence of heavy metals may pose long-term risks to environmental quality and sustainable food production. Arbuscular mycorrhizal fungi (AMF) has been known to benefit plant growth by increasing the uptake of nutrients from soil. Previous studies have shown the ability of AMF to tolerate soil contaminated with heavy metals (Heggo et al., 1990; Hetrick et al., 1994 and Zhu et al., 2001). Mycorrhizal infection reduced the concentration of Zn, Cd and Mn in plant leaves. Besides AMF, there are other beneficial microorganisms that may contribute to the plants' tolerance to heavy metal contamination. Plant growth-promoting rhizobacteria (PGPR) improves plant growth through several mechanisms, such as increased nutrient uptake, phytohormone production and nitrogen fixation. Several mechanisms are involved in reducing the toxic effect of heavy metals to plant growth, including the immobilization of metals in or near the roots and by reducing the metal translocation to the shoots. Currently, there is insufficient information on the interactions between mycorrhizal fungi and PGPR on plant growth and heavy metal uptake in contaminated soil. The following study aimed to determine the effect of AM and PGPR on growth and uptake of heavy metals of lady's finger grown on soil amended with sewage sludge.

### Materials and Methods

Lady's finger (*Abelmoschus esculentus*) seedlings were transplanted into pots containing mixed soil amended with 5% sewage sludge (pH<sub>(H<sub>2</sub>O)</sub> 7.2, Total N 1.25%; Total P 13.99 mg · kg<sup>-1</sup>; Cd 0.32 mg · kg<sup>-1</sup>; Cu 2.67 mg · kg<sup>-1</sup>; Pb 3.41 mg · kg<sup>-1</sup>; Zn 19.63 mg · kg<sup>-1</sup>). Inoculation treatments were, 1) Non-inoculated Control, 2) *Glomus mosseae* (AMF), 3) *Bacillus sphaericus* UPMB10 (UPMB10), 4) AMF + UPMB10. Plants were grown in glasshouse condition, and fruits were harvested three months after transplanting. Whole plants were harvested and separated into leaves, stem, roots and fruits. Plant tissues were analyzed for con-

tents of N, P, Cd, Pb, Cu and Zn. Mycorrhizal root infection and total soil bacterial population were determined.

### Results

Inoculation with both AMF (*G. mosseae*) and PGPR (*Bacillus* UPMB10) significantly increased shoot (leaf and stem), root and fruit yields of lady's finger (Table 1). Plant's uptake of N and P was subsequently increased with inoculation. In general, uptake of heavy metals (Cd, Pb, Cu and Zn) was higher in plant shoots and roots compared to that in fruits. Microbial inoculation had no significant effect on heavy metals uptake except for Zn. Highest Zn content was observed in the fruits of plants inoculated with both AMF and PGPR (Table 2). Concentrations of N and Cu in fruits differed significantly between treatments. Mycorrhizal root infection was significantly high in plants inoculated with AMF individually or in combination with UPMB10.

Table 1. Effect of AMF and PGPR on dry weights of shoot, root and fruit of Lady's finger

Inoculation treatment	Shoot (g · plt <sup>-1</sup> )	Root (g · plt <sup>-1</sup> )	Fruit (g · plt <sup>-1</sup> )
Control	47.55 <sup>b</sup>	8.28 <sup>b</sup>	1.88 <sup>b</sup>
AMF	53.72 <sup>ab</sup>	12.66 <sup>a</sup>	4.27 <sup>ab</sup>
UPMB10	53.33 <sup>ab</sup>	9.02 <sup>b</sup>	2.76 <sup>c</sup>
AMF + UPMB10	61.86 <sup>a</sup>	13.08 <sup>a</sup>	6.75 <sup>a</sup>

Table 2. Effect of AMF and PGPR on uptake of Zn in different parts of Lady's finger

Inoculation	Leaf ug · plt <sup>-1</sup>	Stem ug · plt <sup>-1</sup>	Roots ug · plt <sup>-1</sup>	Fruits ug · plt <sup>-1</sup>
Control	25.97 <sup>a</sup>	14.07 <sup>a</sup>	6.48 <sup>a</sup>	1.51 <sup>b</sup>
AMF	25.95 <sup>a</sup>	7.90 <sup>a</sup>	7.10 <sup>a</sup>	3.20 <sup>ab</sup>
UPMB10	28.60 <sup>a</sup>	13.02 <sup>a</sup>	7.97 <sup>a</sup>	1.94 <sup>b</sup>
AMF + UPMB10	32.27 <sup>a</sup>	15.68 <sup>a</sup>	6.84 <sup>a</sup>	4.96 <sup>a</sup>

Means with the same letters are not significantly different at 5% level

## Discussion

Inoculation with AMF and PGPR individually or in combination increased the growth, yield and nutrient uptake (N and P) of lady's finger grown on soil amended with sewage sludge. At the rate of 5% sewage sludge application, the uptake of heavy metals by plants was relatively low and below the permitted contamination level. Significantly higher Zn content was observed in fruits of plants inoculated with combined AMF and UPMIB10. Interactions between AM and bacteria stimulated root development and subsequently Zn uptake. The higher uptake of Zn compared to other heavy metals could be due to the relatively higher availability of Zn in sewage sludge. In contrast, under high Zn contamination mycorrhiza may reduce Zn uptake in shoots as a protection against the toxic effect (Zhu *et al.*, 2001). The study indicates that AMF and PGPR could be used in the phytoextrac-

tion of Zn in Zn-contaminated soils.

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