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Growth Promotion and Nutrient Uptake of *Eucalyptus urophylla* Co-inoculated with *Glomus* and *Pisolithus* Isolates

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INTRODUCTION

Eucalyptus species are of great importance to plantation forestry and play a significant role in world timber supply. Some 460,000 ha of *Eucalyptus* plantations have been planted in China, and about 60,000 ha are established each year (Bai & Gan, 1996). However, successful plantations of exotic eucalypts in China may require inoculation of nursery plants with effective mycorrhizal fungi, since the diversity of ectomycorrhizal fungi in eucalypt plantations in southern China is low (Dell & Malajczuk, 1996; Gong *et al.*, 1997).

Eucalypt trees form ectomycorrhizas (ECM) and the anatomy, morphology and ecology, as well as physiology of these associations have been extensively studied (Brundrett *et al.*, 1996). *Eucalyptus* seedlings are capable of forming both ECM and vesicular-arbuscular mycorrhiza (VAM), even on the same root system (Brundrett *et al.*, 1996; Chilvers *et al.*, 1987). Colonization of different fungi in the same root system commonly occurs in nature, but little is known about its significance. Tree seedlings with multiple mycorrhizas including both ECM and VAM fungi may withstand a wider range of site conditions than those colonized by one fungus.

MATERIALS AND METHODS

Eucalyptus urophylla S. T. Blake (seedlot no. 14531) seedlings were inoculated with *Glomus caledonium* (isolate Gc90068, pot culture soil) and/or *Pisolithus tinctorius* (isolate Pt9303, cultured mycelial slurry) alone, and in combination. Plants were grown in sand, vermiculite and peat (2:1.5:1 v/v) with a complete nutrient solution for mycorrhizal eucalypts (Brundrett *et al.*, 1996). Heights of seedlings were measured once a month, and seedlings were harvested at 5 months. A randomly selected 2 g sub-sample of roots was cleared with 10% KOH and stained with 0.05% Trypan Blue to examine mycorrhizal formation. The remaining root and shoot materials were dried at 70°C to determine biomass and analysed for N, P, K and B content using standard procedures. Mycorrhizal dependency of fungal treatments was evaluated: $MD = (DWm - DWn)/DWn * 100$, where DWm and DWn represent shoot dry weights of inoculated and uninoculated seedlings respectively. Data collected were subjected to one-way or two-way ANOVA.

RESULTS

Mycorrhizal formation and growth responses

Inoculated seedlings were well colonized by VAM and ECM fungi (Fig. 1). Reduction in colonization in dual inoculated seedlings provided evidence of negative interactions between the two types of mycorrhizas. There was a positive correlation between mycorrhizal root length and the dry weight of seedlings ($r^2 = 0.79$, $P = 0.03$). There were also significant differences in the biomass and mycorrhizal dependency of

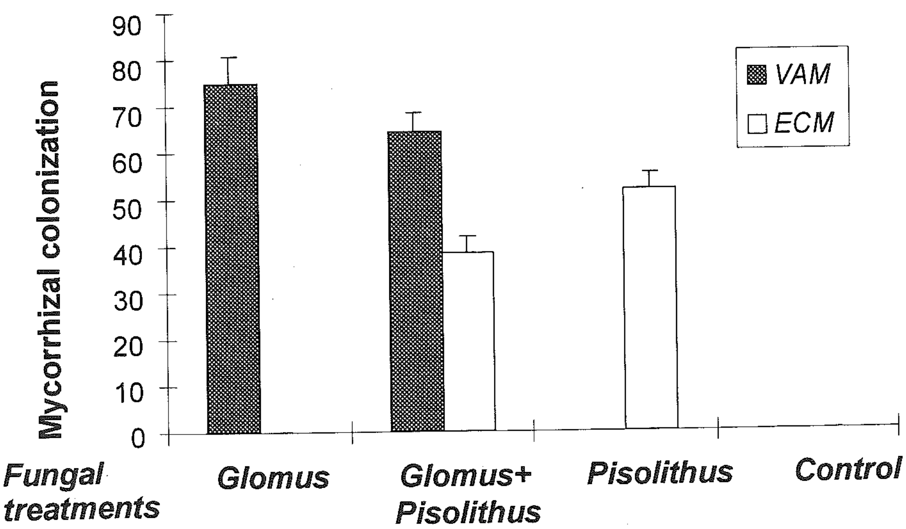

Fig. 1. Mycorrhizal colonization of *Eucalyptus urophylla* seedlings 5 months after inoculation (VAM: % root length colonized + SD; ECM: number of tips/m root + SD).

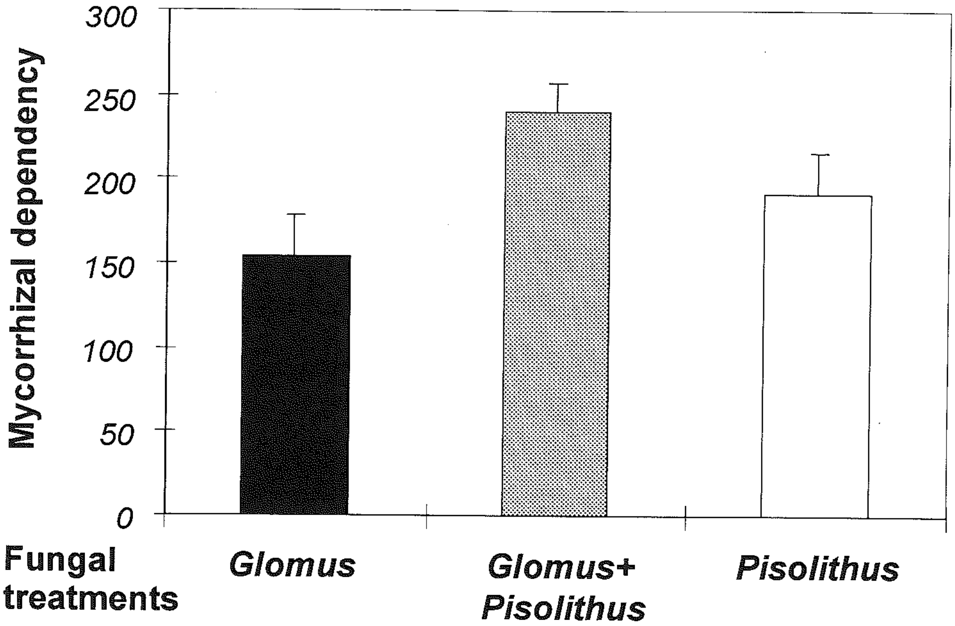

Fig. 2. Mycorrhizal dependency of *Eucalptus urophylla* seedlings inoculated with *Glomus* and/or *Pisolithus*. Values are means with SE.

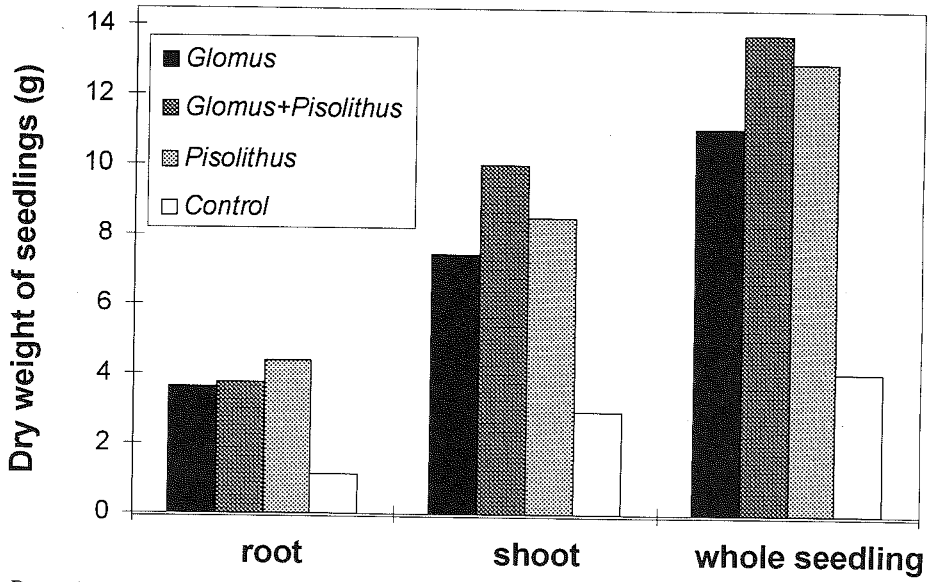

Fig. 3. Dry weight per plant of *Eucalptus urophylla* seedlings 5 months after inoculation with *Glomus* and/or *Pisolithus*.

Table 1. Shoot and root nutrient content of *Eucalyptus urophylla* seedlings 5 months after inoculation.

Fungus	Root (mg/plant)				Shoot (mg/plant)			
	N	P	K	B	N	P	K	B
Glomus	189b	50a	250b	0.023b	528b	195ab	718ab	0.151b
Glomus + Pisolithus	206ab	44ab	235b	0.028b	634a	202a	877a	0.162a
Pisolithus	218a	41b	280a	0.033a	256c	194ab	819a	0.135b
Control	51c	10c	62c	0.008c	69d	75c	288c	0.041c

Note: Means in each column with the same letter(s) are not significantly different (Duncan's NMT, $P < 0.01$).

seedlings between inoculation treatments after 5 months (Figs. 2 & 3). Seedlings inoculated with both *Glomus* and *Pisolithus* showed greater growth increases than those inoculated with a single species.

Effects on nutrient uptake

Total amounts of N, P, K, and B were substantially higher in the inoculated seedlings than in the uninoculated plants (Table 1). Results showed that inoculation with *Glomus* and *Pisolithus*, separately or in combination, increased nutrient acquisition by the roots and shoots.

CONCLUSIONS

Inoculation with VAM and/or ECM fungi significantly enhanced the growth and nutrient acquisition of *E. urophylla* seedlings under nursery conditions. Seedlings inoculated with both *Glomus* and *Pisolithus* grew better than other treatments. *Eucalyptus urophylla* was highly dependent on mycorrhizas in the nursery mix. Although *Pisolithus* and *Glomus* species are extensively used in inoculation programs due to their wide geographic distribution (Smith & Read, 1997), there is some specificity of *Pisolithus* with eucalypts and pines. The results of this study need to be verified in the field since competition between soil fungi and effects of soil fertility are likely to influence root colonization and mycorrhizal development. We have observed that ECM fungi dominate in most eucalypt plantations.

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