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Overcoming Impediments to Reforestation:
Tropical Forest Rehabilitation in the Asia-Pacific Region

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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)/DWm*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...
Fungal treatments

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

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

<table>
<thead>
<tr>
<th>Fungus</th>
<th>Root (mg/plant)</th>
<th>Shoot (mg/plant)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>P</td>
</tr>
<tr>
<td>Glomus</td>
<td>189b</td>
<td>50a</td>
</tr>
<tr>
<td>Glomus + Pisolithus</td>
<td>206ab</td>
<td>44ab</td>
</tr>
<tr>
<td>Pisolithus</td>
<td>218a</td>
<td>41b</td>
</tr>
<tr>
<td>Control</td>
<td>51c</td>
<td>10c</td>
</tr>
</tbody>
</table>

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

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 uptake in 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.
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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