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Use of a systemic fungicide (Benomyl) to improve growth and mycorrhization of white pine (*Pinus strobus*) seedlings

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Introduction

Application of the selective fungicide, benomyl, has been shown to enhance ectomycorrhiza formation (Marx and Rowan, 1981; Pawuk *et al.*, 1980). Benomyl inhibits the growth of Ascomycetes and their anamorphs (which include many important pathogens), but not of most mycorrhiza-forming species; this reduces competition within the rhizosphere (Summerbell, 1985; Sinclair *et al.*, 1982). Field and laboratory experiments were designed to study the impact of pre-treatment with benomyl on the success of white pine seedling growth and mycorrhization.

Field results and discussion

White pine seedlings were grown in a 50-50 peat/vermiculite mixture in Japanese paper pots for six months and then treated with a range of benomyl concentrations [0 (control), 100, 1,000, 10,000 and 100,000 ppm] applied as a root dip immediately before planting. These non-mycorrhizal seedlings were outplanted in the spring of 1987 into a 25 m^2 plot immediately adjacent to an existing red pine plantation, using a randomized block design. Seedlings were harvested in the autumn and measured for growth (height, stem base diameter, dry weight) and the percentage of mycorrhizal short roots. Results were analyzed with ANOVA and other tests of significance and graphed in Figures 1 to 5.

Stem height was significantly greater than controls for all benomyl concentrations, except 100,000 ppm (Fig. 1). Total seedling height was reduced at a concentration of 100,000 ppm (Fig. 1). The mean values for seedling volume (BD2*Ht) were significantly higher at 10,000 ppm and also showed significant increases at 100 and 1,000 ppm, but not at 100,000 ppm (Fig. 2). Total seedling dry weight was not significantly different from controls at 1,000 and 10,000 ppm and declined significantly at concentrations of 100 and 100,000 ppm (Fig. 4). Top weight (weight above the root collar) and stem base diameter were significantly greater than controls for the 10,000 ppm treatment (Figs. 3 and 4). Root weight was significantly reduced with all benomyl treatments, to the greatest degree at 100,000 ppm (Fig. 4).

Mycorrhiza formation was significantly increased at all concentrations except 100,000 ppm, when compared to controls (Fig. 5). The greatest increase was recorded for the 10,000 ppm treatment.

These results indicate that pre-treatment with benomyl at a concentration of 10,000 ppm enhances several aspects of white pine seedling growth, including mycorrhiza formation. Lower concentrations may also enhance some of these growth parameters to a lesser extent, suggesting that the optimal concentration of benomyl is around 10,000 ppm.

Treatment with 100,000 ppm benomyl resulted in poor growth and mycorrhiza formation, compared to control seedlings, suggesting that this concentration is above optimal and having an inhibitory effect.

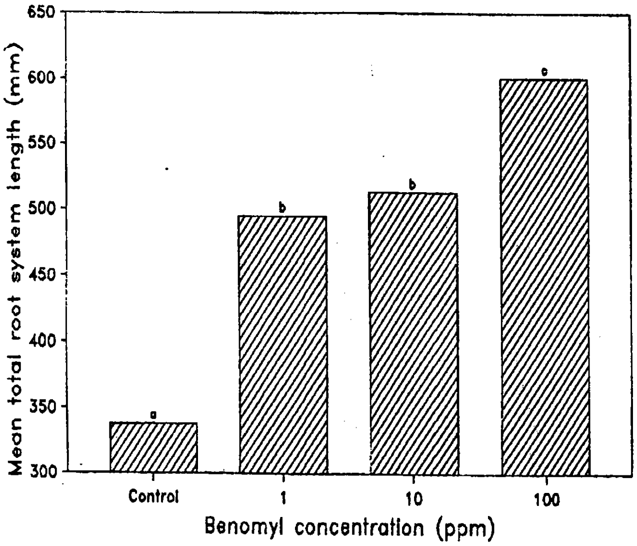
Pre-treatment of outplanted white pine seedlings wih benomyl at near-optimal concentrations can enhance growth and mycorrhiza formation in one growing season. Benomyl treatment may therefore have potential as a management tool to increase the success of reforestation projects.

Laboratory results and discussion:

Four-day-old white pine seedlings were transferred to growth pouches (Fortin *et al.*, 1980) containing 15 mL of a nutrient solution and a benomyl concentration of 1, 10 or 100 ppm; controls containing no benomyl were also started. Two days later, 2 plugs

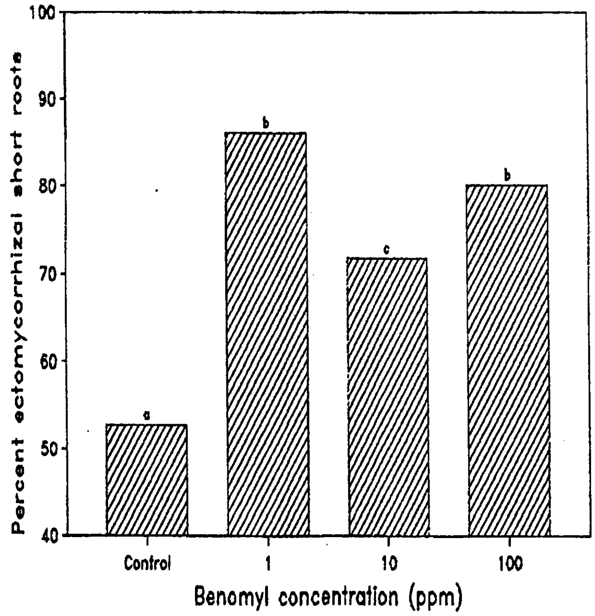
Growth pouch experiment

Figure 8: Influence of benomyl on root growth



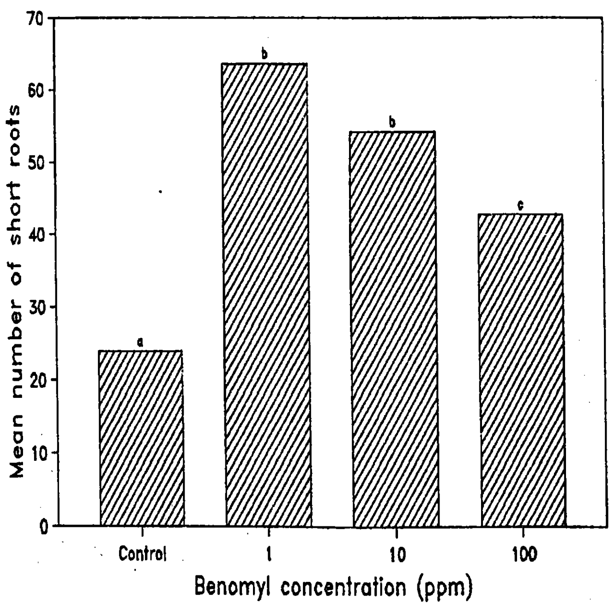
Growth pouch experiment

Figure 10: Influence of benomyl on mycorrhizal development



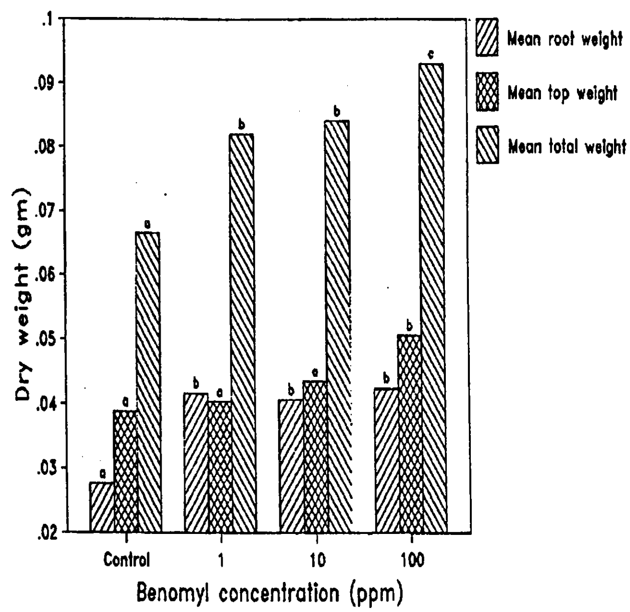
Growth pouch experiment

Figure 9: Influence of benomyl on short root development



Growth pouch experiment

Figure 11: Influence of benomyl on seedling dry weight



each of *Laccaria bicolor* (a mycorrhizal species) and *Mycelium radicis atrovirens* (a root pathogen) were placed beside each root system. The seedlings were grown for 3 months and then harvested. Measurements of pathogen damage (root damage and mortality) and host growth (dry weight, root length and short root counts) were taken. The percentage of mycorrhizal short roots was also determined. Results were analyzed with ANOVA and other tests of significance and graphed (Figs. 6 to 11).

Benomyl treatment improved seedling resistance to pathogenic infection at all of the concentrations tested. Seedling survival, primary root vigour and the number of seedlings producing lateral roots all increased with increasing benomyl concentration (Fig. 6). Both the total number of lateral roots formed (Fig. 7) and total root system length (Fig. 8) increased with increasing benomyl concentration. Total seedling dry weight was significantly greater than controls at all concentrations and increased with increasing benomyl concentration (Fig. 11). Ectomycorrhiza formation was enhanced compared to controls at all of the benomyl concentrations tested (Fig. 10), even though the formation of short roots (the potential sites of mycorrhiza formation) was greatest in control roots and declined with increasing benomyl concentrations (Fig. 9).

Within the range of 1 to 100 ppm, benomyl suppressed pathogen infection of white pine and enhanced both mycorrhiza formation and seedling growth. These beneficial effects of benomyl treatment may be the result of (1) direct stimulation of tree growth, (2) improved tree growth resulting from suppression of a pathogen, (3) enhanced growth of the mycorrhizal fungus, or (4) of some combination of the foregoing factors.

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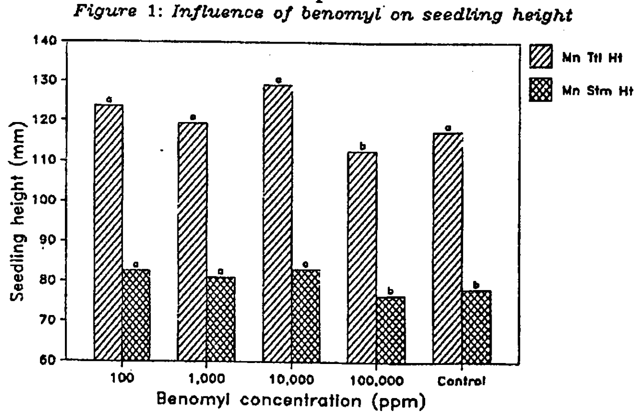
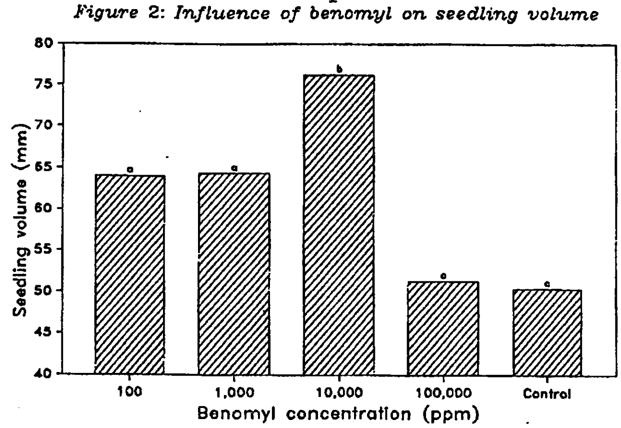
Field experiment

Figure 1: Influence of benomyl on seedling height



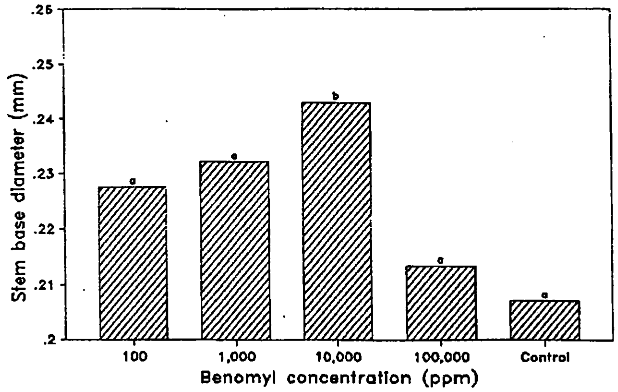
Field experiment

Figure 2: Influence of benomyl on seedling volume



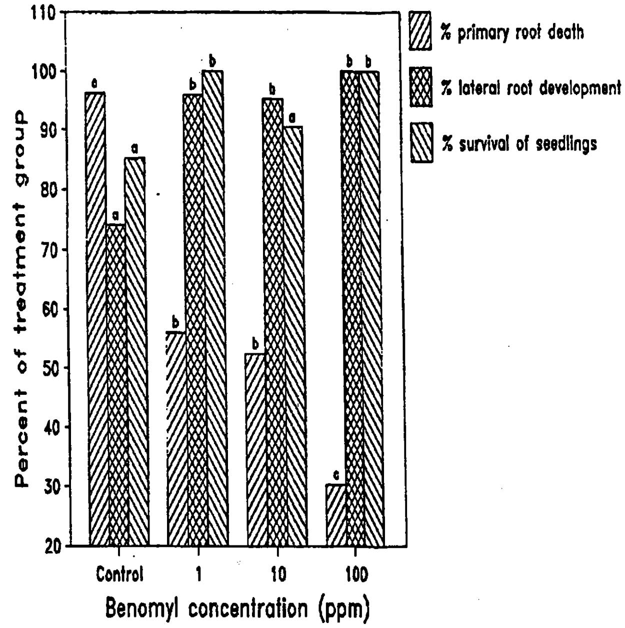
Field experiment

Figure 3: Influence of benomyl on stem base diameter



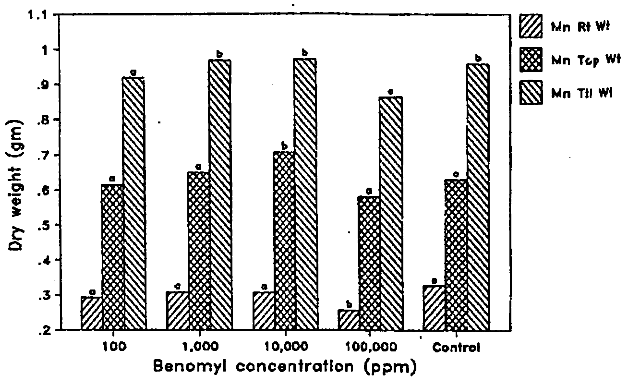
Growth pouch experiment

Figure 6: Influence of benomyl on root development



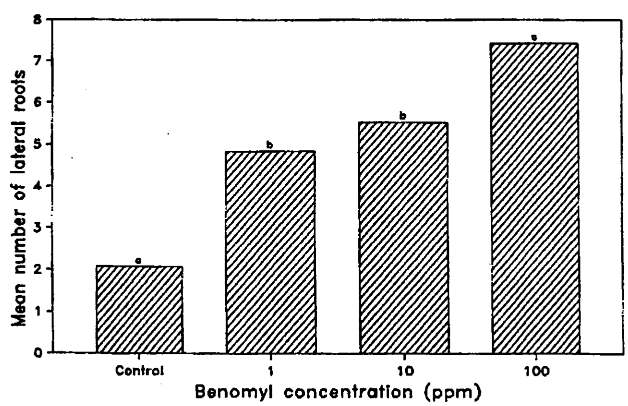
Field experiment

Figure 4: Influence of benomyl on seedling growth



Growth pouch experiment

Figure 7: Influence of benomyl on lateral root growth



Field experiment

Figure 5: Influence of benomyl on mycorrhization