GROWTH RESPONSE OF PINUS CARIBAEA TO CUPRIC CARBONATE AND CONTAINER VOLUME[1]

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Abstract.--Container volume and $CuCO_3$ affected shoot growth and root development of greenhouse-grown Pinus caribaea seedlings. Container volumes of 41, 165, 350 and 740 cm^3 were tested in conjunction with $CuCO_3$ pruning treatments. The chemical root pruner was applied using latex acrylic paint to container walls at concentrations of 0, 25, 50 and 100 g/l. Effects of container size on seedling height growth and root collar diameter were evident eight weeks after sowing. After 10 weeks, seedlings grown in the 740-cm^3 containers were largest and continued to accumulate biomass after 16 weeks when root growth in the smaller containers became negligible.

Cupric carbonate caused proliferation of secondary and higher order laterals but did not influence the number of primary lateral roots. Latex paint and $CuCO_3$ equally stimulated seedling growth , but the addition of $CuCO_3$ was necessary to prevent root deflection. At 25 g/l, $CuCO_3$ effectively pruned lateral roots in 41- and 165-cm^3 containers throughout the experiment. However, the 50 or 100 g/l levels were required to produce similar results in 350- and 740-cm^3 containers.

Additional keywords: Pinus caribaea, chemical root pruner, container seedlings, root modification.

INTRODUCTION

Forest tree seedlings are grown in containers worldwide to provide reforestation planting stock. Containerization is particulary useful in tropical regions where climate precludes the use of dormant bareroot nursery seedlings. Additional advantages of containerization include accelerated seedling growth and closely supervised growing conditions. However, tree seedlings commonly have malformed root systems when grown in containers lacking inner wall ribs to prevent root spiralling. Plantations fail when tightly coiled, strangulated roots severely restrict growth, or fail to anchor young trees. Failures are most evident in

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developing countries where low cost, ribless containers are used to regenerate tropical pine forests (Bell, 1978). Studies have shown that root morphology can be controlled by the judicious use of root pruning chemicals and appropriate container volume. Root pruning chemicals have reduced considerably the occurrence and severity of root malformation (Burdett, 1978; Pellett et al., 1980; McDonald et al., 1984 a). Because growth is arrested when main lateral roots contact the pruning compound, roots do not deflect down the container wall or form a contorted root mass. Root pruning also enhances the development of feeder roots and subsequent seedling growth. Because seedling size is directly related to container volume, rooting volumes poorly matched with production schedules result in stunted, root-bound seedings (Endean and Carlson, 1975). Container volume influences transplant survival, evidenced by southern pine seedling survival data reported by Amidon et al., 1981. This study examined the effects of container volume, $CuCO_3$ and latex paint treatments on the growth and root development of greenhouse-grown Pinus caribaea seedlings. The study specifically addressed the interaction of $CuCO_3$ and container volume over time to examine relationships ignored by previous work.

MATERIALS AND METHODS

A bulked lot of Pinus caribaea seed was obtained from the seed bank at the Escuela Nacional de Ciencias Forestales, Honduras. Seedlings were grown in Spencer-Lemaire book planters (Table 1). Cupric carbonate ($CuCO_3$) was mixed with exterior Pittsburgh acrylic latex paint and applied to container walls at 0, 25, 50 and 100 g/l of paint. An additional control treatment omitted paint and $CuCO_3$.

Table 1. Dimensions of book planter containers used to determine Pinus caribaea seedling response to experimental treatments.

Container	Vol.(cm^3)	Length (cm)	Growing Density ($No./m^2$)
Ferdinand	41	9.5	1,500
Hilson	165	11.0	524
Tinus	350	20.0	336
Super 45	740	25.0	228

Containers were sown at 2-week intervals to combine each container-$CuCO_3$ level combination with eight harvest ages: 8, 10, 12, 14, 16, 18, 20 and 22 weeks. The growing medium was a 1:1 (v/v) mix of peat and vermiculite. After germination was complete, seedlings were irrigated on alternate days with Hoagland's complete nutrient solution.

Data recorded at harvest included root collar diameter (RCD), shoot biomass and height. Root measurements were performed on stored, frozen samples. All primary lateral roots emanating from each seedling were counted. Root fresh weights were recorded for each 4-cm segment of tap root. For each segment, the proportion of pruned roots was qualitatively scored, with 0 = no pruned roots, 1 = $\leq$ 25 % pruned, 2 = > 25, < 50 % and 3 = $\geq$ 50 %.

RESULTS

Seedling height growth and RCD were much less for the 41-cm^3 container than for other containers at 8 weeks. After 10 weeks, seedlings grown in 740-cm^3 containers were largest and continued to accumlulate dry matter after 16 weeks when root growth in the smaller containers became negligible (Fig. 1). Container volume did not influence root/shoot ratio.

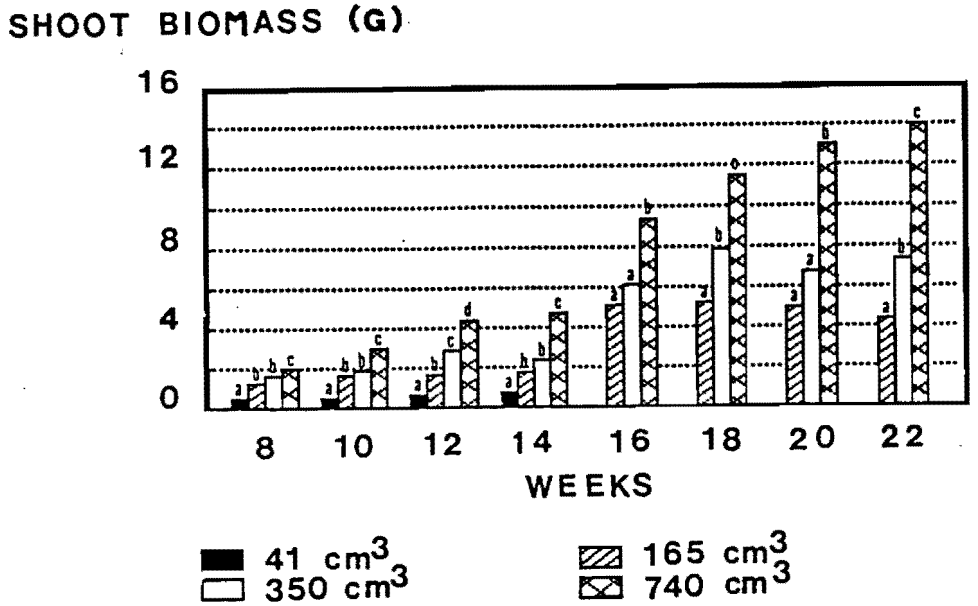
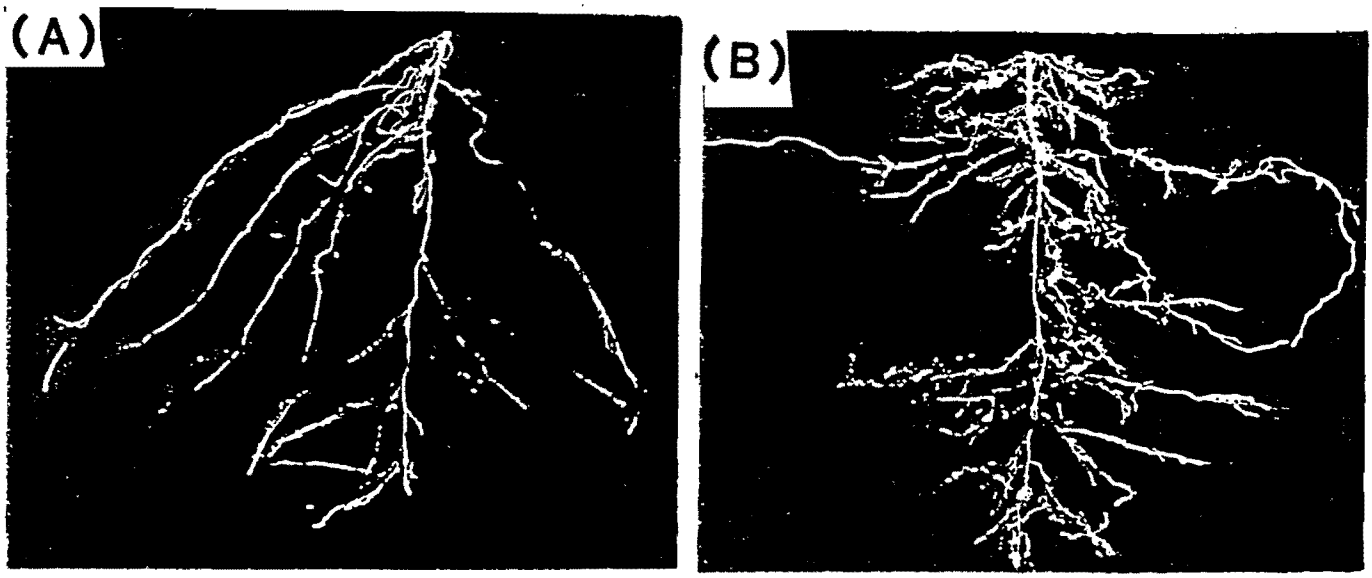


Figure 1-- Effects of container volume on Pinus caribaea seedling shoot growth over time, averaged over all $CuCO_3$ levels. Data for 41-cm^3 container not included in analysis after 14 weeks. Different letters indicate significant differences at P= 0.05, as determined by LSD.

Cupric carbonate did not affect the number of primary lateral roots. However, $CuCO_3$ effectively pruned laterals and caused proliferation of secondary and higher order laterals (Fig. 2). Cupric carbonate significantly increased the proportion of stunted roots at all ages, confirming earlier reports (Burdett, 1978; McDonald et al., 1984a, 1984b; Ruehle, 1985).

Figure 2-- Pinus caribaea seedling root response to control treatment (A) and $CuCO_3$ applied at 50 g/l (B). Seedlings were grown in 740-cm^3 containers for 14 weeks.



Applied at 25 g/l, $CuCO_3$ effectively pruned a high percentage of lateral roots in 41- and 165-cm^3 containers throughout the experiment. However, at 20 and 22 weeks, the 50 or 100 g/l levels were required to produce similar results in 350- or 740-cm^3 containers (Fig. 3). Seedling shoot biomass was equally stimulated by latex paint and $CuCO_3$ (Fig. 4). Seedling height and RCD responded similarly. Root biomass was affected by paint and $CuCO_3$ treatments only at 22 weeks, with root biomass in paint and 25 g/l $CuCO_3$ treatments being significantly greater than the control treatment. Paint only did not prevent lateral root elongation down container walls.

Figure 3-- Percent roots pruned of Pinus caribaea seedlings to $CuCO_3$ x container volume interaction at 20 weeks. Open= 165 cm^3, hatched= 350 cm^3 and solid= 740 cm^3 container volume. Letters as in Fig. 1.

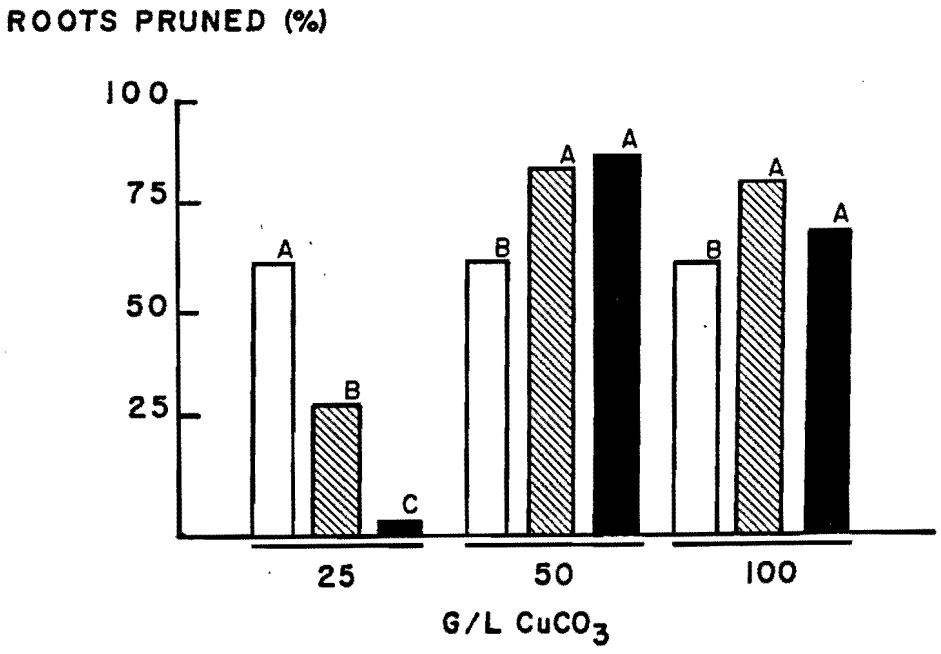
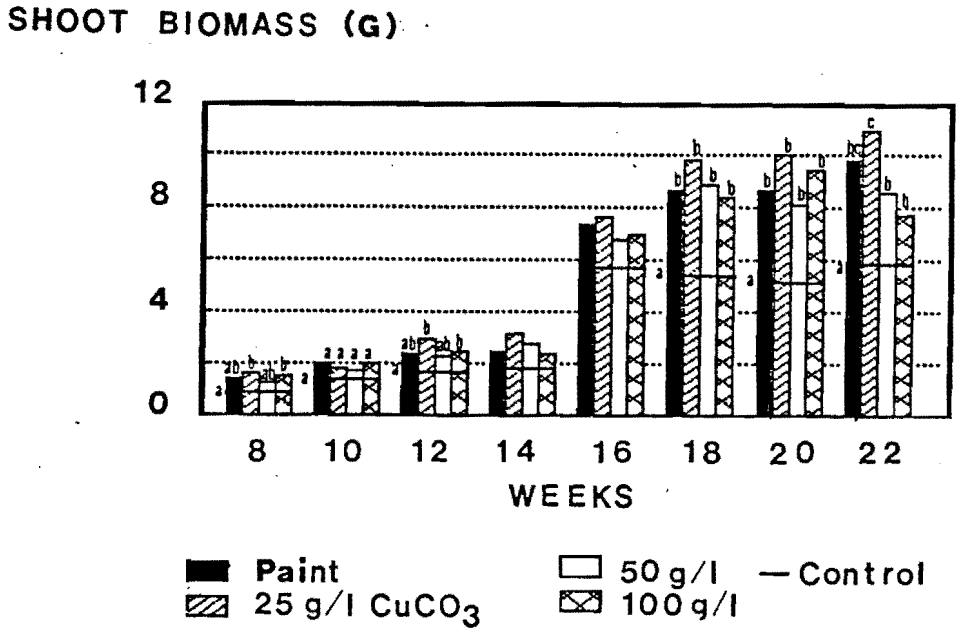


Figure 4-- Effects of $CuCO_3$ on Pinus caribaea seedling shoot biomass over time, averaged over container volumes. Letters as in Fig. 1.



DISCUSSION AND CONCLUSIONS

Unlike Ruehle's finding, $CuCO_3$ did not increase the number of primary lateral roots. However, $CuCO_3$ positively modified P. caribaea root morphology. Long and deflected lateral roots were absent, even with the lowest $CuCO_3$ level applied. Essentially, root weights of seedlings treated with $CuCO_3$ did not differ from the control because the secondary, tertiary and higher order lateral roots stimulated by $CuCO_3$ offset the loss of pruned primary roots. The increased number of feeder roots enhanced growth, evidenced by greater RCD, shoot height and biomass of seedlings exposed to $CuCO_3$. A positive growth response to $CuCO_3$ agrees with similar findings reported by McDonald et al. (1984a, 1984b).

Overall, increased container volume significantly enhanced P. caribaea seedling RCD, root biomass and shoot height and biomass. Additionally, the data support the view that RCD is a function of container volume. Root/shoot ratio was unaffected by container volume, indicating that increases in volume produce proportional increases in roots and and shoots. Root/shoot ratio was decreased by $CuCO_3$ at several seedling ages because $CuCO_3$ increased shoot biomass over controls without affecting root biomass.

Clearly, seedlings should be grown in 740-cm^3 containers if the production cycle extends beyond 16 weeks. However, plantable seedlings were also produced in the 165- and 350-cm^3 containers, which may be better suited to large scale production.

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