ROOT MORPHOLOGY CONTROL IN FOREST TREE SEEDLING CONTAINERS 1

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ABSTRACT

Controlling seedling root morphogenesis in containers with chemicals can result in seedlings which rapidly establish natural root systems following outplanting. Copper and synthetic auxin compounds placed on the interior walls of containers reversibly stop root growth at the container wall. This has resulted in an adventitious proliferation of root tips up and down the root plug cylinder. These tips grow radially outward from the plug when the trees are planted so that many growing points penetrate the soil at various soil depths. As a result, trees should become rapidly established, be better anchored, and grow faster.

INTRODUCTION

Tree seedlings grown in forest tree containers frequently become stunted or die several years following outplanting (Helium 1978). Sometimes they become prone to windthrow (Chavasse 1978). These and other problems with tree growth following outplanting often occur not only with container seedlings, but also with bare-root trees (Van Eerden and Kinghorn 1978). Root system deformities are thought to be the prime cause. These deformities seem to fall into two categories for containerized stock:

1. Root tips are concentrated in the bottom of the planting hole and grow into the soil only at the bottom of the hole following outplanting.
2. Roots penetrate the soil only to a limited extent following outplanting, and form an increasingly compacted mass in the original root plug area.

Is there a way to grow trees at the nursery to prevent these field problems?

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In 1978, Dr. A. N. Burdett (1978) of the BCFS Research Division, Victoria, Canada, reported that copper carbonate in acrylic latex paint applied to container walls would reversibly stop root growth at the wall. This was done by mixing a small amount of copper carbonate (30 to 100 g/1) with acrylic latex paint and painting the inside of the container with the mixture before growing the trees in it. When their tips reached the wall of the containers, many of the lateral roots of the seedlings stopped growing instead of turning and continuing to grow down the walls to the root egress hole. The laterals that stopped often developed a series of adventitious roots. These roots also stopped growth at wall contact. The result was a series of root tips at the container wall. Upon removal from the container, these root tips resumed growth outward from the sides of the root "plug." This lateral root growth promised better lateral anchorage and access to water and nutrients and suggested such root morphogenesis control could be a feasible operational procedure. Accordingly, a cooperative research effort between the U.S. Forest Service and Colorado State University was started to validate Burdett's work and extend knowledge about the technique.

PROJECT DESCRIPTION

The goal was to control seedling root development in nursery containers so root growth following outplanting would take place rapidly and in a more or less natural pattern. Factors to be manipulated were (1) root density in the container, (2) mechanical configuration of the container, and (3) chemical applications to the interior walls of the containers. The first stage, being reported on here, sought to (1) corroborate Burdett's work, (2) evaluate the possibility of using other root growth inhibitors the same way, and (3) to check the effects of these inhibitors over a range of concentrations.

MATERIALS AND METHODS

Spencer-Lemaire 30 cu. in. bookplanters[R] were used in the rate spectrum test. When laid out flat the interior of this type of container is easily painted with a brush. Three chemicals were mixed with the paint:

1. copper carbonate ($CuC03$).
2. indole-3-butyric acid (IBA), a synthetic auxin which has been shown to inhibit root growth in many plants at concentrations in excess of 10^{-7} to 10^{-13}M (Salisbury and Ross 1978).
3. trifluralin herbicide (Eli Lilly's Treflan EC) which inhibits root growth (Nussbaum 1969).

These chemicals were used in the following treatments:

Additive	White Paint[1/]	Black Paint[1/]
None	No paint	No paint
None	Paint only	Paint only
Copper	100 g/1	-[2/]
Copper	10 g/1	-
Copper	3 g/1	-
Copper	1 g/1	-
IBA	50.0 g/1	50.0 g/1
	5.0 g/1	5.0 g/1
	0.5 g/1[3/]	0.5 g/1
	0.05 g/1	0.05 g/1
	0.005 g/1	0.005 g/1
	0.0005 g/1	0.0005 g/1
Treflan	70.88 g/1[4/]	70.88 g/1
Treflan	14.18 g/1	14.18 g/1
Treflan	2.84 g/1	2.84 g/1
Treflan	0.56 g/1	0.56 g/1

1/ Because IBA and Treflan degrade in light and paint pigment differences may affect results, two colors were employed.

2/ Only a white paint treatment was used, since CuC03 is not affected by light.

3/ Approximately 10^{-2}M.

4/ The recommended herbicide dose for silt soils (grams per liter of spray solution) would equal about .12 cc per liter of solution.

The solutions in the tabulation were applied to the inside of the containers, the paint allowed to dry, and the containers filled with growing medium. Ponderosa pine (Pinus ponderosa LAWS.) seeds were placed in the cavities and covered with a thin layer of perlite. There were three replications of four cavities (three books) for each treatment. The replications were randomly placed in wire container rocks and put into a greenhouse for germination and growth. Seeding and culture of the seedlings followed directions in Tinus and McDonald (1979).

When the seedlings were judged to be of plantable size and had enough root development to provide a cohesive root plug, the trees were removed from the containers. Half were transplanted to a greenhouse bench filled with moist vermiculite for continued growth. The growing medium was gently removed from the roots of the other half. Shoot height, number of needles, needle length, dry weight shoot, dry weight root, the number of roots deflected downward at the wall, and the number of roots reaching the egress hole were measured or counted.

RESULTS

The principle results of this work were:

1. Treflan had a deleterious effect on seedlings at all concentrations. It was dropped.

2. There was little difference between trees grown in black versus white containers.

3. At 100 g/l, copper carbonate was effective in limiting root downturn at the wall as shown below:

$CuCO_3$ Concentration (g/l)	Root Deflected	Roots at Egress Hole
0	12.2	21.5
1	7.5	18.5
3	9.0	20.3
10	9.7	21.5
100	3.7	13.2

In addition, the copper carbonate appeared to stimulate growth as the concentration increased:

4. At 50 g/l the IBA effect was similar to CuC03, but not quite so strong. At lower concentrations there was some growth stimulation.

$CuCO_3$ Concentration (g/l)	Height(cm)	Dry Weight Shoot (g)	Dry Weight Root (g)
0	44.2	0.48	0.35
1	48.7	0.60	0.39
3	54.8	0.92	0.54
10	54.8	0.81	0.48
100	65.2	1.00	0.61

5. After removal of the seedlings from the containers, the IBA and CuC03 coatings were still in very good condition and could probably have been used several times more.

The other half of the trees, previously removed from their containers and planted in moist vermiculite, were grown for about five weeks (11/29/79-1/9/80). They were then removed from the growing medium and the total length of each new side or bottom root was measured. The length of side roots as a percentage of total root length was calculated as shown below:

$CuCO_3$ Treatment (g/l)	Side Roots as Percent of Total Roots
0	7.8
1	4.7
3	12.1
10	12.0
100	27.1

IBA Treatment (g/1)	Side Roots as Percent of Total Roots
0	9.4
0.0005	13.3
0.005	5.2
0.05	12.9
0.5	11.7
5.0	18.9
50.0	34.3

DISCUSSION

The prime variable not addressed in the work reported here is root density in the container, a function of growing time. Root crowding in the container may strongly affect how roots develop after trees are outplanted. Work currently underway addresses this question by comparing $CuC0_3$ and IBA wall coatings and lateral root egress holes with various degrees of root development of ponderosa pine. We hope to determine a container treatment - degree of root development combination that will allow seedlings to develop a natural, or better than natural, root system. Other work in progress includes:

1. Finding the actual concentration of copper and IBA ions which cause the root growth inhibition at the container wall.
2. Developing methods for quickly screening a variety of other ions and ion concentrations for temporary root inhibition. The object is to find cheaper, possibly more effective, chemicals to use.
3. Perhaps there will be higher mycorrhizal infection rates in chemically treated seedlings. This should follow, since there are more root tip growing points for mycorrhizal fungi to inhabit. Tests are being conducted with *Pisolithus tinctorius* and *Suillus granulatus* fungi (in cooperation with S. Grossnickle, College of Forestry, Colorado State University).

SUMMARY

There is potential for development of container seedlings that will have root tips, pointing outward and ready to grow, all over the surface of the root plug. Upon planting, the rapid extension of these roots into surrounding soil could very quickly produce a root system as good as, or better than the root system of a tree seeded in place. Roots would grow into the upper soil layers for good lateral force resistance and absorbtion of nutrients as well as downward. Such trees would be healthier, become fully established faster, and be less prone to windthrow in later life. Much more research needs to be done, but initial results are very encouraging.

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