First-season growth of lodgepole pine seedlings grown in three different container types and planted on landings, or on burned or unburned sites

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INTRODUCTION

Good root growth following outplanting is important, but it does not always occur, especially on difficult sites. Most conifer seedlings produced in British Columbia are grown in Styrofoam® containers with conical cavities. In the nursery, major roots grow down the sides of untreated cavities and consequently, most new root growth following outplanting occurs from the bottom of the plug (Balisky et al. 1995). These roots emerge into soils that are colder and have lower nutrient levels than soils closer to the surface. This is a problem especially for lodgepole pine (*Pinus contorta* Dougl. ex Loud.) seedlings because they do not produce adventitious roots from the root collar (Balisky et al. 1995). To overcome this problem, most lodgepole pine seedlings produced in the province are now grown in copper-treated Styrofoam containers. The copper arrests the growth of the roots when they hit the sides of the cavity. Following outplanting, new roots extend laterally out from the sides of the plug, rather than straight down from the bottom.

In the last several years, concerns have been raised about copper leaching into water supplies from the treated styroblocks. Newly introduced containers have cavities with vertical slits. These air-vent blocks are intended to air-prune the roots as they reach the edge of the cavity. The major objective of this study was to evaluate the development and field performance of pine seedlings grown in air-vent blocks compared to those grown in untreated and copper-treated styroblocks, using both morphological and physiological criteria. Seedlings were planted in different rooting environments to determine whether root system development was differentially affected by container type in the different environments.

Many morphological and physiological criteria have been used as indicators of nursery stock quality, but tests currently used operationally are not sophisticated enough to correlate with field performance (Mohammed 1997). We have selected several tests which measure performance attributes, such as drought stress resistance, root growth capacity, and root viability (Mattsson 1997) to determine whether they can be used to predict field performance.

MATERIALS AND METHODS

Lodgepole pine seedlings were grown outdoors from April to November in untreated Styrofoam containers, copper-treated Styrofoam containers, or plastic air-vent containers. "Copper" seedlings were

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given photoperiod extension to 21 hours for 5 weeks to encourage the development of secondary needles. Seedlings grown in copper blocks were separated into those with primary needles (copper-1) and those that had developed secondary needles (copper-2). All other stock types had primary needles only. Following lifting, seedlings were stored at 2°C in the dark for 27 weeks.

In March, 1998, 30 randomly selected seedlings of each type were removed from cold storage and tested for:

- root carbohydrate status;
- drought tolerance;
- root viability (triphenyl tetrazolium chloride [TTC], Steponkus and Lanphear [1967]); and
- location of active root apical meristems (Root Growth Capacity test: 10 days at 24°C, with watering to run-off every 3 days).

In May, 1998, 50 seedlings of each stock type were planted into three replicate plots in each of three planting environments: screefed microsites; burned, unscreefed sites; and ripped landings. In September, 1998, shoot height and root collar diameters of 20 seedlings per treatment per plot were assessed. Data were analyzed by one-factor or two-factor ANOVA.

RESULTS AND DISCUSSION

- Root viability, as measured by TTC, was highest in root systems grown in the air-vent containers and lowest in untreated Styrofoam containers ($p < 0.0001$).
- The air-vent containers were even more effective than copper-treated blocks in allowing root egress from the top of the plug (Figure 1). The total number of new white roots produced was not affected ($p < 0.05$) by container type.
- Injury from drought stress was lowest in primary-needle seedlings from the copper-treated

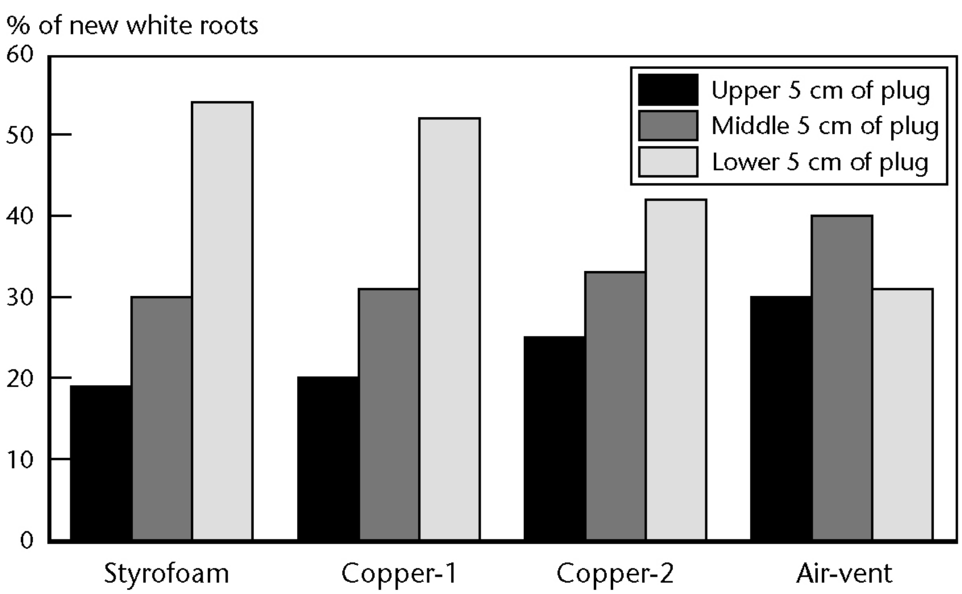

FIGURE 1 *Location of new root growth after 10 days under optimal conditions (Root Growth Capacity test). A one-factor ANOVA detected differences amongst containers at* $p < 0.0001$ *for each location.*

containers. Injury in air-vent seedlings was similar to that of the other three groups of seedlings ($p = 0.03$ for % needle injury; $p = 0.006$ for % root injury).

- Differences in response to drought stress were not due to differences in the levels of total soluble carbohydrates or starch in the roots of the seedlings. No differences were detected in these variables ($p < 0.05$).
- After one season of growth in the field, air-vent and primary-needle copper seedlings were taller than secondary-needle copper seedlings or seedlings grown in untreated Styrofoam containers (Table 1). No differences in root collar diameter were observed.
- Seedlings planted on the cutblock grew better than seedlings on the landings; the differences in needle length were especially marked (Table 1). Needle length was longer on burned sites than on screefed unburned microsites. There were no interactions between container type and planting location.

Our interim conclusions from the first part of this study are that the air-vent containers would be an appropriate substitute for copper-treated Styrofoam. Seedlings grown in these containers were comparable to, or better than, copper seedlings in root distribution and shoot growth in the field. Root viability, as measured by TTC, was the best predictor of height increment during the first growing season. Root carbohydrate status and drought stress resistance were poor predictors.

The next phase of the project tests interactions between microbial inoculants and container types, and will compare growth on rehabilitated and non-rehabilitated landings.

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TABLE 1 *Field assessment of lodgepole pine seedlings planted in late May, 1998 on screefed unburned or unscreefed burned sites, or on ripped landings. Assessments took place in early September, 1998*[a].

Stock/ treatment	Height at planting (cm)	Height increment (cm)	Total height (cm)	Root collar diameter (mm)	Distal needle length (cm)
PAB-1[b]	13.9 ± 0.4 a	10.5 ± 0.4 a	29.6 ± 0.7 a	4.9 ± 0.1	5.2 ± 0.5
PCT-1[c]	13.0 ± 0.8 b	10.3 ± 0.6 ab	28.7 ± 1.0 a	4.9 ± 0.1	5.3 ± 0.5
PCT-2[d]	10.6 ± 0.2 c	10.8 ± 0.5 a	26.8 ± 1.0 b	4.9 ± 0.1	5.4 ± 0.4
PSB-1[e]	12.5 ± 0.3 b	9.1 ± 0.5 b	27.1 ± 0.9 b	4.8 ± 0.1	5.5 ± 0.4
p[f]	0.0011	0.0020	0.0022	0.50	0.76
Screefed	12.3 ± 0.5	10.8 ± 0.4 a	29.2 ± 0.5 a	5.0 ± 0.1 a	6.0 ± 0.3 b
Burned	12.7 ± 0.6	10.1 ± 0.3 a	29.4 ± 0.6 a	5.1 ± 0.1 a	6.7 ± 0.2 a
Landings	12.4 ± 0.6	8.1 ± 0.2 b	24.1 ± 0.6 b	4.6 ± 0.0 b	3.6 ± 0.1 c
p[f]	0.85	0.0001	0.0001	0.0001	0.0001

a Within a column, numbers followed by different letters differ at $p = 0.05$.
b Seedlings grown in air-vent blocks.
c Seedlings grown in copper-treated styroblocks under extended photoperiod; had primary needles at lifting.
d Seedlings grown in copper-treated styroblocks under extended photoperiod; had secondary needles at lifting.
e Seedlings grown in untreated styroblocks.
f Results of two-way analyses of variance, with stock type and planting location as factors; no significant interactions between the two factors.

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