BOX-PRUNING THE ROOTS OF CONTAINER-GROWN TREE SEEDLINGS

A.N. Burdett'

Abstract.--The use of planting stock with a box-pruned root system can reduce or prevent mechanical instability in plantations of susceptible pine species. It can also increase early height growth. This paper describes both chemical and mechanical root pruning techniques for the production of container stock with a box-pruned root.

Résumé.--L'utilisation de semis dont les racines ont été élaguées dans les contenants peut réduire ou empêcher l'instabilité mécanique dans les plantations d'essences de pins fragiles et peut même augmenter la croissance en hauteur précoce. Cette communication décrit à la fois des méthodes chimiques et mécaniques d'élagage des racines pour la production de ce type de semis.

INTRODUCTION

Mechanical instability in planted lodgepole pine *(Pinus contorta* Dougl.) and some other species of pine has been associated with the effects of nursery culture and planting on root form (Clarke 1956, Chavasse 1978, Burdett 1979). Instability leading to toppling or windthrow appears to be particularly severe in plantations established with container-grown stock (Burdett 1979). To eliminate the characteristic effect of the container on root form and thereby improve stability after outplanting, a chemical root pruning technique has been developed for the production of lodgepole pine container stock with a box-pruned root system (Burdett 1978). The technique involves the use of seedling containers coated on the inside with latex paint containing cupric carbonate. Contact with the wall coating is inhibitory to root growth. Thus, instead of growing down or around the container wall, lateral roots reaching the side of the container cease to elongate. The result is a tree with a box-pruned root system.

[1]Research Scientist, Ministry of Forests, Research Branch, Victoria, British Columbia.

This paper reports the effect of this root pruning technique on root morphogenesis and height growth in field planted lodgepole pine. Limitations on the use of the technique for lodgepole pine and other species are indicated. A versatile mechanical root pruning technique for box-pruning the roots of container-grown stock is also described.

METHOD

In 1977 three provenances of lodgepole pine were grown in both copper painted and unpainted styroblock containers at the B.C. Ministry of Forests Skimikin Nursery near Salmon Arm. The containers were 2 cm in diameter, 11 cm deep and had a volume of 30 cm^3. The copper paint was prepared as follows. One kilogram of basic cupric carbonate powder (malachite) was slurried with 5 L of water. The slurry was then mixed into 10 L of white exterior latex paint (Baprok paint supplied by Bapco Paint Co., a subsidiary of Canadian Industries Limited). The styroblock containers were subsequently coated with copper paint by dipping them. When the paint had dried, the containers were filled with a 3:1 peat:vermiculite mix containing 3 kg/m^3

of dolomitic lime (12 mesh and finer). The pH of the peat was about 3.5 and the pH of the mix between 4.5 and 5.0. The containers were seeded in April. Germination took place in a heated greenhouse, after which the containers were moved outdoors. Nutrients were supplied twice weekly with the irrigation water. The trees were extracted from the containers in November and cold-stored until spring.

RESULTS AND DISCUSSION

In the spring of 1978, seedling samples were planted at two locations, Lassie Lake in the Nelson Region and Devick Lake in the Kamloops Region. First season survival and growth of the chemically root-pruned stock was virtually identical to that of the non-root-pruned plug stock (Table 1).

Table 1. First season survival and growth of 1-0 lodgepole pine from copper painted and unpainted styroblock containers.

Location	Container	Survival[a] (%)	Growth[a] (cm)
Kamloops	unpainted	96.4	--
	copper-painted	95.4	--
Nelson	unpainted	100.0	3.8
	copper-painted	97.3	3.7

[a]Mean values for three provenances. At each location there were four or six replicates of 25 trees of each provenance from unpainted containers, and two or three replicates of 25 trees of each provenance from copper painted containers.

Major differences in root form were revealed by excavation of seedlings in the second and fourth years after planting. In the plug seedlings which had not been root-pruned, few roots emerged from the root plug except at the bottom (Fig. 1). However, in the chemically root-pruned stock the main lateral roots emerged from the uppermost part of the root plug very close to the soil surface (Fig. 2). The trees with the box-pruned roots had developed a root system comparable in form with that of a naturally established tree (Fig. 3).

As yet the trees in these plots average less than 1 m in height and therefore are not at the stage when they might be expected to topple. In view of the effect of the root pruning treatment on root morphogenesis it may confidently be predicted, however, that if toppling does occur it will be largely, if not entirely, restricted to the trees that were not chemically root pruned.

In the first two years after planting, shoot extension in the chemically root-pruned trees was comparable with that of the regular plug stock. In the third and fourth years, however, height growth in the chemically root pruned stock was 15% greater than in the conventional plug seedlings (Table 2). A preliminary analysis of the fourth year height growth data, based upon the treatment means, indicates that the effect is highly significant.

Table 2. Annual height growth of chemically box-pruned and unpruned lodgepole pine plug seedlings planted at Lassie Lake, Nelson Forest Region.

Year	Mean increase in height[a] Pruned (cm)	Unpruned (cm)	Pruned as % of unpruned
1	3.7	3.8	97
2	9.3	9.0	103
3	23.6	20.6	115
4	29.3	25.6	115

[a]Mean values for three provenances. At each location there were four or six replicates of 25 trees of each provenance from unpainted containers, and two or three replicates of 25 trees of each provenance from copper painted containers.

The practical significance of this effect depends on its reproducibility and persistence. Its potential significance is indicated by consideration of the fact that, with the first generation of seed orchards, it is expected that a lodgepole pine improvement program in B.C. will achieve something like a 10% increase in rate of height growth (Dr. C. Ying, personal communication). It is possible, therefore, that because of a difference in root form, genetically improved lodgepole pine established by conventional planting techniques will grow more slowly than unimproved trees established naturally. In plantations where there is some natural regeneration the result of this could be the removal of the genetically improved planted trees when the stand is spaced.

Experience with lodgepole pine suggests that the chemical root-pruning technique is useful only when the container is small. The reason for this is that, by the time an extractable plug has been formed in a large container, a second order lateral root,

Figure 1. Root of an ordinary lodgepole pine plug seedling two seasons after planting.

Figure 2. Chemically box-pruned root of a lodgepole pine plug seedling two seasons after planting.

Figure 3. Chemically box-pruned root of a lodgepole pine plug seedling two seasons after planting (right) compared with the root of a naturally established tree.

growing from near the tip of the chemically inhibited first order lateral, will have developed into a major sinker root. This root, being either ageotropic or positively geotropic, grows directly downwards close to, but not in contact with, the container wall. Thus the tree acquires an array of major lateral roots growing down the sides of the root plug which are similar in appearance, though not in origin, to the main lateral roots of an ordinary plug seedling. Moreover, when the tree is planted, the second order sinker roots extend vigorously from the bottom of the root plug while the chemically inhibited first order laterals remain inactive. Whether the failure of the first order lateral roots to elongate after planting is due to correlative inhibition--the well developed second order sinker roots exerting dominance over the chemically inhibited primary roots--or to the abortion of the primary root meristem has not been determined. In either case, the result is that the chemically root-pruned seedling is unable to form a system of major lateral roots growing straight out from the tap root.

In order to assess the influence of the characteristic effect of container growing on root form on the performance of species other than lodgepole pine, the chemical root pruning technique has been tested on nine other coniferous species. Without modification, however, the technique used with lodgepole pine was fully effective only with Scots pine *(Pinus sylvestris* L.). Experiments currently in progress indicate that by increasing the copper content of the wall coating or by reducing the lime content of the growing medium the treatment may be made effective with a number of western conifers. Much remains to be done, however, to define the conditions necessary for a satisfactory result in each species.

That the chemical root pruning technique is not universally applicable without modification constitutes a major limitation to its usefulness. For this reason a more versatile mechanical root pruning technique for box-pruning the roots of container-grown stock has been devised. The method depends upon the use of a slot-sided tray in which seedlings are grown on a grid-spacing. To prune the roots the tray is passed under a set of knives which pass through the slots in the sides of the tray and between the rows of trees (Fig. 4). After the first pass, the tray is rotated through 90° and passed under the knives again. In this way the roots of each seedling are cut on four sides. It is possible with this technique to produce stock of any species and size with a box-pruned root system. By judicious timing, the root pruning treatment should provide a means of controlling height growth, top:root ratio, and possibly root growth capacity.

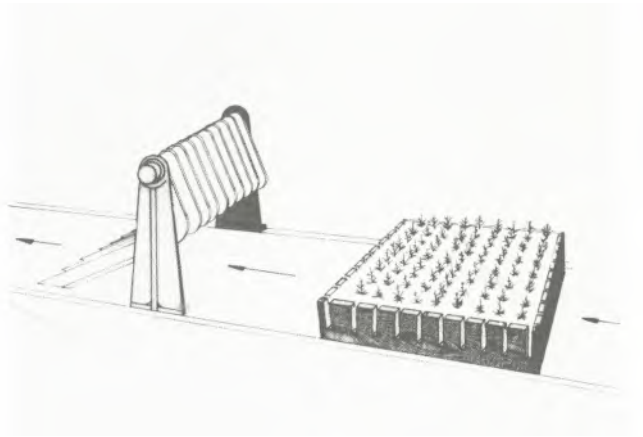

Figure 4. A mechanical system for box-pruning the roots of container-grown stock.

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