Air space controls root extension from open-ended containers during seedling production

J. B. SCARRATT

Great Lakes Forest Research Centre
Canadian Forestry Service
Sault Ste. Marie, Ontario

Des espaces d'air contrôlent l'élongation des racines des semis cultivés en godets à extrémité ouverte. La croissance des racines au niveau du fond des godets à extrémité ouverte (tels les godets en plastique) peut être contrôlée de façon efficace durant des périodes longues, si on cultive les semis au-dessus d'un espace libre sur des supports à extrémités perforées.

Ainsi, le degré de contrôle est de beaucoup supérieur à celui obtenu au moyen de la peinture à base de cuivre en plus d'être plus durable. Ce système empêche également la formation des racines en un amas inextricable normalement rencontré dans le fond des boîtes conventionnelles, et élimine par le fait même les problèmes de manutention au moment de la plantation.

Les plateaux munis de fond perforé suivant des mailles de $\frac{1}{4} \times \frac{1}{4}$ pouce (5 mm x 5 mm) fournirent un excellent contrôle de l'élongation des racines chez l'épinette blanche (*Picea glauca* (Moench) Voss) et le pin gris (*Pinus banksiana* Lamb./P. *divaricata* (Ait) Dumont) cultivés en godets surelevés du fond du plateau suivant un espace libre de 1 pouce (2.5 cm).

Les pertes du milieu de culture utilisé dans les godets furent enrayerés par l'utilisation d'un papier mince placé au fond du plateau. L'auteur indique que ce contrôle dans l'élongation des racines au moyen d'un espace d'air n'a pas eu d'effets négatifs sur le développement des semis ou sur leur rendement postérieur à la plantation.

Tubed seedling production methods in Ontario have evolved to the point where the general objective is now to grow planting stock 3- to 4-inch high within a period of 12 to 16 weeks from sowing. These are considerably larger and older seedlings than those used in the early operational plantings, where the average period recommended to produce a plantable seedling, often barely past the primary needle stage, was only 30 days for pine and 50 days for spruce (Anon. 1967). Roots growing from the bottom of the tubes were usually of little consequence in the rearing of these 30- to 50-day-old seedlings, but, with larger seedlings and longer production periods, the problem of interlacing roots in the bottom of the holding trays becomes more acute. This leads to loss and damage when seedlings are removed for planting, as well as making it difficult to separate and remove individual seedlings.

Root growth from the bottom of the container can be inhibited by growing tubed seedlings on copper foil or coating the bottom of the holding trays with copper paint (Saul

Practical application

Root elongation from the base of tubed seedlings can be effectively controlled for lengthy periods by growing seedlings over an air space in trays with perforated bottoms. By this means the problem of interlacing roots in the bottom of holding trays can be entirely eliminated. The degree of control achieved is far superior to that given by copper paint and is more permanent, while a more desirable form and distribution of roots within the container is obtained as an added benefit. The latter reflects the greatly reduced incidence of circling roots in tubelings grown over an air space, diminishing the risk of root deformation and the subsequent root strangulation which has sometimes been observed with solid-walled containers. There is no evidence to show that the restriction of root elongation has any detrimental effect upon seedling development and performance after planting.

The application of these findings should benefit nurserymen wishing to raise seedlings in open-ended containers where the production periods are relatively long. Mesh size for the perforated tray bottom is not critical but $\frac{1}{4} \times \frac{1}{4}$ inch is a reasonable compromise, permitting free root egress without introducing support problems. A minimum of a 1-inch, well-ventilated air space should be provided beneath each tray. Loss of growing medium through the perforated tray bottom during container loading can be prevented by using a temporary, degradable paper barrier such as Type 1300 Kimwipe.

1968). Although Hocking (1972) has recently reported a reduction in seedling growth resulting from the use of copper, there appear to be no major adverse effects on seedling development or root growth after planting in the field. From 1968 onwards the use of copper-painted holding trays became standard practice in Ontario, providing, for the size of seedlings grown at that time, efficient control of root elongation at little additional cost. However, the copper paint treatment is less effective with older and larger seedlings, because roots eventually find their way under the tube wall producing a root mass in the bottom of the holding tray. The problem is aggravated when seedlings are overwintered. An alternative treatment is required for controlling root elongation over a prolonged period without adversely affecting seedling growth or subsequent performance.

In the study reported here, the practical application of a natural method of restricting root elongation was tested, whereby roots emerging from the bottom of the tube passed through a wire mesh screen into an hostile environment — a ventilated air space — preventing their

further growth. The principle is not new in rearing container stock, and is used to limit root growth outside the package in both the Walters' bullet and the BC/CFS Styroblock. However, open-ended containers such as the Ontario-style plastic tube, paperpots, etc., present a different situation, and this study was undertaken to determine whether the problems associated with excessive root elongation from such containers could be successfully overcome by this means.

Method

Initial tests showed that root elongation from the bottom of the tube could be controlled in white spruce (*Picea glauca* (Moench) Voss) and jack pine (*Pinus banksiana* Lamb. = *P. divaricata* (Ait.) Dumont) tubelings over a 12-week period by growing them in trays with 1/4-inch wire mesh bottoms, provided that an air space was left below the bottom of the tray. Loss of growing medium from the tubes during filling and preparatory handling was the main practical problem encountered, and this, together with more detailed observations of seedling development, was the subject of further study.

Various methods were considered for preventing loss of growing medium from the bottom of the tubes without reducing the effectiveness of root control. Of these, the simplest involved covering the wire mesh screen with a thin barrier before tube loading, with a material that would permit easy root penetration and, preferably, break down during the course of a normal production period. Paper was the obvious choice, and two thicknesses were subsequently tested. One was a single sheet of Kleenex facial tissue¹, the other a single sheet of Type 1300 Kimwipe¹. The former needed care when being placed in the tray bottom, whereas the Kimwipe was better able to withstand the type of rough handling to which it might be subjected in an operational situation.

Root development of jack pine tubelings in the standard 12 1/2- x 6 1/2-inch plastic tray with copper-painted bottom (A) was compared with that of seedlings grown in custom-made trays with perforated bottoms (B-E), viz:

- Tray B — fitted with bottom of 1/10- x 1/4-inch diamond expanded aluminum; no soil barrier,
- Tray C — fitted with 1/4- x 1/4-inch galvanized wire mesh bottom; no soil barrier,
- Tray D — as C, but with Kleenex soil barrier,
- Tray E — as C, but with Kimwipe soil barrier.

The expanded aluminum offered less free space for root emergence than the 1/4-inch wire mesh and made a soil-retaining barrier unnecessary.

Trays B-E were constructed of wood to the same dimensions as the plastic trays and were waterproofed with a coating of wax. All trays accommodated 200 "Ontario" tubes of 9/16-inch diameter and were mounted on corner blocks to provide a 1-inch air space below the tray bottom. This space had to be kept well-ventilated to maintain a low relative humidity, otherwise roots grew into the moist atmosphere which developed. Seedlings were grown for 16 weeks in a heated greenhouse; the growing medium was a well-decomposed peaty muck (pH 5.1) supplemented with potassium sulphate and finely ground 20% super-phosphate. From 21 days after sowing, all seedlings were fertilized at 2-week intervals by substituting a nutrient solution (RX-15) for a routine watering.

After 16 weeks a small number of tubelings were planted into pots to determine whether restricting root elongation by means of an air space had any adverse effects upon subsequent root development after outplanting. Forty seedlings from each of trays A (plastic) and C (1/4-inch wire mesh) were planted individually into 8-inch-diameter clay pots filled with a sandy loam. Roots over 20 mm long, growing from the tubes raised in plastic trays, were removed before planting to simulate losses observed in operational situations. Eight seedlings of each tray origin were excavated at 2, 4, 6, 8 and 10 weeks after planting for measurement.

Results

The use of a paper barrier effectively prevented loss of growing medium during tube loading but had no restrictive influence upon subsequent root growth through the wire mesh screen. By the end of the 16-week production period, both types of paper had virtually disappeared and the growing medium was sufficiently bound together with roots to restrict soil loss during handling. Because of its greater strength, a paper such as the Type 1300 Kimwipe would appear to be the best choice for operational use.

Roots began to emerge from the bottom of the tubes 6 weeks after sowing and by 16 weeks had developed into a mass of interlacing roots in the bottom of the plastic trays (A). By contrast, roots emerging from tubes raised on 1/4-inch wire mesh (C,D,E) passed through the screen into the air space and ceased to elongate after reaching a length of 5 to 7 mm. These roots were about 1/2 mm in diameter with white, pointed, sometimes swollen, tips (Fig. 1). The majority were unbranched, but a few were distinctly branched near the tips. Seedlings raised on the expanded

¹Registered Trade Marks of Kimberly-Clark of Canada Limited.

Fig. 1. Roots emerging from bottom of 16-week-old tubed seedling grown on $\frac{1}{4}$ -x $\frac{1}{4}$ -inch wire mesh. (Scale: tube is $\frac{9}{16}$ inch diameter.)

aluminum (B) presented an intermediate situation with roots growing both through the screen and across its upper surface.

Individual seedlings could be removed easily from trays C, D and E after 16 weeks, without causing root damage or disturbance of individual seedlings. However, this was not always the case with tray B (expanded aluminum bottom) where the number of roots growing on the upper surface of the screen was sufficient to cause some tangling of roots.

At the end of the 16-week production period, 15 seedlings were removed at random from each of the four replicates of the five tray types

for measurement. The restriction of root elongation in wire-bottomed trays had had no apparent adverse effects upon seedling growth, dry matter production being very similar for all five trays (Table 1). However, seedlings grown over an air space showed a distinctly different type of root development from those raised in plastic trays. Not only were the roots growing from the bottom of the tubes much shorter but root branching also appeared to be stimulated within the tubes, resulting in a more vertical root form with a larger number of descending roots and fewer roots circling the inner wall of the tube. This increased root branching is reflected in the significantly higher number of roots emerging from the bottom of the tubes in the wire-bottomed trays. Furthermore, there were numerically fewer roots emerging from the slit in the tube wall in these seedlings. This is a reflection, no doubt, of the more vertical root form and the smaller number of circling roots available for a lateral exit.

The limited trial of post-planting development produced no evidence to suggest that seedlings grown over an air space performed any better or worse after planting than those grown in plastic trays. In general, for those characters measured at each cropping date, differences between the two types of seedling were small and nonsignificant (Table 2). Root

TABLE 1. Dimensions of 16-week-old jack pine seedlings raised in five types of holding tray (means of 60 seedlings)

	Type of tray				
	Copper-painted plastic A	Expanded aluminum bottom B	$\frac{1}{4}$ -inch wire mesh bottom No soil barrier C	Kleenex barrier D	Kimwipe barrier E
No. roots growing from slit in tube side.....	2.2	1.5	0.8	0.8	1.4
No. roots growing from bottom of tube.....	2.4	7.9 ^a	6.6 ^a	7.1 ^a	8.0 ^a
Mean length of longest two roots (mm).....	25.8	13.6 ^a	7.2 ^a	7.6 ^a	6.9 ^a
Shoot dry weight (mg).....	142	145	140	134	143
Total dry weight (mg).....	160	170	165	158	171

^aSignificantly different from seedlings grown in plastic trays at the p.05 level.

TABLE 2. Growth of jack pine seedlings raised in copper-painted plastic (A) and $\frac{1}{4}$ -inch wire mesh bottomed (C) holding trays at five dates after planting (means of eight seedlings)

	Weeks from planting									
	2		4		6		8		10	
	A	C	A	C	A	C	A	C	A	C
Dry weight (shoot) (mg).....	172	181	220	209	286	309	470	374	792	703
Total dry weight (roots) (mg).....	36	46	76	74	105	117	176	158	296	281
Dry weight (roots outside tube) (mg).....	— ^a	— ^a	9	6	33	34	66	55	119	134
No. roots emerging from bottom of tube:										
< 10 mm long.....	1.1 ^b	4.2 ^b	2.5	2.3	0.6	1.9	1.2	1.1	1.5	1.6
> 10 mm long.....	0.2	0.2	3.1	2.1	6.0	4.7	7.6	6.0	7.6	8.9
No. roots emerging from slit in tube side:										
< 10 mm long.....	4.9 ^b	1.6 ^b	4.2	3.2	6.7	5.5	4.9	3.6	3.4	2.7
> 10 mm long.....	0.2	0.4	3.9	1.5	4.1	2.4	4.6	2.4	5.6 ^b	2.4 ^b
Total length of roots growing outside tube (cm).....	— ^a	— ^a	23.9	15.8	87.5	88.8	181.4	146.9	261.2	293.4

^aNot measured.

^bIndividuals in pairs indicated significantly different at p.05 level.

growth into the surrounding soil had started by the second week after planting and the pattern of subsequent root development and proliferation within the soil appeared to be normal. Rates of growth, judged by the dry weight and accumulated length of roots growing outside the tube were similar for both types of seedling. Initially the number of active roots growing from the bottom of the tubes was greatest in seedlings grown over an air space, a reflection of the situation at time of planting. This difference soon disappeared and by the fourth week seedlings grown in plastic trays had caught up. Thereafter, the number of "bottom" roots increased at comparable rates for seedlings grown in both types of tray. The same was not true of roots growing from the slit in the tube wall where, at least up to 10 weeks, numbers were highest for seedlings raised in plastic trays. This again reflects the differences in root form that were present within the tubes before planting. Although seedlings grown in plastic trays did have a significantly greater number of side roots longer than 10 mm at 10 weeks, there were no significant differences in total side roots after the second week from planting. It is unlikely

that the observed differences have any long-term biological significance.

The long-term efficacy of root control in trays with perforated bottoms was confirmed by an additional study in which trays of seedlings sown in April were overwintered and planted the following spring. Whereas the roots of seedlings raised in copper-painted plastic trays had formed a tight mat in the bottom of the tray, those raised on 1/4-inch wire mesh still showed excellent control of root elongation; individual tubelings of the latter could still be removed with ease after 1 year. Planted seedlings showed no adverse effects of this prolonged restriction of root elongation 6 months later.

References

- ANON. 1967. Provisional instructions for growing and planting seedlings in tubes. (Manual for restricted distribution.) Ontario Dep. Lands Forests. 83 p.
HOCKING, D. 1972. Current rearing knowledge. p. 142-150. In R. M. Waldron (ed.), Proceedings of a workshop on container planting in Canada. Can. Forest Serv., Ottawa, Ont., Inf. Rep. DPC-X-2.
SAUL, G. H. 1968. Copper safely control roots of tubed seedlings. Tree Planters' Notes 19(1):7-9.

TIMMERLINN

TEL.: 819 - 326-3559

WILLIAM S. POLLOCK
CONSULTING FOREST ENGINEER

TIMMERLINN WOODLAND SERVICES,
R. R. No. 2, — STE. AGATHE DES MONTS, QUE.

FORESTAL

FORESTRY AND ENGINEERING INTERNATIONAL
LIMITED

FORESTAL

FORESTRY AND ENGINEERING
LIMITED

VANCOUVER 5, CANADA

1409 WEST PENDER STREET

Tel.: 683-6994

Cable: FORESTAL

CONSULTING
FORESTERS
ENGINEERS

**Industrial Forestry
Service Ltd.**

101-1595 FIFTH AVE.,
PRINCE GEORGE, B.C.

TEL.: 563-9207