GROWING SEASON PRODUCTION OF WESTERN CONIFERS 1/

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Abstract.--Describes a workable system of raising seedlings in BC/CFS styroblocks. Cultural schedules cover a period of approximately 20 to 30 weeks in various facilities. Mineral nutrition, especially of phosphorus, varies according to seedling development. The effects of different sowing dates, container sizes and growing facilities on seedling growth are demonstrated in growth curves.

INTRODUCTION

In addition to the primary consideration of costs, the evolution and current status of nursery techniques for the production of containerized stock in British Columbia were fundamentally influenced by container design, the mild coastal climate and early recognition of the fact that deficiencies in seedling size and quality invariably lead to plantation failure, regardless of the container. Present nursery schedules are based on the underlying principle of the plug concept which requires that seedlings must be large enough to form a firm but unbound root plug to permit efficient handling (extracting, grading, packaging and transporting) and planting without impeding potential seedling survival and growth.

Seedling production methodology reported here is based on experimental and semi-operational production of large numbers of seedlings in Walters' bullets (Walters 1961, 1963, 1969) and, especially BC/CFS styroblocks (Arnott 1971, 1973; Kinghorn 1970; Matthews 1971; Vyse et al. 1971) during the past seven years. In the development of these nursery techniques, the British Columbia Forest Service (BCFS) has primarily been concerned with operational aspects of nursery construction and production, while the Canadian Forestry Service (CFS) has been responsible for basic research, development and technical advice (Sjoberg 1972). Close cooperation has characterized the execution of the various responsibilities.

1/Paper presented at North American Containerized Forest Tree Seedling Symposium, Denver, Colorado, August 26-29, 1974.

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GROWING FACILITIES

Because the mild coastal climate of Southern British Columbia is conducive to relatively rapid growth of plants, the majority of container seedlings produced to date have been raised in simple shadehouses at coastal nurseries during the normal growing season, at a low level of environmental manipulation and control. Growing in fully controlled greenhouses is restricted to Duncan nursery on Vancouver Island and to pilot facilities at three locations in the Interior of the province. The Duncan facility, which has a capacity of approximately one million styro-plugs 2(2A) per rotation, was specifically constructed for the production of western hemlock.

To provide effective protection from low temperatures and to permit extension of the normal growing season, current expansion of growing facilities by BCFS emphasizes an intermediate level of environmental control with the construction of "shelterhouses". A shelterhouse is an open-sided structure with a permanent glass or translucent plastic roof designed to withstand peak snow and/or wind loads at a given geographic location. More detail on the design and use of shelterhouses will be reported elsewhere in this symposium.

SEEDLING PRODUCTION

The Container

At present, most container seedlings in British Columbia are being raised in the nodular tapered cavities of BC/CFS styro-blocks (Arnott 1971, 1973; Kinghorn 1970; Matthews 1971; Vyse et al. 1971). Because another presentation to this meeting includes a complete discussion of the styroblock, only those features which are highly relevant to a discussion of seedling culture are presented here. These characteristics are as follows:

1. The conically shaped tip with a drainage hole at its centre, allowing roots which have been guided to the drainage hole to become air-pruned by holding containers off the growing surface (fig. 1), thus preventing pot-binding.

2. Ribbing of cavities to prevent or minimize root spiralling.

3. Three different cavity sizes (Table 1), permitting production of various sizes of plugs according to different requirements of species, sites and environment.

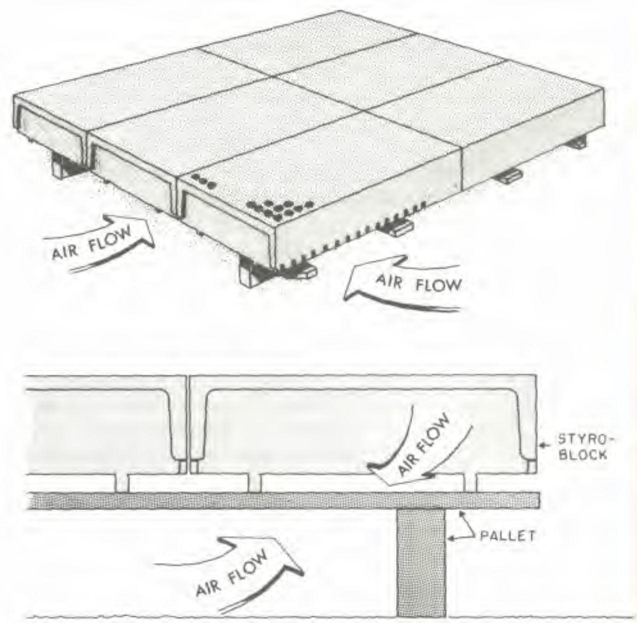

Figure 1.--Air-root pruning of BC/CFS styroplugs.

The Growing Medium

On the basis of overall superiority to other tested mixes (Matthews 1972), a growing medium, consisting of 3 parts of peat and 1 part of horticultural grade vermiculite (by volume) plus dolomite lime, has been used since 1970.

Recommendations for the liming of container-growing media vary widely. Generally, lime amendments range from 3 to 6 kg of lime per m^3 of growing medium (Klougart and Bagge Olsen 1968). However, the use of lime amendments as low as 1 kg/m^3 has also been recommended (Ingestad 1973)3/. Bjerkestrand (1968) noted that smaller amounts of lime resulted in more profuse rooting than higher levels. We made similar observations on the basis of a preliminary study with various rates of lime earlier this year. For the smaller lime amendments, root growth prior to flushing was extensive, while at the highest lime level root growth before flushing was almost non-existent (Table 2).

Present practice in British Columbia is to add 3 kg of Dolomite lime (12 mesh and finer) to each cubic metre of growing medium.

3/Personal communication.

Table 1.--Number, volume, spacing and ribbing of styroblock cavities1/

Styroblock	Number of Cavities per Block	Gross Cavity Volume2/		Spacing Number of Cavities		Number of Ribs
		cm^3	$inch^3$	m^2	ft^2	
2	192	40	2.45	1064	98	4
2A	240	40	2.45	1136	105	4
4	160	64	3.94	765	71	4
8	80	125	7.63	441	41	6

1/Source: Kinghorn (1972) and unpublished data

2/Gross cavity volume refers to maximum capacity; net or effective volume is somewhat less according to the level of soil filling.

Table 2.--The effect of different rates of dolomite lime in a peat-vermiculite growing medium (3:1-by volume) on flushing and number of white root tips on styro-plugs of Douglas-fir as of March 15, after over-wintering outdoors

Observation	Dolomite Lime in Growing Medium - kg/m³			
	4.45[1/]	3.56	2.37	1.78
Percent white root tips	1-5	10-20	30-35	40+
Percent flush	70	40	20	10

[1/]Based on conversion from 7½, 6, 4 and 3 lbs/yd^3, respectively.

This is a reduction from the 4.45 kg/m^3 level previously recommended (7½ lbs/yd^3 - Matthews 1971). At coastal nurseries, where the irrigation water is approximately neutral, the 3 kg/m^3 lime level results in a growing medium pH which ranges from approximately 4.5 to about 5.8 (fig. 2), under the influence of present cultural practices. However, in the Southern Interior of the province, where the

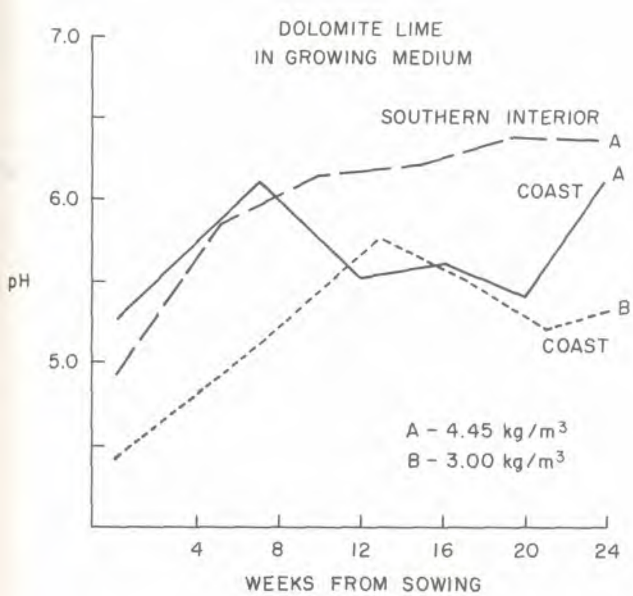

Figure 2.--The pH range of a peat-vermiculite (3:1 by volume) growing medium as affected by liming and source of irrigation water.

water is alkaline, the pH of the growing medium has run considerably higher (fig. 2). In our experience, strict adherence to the prescribed mesh size (12 mesh and finer) of Dolomite lime is highly important, as finer grades may raise the pH-value of the growing medium to 8.0 within two weeks after sowing.

To ensure continued wettability of the growing medium, a soil wetting agent, "Soil wet"4/, is incorporated in the medium (Edwards 1973; Matthews 1971) at a rate of 16 ml per 1000 litres of water; water is added until excess can just be squeezed from the medium (Matthews 1971). The present system of loading styroblocks results in a bulk density of approximately .11 g/cm^3 (Nyborg 1974)5/.

Germination and Seeding

Pretreatment

After soaking in tap water for 24 to 36 hours at room temperature, seed of most species is stratified at 2 C for approximately three weeks. In the absence of stratification, seeds of interior spruce and lodgepole pine have also been germinated by exposing them to 16-hour photoperiods (approximately 475 lux) at 21 C for 5 to 7 days (Ackerman and Farrar 1965).

Temperature and Humidity

Maintenance of optimal incubation conditions is an essential requirement for optimum germination. Temperature should be maintained between 20 and 30 C and relative humidity should be maximized. At the larger nurseries, manual control of temperature and humidity during germination has been replaced by the controlled environment of a germinator. To avoid desiccation and loss of germinants which have etiolated in the dark conditions of the germinator, the incubation period should not exceed five days. Where germination takes place directly in the growing facility, misting or light watering must be frequent enough to maintain temperature and humidity as close to optimum as is practically feasible. Misting (approximately 4.55 litres of water per 100 styroblocks) two to three times daily has generally proven sufficient for temperatures between 20 and 30 C. However, for higher

4/Plant Products Co., Ltd., Port Credit, Ontario.

5/Nyborg, E.O. 1974. Fac. of Agr. Eng., Univ. of B.C. Unpubl. data.

temperatures, a greater frequency of misting will be necessary, especially in shelterhouses, shadehouses and open outdoor facilities. To ensure satisfactory shedding of seed coats, the practice of frequent light waterings must hr continued for several weeks. However, to ensure continued wettability of the growing medium, occasional watering to field capacity (once per week) during this period is recommended. Unheated growing facilities should include provisions for protecting germinants from frost.

Seed Viability

Low seed viability, especially of interior spruce and some lots of western hemlock, is the most common cause of signi ficant reductions in potential seedling output. Limited experience with western larch, true firs and yellow cedar indicates that their seed viability is also generally poor. Although multiple sowing will reduce the number of blank cavities, it has been recommended that seedlots of less than 50 percent should not be used in container seedling nurseries (Vyse and Rudd 1973)6/.

Fungicides

Coating of tree seeds with certain fungicides is to be avoided. As reported by Cayford and Waldron (1967) for captan 50-WP, we have observed deformation and mortality of germinants and, consequently, significant reductions in the number of normal germinants after treatment with captan-50 WP or thiram prior to emergence of secondary foliage.

Seeding

A precision seeder, employing the vacuum seed selection principle, an air brush for removing excess seed and high air pressure to purge the seed orifice (Nyborg et al. 1972) is now used for all seeding operations. Seeding capacity of the current production models runs at approximately 40,000 cavities per hour.

Seed Cover

Contrary to some opinions, our experience continues to indicate the need for and suitability of Granite Grit/ as a seed covering material. No. 2 Granite Grit (particle size 2 to 4 mm) is recommended. The depth of the grit varies between .3 and .6 cm, according to seed size. A grit mulch creates a favorable incubation environment, aids the orientation of the radicle during germination, reduces the build-up of moss and algae on the surface of the growing medium, and provides physical protection. This protection prevents dislodging and loss of seed during styroblock transfer as well as from wind and large water droplets.

Cultural Techniques

Shade

Seedlings of all our major species benefit from partial shade during the first part of the crop cycle. In shadehouses, western hemlock and spruce are raised in 46 percent shade, while Douglas-fir is grown in 0 percent shade, provided by Saran shade cloth 8/. Because of its tolerance to high light intensities, lodgepole pine is now raised in the open. The time of removal of shade varies according to species and geographic location. To benefit from the few degrees of frost protection provided by shade cloth, shade cloth over western hemlock is sometimes left inplace until after the first few autumn frosts. For growing facilities covered with glass, fiberglass or plastic film, the reduction of light which is inherent in the covering material and the supporting structure can be augmented with shading compound or shade cloth to the desired degree of shade.

Cooling

Failure, to provide for prevention of excessively high temperatures leads to substantial loss of growth, if not mortality. Although cooling provided by shade cloth, sidewall and roof vent openings may suffice for shade- and shelterhouses, these methods are not always sufficient for the closed environment of a greenhouse. For greenhouses evaporative cooling has been found to be the most effective method of cooling.

Light and Photoperiod

Light intensities prevailing during our growing cycles are generally satisfactory. However, production of March-sown provenances of white and Engelmann spruce from northern latitude and/or high elevations at southern latitudes in one growing season requires extension of the natural photoperiod. For coastal conditions in British Columbia, interruption of the dark period for 2 out of every 30

6/Sowing Rules for Container Nurseries. A Report to the Reforestation Division of the B.C. Forest Service. Pacific Forest Research Centre, Canadian Forestry Service, Victoria, B.C. Unpubl. 30 pp.

7/International Marble & Stone Co. Ltd., Creston, B.C.

8/Distributed by Nurserymen's Exchange, 475 Sixth Street, San Francisco, Calif.

minutes with 1600 lux of incandescent light was the most effective treatment for preventing terminal dormancy of spruce (Arnott 1974). The practicability of providing intermittent light from a continuously lit sodium vapor light source on a travelling boom was demonstrated during 1973. Testing and development of similar techniques for high elevation coastal species is presently in progress.

Irrigation

With the exception of the germination period, which requires frequent low-volume watering in the form of misting, irrigation practices are based on full saturation of the growing medium at each watering. The practice of frequent light waterings is discouraged as it is considered inefficient, both in terms of plant moisture requirements and labor. The effects of such waterings relative to plant moisture needs are difficult to monitor and they also predispose seedlings to potential injury from high salt levels.

Watering to field capacity (approximately 10,000 litres of water for every million styro-plugs 2 or 2A) two to three times per week has generally proven satisfactory. However, lest it be understood that irrigation schedules are fixed, it is emphasized that more frequent irrigation is often required, especially in shelter- and shadehouses and open outdoor facilities. A greater frequency of irrigation and nutrition during the peak of summer resulted in substantial gains in height and root collar diameter and dry weight of styro-plugs 2 and 8 of lodgepole pine and interior spruce in a plastic-covered frame shelter, at three locations in the British Columbia Interior during 1972 (Table 3). Seedlings in a greenhouse and open outdoor facility responded similarly to those in the plastic shelter (Data not presented). Observations during 1973 indicated that additional irrigation alone may have achieved similar results. To ensure retention of the wettability of the growing medium, "Soil Wet" is applied through the irrigation system at a rate of 10 ml per 1000 litres of water, usually on a monthly basis.

Although present nutritional techniques appear to circumvent the effects of an undesirably large supply of dissolved chemicals in the irrigation water, future correction of various water quality problems may prove necessary to maintain the pH of the growing medium at a suitable level.

Until recently, seedlings in all provincial container nurseries were irrigated by overhead watering from a series of fixed heads. However, inadequacies in the distribution pattern of such systems and the consequent variation in stock size have stimulated design and development of traveling irrigation booms. To protect seedlings in shadehouses and open outdoor facilities from frost, the ability to deliver .25 cm of water per hour to all stock must be built into the irrigation system of such growing facilities (Matthews 1971).

Nutrition

With the exception of calcium and magnesium, which are supplied through the incorporation of Dolomite lime in the growing medium, other essential elements are supplied through the irrigation system via an injector

Table 3.--Effect of increased frequency of irrigation and nutrition on height, root collar diameter and dry weight of styro-plugs 2 and 8 of lodgepole pine and interior spruce in a plastic-covered frame shelter1/

Species	Styroblock	Treatment2/	Height3/ cm	Root Coll. Diam.3/ mm	Total Dry Weight3/ g (105 C)
Lodgepole pine	2	1	7.7	2.6	.7
		2	13.8	3.1	1.2
"	8	1	7.9	2.5	1.2
		2	13.2	3.7	2.4
Interior spruce	2	1	5.9	1.8	.3
		2	9.0	2.2	.5
	8	1	6.8	2.1	.5
		2	8.5	2.3	.6

1/Data based on mean of three nurseries.
2/Treatment 1: Irrigation and nutrition two to three times per week
2: Irrigation and nutrition five times per week
3/Stock sown in May 1972; data collected May, 1973

at regular intervals, most commonly the Fert-O-Ject automatic liquid fertilizer injector. 9/

Nutrient prescriptions are specified according to different species, container sizes and growing conditions, and are based on the use of commercial fertilizers. To suit different developmental stages of seedling growth, the ratio of the major elements nitrogen, phosphorus and potassium is altered by changing fertilizers (Table 4). Although the concentration of nutrient solutions and the frequency of application varies somewhat according to species, differences in nutrition between species are principally reflected in the sequence and timing of various nutrient applications. For example, initiation of nutrition varies according to the duration of the germination period, while commencement of the temporary withholding of nitrogen, to aid reduction or cessation of height growth, depends on the rate of height growth.

The nutrient diet as described by Matthews (1971) has been substantially modified. The supply of calcium and magnesium has been decreased as a result of the previously mentioned reduction of the lime amendment; the concentration and application of phosphorus, iron and potassium has been increased, and nitrogen is temporarily withheld (Table 4) to aid cessation of height growth.

Preliminary testing of various nutritional diets during 1970 and 1971 demonstrated that application of relatively high concentrations of phosphorus during late summer and autumn yielded substantial increases in height, dry weight and root collar diameter of styro-plugs of Douglas-fir. We also observed improved bud development and, after overwintering, increase of root growth in the spring. The well-known chlorosis and clutching of terminal foliage of Douglas-fir and general chlorosis of other species, a problem which had defied solution for six years, has been significantly reduced through supplementary feeding with ferrous sulfate (Table 4). All evidence indicates that the observed chlorosis was symptomatic of iron deficiency and was probably induced by over-liming, accentuated by high alkalinity and high bicarbonate content of the irrigation water in Interior nurseries. Nonetheless, deficiencies of other elements, especially sulfur, have not been ruled out and test work on seedling nutrition continues.

9/Fert-O-Ject Company, Santa Cruz, Calif.

Cultural Schedules

Although production of container stock is no longer limited to shadehouses in the mild south coastal area of British Columbia, cultural schedules are designed to take maximum advantage of natural conditions during the normal growing season. Accordingly, extension of the growing season in shade- and shelterhouses is limited to relatively brief periods at the beginning and conclusion of the normal growing season, regardless of geographic location. However, because the relatively high costs of constructing and operating a greenhouse requires production of at least two crops in one calendar year, the first crop in a greenhouse is usually sown well in advance of the normal growing season.

Table 4.--Generalized nutritional schedule for the production of styro-plugs in British Columbia

Week	Fertilizer	Frequency No. of times per week	Rate g/1000 litres	Concentration ppm N	P	K	S	Fe
4-5	10-52-10 1/	2	625	62	141	52		
6-16	20-20-20 1/2/ +	2	500	100	44	82		
	Ferrous sulfate	.5 or 1	155				17	32
17-18	0-52-34	2	625	0	141	176		
19-26+	10-52-10 1/ +	2	625	62	141	52		
	Ferrous sulfate	.5	155				17	32

1/Contains microelements

2/May occasionally be replaced by 21-0-0 at 500g/1000 litres for some species, especially western hemlock and interior spruce

Generally, cultural schedules cover a period of 20 to 30 weeks between March 15 and November 1, varying according to species, nursery facility and geographic location (Tables 5 and 6). However, to allow for sufficient dry matter production of late-sown greenhouse crops or to provide for winter protection, growing periods may extend beyond November 1 (Tables 5 and 6). Generally, such situations require only a minimum level of care. Of the 20 to 30 weeks in the cultural schedules, the first 13 to 18 weeks are necessary to attain sufficient height and the remaining weeks are required for production of dry weight.

The probability of frost for a given date and location determines when stock can be moved from greenhouse and shelterhouse to outdoor facilities or planting sites. For example, the risk of frost at nurseries it the Northern Interior of the province precluds moving the first greenhouse crop of spruce uts1de prior to June 15 (Table 6) unless the seedlings have been previously conditioned.

Because there is still some uncertainty about the safe duration of cold-storage for styro-plugs, the schedules include recommendations for alternate storage methods if planting cannot be completed during autumn.

Shipping non-dormant stock from one climatic zone to another continues to cause difficulties. For example, good planting conditions in the Interior of the province do not always coincide with the time that stock grown in facilities at coastal nurseries will be ready for shipping. The reverse situation also occurs.

Disease, Insect and Weed Control

Proper sanitation is the best insurance against disease, insect and weed problems. With minor exceptions, container seedling nurseries in British Columbia have been relatively trouble-free. More often than not, suspected disease problems have turned out be cultural problems. With the exception of recommendations for the systematic treatment of gray mould (Botrytis cinera) on western hemlock with benomyl, nursery schedules do no contain any instructions for regular treatment of stock with fungicides or herbicides. Occasional outbreaks of cutworms (Peridroma saucia) have been controlled with carbaryl.

Regular removal of weeds as they appear will ensure a weed-free nursery at relatively low cost, and will preclude growth of weeds at the expense of seedling stock. Heavy infestations of moss and liverworts are however, proving to be a recurring problem, especially in greenhouses and in the absence of a sufficiently deep mulch of granite grit. Application of hydrated ferrous ammonium sulfate at 25 g/litre as a spray (approximately 18 litres per 100 styroblocks) may be used to control moss, if used cautiously.

Table 5.--Potential cultural and planting schedules for production of styro-plugs of coastal species in British Columbia[2]

Species	Rotation	Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
W. hemlock / M. hemlock[1]	1	Coast				Greenh.			Outs.			Plant									
W. hemlock	2	Coast				Outs					Greenh.					Cold Stor.		Plant			
W. hemlock	3	Coast						Shelterh.				Plant									
W. hemlock	4	Coast						Outs.						Shelterh.			Plant				
D.fir(Coast)	1	Coast						Outs.				Plant		Cold Stor.			Plant				
D.fir(Coast)	2	Coast						Shelterh.				Plant		Shelterh.			Plant				
Sitka spruce	1	Coast							Outs.			Plant		Cold Stor.			Plant				
Sitka spruce	2	Coast						Shelterh.				Plant		Shelterh.			Plant				

1/ High elevation seed sources.
2/ Source: Arnott, J.T. unpublished.

Table 6.--Potential cultural and planting schedules for production of styro-plugs of interior species in British Columbia

Species	Rota-tion	Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Int. spruce	1	Interior				Greenh.		Outs.			Plant2/										
Int. spruce	2	Interior									Greenh.				Cold Stor.4/				3/Plant		
Int. spruce	3	Interior				1/	Shelterh.					Plant			Cold Stor.				Plant		
Int. spruce	4	Coast			Shelterh.			Outs.		Ship&Plant											
Int. spruce	5	Coast						Shelterh.				Outs.			Cold Stor.				Plant		
Int. spruce	6	Coast										Outs.									Plant
Lodgep. Pine	1	Interior					Shelterh.				Plant										
Lodgep. Pine	2	S. Interior							Outs.			Plant			Shelterh.				Plant		
D.fir (Int.)	1	Interior					Shelterh.				Plant										
D.fir (Int.)	2	S. Interior							Outs.			Plant			Shelterh.				Plant		
D.fir (Int.)	3	Coast					Outs.				Shelterh.				Cold Stor.					Plant	
W. Larch	1	Interior					Shelterh.				Plant										
W. Larch	2	S. Interior							Outs.			Plant			Shelterh./ Cold Stor.				Plant		

1/Later in Northern Interior
2/Not as late in Northern Interior
3/Different starting dates for Northern and Southern Interior
4/Safe duration of cold storage not known

Root Pruning

Failure to provide sufficient ventilation precludes effective air-root pruning and, therefore, necessitates undesirable removal of growing tips and also predisposes seedling roots to contact with disease organisms (Matthews 1972). Experience during 1973 demonstrated the need for providing more ventilation under the styroblocks to attain efficient air-root pruning. This was accomplished by raising the height of the pallets (Matthews 1971) and by reducing the number of 1 x 4 slats.

Frost protection

Pending development of effective means for inducing frost hardiness at will, a sprinkling system for frost protection is still a vital component of outdoor container seedling nurseries. The sprinkling system is thermostatically set to provide protection (1 C - Matthews 1971.). The system most deliver sufficient water to maintain a coating or free water on all plants, i.e., .25 cm per hour at intervals not exceeding one minute; sprinkling can only cease when temperature is above freezing and until all ice has melted from the plants (Wolfe 1969).

Overwintering

Even the mild winters of our coastal climate do not permit overwintering of containerized stock outside without some protection. Root dieback, especially of Douglas-fir, apparently as a result of frost damage to roots, has been a frequent problem in the past. Damage to western hemlock is usually less severe. In Interior regions of the province, snow cover is sometimes inadequate to protect seedlings from extremely low temperatures or winter-drying in spring. By enclosing the sides of shelterhouses with polyethylene and by occasional minimal heating of these facilities, it is anticipated that past winter storage problems can be effectively eliminated.

Preperation for Shipping and Storage

The practice of shipping plugs to the field in blocks (Matthews 1971) has been discontinued in favor of packaging and shipping extracted plugs. Seedlings are extracted from the styroblocks, wrapped in bundles of 25 with PVC film and shipped in waxed cartons containing 400 to 500 seedlings each. This technique allows culling and grading at the nursery rather than on the planting site, avoids transporting of empty cavities and increases the life of the styroblocks. Consequently, the practice of re-packaging styroplugs has increased overall efficiency.

SEEDLING GROWTH

Establishment of preliminary curves depicting attainable growth rates for various containers, species, growing facilities and geographic locations has received much emphasis during the past year. Principally, data were collected on height and dry weight and, to a lesser extent, root collar diameter. Both operational and experimental production of seedlings at various nurseries provided the data base.

Growth rates of a given species varied according to sowing date (fig. 3), container size (fig. 4) and growing facility (fig. 5). By monitoring growth of specific seedling crops on the basis of curves, such as are presented here, nursery managers will be able to select the best combination of growing facilities, locations, sowing dates and containers to meet seedling orders according to requested specifications of size and quality. Knowledge of the growth rates which can be expected in the nursery, together with some appreciation of the size and quality of stock that is required, also permits definition of attainable target sizes of stock to provide nurserymen with preliminary guidelines for culling and grading of container stock. Table 7 presents such a description for styroplugs 2 of some B.C. conifers.

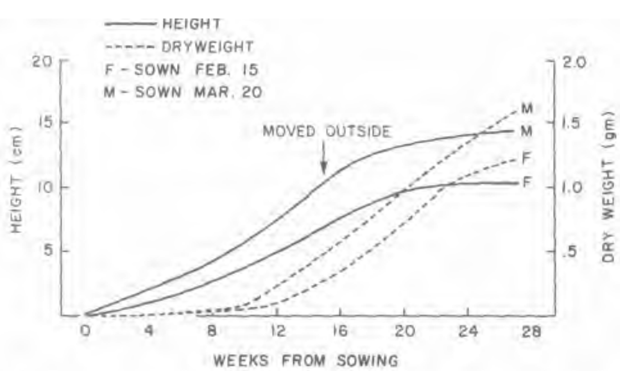

Figure 3.--The effect of different sowing dates on height and dry weight of greenhouse-started styro-plugs 2 of interior spruce.

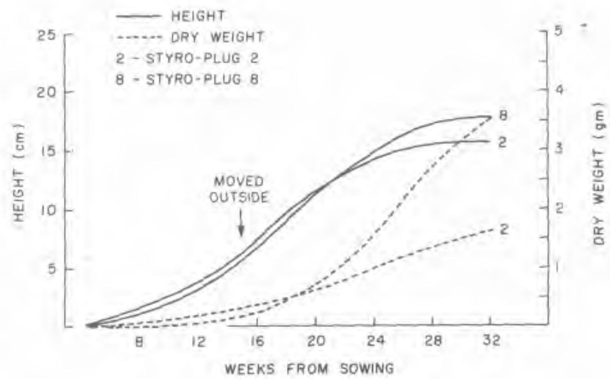

Figure 4.--The effect of container size on height and dry weight of greenhouse-started styro-plugs 2 and 8 of interior spruce.

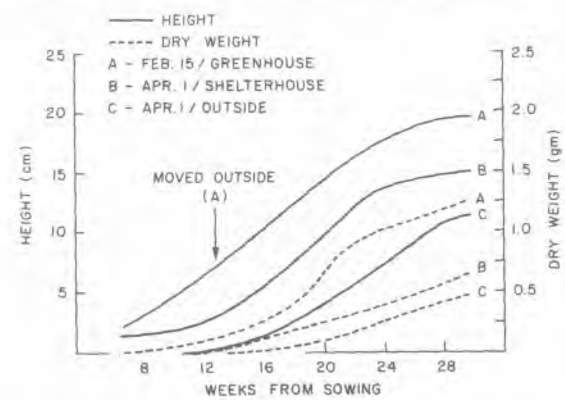

Figure 5.--The effect of different growing environments and sowing dates on height and dry weight of styro-plugs 2 of western hemlock (Source: Arnott, J.T. 1974. Unpublished manuscript).

CONCLUSION

Although the techniques reported here are primarily based on the growth and production of styro-plugs, all small containers confine seedlings to an environment which is characterized by narrow limits of reserves and tolerances. Consequently, reserves of water and nutrient are rapidly depleted while excesses quickly predispose seedlings to injury or mortality. Thus, the need for intensive care of seedlings growing in small containers cannot be overemphasized if the full potential of comprehensive care prescription which container growing offers is to be realized.

Table 7.--Attainable target sizes for styro-plugs 2 of some B.C. conifers

Region	Species	Principal Criteria Height cm	Root Coll. Diam. mm	Supplementary Criteria Dry weight g (105 C)	Shoot:Root Ratio
Coast	Douglas-fir	14	2.5	1.25	2.0-2.5
	Western hemlock	16	2.5	1.25	2.0-2.5
	Sitka spruce	14	2.5	1.50	2.0-2.5
	Mountain hemlock	12	2.0	1.00	1.5-2.0
	Grand fir	10	3.0	1.50	1.0-1.5
Interior	Interior spruce	14	3.0	1.50	1.5-2.0
	Lodgepole pine	10	2.0	1.00	1.0-1.5
	Douglas-fir	12	2.5	1.25	1.0-1.5
	Western larch	14	3.0	1.50	1.5-2.0

In British Columbia, the transition from experimental to semi-operational production of styro-plugs has revealed several problems which had not been obvious during the experimental stages of system development. The effects of poor liming practices and poor water quality are two examples in this regard. Much is still to be learned about growing media, mineral nutrition, growth rhythms, dormancy and frost-hardiness. Improvement of seed quality or development of techniques which will circumvent the adverse effects of low seed viability is vital to the success of container seedling techniques in British olumbia. Although shelterhouses will provide protection from low temperatures, evelopment of techniques for inducing frost-ardiness to permit greater flexibility in shipping and planting of container stock is urgent.

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Question: In obtaining maximum production per container, would you sow double seeds per cavity, then thin, or resow after 2-3 weeks?

Van Eerden: In British Columbia, we sow double because of seed viability (Vyse and Rudd1/). Thinning is one of the more costly operations in getting seedlings established. We do not resow after 2-3 weeks; it is highly unlikely that this could he afforded.

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Question: Gould you sow enough containers to give desired production and not plan on double sowing?

Van Eerden: Yes. There is a sowing allowance of 10 to 20 percent in some cases, depending on the viability of the seed lot (Vyse and Rudd1/).

Question: Do you clean the containe between re-uses?

Van Eerden: Yes. We definitely advocate cleaning between rotations. We get two to three cycles out of our styroblocks. Good sanitation is one of the most certain ways of preventing disease.