manager a relatively inexpensive means of stand conversion. Although less expensive than complete site preparation, such underplanting will result in lower overall survival and a somewhat slower rate of pine growth.

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Container production of western hemlock in British Columbia

J. T. Arnott

Forests officer. Department of the Environment, Canadian Forestry Service. Pacific Forest Research Centre. Victoria. B.C.

The coastal container nurseries of British Columbia have a long growing season. However. all coastal species cannot reach minimum stock standards by fall planting dates (commencing Oct. 1) when grown outdoors in a simple shadehouse which provides little environmental control. The seedling quality standards being proposed for B(:/(:F-,S styroblock-2 (2) production of western hemlock *(Tsuga heleroph ylla* (Raf.) Sarg.) are a5 follows:

Height	16 cm
Root collar diam.	2.0-2.5 mm
Total dry weight	1.0-1.5 g
Shoot/root	2/1

So far, for example, we have not been able to produce such plug seedlings in the styroblock-2 by the fall when grown for the whole season outdoors. We have counteracted this deficiency by growing these styroplug seedlings in a greenhouse or a shelterhouse for at least part of the growing season. The shelterhouse is an open-sided structure with a translucent fiberglass roof which provides additional environmental control through removable side panels.

Greenhouse Production

Ickes-Braun' greenhouse, were built at the British Columbia Forest Service nursery at Duncan on Vancouver Island for the production of at least two hemlock crops in one calendar year. To meet this objective, the first crop must be sown by February 15. When more than one crop is grown in a greenhouse in one season. a delay in the sowing (late of one will automatically delay sowing of the other, and so one of the crops will not he ready for shipment at the scheduled date.

Following soil loading (3:1 peat-*vermiculite plus 3 kg/m³ dolomite* lime 12 mesh and finer), sowing, and covering with No. 2 granite grit (particle size 2 to 4 mm). the styroblocks are placed in the greenhouse, misted 3 times daily and watered to saturation once a week. A soil-wetting agent. "Soil Wet.[2]" is added to ensure continued wettability of the growing medium (3). Before sowing, the seed was pretreated by soaking in tap water for :36 hours and stratified at 2° C for 3 weeks. Germination temperatures should he kept as close as possible to *20⁰ C. the optimum for this species.*

Application of water soluble fertilizers begins in the fourth week following sowing: 10-52-10 PlantProd(2) fertilizer is applied twice a week for 3 consecutive weeks as a starter to build up roots. All fertilizers are applied through the overhead irrigation system from a series of fixed watering heads or, more recently, from traveling irrigation booms.

[1] *Ickes Braun Glasshouses. Deerfield, III.*
2Produced by Plant Products. Ltd.. Bramalea. Ont.

Growing temperatures are kept as close as possible to 18° C. By the seventh week, the seedlings are at the onset of rapid height growth (fig. 1). Following a heavy leaching, the fertilizer is changed to twice-weekly applications of 20-20-20 Plant-Prod. Both 10-52-10 and 20-20-20 contain microelements. The calcium component of the dolomite lime amendment may inhibit the plant uptake of iron, the so-called "lime induced iron-chlorosis" (1). Such chlorosis can be prevented by applying ferrous sulfate every second week. Through April, May, and June the fertilizer regime remains much the same. By the middle of May, an additional weekly watering, just to saturation. may be necessary. It should be stressed that these fertilizer and irrigation schedules are not fixed. Greater frequency of irrigation and nutrition are often required during periods of hot summer weather. However. fertilizing or irrigating to field capacity two to three times a week was found generally satisfactory throughout most of these crop schedules.

Around the twelfth week (midMay). this crop is moved to an outdoor shadehouse that provides 46 percent shade by means of Saran shade fabric(3). The seedlings are usually 6 cm tall at this time (fig. 1). The fertilizer schedule continues as above (20-20-20 twice/week and ferrous sulfate once/2nd week). By July (week 20), with the seedlings approaching the minimum height required (fig. 1). the fertilizer is changed to 10-52-10 to build up roots. We have found that low levels of P at this time lead to poor root and bud development.

At week 25 (August 1), the crop will probably exceed the minimum height requirement of 16 cm and the following steps are taken:

Remove shade fabric:
Water blocks heavily to leach out any N;
Fertilize twice weekly for 2 weeks with 0-52-34.

Such a combination of treatments will slow down, if not stop. height growth (fig. 1). Following this, the seedlings are fed twice weekly with 10-52-10 until shipped for planting on September 1 (week 29). These seedlings will probably meet the following specifications:

Height	20 cm
Root collar diam.	2.5 mm
Dry weight	1.3 g

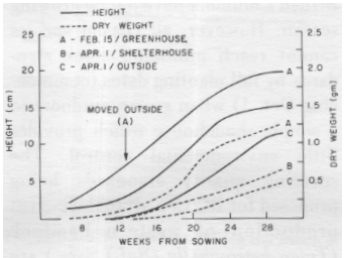

FIGURE 1.—Height growth and dry weight increment of western hemlock styro-plug seedlings grown in a greenhouse, shelterhouse, and outdoor shadehouse.

The complete sequence of fertilization for the first greenhouse crop is summarized in table 1.

To protect the densely grown seedlings from infection *by Botrytis,* we use systematic applications of Benlate(4) every two weeks from the 22nd week onward. Heavy leaching with water is carried out at each fertilizer change and conductivity of the soil media is measured once a month. If it exceeds 300 μmhos, additional leaching is recommended. Soil pH should be in the range 5.0-5.5.

When the February-sown seedlings are moved outdoors from the greenhouse in mid-May, a second greenhouse crop is sown to take their place. The objective is to grow this second crop throughout the late fall by manipulating the greenhouse environment with particular regard to day length and temperature. The seedlings will be hardened in the greenhouse during the winter by progressively lowering temperatures and then shipped for early-spring planting. No further details are available, as the first operational production of this crop is currently being grown for early spring planting in 1975.

Shelterhouse Production

The principal difference between seedling culture in greenhouses and shelterhouses lies in the timing of the various treatments. As optimum germination temperatures are difficult to attain without the use of space heaters in early spring, sowing in shelterhouses has to be postponed until March 15. However, to ensure that the crop will be ready for October planting, sowing must not be delayed beyond this date. This point is illustrated in figure 1, where the shelterhouse crop was not sown until April 1. As a result, seedling dry weight was well below the planting quality standard of lg in early October.

The underlying principle in shelterhouse production is to get the crop started early. Germination temperatures should he kept around 20°C during the day and as warm as is feasible at night.

Sequence of fertilization begins in much the same way as the greenhouse crop (table 1). To promote faster seedling growth. a higher level of 2020-20 is used throughout July (weeks 16-20), switching to a higher level of 10-52-10 in August (weeks 21-24). Ferrous sulfate continues to be applied once every 2 weeks (table 1).

By the 25th week, the trees should be approaching the minimum height required (fig. 1). Consequently, the blocks are heavily leached, and fed

3- Available from nursery suppliers.

Produced by E. I. Dupont de Nemours, Wilmington, Del.

for 2 weeks with 0-52-34, following which they are kept on a twice-a-week application of 10-52-10 until planted (table 1). Leaching between fertilizer changes and monitoring of soil conductivity and pH are carried out as in greenhouse production methods.

Outdoor Production

Seed which is sown in styroblocks on April 1 and placed in an outdoor shadehouse germinate very slowly, so fertilization does not commence until the eighth week at the earliest (table 1). Seedling growth during May and June is extremely slow and begins to accelerate around the 14th week at the beginning of July (fig. 1). As a result, timing of the individual fertilizers differs somewhat from the greenhouse and shelterhouse crops (table 1).

By October 1 (week 27), the stock will not have achieved the minimum height requirement (fig. 1). The seedlings should be moved into a shelterhouse where, in this more favorable environment, increment in both height and weight can be continued throughout October. Lower night temperatures and shorter day lengths will arrest height growth by the end of this month. However, by enclosing the shelterhouse to maintain higher temperatures, together with weekly applications of 10-52-10, root growth and dry weight production will be maintained to the end of November (table 1). As a result, the seedlings will approach the quality required for shipment the following spring.

The seedlings are usually removed from the styroblocks, packaged in bundles of 25, and cold-stored in cardboard cartons at 1°C until shipped for planting. They can also be kept in the styroblocks in the shelterhouse during December and January, where the seedlings are fertilized once every 2 weeks with 10-52-10 (625 g/1000 litres). If minimum soil temperatures drop below -9°C during December and January, root mortality within the cavity will occur. Such low temperatures can be prevented by closing the shelterhouse and using a few space heaters during the sporadic severely cold outbreaks typical of the Pacific Northwest.

Up to this point, references to figure 1 have been made while covering the particular cultural prescriptions for each of the three container nursery facilities described. However, considering all three growth curves simultaneously, one can see the relationship between seedling growth and degree of environmental control according to the different sowing dates. By having such information, nurserymen may select the type of container nursery facility which best suits their needs for western hemlock production, according to their own geographic location and crop quality standards required.

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(Continued on). 14)

TABLE 1.—Summary of fertilizer schedules used for growing western hemlock styro-plug seedlings in three types of container nursery

Fertilizer	Rate	N	P	K	Frequency of use	Time of application (wks. after sowing)		
						Greenhouse	Shelterhouse	Outside
	G/1.000 liters		*Ppm*					
–52–10[1]	625	62	141	52	Twice/wk.	4–6	4–6	8–10
20–20–20[1] plus	500	100	44	82	Twice/wk.	7–19	7–15	11–15
Ferrous sulfate	155				Once/2 wks.			
20–20–20 plus	625	125	55	103	Twice/wk.		16–20	16–18
Ferrous sulfate	155				Once/2 wks.			
10–52–10 plus	625	62	141	52	Twice/wk.	20–24		
Ferrous sulfate	155				Once/2 wks.			
10–52–10 plus	935	93	212	78	Twice/wk.		21–24	19–26
Ferrous sulfate	155				Once/2 wks.			
0–52–34	625	0	141	176	Twice/wk.	25–26	25–26	
10–52–10 plus	625	62	141	52	Twice/wk.	27–29	27–29	27–30
Ferrous sulfate	155				Once/2 wks.			
10–52–10 plus	625	62	141	52	Once/wk.			31–34
Ferrous sulfate	155				Once/2 wks.			

[1]Contains microelements.

Containerized nursery stock for park and roadside planting

Jeff Dawson

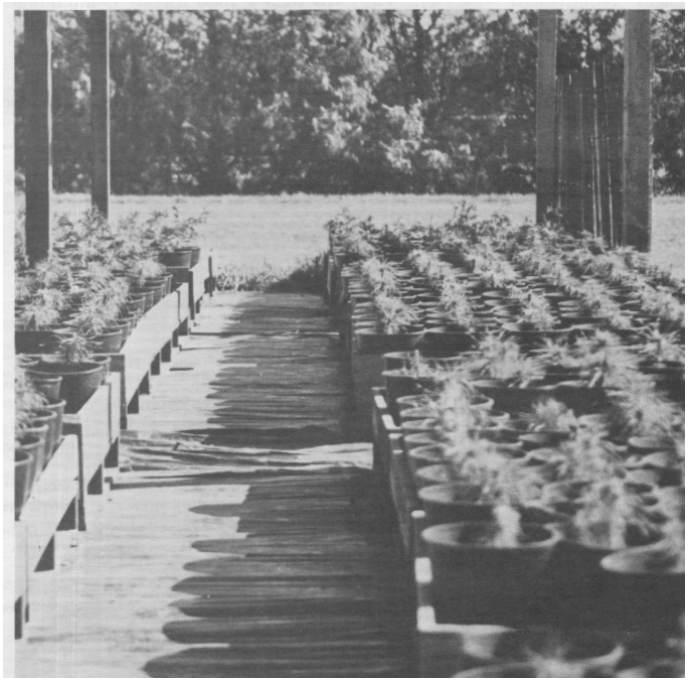
Forestry graduate student. Iowa State University. Ames, Iowa

A system for growing large containerized stock at the State Forest Nursery is helping to meet the needs of park and roadside tree planters in Iowa.

The objective of a program begun in 1972 was to produce trees large enough in one year, to be visible to operators of maintenance machinery and also that could be planted at anytime during the growing season. To avoid damage from maintenance equipment, the Iowa State Highway Commission requested trees taller than 30 inches in height. The Conservation Commission required plant material no less than 12 inches in height. By starting trees in greenhouses during winter months, combining two methods of containerization. and optimizing growth conditions outdoors using lath houses and irrigation, the desired results were obtained for some species.

Procedures

Seeds were started in greenhouses each February. Jiffy-7 peat pellets were prepared for planting by drenching them with a solution containing two tablespoons of captan fungicide per gallon of water. Seeds were sown directly in them and thinned



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