CONTRASTING APPROACHES TO CONTAINERIZED SEEDLING PRODUCTION

2. THE PRAIRIE PROVINCES

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Abstract.-- Six containerized seedling facilities in the prairie provinces produce at least two crops annually for a total of 19 million conifer seedlings. Differences among facilities with respect to container type, growth medium, light intensity, photoperiod, temperature, and mineral nutrition during the growth and conditioning phases result in variable but acceptable planting stock for reforestation.

Résumé.--Six installations de production de semis en pot des Prairies produisent chaque année au moins deux récoltes représentant au total 19 millions de semis de conifères. Des différences entre les installations en ce qui concerne le type de pot, le milieu de culture, l'intensité de la lumière, la photopériode, la température et la disponibilité en substances minérales durant les périodes de croissance et de conditionnement font que leur matériel est variable mais acceptable pour le reboisement.

INTRODUCTION

In the prairie provinces (Alberta, Saskatchewan, and Manitoba) there are six nursery facilities producing containerized planting stock exclusively for reforestation purposes. These nurseries differ in their approach to containerized stock production chiefly because of the size and history of the particular operation. Production systems and cultural practices vary, and this variation is expressed in the quality of stock produced. This paper describes the growing facilities and their production systems, and highlights the significant features of containerized seedling production in the Canadian prairies.

GROWING FACILITIES

Three of the six growing facilities are located in Alberta--one at Hinton (St. Regis [Alberta] Ltd.), one at Whitecourt (operated jointly by Alberta government and Simpson Timber Co. [Alberta] Ltd.), and one at Smoky Lake (government-operated Pine Ridge Forest Nursery). In Saskatchewan there are two government-operated growing facilities--one at Big River (Big River Forest Nursery) and one at Prince Albert (Prince Albert Forest Nursery). The single Manitoba nursery (Pineland Forest Nursery) is government operated and located at Hadashville.

The growing facilities range in size from the 20-greenhouse operation at Pine Ridge to the single-greenhouse operations at Whitecourt and Big River. Approximately 19 million conifer seedlings are produced annually in the region (Table 1), with Alberta producing 80% of the total. Although species produced in the region include black spruce *(Picea mariana [Mill.]* B.S.P.) and red pine *(Pinus resinosa* Ait.), the principal species grown are white spruce *(Picea glauca* [Moench.] Voss), lodgepole pine *(Pinus contorta* Dougl.), and jack pine *(P. banksiana* Lamb.), which account for 62%, 25%, and 12%, respectively, of the regional total.

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Table 1. Containerized seedlings shipped for reforestation in the prairie provinces (1980).

Species	Seedlings (000,000)		
	Alberta	Saskatchewan	Manitoba
White spruce	10.515	0.840	0.180
Lodgepole pine	4.560	--	--
Jack pine	--	2.170	0.145
Black spruce	--	--	0.177
TOTAL	15.075	3.010	0.502

PRODUCTION SYSTEM

Container Type

Containers based on two distinct concepts are used, namely, Spencer-Lemaire "Rootrainers" and Japanese paperpots (Table 2). Choice of container type depends as much on sentiment as it does on practicality. Reasons for choosing the Spencer-Lemaire "Rootrainers", for example, vary from "we were involved with its development" and "it was developed in Alberta" to "it is good for root training", "it can be opened to check the root system", and "it is reusable". Paperpot users made their selection on the basis of lower cost (at the time the decision was made) and the manufacturer's claim of biodegradability. Other types of containers such as the styroblock and the RCA sausage have also been assessed. The styroblock was unacceptable because of root damage sustained during winter, and the 'sausage' was discarded because of the high density of the peat plug and poor wettability following drying. Regionally, optimum cavity size has been determined on the basis of the number of seedlings required to meet reforestation objectives without sacrificing stock quality.

Growth Medium

The most common growth medium is either commercial sphagnum peat or a mixture of peat and horticultural grade vermiculite in the ratio 2:1. In most cases, the peat is tested for pH and for electrical conductivity. Acceptable pH is in the range 4.5-6.0, and liming is recommended for supplies whose pH is below this range. High salinity is rarely a problem, although peat supplies have been rejected because of a high concentration of sodium sulfate. The maximum level for electrical conductivity in acceptable peat is 0.50 milli-siemens/cm. A coarse:fine ratio [2] of at least 0.5 is recommended (Carlson 1979); it is not determined on a routine basis, as experienced nurserymen can assess this characteristic by sight and touch. The growing medium is moistened (until water just appears when the growing medium is squeezed), then is fed mechanically into the containers that are vibrated as they pass beneath the feed hoppers.

Table 2. Container types used in the prairie provinces

Container type	Cavity volume (cm^3)	Cavities per tray
Spencer-Lemaire "Rootrainers":		
Ferdinand (Six)	40	102
Five	70	55
Japanese paperpots:		
FH 308	44	532
FH 315	88	532
FH 408	70	336

Sowing

Sowing is done mechanically with vacuum activated rotating drum seeders that deliver 3-5 seeds per cavity depending on the germination test for the seed lot. Thinning to one seedling per cavity is done 2 weeks after germination. The seeds are covered with No. 2 granite grit, after which the containers are moved to the greenhouse, saturated with water, and covered with burlap, 4-mil polyethylene sheets, or a combination of both materials until germination is complete (approximately 7 days for pine and 10 days for spruce).

[2] A given amount of peat is air-dried and sieved on a 2-mm sieve. The ratio of weight of material retained by the sieve and the weight of material not retained is the coarse:fine ratio.

CULTURAL ENVIRONMENT

Water

Throughout the growing phase water is applied as required. The need for watering is judged visually and by feel. Water is delivered through overhead sprinklers mounted on stationary or movable booms, but even coverage depends on strategic placement of the nozzles and consideration of their angle of spray.

Photoperiod

Beginning a week after germination, greenhouse lighting is regulated. All nurseries in the prairie provinces depend on natural daylight and, as production is restricted to spring and summer, the basic photoperiod is approximately 18 hr. Four of the six facilities also use intermittent light during the dark hours to prolong photoperiod and prevent dormancy. The intensity of this supplementary light can be a minimum of 400 lux (Tinus and McDonald 1979) and, at the various nurseries, ranges from incandescent or fluorescent light of 500 lux cycled on intermittently for 1 minute every 15 minutes to 4500 lux sodium arc lamps cycled on for 2 minutes every 30 minutes.

Temperature

At all nurseries, greenhouse temperatures during the day are generally in the 20-25°C range. The nurseries strive for 22°C for spruce and 25°C for pine, but two facilities operate in the 23-28°C range for pine. At night, greenhouse temperatures are reduced to the 16-20°C range for spruce and 14-19°C for pine. One nursery uses 20°C for both species.

Heating consists of forced air from a natural gas furnace in most cases. At one growing facility, a wood furnace is used. At one nursery, greenhouse benches are heated by electric cables during the germination phase, and at another, heated forced air is used. One nursery also has supplementary gas heaters mounted overhead. Cooling is done simply by means of fans and vents at some locations; at others, water-cooled aspen pads are used in conjunction with fans.

Fertilization

No fertilizers are added to the growing medium prior to filling of the containers. Seedlings are fertilized exclusively by nutrient solutions dispensed through the overhead irrigation system via automatic dilution equipment. Nutrient applications are carried out once a week, and in all cases enough solution is applied to saturate the entire plug of growing medium. Immediately after application of a nutrient solution, the foliage is rinsed with water. Throughout production, water is applied as required.

The commencement of nutrient applications depends on whether the nurseryman feels that such applications are required in the early phase (0-4 weeks) of growth. In some cases, nutrient applications begin 1 week after germination and continue for 3 weeks. While this early growth phase is believed to be critical for root development, nurserymen are undecided whether the level of food reserves in the seed is adequate for the seedling during this period. A nutrient solution consisting of low nitrogen (N), high phosphorus (P), and moderate to high potassium (K) is applied in the early phase of growth (Table 3). Beginning 4 weeks after germination and continuing for 8-10 weeks, a different solution (high N, low P, high K) is used; it is compatible with the rapid growth phase. Each solution also contains micronutrients: iron (5.5 mg/L), manganese (0.2 mg/L), copper (0.02 mg/L), zinc (0.05 mg/L), boron (0.35 mg/L), and molybdenum (0.03 mg/L).

When the required height growth is achieved, the seedling is hardened-off in preparation for planting in the same year or for overwintering. The nutrient solution used during this conditioning phase is characterized by low N, high P, and high K and, in some cases, is identical to that used in the early growth phase. The wide ranges in nutrient concentration of the solutions used during any phase of growth reflect not only personal preferences of individual nurserymen but also the wide tolerance of these species for nutrients under these growing conditions. Some of the formulations being used are those recommended for the region by Carlson (1979), and it is intended that these guidelines will be used in future operations.

Cropping Cycle

Five growers in the region produce two crops per year and one produces three crops. There is no production during the winter months although two producers begin their first crop in February. Most begin in March, and all greenhouse rearing terminates in mid-September. Where only two crops are produced annually, the first crop is usually grown in the greenhouse for 14-18 weeks and the second is grown for 14-19 weeks. However, three facilities use a 14-week greenhouse rearing period for both crops. Where three crops are produced annually, rearing times in the greenhouse are 8, 4, and 8 weeks for the first, second, and third crops, respectively. With one exception, all crops produced in one year are hardened-off and overwintered before planting the following year. At the nursery where three crops are produced annually, the first crop is conditioned in a cold frame before planting in the current year.

Hardening

Hardening or conditioning of the crop follows the rapid growth phase during which sufficient height growth has been achieved, and although it may be initiated in the greenhouse, it is usually completed in a cold frame.[3] The hardening process physiologically conditions both seedlings that will be planted out in the current year and those that will be held over winter for planting in the following year. Seedlings that will be planted in the current year undergo conditioning in the cold frame through partial shading and exposure to ambient air temperature. In preparation for overwintering, dormancy and associated budset must be induced. This is achieved by 1) reducing the photoperiod, 2) inducing moisture stress by witholding water, 3) reducing the nutrient applications to one a week (Table 3), and 4) reducing day and night temperatures gradually over a 2-week period to 10°C and 3°C, respectively. When the seedlings are being hardened in cold frames, the nutrient solution is applied once a week until freeze-up.

Proper hardening of seedlings in the prairies is not always achieved. Success of the procedure requires that the four steps be carried out sequentially (Tinus 1974), with the duration of each depending on the species and age of stock. Under operational conditions, however, temperature is sometimes reduced simultaneously with photoperiod. This might well be an area for further study to delineate the limits for manipulating these factors without jeopardizing the physiological quality of the seedling.

Overwintering

Seedlings are overwintered exclusively in cold frames, some of the containers being set on boards or pallets, some on a sand or gravel base, and still others on asphalt. Hardening-off solution is applied once a week or every two weeks until freeze-up. After thawing in the spring, the same nutrient solution is applied once a week or every two weeks until the seedlings are shipped. Success of overwintering containerized seedlings in the prairie provinces often depends on the availability of adequate snow cover, which provides insulation against the very low or fluctuating temperatures that characterize the region. Snow cover is also important in the few cases in which containers are being overwintered on pallets because of the mobility they afford. Without proper insulation, however, root damage is severe.

Crop Monitoring

At most nurseries, the stock is monitored for shoot height, stem diameter, shoot dry weight, and root dry weight throughout the growing season, starting as early as 4 weeks after germination. There is, however, great variation in the approach to monitoring. One nursery does not monitor consistently, although a visual check is made before the crop leaves the greenhouse. Another monitors root area, pH, electrical conductivity of the growing medium, and even N, P, and K analysis of the foliage, in addition to the four parameters mentioned previously. This nursery also monitors temperature in and around the container throughout the overwintering phase of production.

Only one nursery has morphological specifications for the seedlings produced: height = 10-18 cm, shoot:root ratio = 2-3, total dry weight = 500 mg for spruce and 700 mg for pine, and stem diameter = 2.0-2.5 mm. At other nurseries, the fitness of the crop for outplanting is checked visually (e.g., by opening 'books' and inspecting root systems) and a subjective judgment is made as to its suitability. Nurserymen in the region recognize the deficiencies in this area, and in future containerized stock will be monitored in a more systematic way. We ought to strive for improved stock quality, and therefore we should have clear standards against which to measure our progress. Closer monitoring of each aspect of the operation (especially growing medium, nutrient regime, and hardening-off) is required if nurseries are to capitalize on the technology that has made containerized seedling production a viable undertaking.

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[3]This is a structure with open sides and a 4-m-high roof of shade cloth or snow fencing. One facility uses snow fencing supported 30 cm above the seedlings. The trays are set on sand, gravel, pallets, or wooden slats.

Table 3. Concentration (mg/L) of N, P, and K in nutrient solutions applied during different phases[a] of growth at different prairie nurseries[b]

Early growth			Rapid growth			Hardening-off		
N	P	K	N	P	K	N	P	K
100	228	83	200	88	166	78	170	250
33	103	150	125	61	156	33	103	150
	--		112	55	156	44	101	150
	--		300	38	201	44	101	150

[a]If germination is taken as week 0, the early growth, rapid growth, and hardening-off phases are 0-4, 4-16, and 16+ weeks, respectively.

[b]Each row describes the nursery regime used at one or more nurseries.

CONCLUSIONS

1. Containerized seedling production in the prairie provinces is still evolving. At present, cultural practices are based largely on the personal preferences of the nurserymen. More experimentation is needed to optimize growth factors at each location.

2. Controllable factors should be controlled. For example, uniform application of water and nutrient solution would help to reduce variation in stock size.

3. A greater degree of fine tuning of the conditioning process is required so that it can be achieved more precisely. Overwintering and frost damage would be minimized in consequence.

4. More nurseries need to develop standards for their own stock, based on planting requirements, and to monitor their operation closely to ensure that those standards are achieved.

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