forest management note

Note No. 21 Northern Forest Research Centre Edmonton, Alberta

OPTIMIZING CONTAINERIZED CONIFER SEEDLING PRODUCTION IN THE PRAIRIE REGION

The use of containers is now widely accepted as a means of producing nursery stock. Because greenhouse rearing of containerized conifer seedlings is a lengthy and expensive process, any means of increasing production (while maintaining seedling quality) and improving conditioning and storage practice (and ultimately field performance) would be valuable for commercial operations (Owston and Stein 1977). Silvicultural studies have been carried out by Northern Forest Research Centre staff in recent years using both conventional (seasonal) and optimized (continuous) systems to rear, condition, and overwinter lodgepole pine and white spruce. Detailed reports are being prepared, but in the meantime this note briefly describes differences observed in the condition and performance of seedlings reared by conventional and optimized methods (Tables 1 and 2).

The conventional (Carlson 1983) and optimized methods have similar rearing phases in the greenhouse, but the methods differ considerably once the seedlings leave the greenhouse environment. For both conventional and optimized methods, production of containerized conifer seedlings requires heated greenhouses in order to extend the frost-free season and to permit optimum day and night temperatures of 25°C and 18°C, respectively. The greenhouses should be equipped with lights of a minimum of 550 lux to extend the photoperiod to 20 h and must have shades and a cooling system to control day and night temperatures.

In the conventional method, initiation of the conditioning process often precedes dormancy and results in inferior frost hardening of root systems. The conditioning and dormancy phases are reversed in the optimized method. The storage phase in both systems of seedling production may be similar in timing from fall freeze-up to final spring thaw, but the storage methods differ in physical environment and in facilitating storage throughout the year. Conventional seedlings are exposed to the elements, whereas optimized seedlings are maintained at an optimum temperature for root and shoot systems, without risk of dehardening or frost damage.

Conventional Method

Two conventional cropping systems, here termed A and B, are possible. Cropping system A produces three to six crops per season, with the seedlings 4-9 wk old when set out for hardening. Cropping system B (the more common) produces two crops per season, with the seedlings 10-14 wk old when set out. Seedlings of cropping system A are usually smaller than the standard 12-cm seedlings of cropping system B. In system A the quality of seedlings is sacrificed for a gain in number of seedlings.

In conventional cropping methods, seedlings are produced by a rearing period in the greenhouse followed by outside conditioning, a process that does not consistently result in seedling dormancy because of unsuitable photoperiods. From May to October 24 outside conditioning fails to stop growth and protect seedlings against frost because the minimum 10-h photoperiod stimulates growth; shorter photoperiods (≤8-h) leading to full dormancy do not occur until November-December, by which time the seedlings are usually frost-damaged. The rearing times inside and outside the greenhouse vary by year, number of crop rotations, and nursery.

Frost and the absence of an 8-h day length during September and October are major limiting factors in outside conditioning and subsequent winter performance of seedlings (Zalasky 1978, 1980). Seedlings often fail to become dormant and therefore do not harden off properly before freezing temperatures occur. Root damage lowers the quality of containerized seedlings by reducing the regenerative capacity of the root system and is a frequent problem in lodgepole pine bare-root stock (Burdett 1978). Methods of outside overwintering of containerized seedlings include storage on the ground, on a tarmac, or on raised pallets, and with or without thermal covering.

Optimized Method

Optimized greenhouse rearing can be used continuously to ensure standardized rearing procedures and timing for each crop for conditioning and storage. The seedlings must not be subjected to frost at any time during rearing or conditioning. Following the rearing phase, separate refrigerated rooms are required, one for conditioning seedlings and one for subsequent storage of conditioned seedlings. Seedlings are conditioned 4-6 wk by subjecting them simultaneously to an 8-h photoperiod to induce dormancy and a 5°C temperature to develop hardiness (Christersson 1978) for cold storage. Seedlings should be well watered at the start of the conditioning period. An 8-h photoperiod for 4-6 wk is the minimum required to adjust the reserve food materials in the roots proportionally to that in the shoots (Salisbury and Ross 1978). Any different photoperiod from the one recommended tends to shift the nutrient balance to either the root or shoot system and renders one or the other susceptible to frost damage in prolonged storage (Zalasky 1978). The dormancy and hardening-off treatments stimulate the building of a photosynthetic reserve (Alden and Hermann 1971; Oquist *et al.* 1980) and are applied when seedlings reach peak growth at 14-16 wk.

Once conditioned, 20-wk-old containerized stock is stored in a cold room refrigerated at -2°C. Conditioning followed by a recommended minimum of 5 months prolonged storage at -2°C minimizes frost damage after outplanting. No watering should be done during storage at -2°C because moisture encourages detrimental ice and molds to develop on roots and shoots.

CONCLUSIONS

The optimized production method for containerized stock is recommended for several reasons. It is continuous rather than seasonal in operation and provides a more uniform size of seedlings. As well, the method provides a more balanced conditioning between root and shoot systems. The optimized method reduces planting losses from mortality and deformities resulting from dieback or stunting caused by frost injuries commonly observed in conventional seedlings.

H. Zalasky
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Table 1. Rearing phase and expected seedling condition at the end of rearing phase

Description of crop	Seedling condition at end of rearing period	Comments
Conventional rearing		
Greenhouse:		
Cropping system A: 3-6 crops per season, seedlings 4-9 wk old	-Seedlings not ready for conditioning. -Foliage and shoots not fully developed. -Photosynthesis not at its full potential.	-Sustained greenhouse temperatures rising above 26°C may cause spindly shoots, poor bud development, and loss of tolerance to frost.
Cropping system B: 2 crops per season, seedlings 10-14 wk old	-Seedlings ready for conditioning. -Foliage and shoots fully developed. -Cellulose biosynthesis is rapid. -Photosynthetic reserves are good.	-Keep greenhouse cooling system in working order. -Rearing time may vary to achieve seedling size specification.
Outside hardening off:		
Cropping systems A and B: seedlings variable in age	-Condition variable because seedlings may be set outside from June 1 to September 30. -Seedlings may become stunted or damaged by early or late frost. -Seedlings of crops may differ in size by season.	-Seedlings cannot tolerate freezing temperatures without damage to developing cells and plant parts. -Undesirable overcrowding of root systems may occur by October in 40-cm^3 containers if seedlings are over 20 wk old.
Optimized rearing		
3 crops per year, seedlings 14-16 wk old	-Seedlings ready for conditioning. -Foliage and shoots fully developed. -Cellulose biosynthesis is rapid. -Photosynthetic reserves are good. -Seedlings of crops more uniform in size.	-Seedlings cannot tolerate freezing temperatures without damage to cells and plant parts.

Table 2. Storage phase, condition of seedlings before and after storage, and frost damage and growth defects following planting

Description of crop	Condition of seedlings before and after storage	Observed frost damage, growth defects
Outside storage for conventional seedlings		
Cropping system A seedlings set out for hardening in June	-Spruces generally perform well in storage and first year after planting. -Stunted seedlings do poorly.	Needle droop. Root dieback.
	-Lodgepole pine up to 20 wk old on October 5 perform poorly in storage.	Shoot droop. Shoot tips turn downward, discolor, and turn brittle.
Cropping system B seedlings set out for hardening in June	-All species generally have satisfactory survival in storage and after outplanting	Severe dieback of tops and roots.
	-Expect failure in lodgepole pine when temperature is very cold and the snow cover is poor or shallow.	Some mortality.
4-14 wk old seedlings from cropping systems A and B set out for hardening in July and August	-Generally fair to good survival. -Expect 50% failure in lodgepole pine and 35% in white spruce.	Crown deformities in outplanted survivors.
4-14 wk old seedlings from cropping systems A and B set out for hardening in September	-Lodgepole pine and white spruce store poorly.	Occasional high mortality. Root damage common.
4-14 wk old seedlings from cropping systems A and B set out for hardening in October	-Periderm in roots should be a waxy, pale brown after storage. -Require physiological field and laboratory tests for root regeneration.	Occasional high mortality. Root damage common.
Inside refrigerated cold-storage for optimized seedlings		
Seedlings conditioned in April, cold-stored in May, and planted in August	-Color is unaffected throughout storage, and survival is generally excellent.	Nil. Seedlings perform well on frost-prone sites.
Seedlings conditioned in August, cold-stored in September, and planted in May	-Molding may develop in up to 4% of slower-developing seedlings. -Fungicide (Benlate) may be necessary to control molds.	Nil. Seedlings perform well on frost-prone sites.
Seedlings conditioned in December, cold-stored in January, and planted in May	-Seedlings are in prime condition during and after storage. -Expect subsequent growth activity to be fully satisfactory in pine and spruce.	Nil. Seedlings perform well on frost-prone sites.

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Canada

Northern Forest Research Centre
5320 - 122 Street
Edmonton, Alberta
T6H 3S5 (403) 435-7210

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