Freezer Storage Practices at Weyerhaeuser Nurseries

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The storage of conifer seedlings in freezer units at a temperature of -2 °C has become a matter of routine practice at Weyerhaeuser forest nurseries in Washington and Oregon. The evolution of this practice at Weyerhaeuser and current operating procedures are described in this paper. Tree Planters' Notes 38(3) : 7-10; 1987

Need for Long-Term Seedling Storage

The need for long-term storage of seedlings in our Washington and Oregon operating areas exists for a number of reasons. Our nursery facilities west of the Cascade Range are situated at low elevations, less than 1,000 feet. At these nurseries, seedlings must be lifted between December and early March in order to take full advantage of their frost hardiness and root regeneration potential. Because some of our planting sites at higher elevations are not accessible until May or June, storage periods of 2 to 6 months are common.

For our nursery in the Klamath Basin east of the Cascades, situated at 4,000 feet elevation, spring lifting is often confined to 4 to 6 weeks duration because of winter freeze-up and late thaw conditions. Long-term freezer storage allows lifting during late autumn and shipping the following spring. This provides for a more balanced work load, split between the fall and spring, and enables shipping to planting sites that thaw earlier than the nursery during the spring.

It has been our experience that shipping orders from the field can vary widely depending on weather conditions and crew logistics. We attempt to operate our nursery lift and pack operations on a production flow basis and find that freezer storage provides us with such options as lifting in advance of orders and packing seedlings for transplanting when there is slack in outplant orders. Thus, the freezer provides us with an effective surge buffer between nursery and field production.

Development and Testing

During the early and middle 1970's, most of the long-term storage needs at Weyerhaeuser were met using conventional cold storage methods in which storage temperatures are kept at +1 to +2 °C and relative humidity levels of 85 percent or higher. Although these conditions held seedlings satisfactorily for the most part, we did experience some problems with storage m olds and fungi. Naturally, the more mud and dirt included in the packing bags, the larger the problem with storage fungi. In an effort to eliminate this problem, in 1976 we decided to explore the alternative of storing seedlings at a temperature just below freezing, -1 to -2 °C.

In 1977, we lifted various lots of seedlings grown from coastal and cascade sources during mid-January, divided these into two groups, and placed one group into the freezer for storage at -2 °C and the other into the cooler at +2 °C (1). Coastal lots were in storage for 6 weeks and cascade lots were stored for 6 months.

At the end of the storage period, the coastal lots were outplanted at a site in our Twin Harbors Tree Farm and the cascade lots were outplanted at our Vail Tree Farm. In the Twin Harbors

Table 1—*Percentage survival of seedlings from a cascade source stored in the cooler (+2 °C) or the freezer (−2 °C) for 6 months and then outplanted at the Vail Tree Farm in 1977*

	North aspect				South aspect			
Species class	Cooler		Freezer		Cooler		Freezer	
Douglas-fir / 2+0	85	(5)	90	(3)	23	(8)	15	(5)
Douglas-fir / plug	94	(2)	91	(4)	40	(1)	31	(8)
Western hemlock / 1+1	50	(3)	53	(4)	2	(2)	3	(2)

Standard errors shown in parentheses.

[1]Originally presented at a meeting of the Western Forest Nursery Council, held on August 12-15, 1986, at Olympia, WA.

test, 100 percent of both freezer-stored and cooler-stored lots survived. In the Vail test, no significantly different survival rates were observed between cooler storage and freezer storage for like seedlots (table 1).

Similar tests were conducted with ponderosa and lodgepole pine at Klamath in 1978 comparing freezer-stored with cooler-stored seedlings (2). Seedlings were lifted in mid-October, stored overwinter, then outplanted in late April at Buck Mountain and mid-May at Coyote Creek. Survival percentages (table 2) indicate no significant differences in performance between freezer and cooler storage for either species.

A year later, additional tests were performed with lots of coastal and cascade Douglas-fir, noble fir, and western hemlock seedlings. These were lifted in mid-January at our Mima Nursery and stored in the freezer for intervals of 0, 2, 4, and 6 months. After the designated storage period, these seedlings were outplanted in a research test area at the nursery except for the 6-month lot. These seedlings were potted and evaluated in the greenhouse because by planting time (mid-July) the soil in the research test area had become excessively dry. The results of this test showed no significant decrease in survival percentages with time in freezer storage up to 6 months (table 3). This applied across all three species tested.

Table 2—*Percentage survival of pine seedlings stored overwinter in the cooler (+2 °C) or the freezer (−2 °C) and then outplanted at the Klamath Tree Farm in 1978*

Species	Cooler		Freezer	
Ponderosa pine	87	(8)	84	(10)
Lodgepole pine	88	(10)	93	(6)

Standard errors shown in parentheses.

Table 3—*Percentage survival of seedlings lifted in January and then stored for 0 to 6 months in the freezer (−2 °C) and then outplanted at the Mima Nursery in 1978*

Species	Origin	0		2 mon		4 mon		6 mon[a]
Douglas-fir	Cascade	100	(0)	100	(0)	100	(0)	95
Douglas-fir	Coastal	100	(0)	100	(0)	99	(2)	100
Noble fir	Cascade	98	(4)	99	(2)	86	(7)	100
Western hemlock	Cascade	78	(16)	100	(0)	95	(5)	100

Standard errors shown in parentheses.
[a]Plants were potted and evaluated in a greenhouse because of the excessive dryness of the soil in the test plot.

Test 4—*Survival results for various packing bag treatments*

Bag treatment	Percent survival	S.E.
50#WS + 10#PE/50#WS/50#WS	97	(1)
50#WS + 10#PE/50#WS/50#WS + waxed seam	94	(3)
50#WS + 10#PE/50#WS/50#WS + liner	97	(2)
50#WS + 10#PE/50#WS/50#WS + waxed seam + liner	94	(1)

Initially, we were somewhat concerned over how seedlings for the freezer should be packaged. We knew that the freezer could desiccate the seedlings if the moisture barrier provided by the packaging was not adequate.

Therefore, we experimented with a number of different options (1): a) the standard ply kraft bag (50#WS+10#PE/50#WS/ 50#WS); b) the standard bag with its seam waxed dipped (50#WS+10#PE/ 50#WS/50#WS + liner); c) and the standard bag with the wax-dipped seam plus the poly liner (50#WS+10 #PE/50#WS/50#WS + waxed seam + liner). Acceptable results were obtained with all treatments and the additional safeguards of the wax-dipped seam of poly

liner were not justified (table 4).

Table 5 -Some of the species that have been successfully stored in the freezer

Douglas-fir	*Pseudotsuga menziesii* (Mirb.) Franco
Noble fir	*Abies procera* Rehd.
White fir	*A. concolor* (Gord. & Glend.) Lindl. ex Hildebr.
Shasta red fir	*A. magnifica* var. *shastensis Lemm.*
Grand fir	*A. grandis (Dougl.* ex D. Don) Lindl.
Balsam fir	*A. balsamea* (L.) Mill
Pacific silver fir	*A. amabilis* Dougl. ex Forbes
Fraser fir	*A. fraseri* (Pursh) Poir.
Western redcedar	*Thuga plicata* Donn ex D. Don
Western hemlock	*Tsuga heterophylla* (Raf.) Sarg.
Sitka spruce	*Picea sitchensis (Bong.*) Carr.
Engelmann spruce	*P. engelmannii Parry* ex Engelm.
Norway spruce	*P. abies* (L.) Karst.
Ponderosa pine	*Pinus ponderosa* Dougl. ex Laws.
Lodgepole pine	*P. contorta Dougl.* ex Loud.
Scotch pine	*P. sylvestris* L.
Western white pine	*P. monticola* Dougl. ex D. Don
Eastern white pine	*P. strobus* L.
Western larch	*Larix occidentalis Nutt.*
Giant sequoia	*Sequoiadendron giganteum* (Lindl.) Buchholz
Red alder	*Alnus rubra* Bong.
Quaking aspen	*Populus tremuloides* Michx.
Oregongrape	*Mahonia aquifolium* Nutt.
Red maple	*Acer rubrum* L.

Current Freezer Storage Practice

The use of freezing temperatures for long-term seedling storage has been a routine practice for our nurseries since 1978. We currently store about 25 million seedlings annually in freezers. Over the years we have found that many species can be freeze-stored at -2 °C successfully (table 5).

Some basic elements that are important in the freeze-storing of conifers include physiological condition of the seedlings, packaging, and thawing before planting. As with conventional cold storage, it is always advisable to start with seedlings that are clean, healthy, and disease free. Though most fungi will not grow and spread in freezer storage, they will still be viable when the trees are removed from storage for thawing and planting.

Seedlings should be exposed to the natural chilling conditions that occur in autumn in order to promote dormancy and frost hardiness. In our nurseries west of the Cascades, we find that by the first to second week in December virtually all seedlings are hardy to -5 °C and LT_{50}'s of -10 °C are not uncommon. At our Klamath nursery these conditions will occur at least a month earlier. Once seedlings attain these levels of hardiness they will store well under freezing conditions at -2 °C.

The freezer storage facilities that we use are simply conventional refrigerator units operated at -1 to -2 °C. There are no provisions in these units for humidity control, and because the evaporators are placed directly in the storage areas themselves, the humidity is quite low. It is therefore important to provide a moisture barrier in the packaging of the seedlings. Storage of seedlings in exposed bales will not work, for the seedlings will desiccate.

We pack seedlings in both bags and boxes depending on customer preference. The bags are standard kraft seedling bags, which are widely used by Washington and Oregon forest nurseries. These bags are of 3-ply construction with the inner ply treated with a 10# polyethylene spray coating. This coating provides a suitable moisture barrier.

Seedlings are packed in the bags in a moist (not waterlogged) condition, and the bag is sealed

by folding and rolling the top down. The application of two or three straps secures each package. The packages are then placed on pallets with racks that allow for stacking and the entire palletized stack is moved directly into the freezer.

In the case of boxes, we use a 1.5-mil poly liner placed inside the box to prevent loss of moisture. The liner is sealed by twisting and tucking and is held secure by the top flap. Once palletized, the boxes of seedlings are moved directly to the freezer.

Whatever is used to package the seedlings must provide a seal against moisture loss and be durable enough to withstand normal impact and abrasion in the production operation without sustaining tears and punctures. Should a bag or box be punctured, it can be patched with tape if a wax-coated surface is not involved. Wax surfaces are a challenge to repair.

Freezer temperatures should be checked daily and maintained at -1 to -2 °C. A continuous measuring device such as a thermograph is recommended as it provides the operator with a permanent record of temperature over time. Once in the freezer, seedlings may take up to 10 days before they freeze solid. Plug seedlings will take longer than bareroot seedlings because of the potting soil and additional moisture contained in the root plug. Seedlings handled and packed in the manner described will keep well up to 6 months in the freezer.

Seedlings must be thawed before they are planted, for frozen root systems or stems can cause transpirational drought stress. We thaw seedlings at the nursery before they are shipped to the customer. Thawing is done in a warehouse or similar structure at ambient temperature (+10 to +15 °C). The pallets are spread out to allow for ample air circulation between pallet stacks.

Bareroot seedlings normally take 3 to 5 days for thawing whereas plug seedlings will require 10 to 15 days. Once thawed, the seedlings can be shipped to the customer for planting. It is preferable to plant seedlings as soon as they have thawed; however, our experience shows that they can be held in cooler storage after thawing up to 4 weeks without detriment.

Summary

Storing seedlings at -2 °C is a practical and proven means of holding conifers in a dormant, viable condition for periods up to 6 months before planting. Though cooler storage at +2 °C can provide similar results, the probability of problems with storage molds is much greater. Most western conifers can be freezer-stored provided they are in a dormant and hardy condition before lifting and storing. Packaging seedlings for the freezer must include a moisture barrier. A polyethylene bag placed in the packing box or a polyethylene coating applied to the inner ply of the packing bag served well in this function. Unlike cooler-stored trees, freezer-stored trees require thawing. This step is most practically achieved by simply spacing pallets of seedlings out in a warehouse at +10 to +15 °C.

Literature Cited

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