Freezer Storage Practices at Weyerhaeuser Nurseries[1]

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Abstract.--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. This paper provides background information on the evolution of this practice in Weyerhaeuser and describes current operating procedures.

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 one thousand 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 two to six months are common.

For our nursery in the Klamath Basin east of the Cascades, situated at four thousand feet elevation, spring lifting is often confined to four to six 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 which thaw earlier than the nursery during the spring.

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It has been our experience that shipping orders from the field can fluctuate widely depending on weather conditions and crew logistics. We attempt to operate our nursery lift and pack operations on a constant production flow basis and find that freezer storage provides us with such options as lifting in advance of field outplant 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 our long-term storage needs were met using conventional cold storage methods where storage temperatures are kept at +1°C to +2°C and relative humidity conditions at 85* or higher. Though these conditions held seedlings satisfactorily for the most part, we did experience some problems with storage molds 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, we decided in 1976 to explore the alternative of storing seedlings at a temperature just below freezing, -1°C to -2°C.

In 1977, we lifted various lots of coastal and cascade source seedlings during mid January, divided these into two groups and placed one group into the freezer for storage at -2°C and the remaining group into the cooler at +2°C (Gutzwiler, 1978). Coastal lots were held in storage for six weeks and

cascade lots were stored for six 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 test, both freezer stored and cooler stored coastal lots survived at 100 percent. For the cascade sources at Vail, no significant differences between cooler storage and freezer storage for like seedlots were observed (Table 1).

Similar tests were conducted with ponderosa and lodgepole pine at Klamath in 1978 comparing freezer stored seedlings with cooler stored (Stevens and Heninger, 1986). Here seedlings were lifted in mid October, stored overwinter then outplanted in late April at Buck Mountain and mid May at Coyote creek the following spring. Survival percentages (Table 2) indicate no significant differences in performance between freezer and cooler storage for either species.

Table 1.--Survival percentage of seedlings stored in the cooler versus freezer for six months and outplanted at the Vail Tree Farm in 1977. Standard errors shown in parenthesis.

	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)

Table 2.--Survival percentage of pine seedlings stored overwinter in the freezer versus the cooler and outplanted at the Klamath Tree Farm in 1978. Standard errors shown in parenthesis.

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

A year later, additional tests were performed using coastal and cascade Douglas-fir lots, a noble fir lot and western hemlock lot. These were lifted in mid January at our Mima Nursery and stored in the freezer for intervals of zero, two, four and six months. After the designated storage period these seedlings were outplanted in a research test area at the nursery except for the six months stored treatment. The latter was potted and evaluated in the greenhouse because by then (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 six months (Table 3). This applied across all three species tested.

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. We, therefore, experimented with a number of different options (Gutzwiler, 1978). These included using:

the standard ply kraft bag (50#WS+10#PE/50#WS/50#WS),

the standard bag with its seam waxed dipped (50#WS+10#PE,,/50*WS/50#WS + waxed seam),

the standard bag plus a 1.5 mil poly liner (50#WS+10#PE/50#WS/50#WS + liner)

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 3.--Survival percentage of seedlings stored for 0 to 6 months in the freezer versus the cooler and outplanted at the Mima Nursery test area in 1978. Standard errors shown in parenthesis.

		Months in Storage			
Species	Seedlot	0	2	4	6[1]
Douglas-fir	411-15-01	100 (0)	100 (0)	100 (0)	95
Douglas-fir	030-05-01	100 (0)	100 (0)	99 (2)	100
Noble fir	430-20-04	98 (4)	99 (2)	86 (7)	100
Western Hemlock	412-30-02	78 (16)	100 (0)	95 (5)	100

[1] Evaluated in greenhouse.

Table 4.--Survival results for various packing bag treatments.

Bag Treatment	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)

CURRENT FREEZER STORAGE PRACTICE

The use of freezing temperatures for long-term seedling storage has become 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 the species which can be freeze stored at -2°C are numerous. A partial listing of those species which we have successfully freezer stored is presented in Table 5.

Table 5.--Some species which have been successfully stored in the freezer.

Douglas-fir	Norway Spruce
Noble Fir	Ponderosa Pine
White Fir	Lodgepole Pine
Shasta Red Fir	Scots Pine
Grand Fir	Western White Pine
Balsam Fir	Eastern White Pine
Pacific Silver Fir	Western Larch
Fraser Fir	Giant Sequoia
Western Red Cedar	Western Red Alder
Western Hemlock	Quaking Aspen
Sitka Spruce	Oregon Grape
Englemann Spruce	Eastern Red Maple

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 which are clean, healthy and disease free. Though most fungi will not grow and spread in freezer storage these will still be viable when the trees are removed from storage for thawing and planting.

The seedlings should be exposed to natural chilling conditions which 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 LTso'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 which we use are simply conventional refrigerator units which are operated at -1°C to -2°C. There are no provisions in these units for humidity control and since the evaporators are placed directly in the storage areas themselves the humidity will be 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 as the trees 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 secure the package. These 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 provided a wax coated surface is not involved. Wax surfaces are a challenge to repair.

Freezer temperatures should be checked daily and maintained at -1°C 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 ten days before they freeze solid. Plug seedlings will take longer than bareroot 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 six months in the freezer.

Seedlings must be thawed before they are planted as 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°C to +15°C). The pallets are spread out to allow for ample air circulation between pallet stacks. Bareroot seedlings normally take three to five days for thawing whereas plug seedlings will require ten to

fifteen 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 to date shows that they can be held in cooler storage after thawing up to four weeks without detriment.

SUMMARY

Storing seedlings at -2°C is a practical and proven means for holding conifers in a dormant, viable condition for periods up to six 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 serve well in this function. Unlike cooler stored trees, freezer stored seedlings require thawing. This step is most practically achieved by simply spacing pallets of seedlings out in a warehouse at +10°C to +15°C.

LITERATURE CITED

Gutzwiler, Jerry. 1978. Freezer storage of western conifer seedlings. Weyerhaeuser Technical Report. 21 pp. Weyerhaeuser Forestry Research Center, Centralia, WA.

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