Mr. Landquist: You mentioned peat. In the Lake States in the thirties, we had emergency labor and we made compost. It was rather costly. We used peat as a medium and mixed the fertilizer. We put it in a compost pit using humus with it.

Dr. Wheeting: We have on the west side found that most peat is very hard to decompose. There is the fibrous peat from the sedges and the woody peat. The sedge peats are felty and take a long time to decompose. Same with the moss peats. You need a lot of nitrogen before you really get good luck with peat on forest land. Alders or legumes are high in calcium. Application of sawdust six inches deep and use about 80 pounds nitrogen per acre. Two or three hundred pounds ammonium sulphate, if taken with about twenty tons of sawdust. I think six inches is too much. But give the soil a chance to assimilate it and add more frequently if possible.

Mr. Stubbs: I can see the difficulty in trying to work in six inches of sawdust in the soil.

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Chairman Webster introduced Mr. Forrest W. Deffenbacher, Chief Nurseryman, Wind River Nursery, U.S. Forest Service, Carson, Washington. Mr. Deffenbached presented the following paper on "Storage of Planting Stock."

REFRIGERATED STORAGE OF CONIFEROUS SEEDLING STOCK

by

F. W. Deffenbacher

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The problem of keeping coniferous seedlings in good plantable condition from the time they are removed from the seed beds until they are planted at the planting site is not a new one to nursery and planting men. Of the many methods of storage tried, refrigerated storage appears to give the best results. It not only keeps the seedlings in good plantable condition; it also reduces the seasonal peak work loads in the nursery, because lifting operations can be carried on at a steady rate by a small crew. Refrigerated storage makes it possible to ship dormant stock whether it is ordered during the early spring planting season when the nursery is snowed in, or during the late spring season after growth has started. It reduces the heel-in job at the planting site, because trees can be stored at the nursery and shipped as needed in small quantities to the planting crews.

The cold storage of coniferous seedlings has brought up numerous questions. Some of the most important are:

1. What is the optimum temperature and humidity?

2. What is the best method of storage (bare-root, bundle, or crate)?

3. What is the maximum length of time different species can be stored under refrigeration and remain satisfactory planting stock?

4. What effect does cold storage have on mycorrhizal associations?

Temperature and Humidity

We found by experimentation that controlled temperature and humidity were necessary to prevent mold development and maintain the stock in otherwise good condition.

A hydrothermograph was installed in the cold storage room to obtain a graphic picture of the temperature and humidity. We found that a temperature of 34 degrees and a humidity of 90 to 95 percent gave the best results. When a temperature above 34 degrees was maintained, mold developed. When the temperature was reduced to 32 degrees, dehydration of the tops began and also necessary humidity was difficult to maintain. We found that even with a 34 degree temperature, if the humidity was allowed to drop below 90 percent, dehydration of the tops began.

Methods of Storage

We have tried three different methods of storage -- bare-root, bundles, and crates. When the stock is packed in crates or bundles the root hairs, being in moist shingle tow or moss, are kept moist and no drying takes place; this is not true of the bare-root stock. We have found that aeration of the tops is a vital factor in the prevention and retardation of mold growth.

This can be accomplished best by storing the trees in bundles with an air space of three or four inches between each layer of bundles. When seedlings are stored in crates, the ends of the crates prevent proper air circulation around the tops of the trees. The capacity of the cold storage room is greatly increased when the bundle or crate method is used.

The efficient operation of a cold storage plant depends largely on insulation -- walls, ceiling, and floors. There are a great many satisfactory materials that may be used, such as glass wool, cork, or sawdust. The type to be used depends largely upon which is the most economical in the particular locality. A refrigeration engineer should be consulted before deciding on the number and the size of refrigerant units to install.

Period of Storage

We used Ponderosa Pine, Noble Fir, Douglas fir, and Sitka Spruce in our study of maximum satisfactory period of storage. All the species tested showed a higher percent of moisture in the roots than in the tops after four months of cold storage with the exception of Ponderosa Pine, of which the opposite was true. This ratio continued throughout six months of storage. For periods longer than six months, especially after twelve and eighteen months, the tops were found to have a higher percent of moisture than the roots. All species had a good rate of survival after six to eight months of cold storage. Ponderosa Pine and Noble Fir still had 100 percent survival after twelve months storage. However, Douglas fir and Sitka Spruce had dropped to 39 percent and 79 percent, respectively.

Mycorrhizal Associations

Mycorrhizal associations do not appear to be seriously affected by prolonged periods of refrigeration. However, further observations and tests are needed to verify this.

Refrigerated stock was planted in the nursery for survival tests. Admittedly, the chances for good survival of any stock, refrigerated or otherwise, are greater in a nursery than in actual field plantations. In the same ratio, it is our opinion that such planting tests are indicative of the effect of cold storage.

American Nurseryman Magazine

The problem of how to keep evergreen seedlings after they are dug from the seedling beds and while they are sorted, graded, and until they are shipped has been solved by the Plumfield Nurseries, Fremont, Nebraska, with the construction of an insulated, refrigerated storage room in which bare-rooted evergreens and other stock may be economically protected.

Before constructing the large permanent cold-storage building, the firm had constructed a small cold-storage room and experimented with its effectiveness for preserving evergreen stock. Although this room was designed for storing young evergreens on a temporary basis only, it proved practical for keeping stock dug in the fall until the following spring. In spite of the fact that the small room was enlarged five different times, it became apparent that a new building was needed to give adequate cool space.

So a new building was constructed to hold evergreen seedlings dormant from fall until spring. Now completed, it contains a cooler forty feet wide and sixty feet long, with a clear height of nine feet. The cooler area is insulated with a 4-inch thickness of Armstrong's Corkboard. The interior walls are finished with asphalt emulsion. Roof insulation was applied not only over the cooler, but also over the sorting and grading room, which is adjacent to the cooler and which may be easily converted to additional cold storage space when needed.

With this new building Plumfield Nurseries are able to maintain temperatures of 33 to 35 degrees Fahrenheit and relative humidity of 85 to 90 percent, which have been found to be the most satisfactory for storage of young evergreen seedlings in their locality.

Mr. Lemmon: What are survival checks after six months?

Mr. Deffenbacher: Checks will run from 98 to 100 percent unless your stock is moved. Your checks will often be lower than your storage.

Mr. Lemmon: Should that not be considered?

Mr. Deffenbacher: It will be in the minutes. We are merely considering our dormant stock in comparison with that which was dug the previous fall. We held the temperature at 34 degrees and the relative humidity to 90 to 95. When the tops began to discolor and the moisture content goes down, the plant dies.

Mr. Stubbs: I want to ask the gentlemen from the Nisqually Nursery. Do you dip your stock?

Answer: No.

Mr. Stubbs: I wondered if dipping would help.

Table 1
Data on Coniferous Stock both in and out of Cold Storage and Per cent Survival
Average Cold Storage Temperature (34) and Humidity (90-95%)

Species	Age	Months in Cold Storage	Percent Moisture Roots	Percent Moisture Tops	Condition of growing Tips	Condition of Mycorrhizae	Presence of Mold	Planting Mos. in Cold Storage	Per cent Survival
Douglas-fir (Doty Seed)	2-0	4	144	109	Good	Good	Trace (Roots)	4	-
		5 1/2	117	131	Good	Good	Trace (Roots)	6	100
		7	134	135	Root tips brown	?	Some (Roots)	8	97.9
Pseudotsuga taxifolia		7+1 mo. air temp.	-	-	Dried	Shrivelled	Some (Roots)	7+1	55.8
		12	(Weight samples discarded accidentally) -	-				12	39.0
Douglas-fir (Wind River Seed)	2-0	Never Dug and held in snowbank for 3 mo.	118	125	Good	Good	None	No Plantings	
Douglas-fir (Wind River Seed)	2-0	Never Weighed same day as dug	132 (March)	92	Excellent	Good	None		
			89 (April)	78	Excellent	Good	None	No Plantings	
Douglas-fir (Waldport Seed)	3-0	4 1/4	128	114	Good	Good	Trace (Roots)		
		6	158	117	Good	Good	Trace (Roots)		
		7 1/4	138	146?	Root tips brown	?	Trace (Roots)	No Plantings	
		12	47	87	Fair	?	Trace (Roots)		
Sitka Spruce	3-0	3 1/4	136	99	Good	Good	None	3 1/4	-
		4-3/4	131	89	Good	Good	None	4-3/4	-
Picea sitchensis		6	155?	111	Good	Good	Abundant in tops	6	100
		12	2	63	Fair	?	Rhizoctonia solania in tops	8	100
								12	72
Noble Fir (Race Track Seed)	3-0	4-3/4	193	139	Good	Good	None	4-3/4	-
		6 1/4	157	148	Good	Good	None	6	100
		7 1/2	114	130	Good	Good	Trace (Tops)	8	100
Abies nobilis		12	52	110	Good	?	Trace (Tops)	12	100
		18	62	55	Good	?	Needles falling	-	-
Ponderosa Pine	2-0	4 1/2	101	121	Good	Good	None	4 1/2	-
		6	108	126	Good	Good	None	6	100
Pinus ponderosa		7 1/4	90	110	Good	Good	Trace (Roots)	8	100
		12	31	94	Good	?	Trace (Roots)	12	100
		18	23	75	Good	?	Heavy (Tops)	-	-

Mr. Rindt: I guess it is clear to the fellows that we had no loss of time. We do not try to keep the stock as long. We had no loss of stock that was carried over the winter. We have no loss up to six months.

Chairman Webster: It is unlikely that any planting stock would be held in storage more than six months.

Mr. Augenstein: Is that all right in spruce?

Mr. Deffenbacher: Noble fir and pine would hold even longer without damage.

Chairman Webster: How did you maintain your humidity at 90?

Mr. Deffenbacher: We are in a very wet climate.

Mr. Augenstein: We can't get it below 90.

Chairman Webster: Are you using shingletow for packing?

Mr. Augenstein: Some, and it seems to keep continuous circulation.

Mr. Haddock: You do not need a humidifier.

Mr. Lemmon: That is a special engineering problem.

Mr. Landquist: How much moisture did you put on the packing material?

Mr. Deffenbacher: We put the shingletow in water and sufficient water will stay on to pack the trees.

Mr. Landquist: Pack in peat moss. Dump it in a tub and put in the seedlings.

Mr. Lemmon: We store with moss. We find that the best conditions are to squeeze the water out of the moss.

Mr. Isaac: I would like to hear from Engstrom. He started some studies on this.

Mr. Engstrom: We have packed in moss and packed in shingletow. During the early period of storage, results for both are about the same, but four to eight weeks later, the seedlings packed in shingletow did not show up as well. Tarrant was with us and he was trying out a plant material to make roots grow better. We soaked the roots in that for three hours in the root tones and planted normal stock. The root-toned stock and that in sawdust showed 90 to 96 percent. I am just wondering if that shingletow has some property that hurts the roots. We are going to follow that study further. This was on a small scale.

Mr. Deffenbacher: I tried the same thing. Packed in shingletow. Had 100 percent on seedlings between six weeks to three months.

Mr. Isaac: I do not think it is a killing factor.

Mr. McDaniel: Shingletow is toxic to seedlings.

Mr. Rindt: There is something to it. I think the answer is that shingletow was probably not fresh. If the shingletow is fresh and there was enough leaching out of solid material out of the shingletow, you do not get the leaves that look brown and shriveled in about thirty hours. We have checked trees in shingletow and apparently they have come out O.K. We have to be careful of the shingletow and treat it before using it for packing material. I am not able to say what the treatment should be, but I believe running water through the shingletow, continue leaching out, you can take fresh shingletow and put it in a container, put a lot of water on and when you drain off the liquid, it is about the color of coffee. We can't just say we are not going to use shingletow, but in packing we should know the condition it is in from the standpoint of concentration of liquid, because there is not much water in it after you pack the trees.

Mr. Engstrom: From the look of the stock just in packing material for a period of time, it looks a little better in shingletow than in moss. In unpacking the stock we found that new growth had started, had heavy roots on the trees packed in shingletow and were not turned brown, while that in the moss had.

Mr. Haddock: Is there enough difference in the temperature and amount of moisture?

Mr. Rindt: It was not a case of moisture, but fresh shingletow. This may sound like we are getting away from the cold storage. But important though, is the length of time the stuff is kept in storage. Any extreme is enough to kill the trees. I would think we don't have to cross off shingletow as material for packing. We know that it can be used in connection with storage as we have a packing material.

Mr. Landquist: How much do you pay for shingletow?

Mr. McDaniel: $11 a ton.

Mr. Landquist: We pay $2.95 per 100-pound barrel of peat moss. Ten barrels will pack 200,000 trees. We can still get moss.

Mr. Wright: I wonder if we are considering the effect of temperature, if you just take seedlings and pack them in a room that warms up during the day.

Chairman Webster: We have used shingletow with lots of seedlings and we do not know of any ill effect. We buy it in big quantities. Our present supply is about ten years old. The packing material ties in with wrapping material. Let's hear some discussion on that subject.

Mr. Deffenbacher: We do not use burlap. We are using ocean wrap. Army surplus. It has a coating of cellophane and a coating of wax.

Chairman Webster: Has anyone else anything to add about material for baling?

Mr. Deffenbacher: If your trees are shipped out the same time as they are packed, of course the trouble is not due to storage. Storing with burlap - the mold develops faster.

Mr. Lemmon: Do you store in bales or bundles?

Mr. Deffenbacher: The same thing is used for either.

Chairman Webster: Roots should be in and the tops out.

Mr. Augenstein: We found that the trees packed in burlap had the mold inside the burlap.

Chairman Webster: Are you using anything inside the burlap?

Mr. Augenstein: Butcher paper. You do not get too much evaporation.

Mr. Lanquist: We have used the same kind of paper for years - ocean wrap.

Mr. Wells: Has anyone had any experience with treating burlap?

Mr. Lanquist: I read an article which tells how to treat it.

Chairman Webster: I do not believe it is too much of a problem to get it. Pacific Marine Supply Company in Seattle has a treatment for hose and fish nets which is known as pacolizing. It should not be too expensive.

Mr. Isaac: There is a simple chemical to prevent mold.

Mr. Wright: The Department of Agriculture is doing work on that. How this would affect seedlings I don't know. This would apply to decay as well as mold. Decay is brought about by the same type of fungus as mold.

Mr. Augenstein: There is one thing that a building needs for cold storage. Sometimes they do not have enough circulation of air to help to keep the mold down. They had plenty of air blowing in, but it could not get away, and we got mold. We cut holes in the building and we got away from that right away. We got more dehydration, but it kept the mold down. About the use of burlap for wrapping material, we found no mold around the burlap, but found mold around the weeds and stems.

Chairman Webster: On the circulation, is this new air or re-circulation?

Mr. Augenstein: It is re-circulation. No new air. For a room 30' x 45', it might be necessary to bring in fresh air occasionally. We use heavy weight twine. Binder twine is too sharp. The twine does not mold.

Mr. Lanquist: I would like to say a little more about air circulation. We have a circular system of air ducts. These ducts are constructed in the ceiling.

Mr. Deffenbacher: The way ours is arranged is the cooler unit with big fans with two auxiliary fans to circulate the air.

Chairman Webster: Doesn't this have to be worked out by engineers? You have to change the air so many times per cubic content per minute.

Mr. Augenstein: Jim Burns, Regional Engineer, Region 5, handled our problem after the cold storage man told him he realized we were not getting enough air circulation. We have 5 HP unit motors.

Mr. McDaniel: We have big blowers set up in the cooler. Lots of air moves all the time.

Mr. Augenstein: Our blower is one HP with circular-type fans.

Chairman Webster: Air circulation to eliminate mold is very important in any type of storage.

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Chairman Webster introduced Dr. Ernest Wright, Pathologist, Bureau of Plant Industry, Region 6. Dr. Wright presented the following paper on "Microbiological Management of Nursery Soils."

MICROBIOLOGICAL MANAGEMENT OF NURSERY SOIL

by
Dr. Ernest Wright

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The microbiological management of nursery soil is a difficult topic to discuss. At least it is difficult for me to discuss adequately. I will have to plead guilty to having worked on some phases of the problem, but please do not consider me as an authority on the subject. There are a number of reasons for the complexity of the problem. Each nursery site differs in respect to soil management and, furthermore, the same success may be obtained for any one site by several essentially different types of soil management. With considerable temerity I will therefore attempt to discuss the general principles of microbiological management of nursery soil by drawing on a few examples of my own experience.

Let us start with a definition of soil microbiology. We may define it as a study of the microflora and microfauna of the soil and the relation of these organisms to one another. By microflora we mean bacteria, actinomycetes and soil fungi. Under microfauna we have such minute forms of animal life as amoeba, protozoa, nematodes, etc. The microbiological populatinn is heaviest in the upper few inches of the soil. Now what can we say about microbiological management of nursery soils? I am sure that you are all aware that soil is a dynamic, ever changing medium and that it is not static nor can it be held so in spite of ourselves. What then can we do to maintain a desirable balance? We have just heard an excellent paper on the maintenance of soil fertility. Perhaps we should start with how soil fertility affects the microbiological balance of the soil. Here we can start with the statement of an important fact; namely, that an increase in the nitrate-nitrogen level in the soil at the wrong time will increase damping-off losses. Nitrate-nitrogen has a subsequent effect on damping-off by directly affecting the activity of soil micro-organisms. The obvious answer is to maintain a nitrate-nitrogen balance in your nursery soil that is relatively low during the early part of the season, when the seeds are germinating, and gradually increase it as the season advances for the normal development of the seedling crop. This can