Cultural Perspectives

Seedling Storage

It's that time of year when nurseries are either harvesting their seedlings and putting them in storage, or are planning to lift and pack their stock during the late winter or early spring for storage until outplanting. So, it seems like a good time to review some basics about seedling storage. In this issue, we'll discuss the different types of storage and storage facilities; in upcoming *FNNissues, we'll* continue with a discussion of storage physiology, and seedling packaging and handling techniques.

Seedling storage wasn't a serious consideration back in the days when all nurseries were built close to the outplanting project. Seedlings were just dug up in the nursery one day and then outplanted the next. Transportation was slow and seedling handling and packaging was rather simple (Figure 1). Reflecting back on those days and knowing what we now do about seedling physiology, it's amazing how well those early plantations performed.

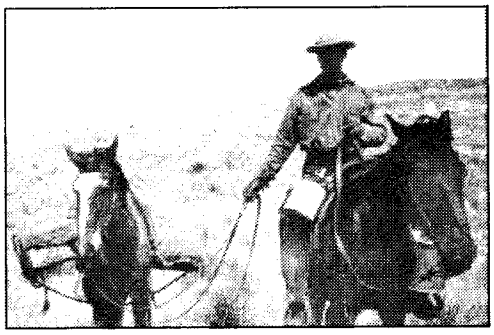

Figure 1. Seedling storage and delivery were quick and easy when nurseries were located close to the outplanting site.

Today, however, we realize that forest and conservation seedlings are a **perishable commodity.** Unlike many other products that can be stored for extended periods without a decrease in quality, nursery crops are living, and therefore have a **very limited shelf life.** Another contributing factor is that today's seedlings typically are grown at considerable distances from the outplanting site-sometimes in different states or even different countries. Therefore, well-designed seedling storage facilities are a necessity at all nurseries, and many large outplanting projects also have their own on-site storage.

There are two basic types of seedling storage: sheltered storage and refrigerated storage.

Sheltered storage.
Traditionally, bareroot nurseries used to store their seedlings outside in "heel-in" beds or in naturally cool structures such as potato cellars, but these techniques are much less common today. Some nurseries still "heel-in" their hardwood seedlings, although the latest research shows that the physiological quality of these seedlings is reduced and their roots are often damaged by pathogenic fungi. If seedlings must be "heeled-in", then mulching the beds with straw or other insulating material reduces injury.

In mild climates, container seedlings are sometimes stored in the propagation area until they are shipped to the outplanting site. The seedlings continue to receive irrigation and are protected from drying winds by shelterbelts. At higher latitudes and elevations where freezing weather is likely, container seedlings are placed directly on the ground for the winter to lessen the possibility of cold injury to the roots. Survival is good when snow covers the seedlings throughout the winter (Figure 2A). A recent study found that outplanting performance of spruce seedlings stored outdoors under a Styrofoam insulation blanket was as good as conventional freezer storage (Figure 2B). Shadehouses have been used as a combination hardening and storage structure for container stock. The typical shadehouse for overwinter storage has shadecloth or snow fencing on both the roof and sides that protects seedlings from adverse weather, including: high winds, intense rains, hail, and heavy snow. Fully-enclosed shadehouses also protect seedlings from large animal pests, such as deer and rabbits. Hoop houses and tunnels are low-cost Quonset structures that have been used to store forest and conservation seedlings in some high-latitude nurseries.

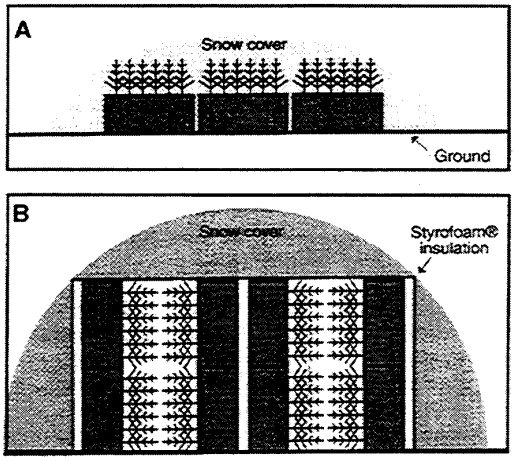

Figure 2. When container seedlings are stored outside over the winter, snow provides a good insulating cover (A). The addition of a Styrofoam blanket helps extend the period of snow cover and protects seedlings in low snow years.

The size of the sheltered storage area that will be needed depends on the type of propagation system, the number of crops produced per season, and the length of the time that the seedlings will have to be stored. Nurseries that produce more than one crop per year will need to carefully calculate the necessary amount of storage space; experience has shown that a storage area of 2 to 3 times the propagation space is often required.

Refrigerated storage.
Bareroot seedlings have been stored under refrigeration for many years, but this practice is relatively new for container nursery stock. When forest and conservation seedlings were first produced in containers, it was assumed that container seedlings could be planted all year, and many nurseries shipped their stock to the outplanting site in the growth container. Then, growers observed that container stock stored in sheltered storage broke dormancy very early, especially the root systems. This often occurred before the planting window opened on many sites, and operational trials revealed that non-dormant container seedlings did not tolerate the stresses of handling very well. So, to minimize storage volume

and maintain the seedlings in a fully dormant condition until the outplanting sites were ready, nurseries began extracting **(pulling)** the seedlings from their containers, grading them, and packing them **(wrapping)** for refrigerated storage.

There are two different types of refrigerated storage used in forest and conservation **nurseries, cooler storage and freezer storage,** which are differentiated by their operational temperatures:

In-box Temperature

Cooler Storage 1 to 2 °C (33 to 36 °F)
Freezer Storage -1 to -4 °C (25 to 30 °F)

Cooler storage is recommended when seedlings are going to be stored for less than 3 months and when seedling shipments occur throughout the storage period. When the storage period is going to be more than 3 months, many nurseries use freezer storage because the lower temperatures suspend seedling metabolic activity and conserve stored carbohydrates. Spruce seedlings in freezer storage have also been shown to develop greater root cold hardiness than those stored outdoors, and they also maintain their hardiness longer. Freezer storage also significantly reduces the incidence of storage molds. Because freezing the seedlings converts all the free water in the storage container to ice, the development of pathogenic fungi such as gray mold *(Botrytis cinerea)* is retarded.

The type and duration of seedling storage depends on the distance to the outplanting site and the outplanting window:

- **Summer outplanting:**

  Seedlings that will be harvested and outplanted during the summer on relatively low stress sites are still actively growing and have little cold hardiness. Because these "hot planted" seedlings must be shipped while still relatively succulent, they should only be held in sheltered storage or cold stored for a few days. Container seedlings can be shipped in the container and held on the outplanting site, and either bareroot or container seedlings can be "jelly-rolled" (Figure 3) and boxed. In either case, the seedlings can still be irrigated if there are delays in outplanting.

- **Fall outplanting:**

  By this time of the year, seedlings have received a moderate amount of cold hardening, but are not fully-dormant when harvested. Nurseries either can ship seedlings in the container, or jelly-roll them as done for summer outplanting. If refrigerated storage is available at the nursery or on the outplanting site, only cold storage is recommended, because freezer storage may damage non-hardy tissue. The storage duration should be limited to a few days or weeks.

- **Winter or spring outplanting:**

  These outplanting windows require fully-hardened seedlings with dormant shoots, and this stock either can be cold-stored (if the storage period is less than 3 months) or freezer-stored (if over 3 months).

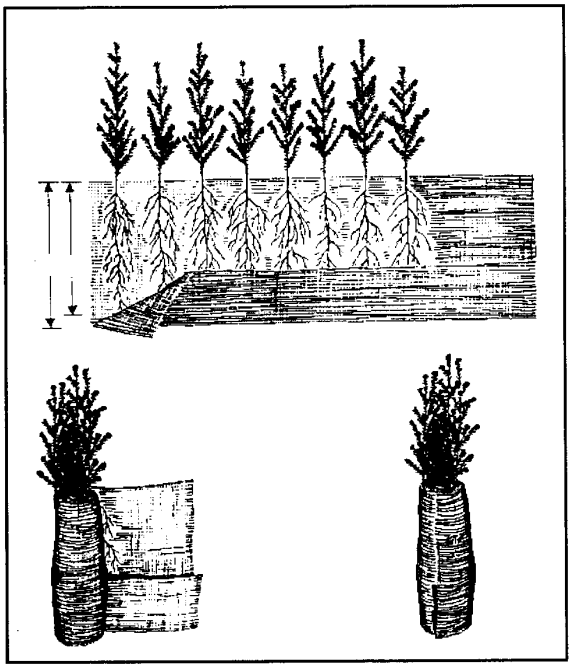

Figure 3. Both bareroot and container seedlings can be "jelly-rolled" in wet cloth wrappings for short-term storage before outplanting.

The seedling storage period is a critical phase in the nursery crop cycle. Nursery managers must design the proper type of storage facility that compliments the condition of the seedlings when they will be harvested, and that will maintain them in top physiological condition until they can be outplanted.

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