CHAPTER 10—PACKING, STORAGE AND SHIPPING

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SYSTEMS

Systems of packaging and storage should be considered before nursery construction. Factors to be considered in selecting a new system of handling seedlings or modifying an old system are:

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3. Packaging in the field or in a shed
4. Interval between lifting and shipping or planting
5. Maximum number of seedlings to be held in storage
6. Method of storage at the nursery and in the field
7. Method of shipment

Small nurseries have more flexibility than large nurseries in the choice of packing and storage methods. Storage is seldom critical when seedlings are planted within 2 to 3 days after lifting.

PACKAGING

The manner in which seedlings are packed for shipment influences the length of time they can be safely kept in storage. The packing process also affects the condition of the plants when received at the planting sites. Efficient packaging requires containers that are:

1. Light in weight. Packages must be light enough to permit efficient handling by hand in the field (Ward 1962, Landquist 1965, King 1972).
2. Moisture-proof, i.e., will prevent moisture loss and also will safeguard adjacent objects from getting wet when shipped by mail, bus, express or other forms of public transportation.
3. Strong enough to withstand rough handling and long storage.
4. Capable of holding a packing material that has a high capacity to keep seedling roots moist with minimum weight and bulk. (The ideal packing medium will allow storing of packed seedlings for a few days to several weeks without injury to the seedlings.)
5. Low in initial cost for containers and packing material, and possibly capable of salvage and reuse.
6. Adaptable to high-speed packing, with minimal handling and without injury to the seedlings.

The favorite method of packaging seedlings in southern nurseries through the 1950's was the standard Forest Service bale, using waterproof paper and sphagnum moss as a packing material (Wakeley 1954). See figure 10-1. As the moss supply decreased and the cost of moss and waterproof paper increased, other types of containers and packing materials were tested including: tubs, polyethylene-lined bags, 2-to 6-layer paper bags, waterproof wrapping paper, table cloth material, wooden crates and boxes and cardboard containers. Currently the most widely used containers are bales covered with waterproof paper and the kraft polyethylene (K-P) bags (Duffield and Eide 1959; Ursic 1963; MacNaughton 1966; Neal 1964). See figure 10-2.

Materials

Materials that have ben used include peat and sphagnum moss, clay slurry, wood fiber, felt blanket, cotton batting, excelsior waste, sawdust, shavings, bark peelings, chips, shingle tow, sisal fibers, chopped hay, bagasse, burlap, seaweed, fabric liners, Kim-pac, root-rap and starch compounds. The more commonly used materials are clay slurry, peat or sphagnum moss, wood fiber, wood shavings or chips, and liner material (Mullin 1956, 1973; Bland 1962; Eliason and Carlson 1966; Jordon 1964, 1966; Breeneman 1966; Jankowski 1966; Hammer and Broerman 1967; Owston and Stein 1972; Eagle 1974, Fisher 1974; Wakeley 1954).

Precautions may be warranted when using commercial wood fiber mulches as seedling packing material, as they have recently been found to harbor harmful yeasts that damage the seedlings in storage. See appendix 10-1 for more details.

Sphagnum Moss.—This has been the traditionally favorite packing material because of its high water-holding capacity and its low pH. The low pH is particularly important because it affords unfavorable conditions for the growth of many bacteria and fungi. Limitations of sphagnum moss include the need to thoroughly soak and drain the moss before use, the increasing cost, and the danger of sporotrichosis (discussed later).

Clay Slurry —This is often used in lieu of moss or other packing materials in both bales and bags. Advantages of the clay slurry are:

1. Bales will require no watering after packing for at least 4 weeks or longer.
2. Better adapted to a mechanized operation in a packing shed than is moss.
3. Protects seedling roots before and after planting, i.e., keeps the roots moist longer.
4. Reduces hazards of heating or molding of seedlings in bales and bags (a greater risk when moss is used).
5. No need for special racks to drain excess water from bales.
6. Avoids the chance of infection of workers by sporotrichosis from moss.
7. No need for water in the planting machine hopper or in buckets when planting clay-packed seedlings (Slocum and Maki 1960; Bland 1962, 1964; Davey 1964; Brenneman 1965; Hamner and Broerman 1967; Williston 1967; Bacon et al 1979; Dierauf and Marler 1969; Owston and Stein 1972).
8. Pesticides may be easily applied to the seedlings by mixing the material with the slurry.

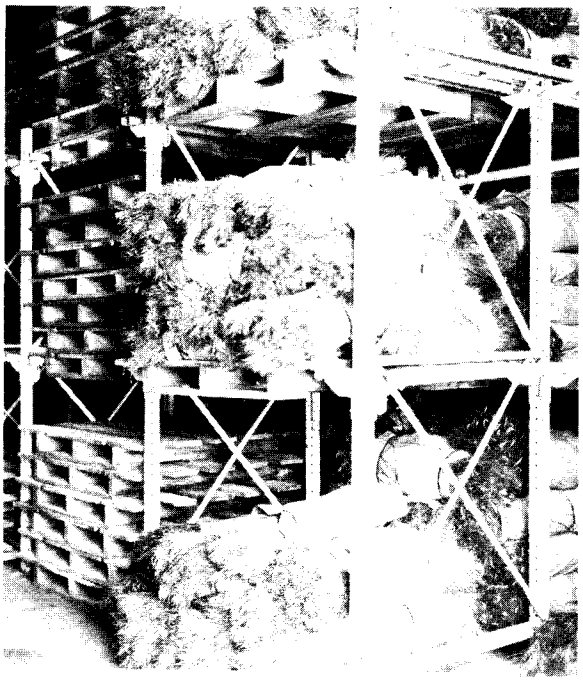

Figure 10-1. – Forest Service bales.

Figure 10-2. – Packing in K-P bags.

A talc-like kaolinitic clay is mixed with water to form a slurry of 50 pounds of clay in 14 gallons of water (Brenneman 1965). The mixing tank should be large enough to hold a day's supply of slurry. Clay is added to the water and agitated to form a slurry free of lumps. Seedling roots can be dipped into the solution or the slurry can be sprayed on roots of seedlings as they move along conveyor belts. About 40 percent less clay is required by the spray system as compared to hand dipping. See figure 10-3. The spray system may use 1,500 to 3,000 pounds of clay per million seedlings depending on the recovery rate of slurry that drains from the seedlings. The forced circulation of the slurry in a spray system keeps it in a rather uniform consistency. Hand dipping may use 5,000 to 6,000 pounds of clay per million seedlings as the clay tends to settle to the bottom of the dipping pan (Bland 1962, 1964; Brenneman 1965; Hamner and Broerman 1967). The relative advantages and disadvantages of moss and clay are compared in table 10-1.

Equipment

1. Packing tables: Several types have been developed; some have one or two bins for shaping bales and may be stationary or on rollers. Others are mounted on a vertical axis and may be rotated manually (figure 10-4).
2. Wetting tanks: Tanks for wetting the packing material may be located inside or outside the packing shed, but should be accessible to the packing tables.
3. Staplers, strapping machines and bag-closing machines: May be either portable or stationary, and operated either manually or by power.
4. Pallets, dollies and forklifts are used to move packaged seedlings to storage or shipping vehicles (Bigelow and Betts 1963, Blank 1964, Hall 1964, Brenneman 1965, Bailey 1966, Gehron 1968, Slayton 1969).

Figure 10-3. – Packing with clay slurry.

Temporary Storage for Bare Rooted Seedlings

From the time the seedlings are lifted until they are packed, there is a constant danger that they may be injured by heating or drying during the handling process.

Table 10-1 — Sphagnum moss vs clay as a packing medium.

Characteristic	Moss	Clay
Primary advantage:	moisture retention	protection of roots during exposure
Moisture-holding capacity:	high	low
Ease of handling:	difficult: must be soaked and drained	easy: mix, spray or dip
Need to add water for long-term storage in bales	weekly	depends on storage conditions
Medium for bacterial or fungal growth:	acid medium discourages growth	not known
Hazard to workers:	sporotrichosis	creates slippery surfaces and messy working conditions
Relative cost:	higher	lower

Shed-packed seedlings are transported from the field to the grading table or packing table in open tubs or in slings. The elapsed time from lifting to packaging may extend from less than an hour to 24 hours or longer. The container of seedlings should not be exposed to the sun or wind while in the field. If the soil is relatively dry at the time of lifting, water the seedlings immediately before the roots become dry. A modification to the Grayco lifter permits seedlings to be sprayed with water and covered with moist burlap during dry weather (McDonald 1976).

Seedlings stored overnight in containers should not be allowed to heat or freeze during the temporary storage. Occasionally seedlings are heeled-in in moss covered with burlap in the packing shed or adjacent building. There is always a danger of mechanical injury to the roots and tops in the process of handling seedlings for temporary storage.

Packing in Bales

The standard Forest Service bale is fabricated on a baling table using waterproof paper, a moisture holding packing material or clay slurry, one or two slats to give rigidity to the bale and two straps to bind the bale (figure 10-5). A layer of drained moss is spread across the paper at the bottom of the bale and partly up the side of the bale. Loose or bundled seedlings are placed on the moss with the lower parts of their roots overlapping the center line of the wrapper. The root collars are well inside the edges of the wrapper. The layer of seedlings should not be more than 3 to 4 inches thick. Two to 3 inches of moss is spread on the roots and lower stems of each layer of seedlings.

This process is repeated by alternating the layers of seedlings and moss, until the bale is of the desired size or weight. There should be 2 to 3 inches of moss between all seedlngs and the wrapping paper. Woody materials used include sawdust, shavings, bark, shingletow and peelings used alone or mixed with peat or sphagnum moss. Sheets of cotton batting, wood pulp or liner stock are sometimes substituted for moss. Moss is omitted when roots are dipped into or sprayed with a clay slurry.

The standard bale weighs about 50 pounds before adding supplemental water. The ends of the paper are rolled together around a slat pulling the bale together into a compact bundle. Straps around the bale are tightened firmly with the strapping machine. The finished bales are moved to a storage or a shipping area. The number of seedlings per bale varies according to the size of stock. There is a range of 1,000 to 2,000 loblolly, slash, shortleaf and Virginia pine seedlings in a bale. From 500 to 1,000 longleaf or white pine seedlings may be in a bale.

Packing in Bags

The multiwall K-P bag is used widely in the South. Specifications vary, but a typical bag has a 24-inch face

width, a 30-inch face height and a 11.5-inch gusset. K-P bags are available in either two- or three-ply kraft paper. Polyethylene (or unithane, which is waterproof but permeable to gases) is applied as a 10-pound laminate to the inner-facing wall of the kraft paper. The outer wall is 50-pound, wet-strength kraft. The bottom is sewn. The three-ply bag has a middle wall of 50-pound wet-strength kraft which helps reduce the possibility of tears and punctures.

A bag holder is substituted for a baling table. Bag-packed seedlings that are dormant, moist and packed without moss can be held in cold storage for 2 to 3 months or in a well-ventilated warehouse for 2 to 3 weeks. However, packing with moss or similar water-absorbent material is recommended. One to 1 1/2 pints of damp moss is sufficient because excess water collects in the bottom of the bag, causing the immersed seedlings to mold and decay. After the bag is filled, excess air is expelled and the bag is sealed by sewing the top or by rolling and strapping. See figure 10-6.

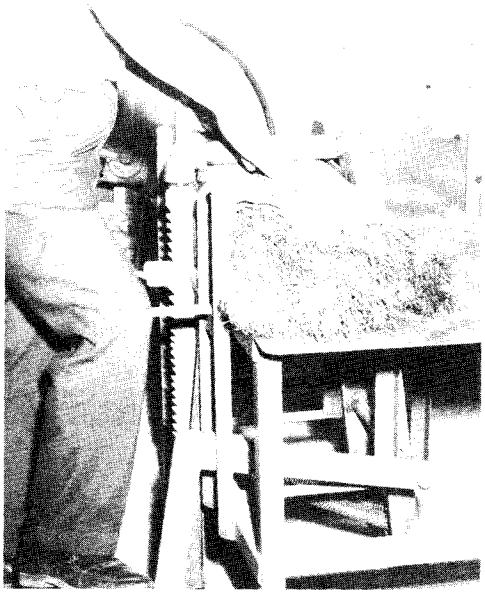

Figure 10-5. – Packing a bale of seedlings.

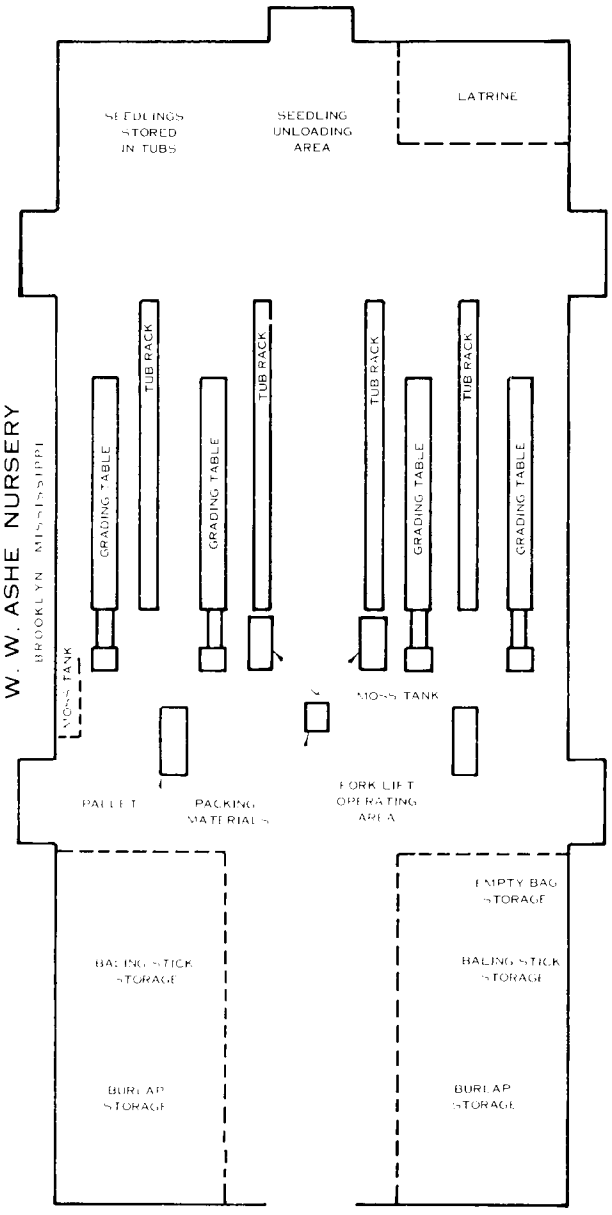

Figure 10-4. – Design of packing area.

K-P bags require special precautions during nursery handling, storage, shipment and subsequent field storage. The relative humidity within the bags should be about 100 percent, but excess free water should be avoided. Icing the moss vats keeps the moss from fermenting and keeps the seedlings cool, which will reduce the risk of heating and mold. Air circulation is essential for bagged seedlings stored in cool warehouses or open sheds at ambient air temperature.

Seedlings in K-P bags should be protected from freezing as well as exposure to the sun. Bagged seedlings will spoil rapidly at warm temperatures. K-P bagged seedlings can be kept in cold storage at 30 to 37 °F for up to 2 to 3 months *if dormant when lifted.* Seedlings lifted too early, i.e., prior to dormancy, are apt to heat, mold and deteriorate if storage is prolonged (Ursic 1964, Williston 1964, 1965, MacNaughton 1966, Walters 1972, Chatterton and Ryker 1976, Mullin et al 1974).

Other Types of Packaging

Many types of packaging other than the Forest Service bale and the K-P bags have been tested and used occasionally. The wraparound seedling crate used by the Georgia Forestry Commission was constructed of wire-bound, wood veneer (1/9 inch thick). See figure 10-7. The crates were lined with polythylene film before being

Figure 10-6. – Packing a K-P bag.

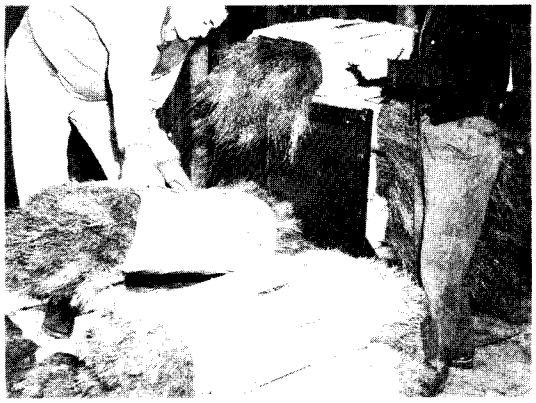

Figure 10-7. – Georgia Forestry Commission "wraparound crate."

packed (Darby 1961). The crates were made in two sizes: 500 and 2,000 seedlings. Theoretical advantages of the wraparound crate are:

1. No special tools or skills are needed by workers to fasten the package.
2. Maximum daily output of the nursery is increased by removing the packaging bottleneck.
3. Packages are easy to open for inspection of stock quality, watering, etc.
4. Planters have less difficulty in getting seedlings from the packages.
5. Seedlings in partial packages can be stored in the field to be used as needed without damage to the seedlings.
6. Crates can be reused.

The jellyroll package is very similar to the bale. However, the seedlings and packing material are placed on waterproof paper on a long, flat surface and the paper, moss and seedlings are rolled into a bale. The major advantage is that fewer plants are exposed as the package is unrolled and the trees are removed.

Various types of boxes and similar containers have been tested, used occasionally, and then dropped—to be replaced by bales or bags. For example, in 1934-35, the Stuart nursery seedlings were dipped in a clay slurry, tied in bundles of 50 or 100 seedlings and shipped to the field in tubs (May 1935; Darby 1961, 1966; Neal 1964). Seedlings that are planted within a day of lifting can be packed in open boxes or tubs with sawdust or moss surrounding the roots.

Other Considerations in Seedling Handling and Packaging

From the time seedlings are lifted until they are planted, there is constant danger that the stock may be injured by exposure to sun and wind. The roots are especially vulnerable. Heating, drying or freezing are other risks during grading, packing, storage and shipping. The principal safeguard against such injuries up to and during shipment is the skill, care and supervision used by nursery workers in handling the stock.

The North Carolina Division of Forest Resources has developed seedling handling standards for lifting, storage, delivery and field planting (Jeffries 1983): (See appendix 8-2.) These standards are keyed to the local weather and soil conditions at the nursery, storage or planting location.

Throughout lifting, grading and packing, the seedlings may be weakened or killed if the roots are exposed. To prevent excessive drying keep seedlings out of the sun and wind, keep roots within the containers or cover them with wet burlap or moss, and spray or water seedlings at the first hint of root drying. Wetting of roots after they have completely dried out does not revive the dead root tissue but merely makes it difficult to see that they were allowed to dry out.

The most consistent problem in baling seedlings is to get enough moss or other packing media completely around the roots especially between the roots and the sides of the bale. Too much moist material on the needles and stems in the ends of the bale reduces aeration and transpiration. The storage quality of the seedlings will then decline while in the bale, and mold on needles and stems is likely.

The straps around the bale should be sufficiently tight to hold the bale together during handling but not so tight that water will not move in and out of the bale.

A problem with packing in bags is to get the correct amount of moisture in the bags without having free water in the bottom of the bag. Usually 1 to 1 1/2 pints of damp moss is sufficient to maintain a high humidity in the bag. Upon opening of the bags, the roots at first observation may appear to be dry, but a brief exposure of the roots to sun or wind will show the appearance of truly dry roots.

Sporotrichosis

A serious problem for persons handling sphagnum moss is the possibility of sporotrichosis infection by the fungus

Sporothrix schenckii (Powell et al 1978). Most infections affect only the skin and lymph channels beneath the skin. The typical infection follows an abrasion, scratch or prick, giving entry to the spores of the fungus. In 1 to 4 weeks, after exposure, a small, painless pus-containing blister is formed, which may open, become raw, and slowly enlarge. Areas distant from the point of contact may be infected. The fungus spreads through the lymph vessels, which may become visibly reddened and hard. Nodules may form along the infected lymph channels, which lead away from the point of initial infection. Lymph glands in the armpit or elbow may become enlarged and sore. The disease progresses slowly if untreated, and through the bloodstream fungi may be carried to the bones, abdominal organs, and the uninvolved skin. The disease is rarely fatal if adequately treated.

Frequently the disease is not properly identified and treatments after the wrong diagnosis are not effective. The diagnosis is made by growing and identifying the fungus in the laboratory.

Iodides, given by mouth, specifically cure this disease. The iodine is usually given in the form of potassium iodide solution, five drops three times daily, the dose being increased by one drop a dose to a final dose of 35 to 50 drops three times daily. Penicillin and other antibotics are not effective.

Healing with only a small scar remaining may be expected within 1 to 4 months after iodide therapy is started. However, such scars may be large and disfiguring if infected sores are allowed to progress and enlarge for a long period before being treated. To assure total healing, iodides should be continued for 1 month after healing is considered complete.

Preventive measures can be taken by treating all breaks in the skin regardless of size. Personal cleanliness, including washing the hands and arms with warm water and soap, helps to prevent infection. Gloves and other protective clothing are recommended, but must be used with a program of good personal hygiene to include washing hands and arms following exposure to moss. At the first sign of any infection the employee should be given medical treatment by a physician.

STORAGE AT THE NURSERY

Between lifting and shipping, seedlings may be stored, moved, and restored one or more times. Methods of storage and treatment during storage can vitally affect the physiological condition of the seedlings and their subsequent survival. Storage within the nursery may include the following conditions:

1. Temporary storage between lifting and packaging.
2. Storage of seedlings in bales or open containers at air temperature in warehouses or sheds.
3. Storage of bagged seedlings (in sealed containers) at air temperature in warehouses or sheds.
4. Storage of baled seedlings in cold storage.
5. Storage of bagged seedlings in cold storage.

Storage Facilities

Temporary storage of seedlings between lifting and packaging should be inside a packing shed where temperatures can be controlled so that seedlings will not freeze, become heated or dry out.

Warehouses or storage sheds are subject to temperatures ranging from subfreezing to about 80° F or higher. Sheds should be equipped with racks to provide good air circulation around all packages of seedlings. Racks for baled seedlings should be slanted so that water supplied to the upper end of the bale can move through the bale and excess water can drain from the bale. A water supply must be available to the entire storage area.

Most refrigerated storage rooms or coolers are kept at 33 to 40 °F. However temperatures from 20 to 32 °F have been used for *short periods* with no adverse effect on survival. The usually high relative humidity in cold storage units is beneficial for seedling storage. When relative humidity levels are low, the walls of the cooler can be sprayed periodically with water. Automatic humidity controls are also available. Many refrigeration units recycle moisture back into the air in the storage room. Specifications for relative humidity in coolers are much less precise than for temperatures. Relative humidity is difficult to control and maintain at the low temperatures maintained in the coolers and especially with some types of seedling containers. Relative humidity of 85 to 95 percent is probably about normal for most coolers. Because of the trend toward packaging seedlings in waterproof, sealed containers, precise humidity control is important only when exposed seedlings or seedlings in bales are stored.

Bale Storage without Refrigeration

Tops of pine seedlings in open-ended bales transpire continuously, translocating moisture from the roots and possibly the packing material. Water is also lost by evaporation from the packing media of open-end containers. The rate of transpiration and evaporation is strongly affected by the air temperature and relative humidity surrounding the bale and by the rate of air movement. Bales packed with moss or similar material must be watered every 2 to 3 days.

After storage of about 1 week in bales, the survival rate of the seedlings may decline, with the decline increasing with time. Baled seedlings stored without refrigeration should be planted within 1 to 4 weeks after lifting. Clay-packed bales in shaded, ventilated storage generally require no watering for at least 3 weeks, as roots of clay-treated seedlings do not dry as quickly as seedlings in moss-packed bales.

Bag Storage without Refrigeration

Bag storage of seedlings at ambient air temperatures in ventilated warehouses or storage sheds is usually acceptable up to 6 weeks, after which survival decreases with time of storage. Temperatures within the bag increase as daytime temperatures increase. As day temperatures approach 80 °F the seedlings begin to die. They first become moldy, then stems and needles become black, the bark becomes loose and slippery, tops begin to rot and the plants begin to decay. Meanwhile, the moisture content within the bag remains high. Clay-treated seedlings do not mold as quickly as seedlings in moss-packed bags. Air circulation around bags is essential for good storage.

Bale Storage with Refrigeration

Seedlings packed in bales have been successfully stored at temperatures of 32 ° to 38 °F for 8 to 12 weeks, provided roots do not become dry. Seedlings stored with exposed tops may be more physiologically active than seedlings stored in sealed containers. New flushes of growth may appear first in baled seedlings and later in bagged seedlings.

Bag Storage with Refrigeration

Seedlings in K-P bags can be held in cold storage for 3 months without moss in the bag if the seedlings are dormant and moist when bagged. Dormant seedlings packed with about 1 pound or 1 pint of wet moss have been kept in cold storage for 3 to 6 months with no detrimental effect on survival. This is not a recommended procedure however.

Other Considerations in Nursery Storage

Seedling handling and storage requires considerable space to ensure good air movement around packages and to ensure that the seedlings in storage for the longest time are shipped first ("first in = first out"). Storage areas must be equipped with racks or pallets that fit the racks. Packages should be separated by spacers to allow air circulation. Most operations are mechanized with forklifts to handle packages of seedlings or pallets with packages.

Season of lifting and physiological condition of seedlings have strong effects on the storability of pine seedlings. Nondormant seedlings lifted in the fall do not store well. Such seedlings, planted immediately after lifting, may survive satisfactorily if soil moisture is adequate but storage periods of even 2 weeks can cause survival to drop below satisfactory levels. In contrast, seedlings that have made the first flush of growth in early spring before being lifted have been satisfactorily stored in bags in cold storage for three months. This practice is not recommended, however.

Seedlings that break dormancy while in storage are still good planting risks, especially those stored in sealed containers. However, breaking of the tender terminals of nondormant seedlings will result in some loss in first-year height growth.

Package temperature should be monitored in both air temperature and cold storage facilities. Accurate and complete information on temperature variation with time and with position of packages within the storage facility is essential for the proper understanding of the storage process. Temperatures should be monitored in several packages in well distributed locations. Seedlings will heat, particularly if packages are placed too closely together. In one cold storage study the internal temperatures of bags with poor air circulation averaged 22 °F higher than those with good air circulation. Piling bags more than two deep resulted in a 10 °F increase in temperature (Lantz 1979). Recent studies by Barnett (1981) also indicate that ethylene may play an important role in the storage of pine seedlings.

No mechanized operations are free of trouble, and cold storage units are no exception. Refrigerated units should be equipped with a warning device such as a bell or flashing light to inform the nursery staff that a malfunction has occurred. In enclosed areas the heat produced by seedlings can quickly change a cold storage facility into a warm storage facility. Frequent inspections are necessary to ensure that temperature controls are functioning properly. Constant attention to all factors involved in the storage operation will pay off in shipping healthy seedlings to the planting operations (Kahler and Gilmore 1961; Eliason and Carson 1962; Ursic 1956, 1963; Walley 1964; Williston 1965, 1974, Lanquist 1965; Hocking 1972; Dierauf 1976; Hill 1976; Wycoff 1960; Cossitt 1961; Evans 1962).

SHIPPING

There are almost as many shipping procedures as there are nurseries and frequently two or more procedures may be used by the same organization or the same nursery. The objectives common to all nurseries are:

1. supply seedlings to the field as needed;
2. package seedlings so that they can be handled, stored and planted with a minimum of effort and without injury to plants;
3. lift seedlings when soil conditions are as close to optimum as possible;
4. avoid overstocking with lifted seedlings;
5. complete lifting of seedlings before new flushes of growth in the spring.

Distribution Processes for State Nurseries

Some problems common to all State nurseries are:

1. Seedlings are provided to hundreds of different customers and seedling orders may vary in size from 500 to more than 1,000,000 seedlings.
2. Several methods of transporting seedlings may be used, including pick-up by the customers or delivery by the State to pick-up points.
3. Nurseries must arbitrarily set delivery schedules.

One record-keeping system used in several states involves two divisions within the agency: an administrative division and the reforestation (nursery) division. Orders are processed by computer. Orders are received by the Reforestation Division, accepted, checked for correct payment, assigned a number and then sent to the administrative division computer handling as follows:

I. During the shipping season, the administrative division receives paid orders daily from the reforestation division. The orders are accompanied by a correct adding machine tape showing the amount of money due. The administrative division prepares:
   1. Name and address card
   2. Payment record card
   3. Order card showing number ordered, method of shipment, and species.

II. The administrative division will furnish the reforestation division, weekly, a complete ledger showing:
   1. Landowner or customer name (alphabetized)
   2. Order number
   3. Species
   4. Number of trees
   5. Shipment method
   6. Amount of money received
   7. Date of deposit
   8. Deposit number
   9. Refunds and cancellations are listed along with the above and subtracted from the total of seedling sales. A symbol is placed beside refunds and cancellations to identify them.
   10. Total funds received.

III. The reforestation division ships seedlings based on the above orders.

IV. The reforestation division will submit completed orders to administration for statistical purposes. The following information is keypunched:
   1. Order number
   2. Species
   3. Number of seedlings
   4. Method of shipment
   5. Nursery shipping seedlings (if more than one nursery is involved)
   6. Type of ownership
   7. Type program
   8. District
   9. County

V. At the completion of the shipping season, the administrative division will prepare a summary of statistical data on seedling orders for preparation of the annual public report.

Industry Shipping Schedules

Since industry nurseries usually provide seedlings for their own use, the relationship between field planting operations and nursery seedling distribution is frequently planned a year in advance. The nursery manager knows the number of seedlings that will go to each planting site and approximately when. The method of transportation to be used is also known, i.e., whether the nursery delivers the seedlings, or the field workers pick them up or whether seedlings will be delivered by refrigerated vans.

In many industrial operations, seedlings are planted within 2 to 3 days after lifting, which means a continuing supply of freshly lifted seedlings. However, bad weather and other problems sometimes require storage of stock for several days, either at the nursery, or in the field. Shipping schedules in industry operations are usually very flexible and are frequently handled directly by radio or telephone communications.

Methods of Shipping

Most seedling shipments are by truck or refrigerated van. Shipments that require only 2 to 4 hours are usually made in open trucks, except when refrigerated vans are also used for storage. Bales or bags of seedlings are systematically loaded on the trucks on racks or with spacers between layers of seedlings. If bales are piled on top of each other, the weight of the upper bales may force water out of the bottom bales. If bales are stacked too closely together, heat may build up from seedling respiration. Seedlings should be covered by a tarpaulin during shipment if there is a danger of overheating from the sun or dessication from exposure. After arrival at the destination, seedlings should be unloaded from trucks and stored immediately.

Overnight transportation of seedlings or travel exceeding 5 hours should be made in refrigerated vans. Nonrefrigerated trucks may be used if travel is confined to night hours and unloading is done immediately. Many industries have their own vans that are especially equipped for loading, storage and unloading of seedlings. Company-owned vans are usually used as refrigeration units in the field and shuttle between the nursery and the planting site.

Loading ramps at nurseries are equipped with fork lifts and pallets or racks or with hydraulically adjustable conveyors to load seedlings into trucks or vans.

Field Storage

Handling and storage of seedlings in the field is as critical as at the nursery. Field handling and planting standards developed by the North Carolina Division of Forest Resources are adjusted to "Normal," "Critical," or "Severe" weather and soil conditions (Jeffries 1982): Appendix 8-2. Field storage methods include the use of:

1. The same refrigerated vans used for transportation.
2. Refrigerated railroad cars or vans near the planting site.
3. On-site coolers.
4. Open sheds or warehouses near the planting site.
5. Areas protected from wind and sun.
6. Pits in the ground.
7. Heel-in-beds near the planting site.

Field heel-in-beds were frequently used for storage up to the 1950's. All too often, insufficient ground preparation and improper soil texture in locations far removed from an adequate supply of water caused seedlings to deteriorate. Roots may become dry in excessively drained soil or rot in poorly drained areas thus causing heavy mortality. Heeling-in also results in excessive root damage from the extra handling required.

Baled stock, kept in a cool place and watered frequently, survives at a rate as high or higher than identical stock heeled-in in the best possible manner. Storage in pits of well-drained, sandy soil is practical and effective where cold storage is not available. A pit can be prepared with the dozer blade of tractors used in planting. However, the best storage is in refrigerated units with controlled temperatures.

Freezing and Heating

Freezing of baled or bagged seedlings will often lower the survival of seedlings even when they are allowed to thaw slowly and are watered hours before planting. Freezing at 20°F for 6 to 24 hours slightly lowered the survival of slash and loblolly pine seedlings and completely killed longleaf pine seedlings (Williston 1974). Although some western pine seedlings have been successfully stored at subfreezing temperatures (Hocking 1972), consistently good results have not been obtained with southern pine seedlings that were frozen during storage (Garner and Dierauf, 1972, 1974).

Heating of seedlings in bales or bags is as injurious as freezing. When heating results from exposure to the sun, seedlings on the exposed side of the bale are the first to be injured (Cossitt 1961; Ursic 1961; Hodges 1961; Powers 1964, Brenneman 1965, Nugent 1974, Williston 1964, Hill 1976, Hintz 1978).

SUMMARY

Nursery production culminates in the packaging, storing, and shipping of seedlings. Many materials and techniques for packaging seedlings have been used. The most widely used methods of packaging seedlings in the South are the standard Forest Service bale and the kraft/polyethylene bag. Seedling containers hold 500 to 2,000 seedlings, depending on the size of the plants.

The most frequently used packing media are sphagnum moss, wood fiber, wood shavings or similar material and cotton batting. Treatment of roots with clay slurry is sometimes used in lieu of a packing medium. Seedlings in bags and bales may be stored at the nursery and in the field in ventilated warehouses or sheds at ambient air temperatures. Cold storage units should maintain temperatures of 33° to 40°F. Air circulation around packages is essential for both types of storage.

Baled seedlings must be watered every 2 to 3 days, especially when stored without refrigeration. Seedlings may be stored for 2 to 3 weeks without refrigeration or for 3 to 4 months in cold storage. Shipments from the nursery are almost entirely by trucks or refrigerated vans for trips longer than 4 to 5 hours or 200 miles.

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APPENDIX 10-1.

United States Department of Agriculture | Forest Service | SA

Reply to: 3230 Forestation and Tree Improvement | Date: December 22, 1981

Subject: Wood fiber mulch and gelatinized starch should be carefully evaluated as seedling packing media

Southeastern Forest Nursery Personnel

Recent studies by Dr. Ed Barnard (Florida Division of Forestry) and Dr. Jim Rowan (Southeastern Forest Experiment Station) have indicated the possibility of seedling deterioration when wood fiber mulch or gelatinized starch are used as packing materials.

Although the research studies are not complete, several preliminary conclusions appear to be justified:

1. Wood fiber mulch may be fermented by certain organisms under some storage conditions. The by-products of this fermentation are toxic to pine seedlings.

2. Additional data is needed for the evaluation of gelatinized starch as a packing medium.

3. With both wood fiber mulch and gelatinized starch, the potential for seedling deterioration increases as the period of storage increases and as the age of the packing material increases. (The longer the material is wet the greater the possibility of fermentation.)

4. Seedlings stored and shipped under refrigeration are less likely to deteriorate than those stored in non-refrigerated areas. When wood fiber mulch is used as a packing medium refrigeration will retard fermentation.

5. The risk of seedling deterioration appears to be reduced when peat moss is used as a packing medium rather than wood fiber mulch or gelatinized starch.

Deterioration of seedlings in storage is a function of many variables: e.g. temperature, moisture, aeration and length of storage. The primary characteristics of a good packing medium are to provide good moisture retention, adequate aeration and an unfavorable medium for pathogenic microorganisms.

Peat moss provides good moisture retention, good aeration, and appears to retard the fermentation process.

When wet packing material is stored in vats sodium or potassium metabisulfite will prevent fermentation. This should be mixed with water the rate of 6.9 oz/100 gal. water. The cost of treating 1,000 gallons of water used to soak the packing medium should range from $9-10.

Nursery and reforestation personnel are encouraged to establish research studies comparing different packing materials. We will be glad to assist with the design and/or interpretation of these studies.

E. L. BARNARD
Forest Pathogist
Florida Division of Forestry

S. J. ROWAN
Principal Research Plant Pathologist
USDA Forest Service

C. W. Lantz
Nursery/Tree Improvement Specialist
USDA Forest Service

Enclosure

STATE OF FLORIDA

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I&D

July 28, 1981

MEMORANDUM

TO: Industry Forest Nurserymen - Florida

FROM: E. L. Barnard, Forest Pathologist

SUBJECT: Preliminary Results - Comparative Seedling Packaging Trial (1980-81)

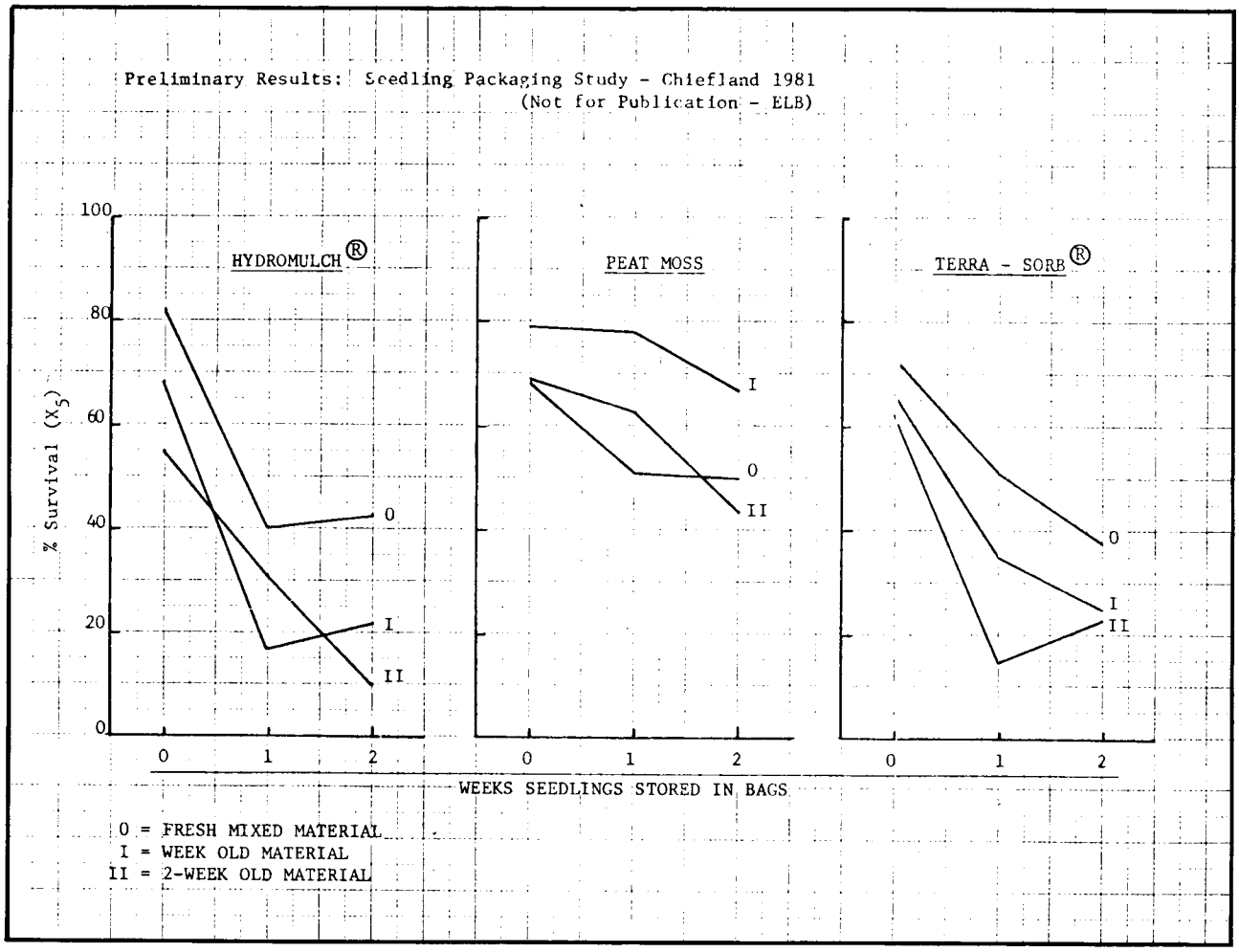
During our "comparative evaluation of seedling quality" studies over the past few years we became concerned over the suitability and/or potential hazards of Hydromulch® as a seedling packaging material. Specifically, we were (and are) concerned over 1) the ability of Hydromulch® to maintain adequate root moisture and 2) the potentially adverse effects of microorganisms which appear to thrive in this material. Accordingly, we performed a small experiment (135 plots - 25 trees each) comparing the outplant survival of seedlings which had been packaged for varying lengths of time in fresh and "aged" materials (i.e., peat moss, Hydromulch® and Terra-Sorb®). Attached is a graphic summary of our results.

To aid in your interpretation of these results let me add the following. Seedlings were packed in seedling bags (KP type) in the materials indicated and stored outside in the shade for the times indicated. As you will recall this past year was unusually cold - we have reason to believe that this cold certainly had an effect on our results (if anything, the cold retarded seedling degradation). However, the trends depicted on the graphs are (we believe) valid.

Please keep in mind that these results should be viewed on a comparative basis and with due regard to our experimental variables, etc. Operational seedling survival is a function of many more variables (as you are well aware). Nonetheless, under our test conditions it appears that seedling quality held up® longer in the peat moss than it did in either the Hydromulch® or Terra-Sorb®

I hope this information is of interest and use to you. Call or write if you have comments or questions.

cc: Dr. Clark Lantz
Mr. Lee Draper
Mr. Homer Gresham
Dr. Walt Beers
Mr. Curtiss Goodwin


Preliminary Results: Seedling Packaging Study - Chiefland 1981
(Not for Publication - ELB)
HYDROMULCH®
PEAT MOSS
TERRA - SORB®
% Survival (X_5)
100
80
60
40
20
0
0
1
2
I
II
WEEKS SEEDLINGS STORED IN BAGS
0 = FRESH MIXED MATERIAL
I = WEEK OLD MATERIAL
II = 2-WEEK OLD MATERIAL

(S. J. Rowan 1981. Control of fermentation in wetted packaging material prevents phytotoxicity to pine seedlings during storage. Tree Planters' Notes - In Press)

Table 1. Effects of sodium and potassium metabisulfite on mortality of 1-month and 9-month-old loblolly pine seedlings after their roots were exposed at room temperature for 24 and 48 hours, respectively, to Cellin or Hydromulch wetted at room temperature for 36 hours or 31 days.

K- or Na-metabisulfite rate and time wetted	Cellin*		Hydromulch°	
	Seedling age (months)			
	1	9	1	9
	---Percent Mortality[1]/---			
0 ozs/100 gal				
36 hrs	100 a[2]/	20 a	100 a	70 a
31 days	39 b	4 b	100 a	28 b
3.5 ozs/100 gal				
36 hrs	98 a	8 b	100 a	68 a
31 days	26 c	3 b	100 a	27 b
6.9 ozs/100 gal				
36 hrs	0 d	0 c	0 b	0 c
31 days	0 d	0 c	0 b	0 c

1/ Mortality, based on five replicates of 20 seedlings for each treatment, was essentially identical for the two salts of metabisulfite, and was assessed 1 month after transplanting the 1-month-old and 3 months after transplanting the 9-month-old seedlings.

2/ Within columns, means followed by a common letter do not differ (P = 0.05) according to Duncan's multiple range test.

* Cellin: ground newsprint mulch

° Hydromulch: wood fiber mulch

APPENDIX 10-2.