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Practical Guidelines for Producing Longleaf Pine Seedlings in Containers

James P. Barnett
and John M. McGilvray

The Authors:

James P. Barnett is Chief Silviculturist and **John M. McGilvray** is Biological Science Technician, Southern Research Station, U.S. Department of Agriculture, Forest Service, Alexandria Forestry Center, Pineville, LA 71360.

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Preface

These guidelines are based on the current knowledge on container tree nursery management for longleaf pine. Recommendations are made using the best information available at the time and are, therefore, subject to revision as more knowledge becomes available. There is no substitute for individual experience, and recommended cultural practices should be tested and developed by local growers before implementing on an operational scale. Nursery managers will need to adapt these principles and procedures to their own nursery conditions.

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James P. Barnett and John M. McGilvray

Abstract

Longleaf pine, although widely distributed in the presettlement forests of the southern Coastal Plain, now occupies less than 10 percent of its original range. It is a highly desirable species because it resists fire, insects, and disease and produces excellent quality solid-wood products. Regeneration of the species either by natural methods or by planting of bare-root nursery stock has been difficult, and renewed interest in it has resulted in evaluation of new approaches to seedling establishment. Using container stock has greatly improved the success of longleaf pine establishment. Practical guidelines are presented that will help nursery personnel consistently produce good container stock that will survive well and initiate early height growth.

Keywords: Nursery practices, *Pinus palustris* Mill., planting techniques, seed germination.

Introduction

Of all the southern pines, many consider longleaf pine (*Pinus palustris* Mill.) the most valuable in terms of wood-product quality, aesthetics, and resistance to fire, insects, and disease. In the presettlement era, an estimated 60 million acres of the longleaf pine ecosystem extended from east Texas through the lower Coastal Plain to Virginia (fig. 1). Heavily harvested in the late 1800's and early 1900's, few longleaf stands survived. By 1935, only about 6 percent of old-growth longleaf pine remained in Louisiana (Wahlenburg 1946). Few seed trees endured these harvests, and much of the area was converted to other species or abandoned to grassland (fig. 2). Today, natural regeneration is only feasible on a small portion of the area in the longleaf pine type.

Because longleaf pine is considered a desirable tree, why have we failed to regenerate more of the longleaf sites? The answers to this question are related to the unique botanical characteristics of the species: (1) low and

Figure 1—Virgin stand of longleaf pine near Flatwoods, LA, is typical of those found across the lower Coastal Plain before harvest in the late 1800's and early 1900's.

Figure 2—Cutover longleaf pine forest that remained a grassland until reforested several decades later. The stumps were removed and processed for naval stores' products.

infrequent seed production, (2) a seedling “grass” stage characterized by delayed stem elongation, (3) poor storability of bare-root nursery stock that results in low survival, and (4) seedling intolerance to shade conditions caused by competition.

The knowledge and technology to reestablish longleaf pine by planting bare-root nursery stock have improved significantly in the last decade. The components of successful regeneration include: (1) well-prepared, competition-free sites; (2) healthy, top-quality, fresh planting stock; (3) meticulous care of stock from lifting to planting; (4) precision planting; and (5) proper post-planting care. All these elements are essential to successful planting of bare-root stock. Because controlling all five elements is difficult in many cases, planting success with bare-root longleaf pine stock remains elusive. These same components apply to container stock, where regeneration success is markedly better. Therefore, many silviculturists now prefer to plant container longleaf pine seedlings.

Numerous studies have demonstrated that under adverse planting conditions, such as poor sites, conditions of moisture stress, and out-of-season planting, container seedlings survive and grow better than bare-root stock (Barnett and McGilvray 1993). These improved survival and growth rates are generally attributed to root systems that remain intact during lifting while roots of bare-root plants are severely damaged. Thus, container seedlings experience a significantly shorter period of transplant shock or adjustment than bare-root seedlings.

Successful production of container seedlings requires thoughtful planning before sowing and daily attention while growing (Landis and others 1994). The goal should be to produce longleaf pine seedlings with root-collar diameters of at least one-fourth inch, an abundant presence of secondary needles, and a healthy root system with obvious mycorrhizal development. This paper provides basic information that will help nursery managers produce good quality longleaf pine container stock.

Facilities

Structures

Structures for growing container seedlings in the South may vary from the simple to the complex (figs. 3A, 3B, 3C). Longleaf pines can be grown in the open without a structure or, at most, in semi-controlled greenhouses. Most research shows that longleaf pine seedlings grown in full sunlight are superior to those grown in shaded structures (Barnett 1989).

Protective Covering

Some protection from hard rainfall is encouraged during germination because large raindrops can wash seeds and some of the medium from the container. It can also cause the newly emerging radicle to become disoriented, resulting in an abnormal crook. A 30-percent shade cloth over a simple framework will greatly reduce this hazard. Raindrops, even during a downpour, are reduced to a fine mist under the shade cloth. The shade cloth should be removed as soon as germination is complete. If crops are overwintered and greenhouse protection is unavailable, polyethylene or other protective coverings may be used to protect seedlings from strong desiccating winds and temperatures below 25 °F.

Figure 3—Structures for growing container seedlings may vary from (A) open benches, to (B) simple shade houses, to (C) elaborate glass greenhouses.


B
Georgia-Pacific


C

Watering Systems

An adequate water system is essential for growing container stock. The system should supply an even distribution of water and provide nutrients and fungicides as prescribed (Landis and others 1989). A simple, stake type with a sprinkler head is usually adequate (fig. 4).

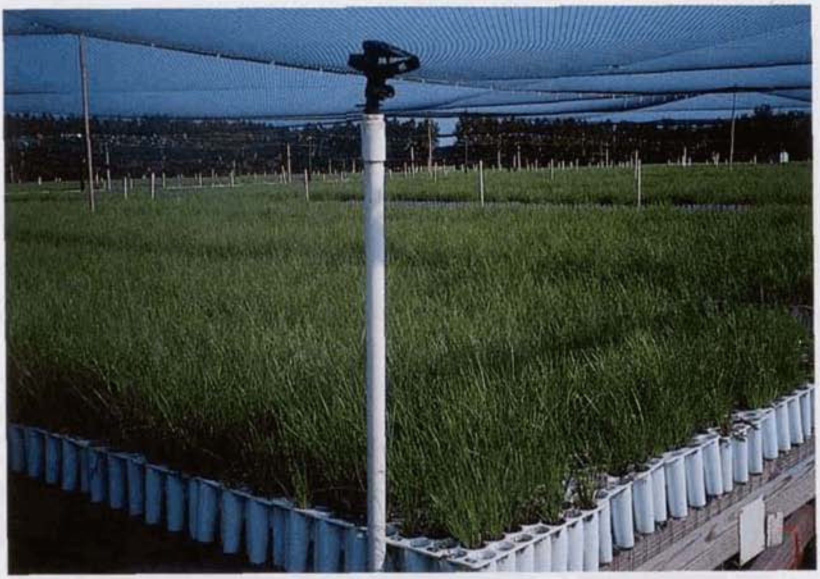


Figure 4—A simple, stake-type sprinkler head typical of those used for open irrigation situations.

Preparation of Recommended Materials

Container Selection

One of the first and most important decisions involves selecting the type of container to use (Landis and others 1990b). Experience has shown that a "plug"-type container, where the root system is extracted with the medium intact before planting, should be used (fig. 5). The ideal individual container cavity should have a volume of about 6 cubic inches, a minimum depth of 4.5 inches, and a seedling density of <50 per square foot. Smaller containers that improve the economics of container production can be used if cultural practices are carefully controlled. Only one type and size of container should be used within a growing area because cultural techniques, especially irrigation, differ among areas and growth phases. If container types are mixed, each type or size should be kept under separate watering systems. Examples of types of containers are listed below:

Figure 5—Longleaf pine "plug" seedling extracted from a Multipot container.

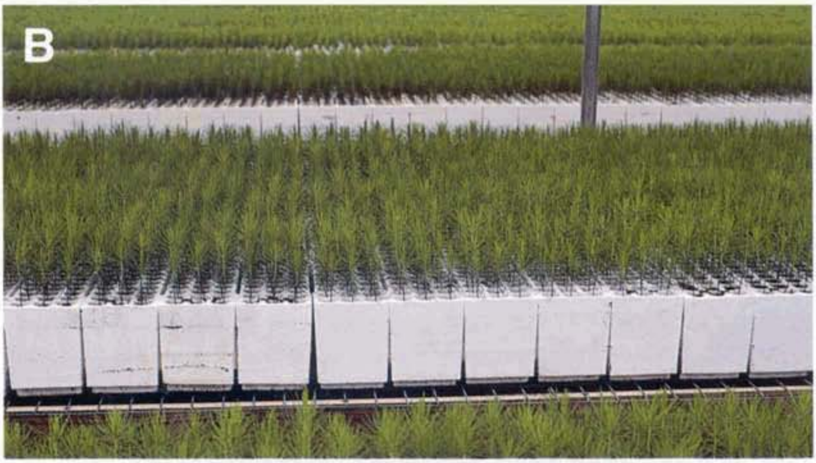
Container types	In^3/cavity	Depth (in)	Number/ft^2
RL Stubbies	7.0	5.5	49
Styroblock 6	6.3	5.9	49
Styroblock 8	8.0	6.0	41
Multipot 3/96	6.0	4.8	41
Multipot 4/96	9.0	6.6	41
Multipot 2-67	4.0	4.8	79
HIKO V-93	5.7	3.5	49

Excellent quality seedlings can be produced in these, or similar containers, although some have properties more favorable to a particular species, nursery operation, or outplanting site.

- RL Stubbies are probably the best containers for growing small quantities, such as progeny tests, because empty individual cavities or cells can be removed and remaining full cells can be reorganized (fig. 6A). The cells extend 1.0 inch above the top of the tray that holds them together, and media falls between the cells when they are being filled. The excess media should be removed to allow good air circulation between seedlings, a process that adds time to the filling operation. Care must also be used when handling trays, because individual cells may fall from the tray if it is tipped.
- Styroblocks are relatively inexpensive, but they are easily damaged during handling. Moreover, if seedlings are held for extended periods, roots will begin to penetrate the styrofoam, making plug extraction difficult (fig. 6B).

Figure 6—Containers frequently used to produce longleaf pine seedlings include (A) RL Stubbies, (B) Styroblocks, and (C) Multipots.

- Multipots are suitable for large-scale operations, because they are durable and easy to handle (fig. 6C). However, they are relatively expensive and lack ridges or other supports on the bottom that allow air circulation needed for root pruning. Air movement beneath the containers must be provided.



Media Preparation

Selecting media—Materials such as peat, composted organic material, sawdust, bark, vermiculite, topsoil, and perlite have been evaluated for use as container-growing media (Landis and others 1990b). A 1-to-1 mixture of sphagnum peat moss and medium-grade (#2) horticultural vermiculite has been a consistently good product (fig. 7). This mixture has physical, chemical, and biological properties that result in good water-holding capacity and aeration and high cation exchange capacity. The quality of the peat and vermiculite varies among sources. The peat should be screened (free of large sticks, etc.), and the vermiculite a course grade. Fine grades of vermiculite result in a medium that compacts in the container and, thus, reduces aeration and restricts drainage.

Good quality seedlings can be grown using other blends of media, especially those that include perlite. A small proportion of perlite can improve drainage and aeration in wetter spring months when lower transpiration occurs. The grower must recognize that changing the blend of the media can drastically change cultural practices such as irrigation and fertilization.

Figure 7—A 1-to-1 mixture of peat and vermiculite is a commonly used growing medium for southern pine container stock.

The nursery manager may purchase a commercial medium or blend it at the nursery. Many commercial blends are designed for horticultural use and the pH is too high (about 6.0) for conifer use. If commercial products are used, the grower should specify the components and the pH of the media. The pH should be adjusted to about 4.5 to 5.0. When higher pH water is used, the pH of the media increases to the optimum of 5.0 to 5.5. This level also restricts pathogen development.

Mixing media—If large amounts of media are needed, on-site blending is encouraged because the chance of crushing or compacting the vermiculite particles is reduced. Such crushing frequently occurs during bagging, stacking, and transporting. Although blending can be done with hand tools or equipment such as concrete mixers, equipment specifically designed for blending is recommended for large operations (fig. 8). This blending equipment is recommended for three important reasons. First, it mixes the media thoroughly in a short amount of time. (To avoid crushing the vermiculite, blending time should not exceed 2 minutes.) Second, it facilitates incorporation of amendments, such as lime needed for pH adjustment. Third, it allows water to be added during mixing. Adding water reduces dust and moistens the medium for better filling of containers. The medium should hold its form without dripping water when squeezed in the hand. If too wet, the medium will become too compacted during the blending and filling process. If too dry, it will not compact properly and will be too porous, making irrigation difficult.

Figure 8—A mechanized blender is recommended for larger commercial operations where on-site mixing of media is desired.

(Photo courtesy of Gulf States Paper Corporation.)

Amending media—Although adding a surfactant or wetting agent would increase the uniformity and rate at which moisture spreads through hydrophobic peat moss, many of these products reduce germination of southern pine seeds when added at their recommended rates (Barnett 1977). Adding surfactants in the blending process is not recommended without preliminary evaluation.

Growers may add lime to the medium to adjust pH to the recommended levels of 5.0 to 5.5. The amount of lime added depends on the initial pH of the media (Landis and others 1990b).

Normally, water-soluble fertilizers are supplied through the irrigation system. However, because longleaf pine seedlings have little stem elongation, incorporating a slow-release fertilizer, such as Osmocote 18-6-12 NPK, into the media can be very helpful, especially for an inexperienced grower (Landis and others 1989). The recommended rate for Osmocote 18-6-12 is 6 to 10 pounds per cubic yard of media. Some growers use about half the recommended rate to maintain more flexibility in fertilization. This treatment supplies most of the NPK needed, but additional nutrients will be necessary. Using slow-release fertilizers is particularly valuable when frequent rains leach water-soluble nutrients and frequent irrigation is infeasible. Incorporating slow-release fertilizers will also reduce the time spent applying nutrients through the irrigation system.

Fungus gnats (*Bradysia* spp.) are small, dark, mosquito-like insects that can damage roots and spread fungi and disease from one container to another (James and others 1995). The larvae are small and maggot-like and thrive on organic matter in high-moisture-content growing media. Using a well-drained medium and allowing it to dry between irrigation impedes fungus gnat development. However, some nursery managers incorporate Pratt-Oxamyl 10-percent granular insecticide into the medium at 2 to 3 ounces per cubic yard to control fungus gnats. Nursery personnel should wear gloves and respirators when mixing this material into the media.

Although seedlings are naturally inoculated with ectomycorrhizae by wind-borne spores, inoculation with a specific mycorrhizal fungus such as *Pisolitus tinctorius* (Pt) is feasible and may be desired by some growers (Landis and others 1990a). Inoculation can be accomplished by incorporating specially produced vegetative mycelium into the growing medium. The high cost and limited availability of this vegetative mycelium usually makes this option prohibitive. The most practical approach is to inoculate with a spore suspension of Pt. *Pisolitus tinctorius* spores can be obtained from local-source fruiting bodies or from a reputable commercial source. Inoculating with a water suspension of spores, the dosage rate should be 5 grams of double-sifted spores per 3 gallons of water per 10,000 seedlings. The spore suspension can be applied to the medium surface after seed germination using a diaphragm-type backpack sprayer. A mycorrhizae specialist should be consulted about the specific techniques and methods associated with the collection, extraction, storage, and application of Pt spores.

Container Filling

During container filling, either by hand or mechanical equipment (fig. 9), the medium should be slightly packed by vibrating or bouncing. The amount needed to fill containers should include an additional 20 percent to allow for compaction. For example, a 6-cubic-inch container cavity will need 7.2 cubic inches of medium for proper filling. The containers should be filled

Figure 9—Mechanical equipment is needed in large operations to fill containers with growing medium.

completely and the excess should be brushed off, leaving the medium approximately one-half inch below the top of the containers. This depression keeps the seed in place and facilitates watering. The depression will become deeper as irrigation and rainfall continue to pack the medium.

Seed Preparation

Selecting seeds—High-quality seeds should be used in container nurseries. Seeds should have a minimum viability of 75 percent (fig. 10). Longleaf pine seed collection, processing, storage, and treatment requires exceptional care to maintain quality equal to that of other well-processed southern pine seeds (Barnett and Pesacreta 1993). Although stratification of longleaf seeds will increase speed of germination by 1 to 2 days, it may reduce total germination and is not recommended without preliminary evaluations.

Figure 10—Longleaf pine seeds are large, thin coated, and sensitive to damage during collection, processing, and storage.

Treating seeds—Longleaf seed coats commonly have significant populations of pathogenic fungi that may cause damping-off of germinants. If seeds have low viability or vigor, treating them with hydrogen peroxide or a fungicide may minimize disease losses. Soaking seeds in a 30-percent peroxide solution for 30 to 60 minutes and rinsing thoroughly in water removes most seed-coat pathogens and generally improves germination of low-viability lots (Barnett 1976).

Personnel at the North Carolina Claridge State Nursery routinely use a hydrogen peroxide treatment on their longleaf pine seeds. They soak 20 to 25 pounds of seeds in special nylon bags. After soaking for 55 minutes in a 30-percent hydrogen peroxide solution at a temperature of 75 ^{O}F or less, the bags are drained and drenched in three separate containers of clean water. The seeds are then removed from the bags and allowed to surface dry.

A more practical but less effective alternative involves lightly coating or drenching seeds with a fungicide, such as thiram or benomyl, just before sowing. A benomyl soak prevents disease development from seed-coat organisms of longleaf pine. A 3- to 5-minute soak (2 tablespoons per gallon of water) is used at some nurseries. Germination is typically improved by about 5 percentage points. However, this use of benomyl is not currently registered.

Cultural Practices

Growing Schedule

The best growing schedule, both biologically and economically, for longleaf pine is to sow seeds in the spring, grow the seedlings through the summer, harden the seedlings naturally in the fall, and outplant them in late fall or early winter (Brissette and others 1991). This schedule eliminates the need for an elaborate greenhouse structure, provides full sun for optimal growth, and achieves natural hardening. The optimum dates in the following growing schedule for longleaf pine may vary by location of the nursery.

Production phase	Approximate dates
Preparation	April to mid-May
Germination	May
Juvenile growth	June
Exponential growth	July to mid-September
Hardening	Mid-September to shipping

Preparation Phase

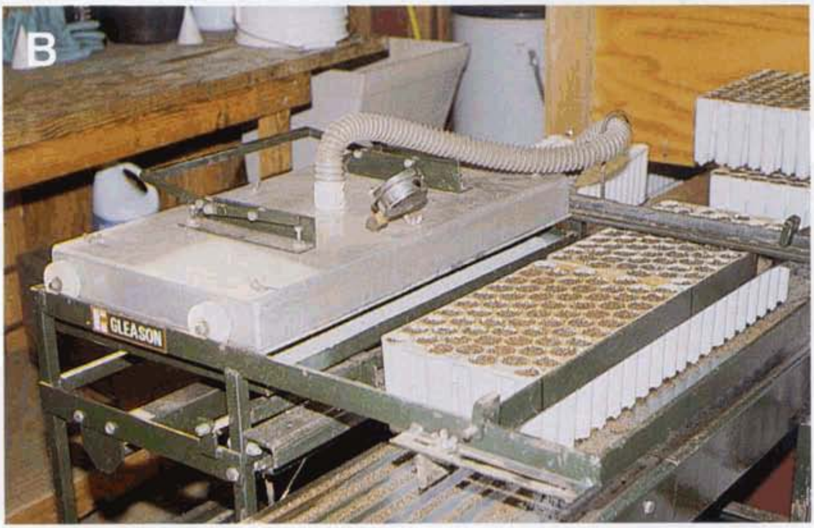
This phase includes the activities of mixing media, filling containers, and sowing seeds. These three distinct procedures make up one operation. Batches of freshly blended growing medium should be used to fill containers. Filled containers should be seeded immediately and placed under an irrigation system. Completing these activities sequentially keeps the medium moist in the containers and makes rewetting unnecessary.

Sowing seeds—Because all cells, with or without seedlings, cost the same to carry through a growing cycle, vigorous seedlings should be grown in as many cells as possible. Seed-sowing strategies should be based on current germination test results. If the viability of the seedlot used is in the 70 to 80 percent range (typical for most lots of longleaf seeds), two seeds per cavity should be sown, then thinned to one seedling before the seed coats are shed. Regardless of the sowing strategy, oversowing and thinning is preferred to transplanting germinants (Pawuk 1982).

Situations may arise where sowing of one seed per cavity is the best option, even when seed quality is low. One such situation is an inadequate seed supply, a frequent occurrence in longleaf pine. Another possible situation occurs when the labor force is inadequate for thinning or transplanting. However, economic considerations of carrying empty cells must be evaluated against the cost of thinning.

The scale of operation determines whether the seeds are sown by hand, by simple templates (fig. 11A) or by more elaborate seeding machines (fig. 11B). When mechanical sowers are used, the containers should be

Figure 11—Containers can be seeded (A) by hand, by simple templates or



(B) by more elaborate vacuum seeding machines.

visually checked after sowing to ensure that the prescribed seeding rate has been met. In some instances, hand seeding may be needed to complete the operation.

Covering seeds—After filling and seeding the containers, most growers cover the seeds with a light layer of media or vermiculite. Vermiculite may be the better choice, because it allows more light penetration to the seed. This covering improves the moisture relationships around the seeds and, thus, improves and hastens germination. Seeds should be covered with no more than one-eighth inch of material. Deep covering slows germination and increases the chance of damping-off and other disease problems (Barnett 1988).

The need to cover seeds varies by the type of watering system used. Germination is usually most complete and rapid when seeds remain uncovered and receive water by a misting system (Brissette and others 1991). If seeds are watered less frequently, a light seed covering facilitates germination by mulching that retains water near the seeds (fig. 12).

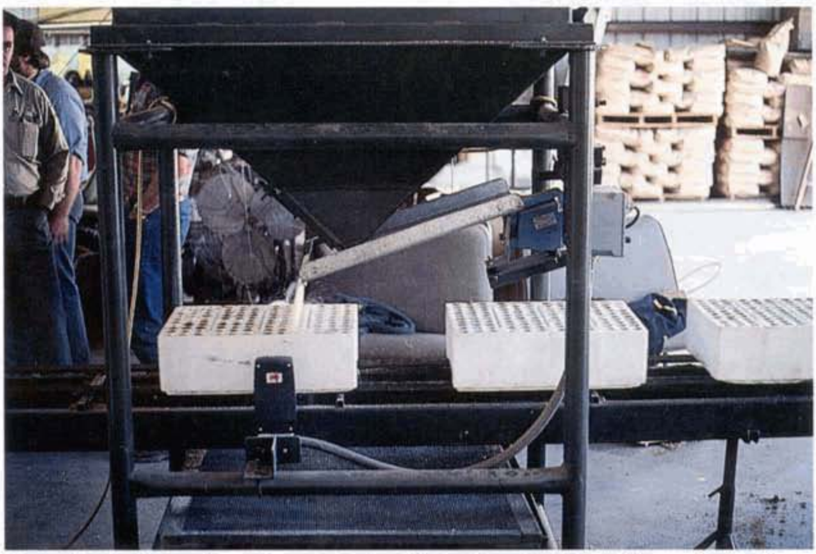


Figure 12—Seed covering equipment can be added to the end of the seeding production line to provide a covering that will enhance seed germination.

Germination Phase

Controlling temperature and moisture is critical during the germination phase. Longleaf pine seeds germinate better at cooler temperatures than other southern pine species, because they are ecologically adapted to fall germination (Wahlenburg 1946). Day and night germination temperatures should be near 70 °F with a permissible range of 60 to 80 °F. Therefore, crops should be started in April or early May when temperatures are usually near this range.

Containers must be watered frequently to keep the surface of the medium moist. The moisture content of the medium near the surface should remain near field capacity. However, care should be taken to avoid overwatering, which can lower germination and promote disease problems. In a typical watering schedule, seeds would be misted 30 to 40 seconds every 30 minutes. Cycles vary among different types of irrigation systems. When germination is complete, frequent misting should be stopped, any shade cloth removed, and less frequent watering begun.

Fungicide applications should begin as soon as feasible to reduce damping-off of germinants and to inhibit pathogenic fungi development. The following fungicide, rate, and application method works well:

Fungicide—benomyl 50WP
Rate—1 rounded teaspoon per gallon of water
Method—apply as a thorough drench
Time—apply at biweekly intervals until October 1

Heavier rates of benomyl are not detrimental to seedling growth; therefore, more frequent applications are much better than applying too little. If inoculation with a spore suspension of Pt is planned, using benomyl is appropriate because it does not adversely affect Pt development. In fact, most studies show that it promotes Pt development (Pawuk and Barnett 1981).

Juvenile Growth Phase

Because longleaf pine seedlings are sensitive to shade, they should be grown and hardened in full sunlight (Barnett 1989). During the first few weeks after germination, top growth is minimal, but root growth is extensive. Thinning or transplanting should be completed early in this period. Although not generally recommended, needed transplanting must be done before radicle elongation exceeds about 2 inches. A broken radicle slows seedling development and results in smaller seedlings that do not compete well with uninjured seedlings (Pawuk 1982). Seedlings should be thinned before root branching begins and preferably before seed coats are dropped (fig. 13).

Figure 13—Longleaf pine germinants thinned to one per container cavity.

If slow-release fertilizers are not used, fertilization of seedlings should begin as soon as possible after germination and the first fungicide application. The following fertilization program has produced quality longleaf pine seedlings:

Fertilizer—Peters' 15-16-17 NPK Peat-Lite Special or equivalent
Rate—350 p/m (based on nitrogen only)
Time—Apply as needed
Method—Apply through the watering system

The timing of fertilization depends on seedling development. Weekly application will result in maximum development of seedling diameter growth, but the timing of applications will vary with weather conditions. Lower frequencies of application reduce or eliminate the need to clip longleaf pine needles. This program can also be used to supplement slow-release fertilizers.

Seedlings should be watered thoroughly and the medium surface allowed to dry between waterings. Early morning irrigation is preferred, because the seedlings will dry before evening, reducing fungal growth. During irrigation, enough water should be applied to leach the cavities. Because the outer edges of rows or benches will dry faster than those toward the center, they will need additional watering (usually by hand). Water management is critical during this phase and requires daily observation.

During the latter part of the germination or juvenile phases, weed growth in the containers may become a problem. Weed seed may be incorporated in some grades of peat, borne by the wind, or spread through the water system if the water source is a pond or river. If weeds are spread throughout the crop, a herbicide may be applied. GOAL 1.6E (oxyfluorfen) is a selective, pre- and post-emergent herbicide that controls a broad spectrum of grasses and broadleaf weeds in conifer seedbeds and container stock. However, because newly germinated longleaf pine seeds are sensitive to herbicide damage, the application rate should be reduced to prevent damage. Tests have shown that applying 12 milliliters of GOAL 1.6E per gallon of water over 800 square feet does not result in damage. This reduced rate may require subsequent applications (at weekly intervals) to obtain complete weed control.

The crop must be carefully observed for other pest problems. Insect problems may include cutworms, fungus gnats, and ants. Applying diazinon at labeled rates will control most of these pests. Diseases may occur, such as rhizoctonia, and a pest control specialist should be consulted for treatment recommendations.

Exponential Growth Phase

The rapid growth during this phase is exhibited primarily by needle elongation. The initiation and length of the exponential growth phase is determined by both needle and stem development. Control of moisture is not as critical as during the previous growth phases. However, the seedlings must be monitored closely for signs of stress due to disease, nutrient deficiencies, or insufficient water.

Fertilization as outlined for the juvenile phase should continue unless observations indicate a need for change such as more frequent applications. If growth remains slow or nitrogen deficiency is observed, a few applications of Peters' 20-10-20PL NPK will usually correct the problem. If higher fertilizer rates are used, especially with the nitrate-rich 20-10-20PL NPK formulation, the fertilizer should be washed off the foliage to prevent possible burning.

The rate of fertilization will determine whether clipping the longleaf pine needles is necessary. When the needles begin to lie over surrounding seedlings, problems in uniform growth and in pathogen development occur, and clipping or mowing is recommended (fig. 14). Care should be

Figure 14—Gasoline-powered hedge clippers are often used to clip seedlings and prevent lodging.

taken to clip only enough of the needles to reduce the problem, because excessive pruning will reduce growth. The needles should not be clipped to less than 6 inches, and all clippings should be removed to minimize fungal development. More than one clipping or mowing may be required during a growing cycle.

As the seedlings become large in the latter stage of this phase, they will use more water. This increased usage combined with the normally hot, dry weather will result in the need for more frequent and heavier periods of irrigation. Irrigation should thoroughly leach the containers.

Hardening Phase

Hardening should start when stem diameters are near the desired size or when day lengths and temperatures restrict growth. The seedlings should be stressed by reducing moisture availability. The media should be allowed to dry to near the wilting point between waterings. No nutrients need to be applied. Just before shipping, the root plug should be brought to field capacity.

Extraction, Storage, and Transport

The grower may extract seedlings from the containers at the nursery or ship the containers with seedlings and extract them in the field. Extracting seedlings at the nursery reduces the bulk for shipping and limits the loss and damage of costly containers that are reused to reduce production costs.

During the extraction process, poorly developed seedlings can be discarded and the containers recycled. Seedlings should be placed in cardboard boxes for storage and shipment. Properly hardened, container longleaf seedlings can be extracted, boxed, and stored under refrigeration similar to bare-root stock.

They can also be held in containers in the nursery until ready for shipment. Seedling boxes should be designed for proper stacking strength, and racks may be needed in the trucks or trailers used for transportation. These boxes can also be used to facilitate distribution in the field (fig. 15).

(Photo courtesy of Gulf States Paper Corporation.)

Figure 15—Container seedlings have considerable bulk, and all-terrain vehicles provide a good means to distribute the seedlings to planters in the field.

Planting

Despite their bulk and weight, container seedlings are easy to plant by hand or machine because their root systems are uniformly shaped. The control of planting depth is critical for longleaf pine. The bud should be at about the soil surface (fig. 16). Dibbles shaped like the root plug work well because the problem of planting too deep can be avoided (fig. 17A). Most mechanical planters designed for bare-root seedlings can be adapted for container stock with only minor modifications (fig. 17B).

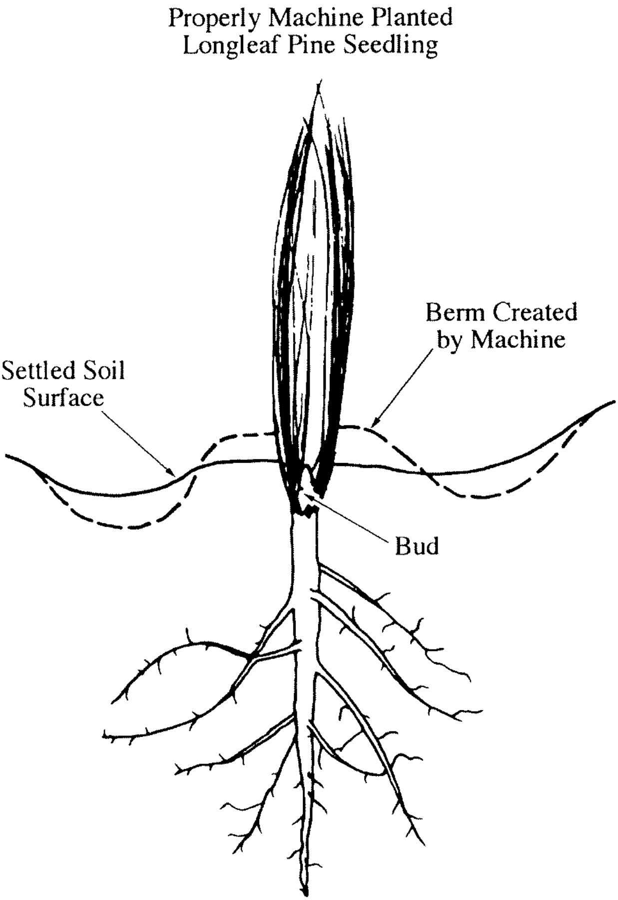


Figure 16—Controlling planting depth is important for longleaf pine seedlings.

Figure 17—Planting container stock can be accomplished (A) by dibbles shaped like the root plug, or

(B) with mechanical planters designed for planting bare-root stock.

Because survival of container seedlings is very good, the planting season can be extended (Barnett and Brissette 1986). Planting longleaf pine seedlings in the fall, as soon as adequate soil moisture is obtained, results in good field performance. Root systems become well established during the winter months and as a result, the length of the grass stage can be shortened.

Conclusions

Reforestation success for longleaf pine can be improved by planting seedlings produced in containers. Container stock survives better than bare-root stock on typical longleaf pine sites and the length of time seedlings stay in the grass stage is reduced. Thus, planting of container stock generally improves the reforestation success of longleaf pine seedlings (fig. 18). However, using container stock does not eliminate the critical need for controlling competition during the first growing season to ensure that seedlings begin height growth during the second year after planting.

Figure 18—Using container stock to establish longleaf pine plantations has markedly improved reforestation success.

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Longleaf pine, although widely distributed in the presettlement forests of the southern Coastal Plain, now occupies less than 10 percent of its original range. It is a highly desirable species because it resists fire, insects, and disease and produces excellent quality solid-wood products. Regeneration of the species either by natural methods or by planting of bare-root nursery stock has been difficult, and renewed interest in it has resulted in evaluation of new approaches to seedling establishment. Using container stock has greatly improved the success of longleaf pine establishment. Practical guidelines are presented that will help nursery personnel consistently produce good container stock that will survive well and initiate early height growth.

Keywords: Nursery practices, *Pinus palustris* Mill., planting techniques, seed germination.