Longleaf Pine Seed Quality: Can it be Improved?

James P. Barnett[1]

Barnett, J.P. 1996. Longleaf Pine Seed Quality: Can it be Improved?. In: Landis, TD.; South, D.B., tech. coords. National Proceedings, Forest and Conservation Nursery Associations. Gen. Tech. Rep. PNW-GTR-389. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 69-74. Available at: http://www.fcanet.org/proceedings/1996/barnett.pdf

Abstract-Long leaf pine (*Pinus palustris* Mill.) seeds are sensitive to damage during collecting, processing, storing, and treating activities. High quality seeds are essential for successful regeneration of the species by either direct seeding or planting. Results from recent tests are combined with earlier data to develop recommendations for producing and maintaining longleaf pine seeds of high quality.

Keywords: *Pinus palustris*, southern pines, nursery production, germination, cone and seed production.

INTRODUCTION

Longleaf pine (*Pinus palustris* Mill.) is a highly desired pine species for reforestation in the southern Coastal Plain of the United States. Vast acreage of virgin longleaf pine previously existed across the South from eastern Texas to North Carolina. However, the species is characterized by a lack of regeneration on sites with extensive amounts of competing vegetation. Longleaf pine has no early epicotyl growth, and its peculiar "grass stage" contributes to its sensitivity to competition and brown-spot needle blight (*Mycosphaerella dearnessii* Barr).

Regeneration of longleaf pine has become more difficult with the advent of fire control, and longleaf has failed to maintain its competitive position because other southern pine species are relatively easier to regenerate. Acreage in longleaf pine is now less than 10 percent of that in the original forests. However, interest in longleaf pine is increasing because it resists insects and diseases and produces high quality solid-wood forest products.

An essential element to improving reforestation success is increasing the quality of longleaf pine planting stock. A number of nursery cultural treatments can be used to improve the quality of seedlings (Barnett 1990; Shipman 1958; Shoulders 1963; Wakeley 1954), but the key to seedling quality is uniform germination and early establishment in the nursery. Developing a uniform nursery crop depends upon the availability of high quality seeds. Cultural practices, either in container or bareroot nurseries, can not effectively overcome the problems resulting from inadequate germination.

Longleaf pine seeds are the most difficult southern pines to collect, process, store, and treat successfully (Wakeley 1954; Barnett and Pesacreta 1993). Because the seeds are large, have thin seedcoats, and are unusually moist when extracted from cones, collecting and processing them without adversely affecting quality requires special handling and unique procedures. Producing longleaf pine seeds to meet the increasing demand in recent years has been plagued by low seed quality. This paper presents results from recent tests, combines these results with other documented findings, and develops recommendations that may improve the potential to produce high quality longleaf pine seeds.

COLLECTING SEEDS

The greatest early losses in seed quality result from collecting cones before seeds are fully mature. Generally, timing southern pine cone collection is based on Wakeley's (1954) results that indicate cones are mature enough for seed extraction when their specific gravities drop below 0.89. More recent data confirm that collection should be delayed until cones are fully mature, because viability of longleaf seeds from immature cones may decrease during cone storage (Barnett 1976a; McLemore

1975a) if some undetermined stage of ripeness -has not been reached (Barnett and Pesacreta 1993).

Tests were conducted in fall 1994 to determine where major losses in seed quality were occurring. Specific gravity (SG) was measured on cones from several clones that were collected on an operational basis in the Stuart Seed Orchard at Pollock, LA. The cones were collected during two collection periods and both lots were divided for shipment to two commercial seed processing plants. Collection 1 (October 5-6) was delayed until average cone specific gravity was below the level that indicated maturity (table I). In collection 2 (October 20), cone SG was lower. It is important to note that even with an average SG of 0.86, a large portion of the cones had a much higher SG. Wakeley (1954) recommends that cone collection begin when **19 of 20 cones** have a SG of less than 0.89. The data from the 1994 tests indicated that average SG must be about 0.81 before Wakeley's criteria are met.

The data also confirmed the previously reported influence of SG on seed yields (figure 1); the lower the SG, the higher the seed yield (table 1). Seed germination was also markedly affected by cone maturity. Average germination of seeds from collection 1 was 51 percent compared to 69 percent for collection 2 (table 2). Ripening immature or holding mature longleaf cones before extraction may or may not improve seed viability (Barnett 1976a; 1976b; Bonner 1987; McLemore 1959; 1975a), but some cone storage is needed to improve seed yields.

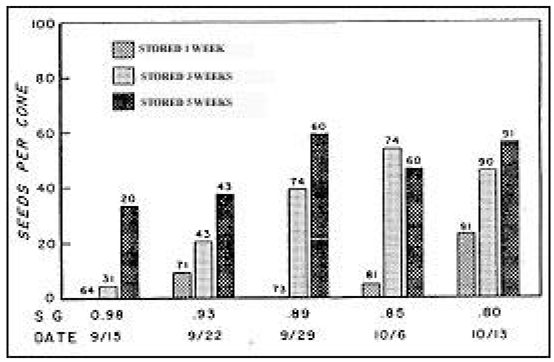

Figure 1. Seed yields and germination (shown above bars) of longleaf pine as affected by date of collection and cone storage (from Barnett 1979b).

Table 1 - Longleaf pine cone specific gravity[1] and seed yields by collection date.

Collection period	*Cone specific gravity* Average	Above 0.89 (percent)	Above 0.87 (percent)	Seed yields (lbs/bu)
1 (Oct. 5-6)	0.86	27	44	0.49
2 (Oct. 20)	.81	4	7	0.73

[1]Values represent an average of 20 replications of 10 cones each per collection.

After SG's were measured, the cones were shipped to two processing plants. Dataloggers included in the bags of cones recorded hourly temperature exposures during cone storage and processing periods. Duplication of processing provided a greater range of environmental conditions and thus improved the opportunity to identify conditions that might affect seed quality. Table 2 provides a summation of cone and seed exposure.

Table 2. Longleaf pine cone and seed exposures during processing and resulting seed germination.

Variables	*Collection date 1* Plant A	*Collection date 1* Plant B	*Collection date 2* Plant A	*Collection date 2* Plant B	Avg.
	Cone and seed exposure				
Days of cone storage	44	42	28	20	
Kilning - total hours	96	92	119	94	
Kilning - hours >86°F	66	80	82	80	
Seed drying - total hours	117	21	116	17	
Seed drying - hrs. >86°F	60	19	58	17	
	Seed germination				
After kilning	59	52	76	81	67
After Dewinging	46	46	59	65	54
After Seed drying	54	47	64	67	58

Information collected on the dataloggers shows differences between processing plants in the length of time the cones were held before kilning and in the temperature exposures during kilning and seed drying (table 2). Delaying cone extraction beyond 30 days may begin to reduce seed quality (figure 2), but the effects of cone storage are difficult to separate from those of exposure to temperature. These two variables may interact. For instance, longer cone storage could improve seed germination (Bonner 1987), but the corresponding longer exposures to high seed drying temperatures might reduce viability.

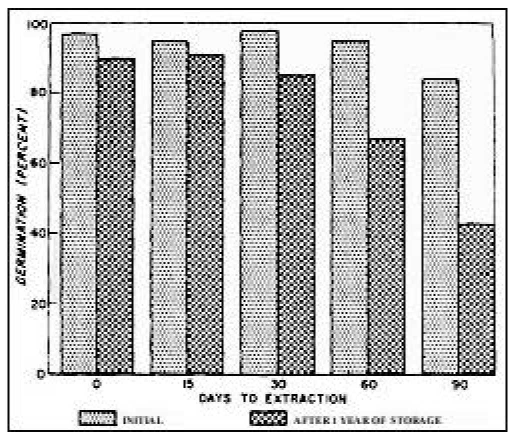

Figure 2. Effect of delayed extraction on longleaf seed germination initially and after one year of seed storage (from McLemore 1961).

PROCESSING SEEDS

During the processing stage, dewinging may adversely affect the quality of seeds collected from mature cones. During our 1994 operational tests, dewing caused germination to drop an average of 13 percentage points. Earlier studies have shown that if longleaf seeds are dewinged carefully, germination is not reduced (Barnett 1969; Belcher and King 1968). Three possible causes of dewing damage are lack of seed drying, inappropriate dewing equipment, and large size seeds.

First, processors may dewing seeds before drying for storage. Although this seems to be a logical approach, earlier studies have shown less damage to seeds dried before dewinging (Barnett and McLemore 1970). Figure 2. Effect of delayed extraction on longleaf seed germination initially and after one year of seed storage (from McLemore 1961). Drying results in more brittle wings that are quickly and easily reduced to stubs. However, because longleaf pine seeds are known to be relatively sensitive to high temperatures (Barnett 1979a; Rietz 1941), the length of exposure to high drying temperatures may reduce seed quality.

Second, equipment designed for optimal dewing of loblolly (*P. taeda* L.) and slash (*P. elliottii* Engelm.) seeds may cause damage to the more sensitive longleaf seeds (Barnett and Pesacreta 1993). Many tests have shown that the harshness and length of dewing must be minimized. Clearly, equipment must be modified to prevent injury to longleaf pine seeds.

Third, fertilization and other cultural practices in the orchard usually produce relatively large seeds (McLemore 1975b). Larger seeds are more likely to be damaged during processing because the portion of the seedcoat of total seed weight is less than in smaller seeds within the species. Sizing of longleaf seeds may be desirable to improve uniformity of germination in the nursery. A gravity table can be used to size seeds and remove empty or partially developed seeds that have lower viability.

STORING SEEDS

The critical factors affecting storage are seed moisture content and storage temperatures. Results of long-term storage tests with longleaf pine seeds show that seeds must be dried to moisture contents below 10 percent and sealed in airtight containers (Barnett and Jones 1993). Tests have shown that longleaf pine seeds can be satisfactorily stored for 3 years or less at temperatures slightly above freezing (34°F) (Barnett 1969; Jones 1966). For longer periods, storage should be at subfreezing temperatures, preferably near O°F (figure 3). Longleaf pine seeds have retained their viability for 20 years when held at O°F temperatures (Barnett and Jones 1993). Seed quality can be maintained for periods to meet all practical needs. In fact, because damaged or less vigorous seeds are best preserved by lowering storage temperatures (Kamra 1967), the lower temperatures are recommended as a routine practice.

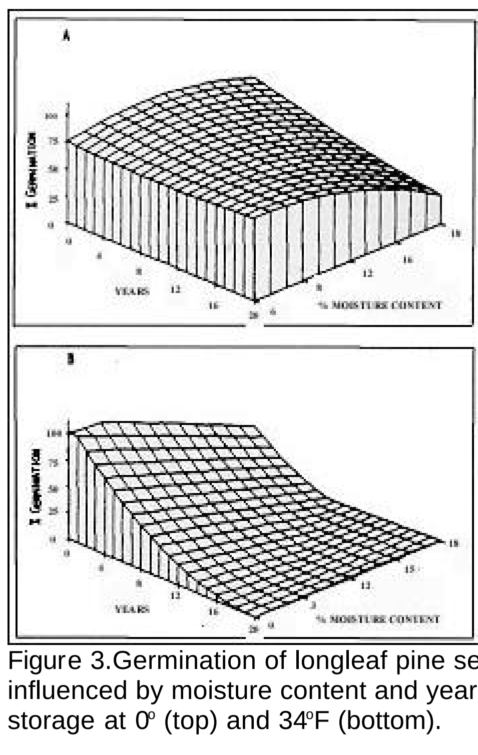

Figure 3.Germination of longleaf pine seeds as influenced by moisture content and years of storage at 0° (top) and 34°F (bottom).

TREATING SEEDS

Although early research had suggested that some seedlots might benefit from short periods of stratification (USDA Forest Service 1948; Wakeley 1954), caution was urged because longleaf pine seeds frequently begin to germinate during stratification. As knowledge about how to properly collect, process, and store longleaf seeds increased, most researchers and practitioners felt stratification was unnecessary. In recent years, however, renewed interest in stratification of longleaf pine seeds has occurred-a result of the desire to upgrade or improve performance of seedlots of poor quality. Karrfalt (1988) reported that stratification for 14 days improved both speed and total germination in almost all 54 longleaf pine seedlots tested; most of which had relatively low viability.

Others provide data showing that stratification, while hastening germination by about 2 days, reduces total germination by about 10 percentage points (Barnett and Jones 1993). The disparity in these results may relate to the method of imbibition needed for stratification. Operationally, seeds are stratified by soaking them overnight in water, draining the water, placing the seeds in polyethylene bags, and holding the bags under refrigeration for an appropriate period. Karrfalt (1988) placed the seeds in germination dishes and imbibed them with the germination medium. Barnett and Jones (1993) soaked the seeds in water alone for 16 hours which reduced germination by 10 percentage points.

Longleaf seedcoats are hosts to significant populations of pathogenic fungi (Barnett and Pesacreta 1993; Pawuk 1978). Germination of less vigorous seeds may be improved by treating with a sterilant, such as hydrogen peroxide (Barnett 1976b), or applying a fungicidal drench with benomyl (Barnett and Pesacreta 1993). Both treatments are used in southern forest nurseries

CONCLUSIONS

Longleaf pine seeds are sensitive to injury during collection, processing, storage, and treatment. Because longleaf pine seeds are large, have relatively less dense coats, and are difficult to dewing, the techniques used for processing other southern pines are inadequate. However, when properly handled, high quality longleaf pine seeds can be produced.

RECOMMENDATIONS

The following recommendations include factors essential to maintaining high quality longleaf pine seeds:

1. Collect longleaf pine cones when fully mature (19 of 20 cones have a specific gravity of 0.89 or less) and hold for 3 to 4 weeks before processing. Do not delay processing of cones beyond 4 to 5 weeks.

2. Maintain kiln temperatures between 95°F and 105°F. As soon as the cones open, remove seeds from the kiln. Dry seeds to moisture contents below 10 percent by placing in seed dryers on clear, dry days when the ambient relative humidity is low.

3. Use dewing equipment designed for longleaf pine to ensure that the wings are reduced to stubs without injury to the seedcoats. Dewing the seeds only after they have been dried to

moisture contents of 10 percent or less.

4. Remove trash, wings, and empty seeds carefully in a cleaning mill, on a gravity table, or by flotation in *n*-pentane (Barnett 1971).

5. Store in sealed containers at moisture contents less than 10 percent and at subfreezing temperatures, preferably near O°F.

6. Conduct germination tests when seeds are placed in storage and if storage is longer than I year, again before use. If stratification is considered, conduct paired germination tests (stratified and control lots). Tests should follow pre-sowing treatments that duplicate operational procedures, i.e., water soaking as used in stratification.

7. Consider control of seed microorganisms if lots are of low quality. The use of sterilants or fungicide soaks will significantly reduce populations of microorganisms on the seedcoats and may improve seed performance, particularly under nursery conditions.

---

[1] *USDA Forest Service, Southern Research Station, 2500 Shreveport Hwy., Pineville, LA 71360; Tel: 3181473-7216.*

LITERATURE CITED

Barnett, J. P. 1969. Long-term storage of longleaf pine seeds. Tree Planters' Notes 20(2): 22-25.

Barnett, J. P. 1971. Flotation in ethanol reduces storability of southernpine seeds. Forest Science 17: 50-51.

Barnett, J. P. 1976a. Cone and seed maturation of southern pines. USDA Forest Service Research Paper SO- 122. New Orleans, LA: Southern Forest Experiment Station, 11 P.

Barnett, J. P. 1976b. Sterilizing southern pine seeds with hydrogen peroxide. Tree Planters' Notes 27(3): 17-19, 24.

Barnett, J. P. 1979a. Germination temperatures for container culture of southern pines. Southern Jour. Applied Forestry 3: 13-14.

Barnett, J. P. 1979b. Southern pine cone maturation and storage. In: Proc., Seed Collection Workshop. USDA Forest Service Tech. Bulletin SA-TP 8. Atlanta, GA: State and Private Forestry, 8 p.

Barnett, J. P. 1990. Seedbed densities and sowing and lifting dates affect nursery development and field survival of longleaf pine seedlings. Tree Planters' Notes 42(3): 28-29.

Barnett, J. P.; McLemore, B. F. 1970. Storing southern pine seeds. Jour. Forestry 68: 24-27.

Barnett, J. P.; Jones, J. P. 1993. Response of longleaf pine seeds to storage conditions and pregermination treatments. South. J. Applied Forestry 17: 174-179.

Barnett, J. P.; Pesacreta, T. C. 1993. Handling longleaf pine seeds for optimal nursery performance. South. J. Applied Forestry 17: 180-187.

Belcher, E. W., Jr.; King, J. 1968. Storage of dewinged longleaf pine seed is possible. Georgia Forestry Research Counc. Research Paper 5 1. Macon, GA: Georgia Forestry Commission, 4 p.

Bonner, F. T. 1987. Cone storage and seed quality in longleaf pine. USDA Forest Service Research Note SO34 1. New Orleans, LA: Southern Forest Experiment Station, 4 p.

Jones, L. 1966. Storing pine seed: What are best moisture and temperature conditions? Research Paper 4 1. Macon, GA: Georgia Forest Research Council, 8 p.

Kamra, S. K. 1967. Studies on storage of mechanically damaged seed of Scots pine (Pinus silvestris L.). Studia Forestalia Suecica 42, 27 p.

Karrfalt, R. P. 1988. Stratification of longleaf pine. In: Proceedings Southern Forest Nursery Assoc. Meeting, July 25-28, 1988, Charleston, SC. Columbia, SC: Southern Forest Nursery Association: 46-49.

McLemore, B. F. 1959. Cone maturity affects germination of longleaf pine seed. Jour. Forestry 57: 648-650.

McLemore, B. F. 1961. Prolonged storage of longleaf cones weakens seed. USDA Forest Service Southern Forestry Notes 132. New Orleans, LA: Southern Forest Experiment Station.

McLemore, B. F. 1975a. Collection date, cone-storage period affect southern pine seed yields. Tree Planters' Notes 26(l): 24-26.

McLemore, B. F. 1975b. Cone and seed characteristics of fertilized and unfertilized longleaf pines. USDA Forest Service Research Paper SO- 109. New Orleans, LA: Southern Forest Experiment Station, 10 p.

Pawuk, W. H. 1978. Damping-off of container-grown longleaf pine seedlings by seedborne Fusaria. Plant Disease Reporter 62: 82-84.

Rietz, R. C. 194 1. Kiln design and development of schedules for extracting seed from cones. U.S. Department of Agriculture Tech. Bulletin 773. Washington, D.C.: Government Printing Office, 70 p.

Shipman, R. D. 1958. Planting pine in the Carolina sandhills. USDA Forest Service Station Paper 96. Asheville, NC: Southeastern Forest Experiment Station, 43 p.

Shoulders, E. 1963. Root-pruning southern pines in the nursery. USDA Forest Service Research Paper SO-5. New Orleans, LA: Southern Forest Experiment Station, 6 p

USDA Forest Service. 1948. Woody-plant seed manual. USDA Forest Service Miscellaneous Publ. 654. Washington, DC: U.S. Govt. Printing Office, 416 p.

Wakeley, P. C. 1954. Planting the southern pines. USDA Agricultural Handbook 18. Washington, DC: U.S. Govt. Printing Office, 233 p.