PRINCIPLES OF SOWING SOUTHERN PINE SEEDS

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Abstract--Seed sowing is one of the critical cultural aspects of producing high-quality nursery seedlings. To obtain rapid and uniform germination and seedling establishment, it is necessary to use high-quality seeds and appropriate prechilling treatments. The date of sowing is also important, as it can greatly influence the size and quality of seedlings produced. Density of the established stand is another important determinant of the number of plantable seedlings obtained from the nursery.

Additional Keywords: Southern pines, *Pinus*, germination, stratification, seed treatments, seed sizing.

INTRODUCTION

The proper selection, treatment of sowing southern pine seeds will determine whether a crop of high-quality pine seedlings can be grown. The goal for any nursery should be to have seed lots with greater than 90 percent germination and losses, after emergence, of less than 10 percent (Barnett et al. 1984). If there is greater uncertainty than this, it will be difficult to consistently produce a high-quality crop of seedlings every year because of the required oversowing to compensate for poor emergence and establishment. Oversowing results in too high a seedling density on a high percentage of the seedbed within any year and large year-to-year variations.

Meeting the goal of 90+ percent germination that is prompt and uniform requires considerable care in collecting, processing, and storing seeds and in applying appropriate pregermination treatments. Seeds of the southern pines vary by species as to how they mature and in dormancy. Collecting, handling, and processing affects initial seed viability (Barnett and McLemore 1970, Barnett 1976a). Dormancy slows initiation and rate of germination, particularly in nursery beds where germination temperatures and photoperiods are less than optimal (McLemore 1969). When viable seeds are sown, the largest losses are seen during the initial 2- to 3-week period after sowing. Nursery workers attribute much of their seedling losses to high winds and rainfall during the sowing period. This shows how important it is to insure rapid seed germination and seedling establishment.

SEED QUALITY

The increasing emphasis on reforestation requires large quantitites of seeds whose high quality can be depended on. Lack of proper collecting, handling, and storing of southern pine seeds may decrease seed viability by 20 to 30 percent, making nursery management difficult.

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Numerous factors during cone collection and seed processing can affect seed performance. The most important of these are cone maturity and storage, cone and seed processing, seed moisture content, and storage temperature. Unfavorable conditions in any of these areas can cause secondary seed dormancy, reduce ability to store well, or cause immediate loss of viability.

Cone maturity and storage

Initial germination of longleaf (*Pinus palustris* Mill.), eastern white pine (P. *strobus* L.), and slash pine (P. *elliottii* Engelm.) seeds is directly related to cone maturity at the time of extraction (Barnett 1976a, 1986; McLemore 1959, 1975). Germination of loblolly pine (P. *taeda* L.) seeds is less affected by cone maturity. Cone storage before processing increases the seed yield of loblolly pine cones collected early in the season and both increases yield and germination of seeds from immature slash pine cones (Barnett 1976a, McLemore 1975). Storage for 3 to 5 weeks is recommended before processing cones collected before they reach maturity. Longleaf cones should be collected only when mature; storage frequently decreases the germination of seeds from immature cones. Cones can be picked when ripe and stored 3 to 5 weeks to increase seed yields without reducing viability (Barnett 1976a), but the storage period should not exceed 8 weeks (McLemore 1960).

Response of other southern pines, especially shortleaf (P. *echinata* Mill.) and spruce (P. *glabra* Walt.) pines, is similar to loblolly pine under the same collection and storage conditions. Eastern white pine provides different cone collection concerns because cone shrinkage during drying makes specific gravity, the traditional maturity index, unreliable (Barnett 1986).

Processing and storing seeds

Seeds are usually extracted from southern pine cones in forced-draft kilns. Temperature and duration of kilning are critical for southern pines, particularly longleaf; temperatures of 115°F or more markedly reduce germination (Rietz 1941). Optimal temperatures are 95° to 105°F. Increases in the length of extraction treatment may also reduce viability.

After seeds are extracted, they must be dewinged, cleaned and dried. The wings on all southern pine seeds, except longleaf, are completely removed by brushing and tumbling in mechanical dewingers. The nature of longleaf seeds makes dewinging difficult; the wings can only be mechanically reduced to stubs, so dewingers must be carefully regulated to prevent injury to these thin-coated seeds. Wing removal that does not damage the seedcoat has no effect on the storage of seed (Belcher and King 1968, Barnett 1969), but dewinging is a common cause of seed injury and loss of viability. The dewinging process for pine species other than longleaf is hastened and improved by moistening dry seeds, but this excess moisture should then be removed before storage. The newly developed precision seeders work properly only if no wings are on seeds and if little trash is in the lot.

Before seeds are sown, all empty seeds should be removed from the seed lot. This can be accomplished by mechanical cleaning equipment or, when seed lots are small as in progeny tests, flotation in water or organic solvents can be used to separate empty seeds. In the appropriate liquid, sound seeds sink, while unsound seeds float and can easily be skimmed off. Different liquids are appropriate for different species: water for loblolly pine; a 1:1 water-ethyl alcohol mixture for slash pine; n-pentane for longleaf pine; and 95 percent ethyl alcohol for shortleaf, sand, and spruce pines (Barnett and McLemore 1970). To maintain high seed viability, flotation in ethyl alcohol should be delayed until just before seeds are used because if the alcohol is not thoroughly removed by drying, seeds so treated rapidly lose viability while they are in storage (Barnett 1971).

Seeds that are going to be stored should be dried to a moisture content below 10 percent and sealed in airtight containers. Although seeds with a moisture content above 10 percent will remain viable for several years if stored at temperatures below freezing, the combination of a moisture content below 10 percent and a temperature below 32°F is recommended for the best storage. Under these conditions, seeds of most pine species will remain viable for as long as 50 years (Barnett and Vozzo 1985).

Seed moisture content can also affect the amount of secondary dormancy that develops during storage. Loblolly seeds stored 1 to 5 years at moisture levels below 10 percent are less dormant than those held at levels between 12 and 18 percent (McLemore and Barnett 1968).

Predicting seedbed performance

For decades nursery managers and seed physiologists have sought techniques, generally with little success, that would more accurately predict seed performance in the nursery. In a recent evaluation of the problem, Barnett and McLemore (1984) found that laboratory germination tests performed on prechilled seed lots provided the best predictors of seedling yield in a nursery for both loblolly and slash pine. However, it is important that the germination tests be performed within 6 months so that the results can be used by the nursery managers to establish sowing rates.

SIZING

The potential benefits of seed sizing are more uniform germination in the nursery and, therefore, more uniform seedling development in the seedbed. Both of these qualities are important in the nursery to increase the seedling-to-seed ratio. However, reports on the value of sizing southern pine seeds are mixed (Barnett and Dunlap 1982). Dunlap and Barnett (1983) found that under laboratory conditions of minimal environmental stress, larger seeds would germinate more quickly and produce a larger germinant. In a similar experiment conducted under greenhouse growing conditions, large seeds produced the largest seedlings. Size differences of seedlings in both experiments resulted from differences in the rate of germination unique to each seed size class. Consequently, seedling size and possibly uniformity of growth were considered a function of germination patterns that were influenced by seed size. Lengthening the stratification period should minimize the effect of seed size on seedling development. It has been observed, however, that seedlings from large seeds did develop some faster when compared to seedlings from small seeds that were germinated on the same day (Barnett and McLemore 1984).

After high-quality seeds have been obtained and stored, they must be properly prepared before sowing. Overcoming seed dormancy is the next major step in insuring prompt and uniform germination in the nursery bed.

Seeds of southern pines vary considerably in dormancy as measured by rate of germination. Loblolly pine seeds are the most dormant and longleaf pine seeds the least dormant (Barnett 1976b). Dormancy is traditionally overcome in southern pine seeds by stratification or moist prechilling (Bonner et al. 1974). Most nursery managers prechill loblolly seeds for 30 days and other dormant-seeded pine species for 30 days or less. However, prechilling beyond 30 days markedly increases the speed and uniformity of germination of loblolly pine seeds (Mann 1956, McLemore and Czabator 1961). Longer prechilling also decreases restrictions imposed on germination by the unfavorable environments often found in bare-root nurseries at the time of sowing (Table 1) (McLemore 1969, Dunlap and Barnett 1982).

Table 1.--Effect of length and method of stratification of a mixed loblolly pine seed lot in two testing environments (adapted from McLemore, 1969)

Days stratification	Stratified in refrigerator at 34°F: Germination percent	Stratified in refrigerator at 34°F: Germination value [a]	Stratified outdoors: Germination percent	Stratified outdoors: Germination value
	Tested at 60°F with 11-hour photoperiod			
0	< 1	0.0	< 1	0.0
30	68	7.1	59	6.0
60	95	17.3	91	11.4
113	99	24.0	98	19.6
	Tested at 72°F with 16-hour photoperiod			
0	96	20.8	96	20.8
30	99	37.6	98	41.8
60	99	47.1	99	47.0
113	100	50.3	99	56.3

[a] Germination values represent the speed as well as completeness of germination (Czabator 1962).

Both speed and incidence of germination of loblolly and shortleaf pine seeds increase with extended prechilling treatments (McLemore and Czabator 1961, Barnett and McGilvray 1971). However, 30-day prechilling can be detrimental to some lots of less dormant seeds such as slash pine (Barnett and McLemore 1984).

Seed moisture content is critical for both stratification and germination of southern pine seeds. Germination can be substantially slowed or even inhibited by moisture stress. Although all southern pines are affected by moisture stress, the moisture content threshold for germination differs by species. Unimproved seed lots of loblolly slash, and longleaf pine required 36-, 40-, and 55-percent seed-moisture contents (expressed on a dry-weight basis), respectively, before germination could begin (Barnett 1981).

To better characterize the role of moisture content, seeds were prechilled at several time intervals and moisture contents. Seeds prechilled at 100 percent of full moisture capacity demonstrated an increase in vigor through 60 days of prechill treatment. Any reduction in moisture content below full capacity resulted in decreased response to prechilling, as indicated by slower germination. Consequently, maximum prechilling response can only be obtained by maintaining full seed imbibition, which varies among species and sources.

PROTECTION

Before sowing, most nursery managers apply a protective repellent coating to limit bird depredation. The chemicals recommended, thiram or anthraquinone [2/], were developed for a direct-seeding program (Derr and Mann 1971). Anthraquinone with a latex sticker is safer to handle and has less effect on germination, but it is more troublesome to apply because it is supplied as a powder formulation. Recommended rates of anthraquinone or thiram should be used (May 1985), because heavier rates may slow germination, particularly when seeds are covered with soil or mulch. The light required for germination of southern pines may be drastically reduced by these repellent treatments.

TIME OF SOWING

The correct timing of sowing is one of the important factors that determine the size and uniformity of seedlings produced. If sowing is done too early in the spring, germination may be slow, resulting in nonuniform seedlings and a low yield of plantable seedlings. If sown late, germination is often variable and seedlings are adversely affected by heat and soil pathogens. May (1985) listed a number of factors that influence the choice of time of sowing:

1. Season of lifting, i.e., summer or winter.
2. Desired size of planting stock.
3. Temperature requirements for germination.
4. Precipitation and temperature patterns at the nursery site.
5. Germination and growth patterns of the species.
6. Soil texture.
7. Rotation scheme.
8. Fumigation schedule.

[2/] Though this paper refers to research involving pesticides, it does not contain recommendations for their use nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

Other factors such as a limited amount of equipment and staff may require additional flexibility.

Seed of some species may be sown either in the fall or spring. Fall seeding is generally considered best for longleaf pine and is used occasionally for Virginia, sand, and eastern white pine seed. Such slow-growing species are adversely affected by high summer temperatures. An additional benefit from fall sowing is that the longer growing season produces larger seedlings.

Fall sowing dates are usually between October 15 and November 30 (May 1985). Longleaf pine seeds sown during this time germinate immediately after sowing, allowing young plants to establish a deep tap root. Fall-sown seeds need not be stratified. Species other than longleaf germinate in the spring when the soil warms, resulting in prompt and uniform germination. There is no need to stratify these seeds, as the overwinter conditions serve the same purpose.

Most seeds are sown in the spring, usually in late March or April. South (1984) notes that when fertilization was practiced less, nursery managers often sowed earlier in the spring. Wakeley (1954) reported that in the lower South, most sowing was in February or March with slash usually sown in April. More recently, nursery managers have tended to delay sowing in order to keep genetically improved seedlings from growing too tall. While late sowing does limit height growth, it also adversely affects seedling biomass. South (1984) presents data from Rowan and Marx (1976) that showed there is about a 1.2 percent decrease in fresh-weight production for every day sowing was delayed (Figure 1). This means that a delay in sowing from April 15 to May 15 can result in a 36 percent reduction in biomass production.

Lengthening the period of stratification from 30 to 45 or 60 days increases the speed and uniformity of germination and reduces delays in germination that result in poor-quality seedlings. Boyer et al. (1985) found that loblolly pine seedlings that emerged earliest (first 40 percent) attained significantly larger diameters than seedling from seeds that germinated later. Stratification improves germination at both lower and higher than optimum temperatures, but the response is better at the lower temperature extremes. Late-germinating seeds seldom become plantable seedlings.

Sowing by half-sib family will also increase seedling uniformity. Seeds from different families can germinate at different rates. Subsequently, seeds from a slow germinating family develop into seedlings with smaller diameter when sown in mixed lots Nasser 1978). Seedling diameters were more uniform when seeds were sown by family.

DEPTH OF SOWING

Seed sowing depth can have a major influence on speed and uniformity of germination. Southern pine seeds have a definite light requirement for germination. However, because the soil surface dries so rapidly, some covering or mulching is required to obtain prompt germination. Seeds can be sown on the surface of the soil or in shallow grooves and pressed into the soil surface by a roller. The seedbed should then be covered with a mulch of some sort. The type of mulch affects the optimum depth of sowing. Rowan (1980) found that surface sowing of slash pine is a better practice when sawdust or pine straw is used as the mulch. Sowing at a 1/4-inch depth is best when using a hydromulch.

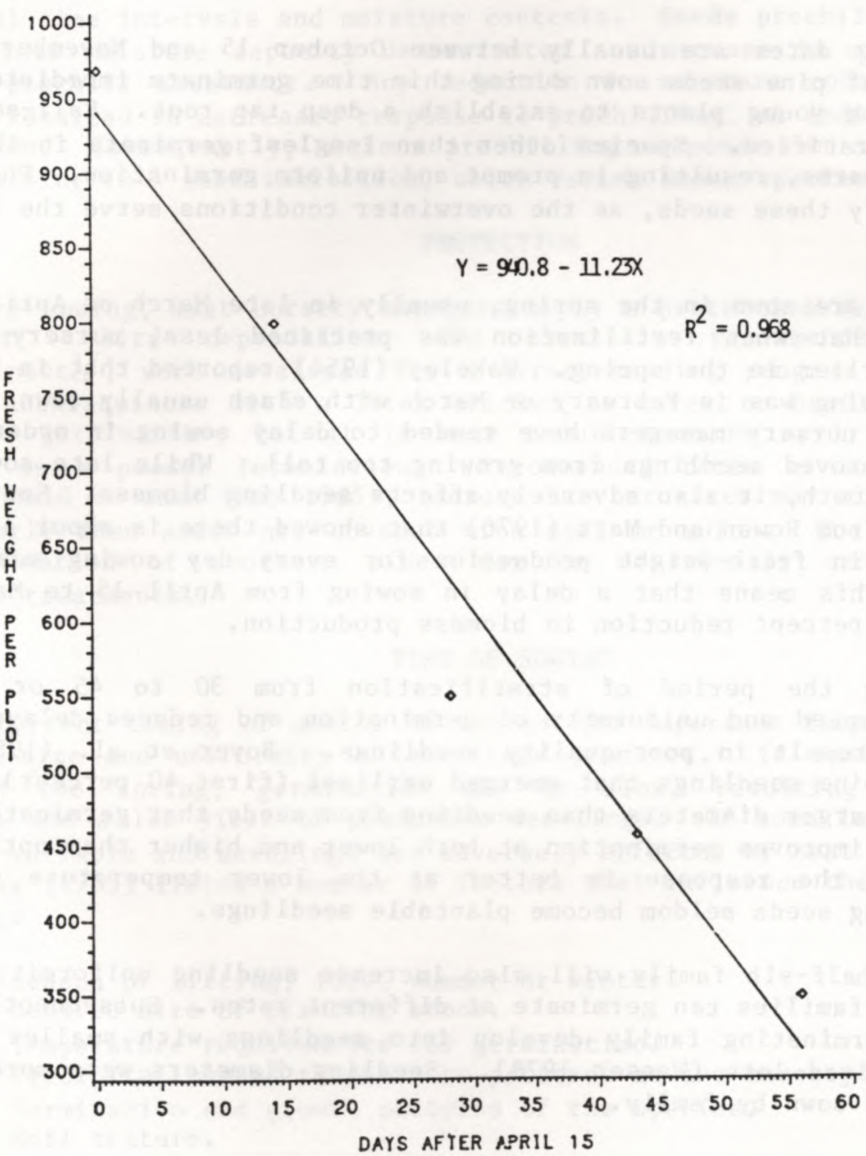

Figure 1.--Effect of sowing date on fresh-weight production of loblolly pine seedlings (From South 1984).

Covering seeds with more than 1/4 to 1/2-inch of soil will result in slow and staggered germination. The germinating seeds also are subject to greater attack from soil pathogens.

DENSITY OF SEEDLING STANDS

Spacing of seedlings is another major factor influencing seedling morphology. Seedlings grown close together (at high densities) often have small diameters and limited root systems. Optimum seedling spacing is dependent on desired seedling diameters, fertilization, soil moisture, drill spacing, date of sowing, and economics (South and Mexal 1984). In most nurseries the average density of seedlings ranges from 24 to 30 per square foot throughout the growing season. This standard applies to all southern pines except longleaf. The biological optimum seems to be about 19 per square foot (Mexal 1981). Densities below 19 per square foot may not fully utilize the capacity of the soil and they would be uneconomical to produce. Studies of field survival showed that Wakeley's Grade 1 seedlings produced in seedbeds containing fewer than 30 per square foot survived better on poor sites and under adverse conditions than did smaller seedlings (Shoulders 1961, Shipman 1966).

Longleaf pine seedlings must be grown at a density of about 15 per square foot or less if Grade 1 seedlings with a root-collar diameter of 1/2 inch or more are to be produced (May 1985). Optimum seedling density may vary for each nursery due to fertilizer rates and other cultural options and must be determined by local experience.

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