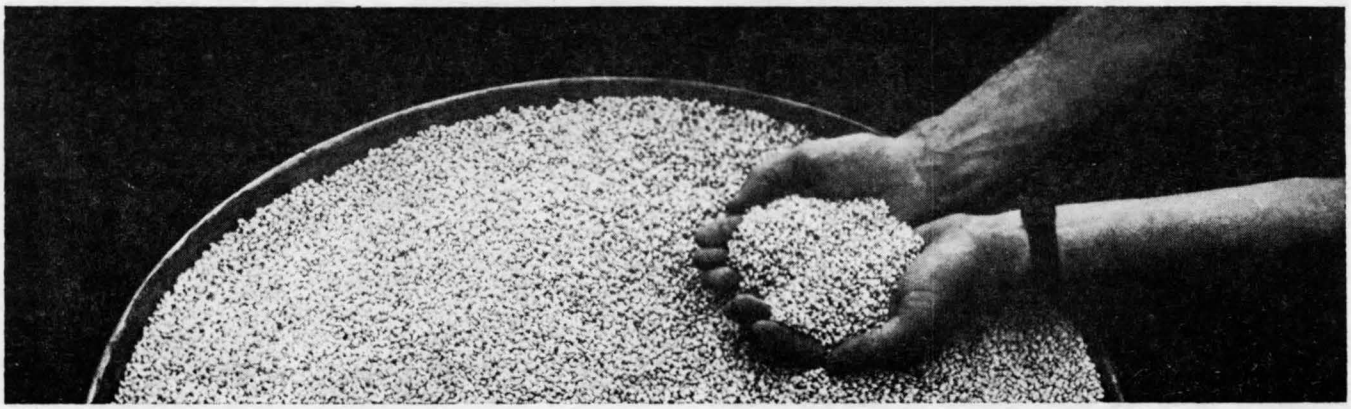

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Storing Southern Pine Seeds

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ABSTRACT—Viability of seeds of all southern pine species can be maintained long enough for practical needs. Control of moisture content and temperature is of primary importance in prolonging viability, but cone maturity, time from harvest to extraction, and seed extracting and processing techniques are also influential.

SINCE southern pines do not produce abundant cone crops every year, large quantities of seeds must be collected in good years and stored to provide for intervening periods. With the increase in popularity of direct seeding, storage has become a task for landowners and land managers as well as nurserymen.

A series of studies on southern pine seed storage was initiated in Alexandria, La., in the early 1950's. This paper summarizes the results of these studies and reviews related work at other locations. Longleaf pine (*Pinus palustris* Mill.) was used most frequently in our tests because its seeds are reputed to be the most difficult of the southern pines to store (*34*). They are large, have thin seedcoats, and are unusually moist when extracted from cones. Conditions under which longleaf seeds can safely be stored are satisfactory for the other southern pines.

Tree Selection and Treatment

A previously unreported study in Alexandria indicates that storability of longleaf pine seeds is not genetically controlled. Sufficient seeds for reliable tests of viability were collected from the same 30 trees in two different years. Germination percents were determined by parent tree and collection year both initially and after two years of storage at 34° F. Although storability varied by tree for individual seed crops, there was no statistically significant individual-tree correlation between the two seed crops. Thus, it appears that seeds collected from a tree in one year may store well while seeds collected from the same tree in a different year store poorly.

Dormancy in loblolly pine (*P. taeda* L.) seeds (*24*) and the order of cone ripening in longleaf pine (*23*) are genetically controlled. These and other traits that may influence storability could be improved by breeding, but the efforts would almost certainly not be justified by gains in storability alone.

A limited test of the effect of seed source on storability was made with longleaf pine (*2*). Seeds from one geographic source in Louisiana and two in Mississippi were stored under 14 combinations of moisture and temperature conditions. The results, though not conclusive, indicate that seeds from differ-

Table 1.—Germination of Stored Seeds from Fertilized and Unfertilized Longleaf Trees

Year	Treatment	Germination after 0 years	2 years	4 years	7 years
		percent			
1957	Fertilized	89	83	62	50
	Unfertilized	92	86	66	63
1958	Fertilized	90	94	93	90
	Unfertilized	92	95	95	90
1959	Fertilized	95	92	91	84
	Unfertilized	93	93	92	86
1960	Fertilized	99	90	91	81
	Unfertilized	96	93	91	85

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ent sources and with different viabilities store equally well.

Wakeley (*34*) reported that tree age has little influence on initial viability of seeds. A more recent study indicates that tree age does not affect storability either (*3*). Mature cones were collected from longleaf pines averaging 21, 40, and 85 years old. Initial viability was high for all trees—averaging 82 percent. After five years at 10 percent moisture content and 34° F, germination ranged from 79 to 82 percent for the three age classes. Differences in loss of viability by age class were not statistically significant (0.05 level).

A study now in progress indicates that complete fertilizers, which are often applied in seed-production areas and seed orchards, do not influence storability. Seeds were collected yearly for four years from 22 matched pairs of fertilized and unfertilized longleaf pines. Germination, by parent tree, was tested initially and after two, four, and seven years at 10 percent moisture content and 34°F. The results are shown by treatment and year in Table 1. Average germination after storage was 83 percent for seeds from fertilized trees and 86 percent for those from unfertilized trees. The difference was of neither practical nor statistical significance.

Cone Collection

Rough handling, such as the shock when a cone falls to the ground, does not affect initial germination of loblolly seeds (*16*). Storability is probably not influenced by cone collection procedures either.

Cones must be ripe, or almost ripe, before they will open and release their seeds. Cone maturity also influences germination both initially and after storage.

Wakeley (*34*) reported that cones of longleaf, slash (*P. elliotti* Engelm.), loblolly, and shortleaf (*P. echinata* Mill.) are mature enough for seed extraction when their specific gravities drop below 0.89—when they float in SAE 20 lubricating oil. The same is true for spruce pine (*P. glabra* Walt.) cones (*7*). Sand pine (*P. clausa* [Chapm.] Vasey) and Virginia pine (*P. virginiana* Mill.) cones mature at specific gravities of about 1.0—when they float in water (*4, 6, 12*).

Initial germination of longleaf pine seeds is directly related to cone maturity at the time of extraction. Immature longleaf pine cones were collected near Alexandria on September 9, September 24, and October 7, and mature cones were picked from the same trees between October 14 and November 1. Seeds were immediately extracted, and germination was tested on some, while the rest were stored at a moisture content of 10 percent and a temperature of 34°F. Initial viabilities, by collection date, were: September 9, 46 percent; September 24, 66 percent; October 7, 88 percent; and October 14 to November 1, 94 percent (*18*).

The influence of cone maturity on storability is complex. In the study just described, seeds from the September collections were more viable after ten years than initially (Table 2). Storage did not influence the viability of the seeds collected on October 7, but it reduced the viability of those collected on later dates. Apparently, seeds that were extracted before they were ripe matured in storage, while those that were ripe initially deteriorated.

Table 2.—Germination of Longleaf Pine Seeds, by Date of Collection and Length of Storage

Date of collection	Germination after				
	0 years	2 years	4 years	7 years	10 years
			percent		
Sept. 9	46	72	75	45	76
Sept. 24	66	85	81	60	83
Oct. 7	88	94	84	75	85
Oct. 14 to Nov. 1	94	92	81	65	64

Schubert (*32*) and Rediske (*30*) reported contrary findings for seeds of four western conifers. They found that the viability of immature seeds was low initially and decreased in storage.

A supplementary study was installed in Alexandria with an increased range in collection dates and, therefore, specific gravities of cones. In this study, viability of immature longleaf pine seeds did not increase in storage:

Date of collection	*Germination*	
	Initially	*After two years*
	percent	
August 14	5	4
September 14	81	46
October 18 to November 5	91	86

Apparently, immature seeds cannot be expected to ripen after extraction. If they have not reached some undetermined critical stage in maturity, they will fail rapidly.

Seeds in slightly immature cones can be ripened by holding the cones in a well-ventilated, unheated shed for about four weeks (*10, 34*). Ripening immature cones prior to extraction usually increases seed recovery as well as germinability. It can also extend the collecting season for southern pines by one or two weeks. The cones of the four major southern pines can be ripened in storage, but in no case should they be picked before their specific gravity drops to 1.0.

In contrast to storage of immature cones, prolonged storage of ripe cones may reduce initial viability of longleaf seeds and substantially reduces germinability after storage (*20*). Ripe longleaf cones were placed in one-bushel burlap bags and held for 0, 15, 30, 60, and 90 days in an unheated shed. Separate lots were extracted and cleaned to 100-percent soundness for initial germination tests. The remaining seeds of each storage treatment were dried to a moisture content of 10 percent and stored at 34°F for one year.

Initial viability was unaffected by cone storage for up to 60 days; germination of seeds from cones held 90 days was significantly reduced (Fig. 1). Seed from cones held for 0, 15, and 30 days kept well for one year; viability of those from cones held 60 to 90 days was substantially reduced.

Mature longleaf cones should be held in bags no longer than 30 days before extraction unless the seeds will be used during the year of collection (*20*). Observations indicate that seeds from ripe cones of the other southern pines are not as adversely affected by delayed extraction as are longleaf seeds.

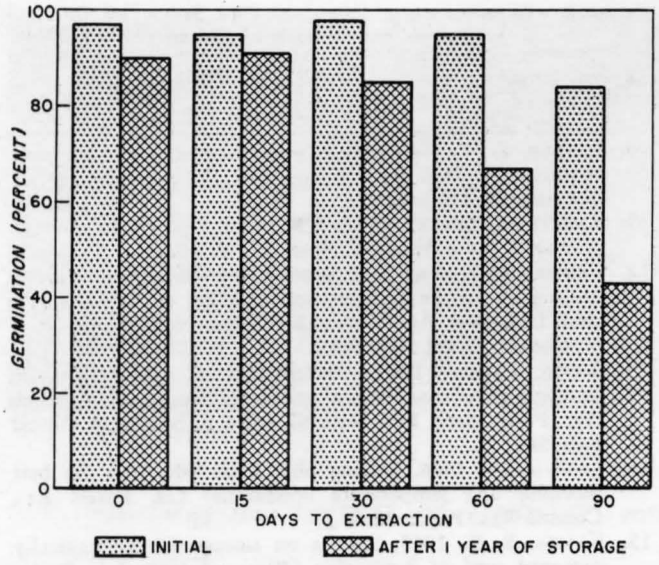

Fig. 1.—Effect of delayed extraction on longleaf seed germination initially and after one year of seed storage.

Seed Processing

Seeds are usually extracted from southern pine cones in forced-draft kilns. Temperature and duration of kilning are critical for southern pines, particularly longleaf. Rietz (*31*) found that temperatures of 115°F or more markedly reduced viability of longleaf seeds. Increases in the time the seed remained in the kiln at high temperature also reduced germination.

In a forced draft kiln, an input temperature of 100° to 105°F will usually open ripe southern pine cones in 48 hours (*19*). This temperature and duration does not reduce viability either initially or after storage.

After they are extracted from cones, seeds must be dewinged, cleaned, and dried. The wings on seeds of all southern pines except longleaf are completely removed by brushing and tumbling in mechanical dewingers. The process is hastened by moistening dry seeds, but this excess moisture must be removed prior to storage.

The structure of longleaf seeds makes dewinging difficult. Wings rarely can be completely removed without injuring the thin-coated seeds. Hence, longleaf seed wings are mechanically reduced to stubs. This process is speeded by drying the seeds. Particularly with longleaf, mechanical dewingers must be carefully regulated to prevent injury. Wing removal which does not damage seedcoats has no effect on seed storability (*2, 9*).

Trash, wings, and empty seeds are usually removed from lots in a cleaning mill or by flotation. Cleaning mills are ideal for large seed lots and have little effect on viability. Small lots are usually cleaned by flotation in a liquid of suitable specific gravity. Loblolly pine seed can be cleaned in water; longleaf pine in *n*-pentane; shortleaf, sand, and spruce pine in 95-percent ethanol; and slash pine in a 1:1 water-ethanol mixture. Soaks of four hours in *n*-pentane and in ethanol promoted initial germination (*4, 22*). Baldwin (*1*) reported similar results for red spruce seeds (*Picea rubens* Sarg.) in absolute ethanol, but found that soaking decreased storability. Until results of studies now under way are available, it is recommended that southern pine seeds cleaned by flotation be sown immediately.

Storage Conditions

Careful control of seed moisture content and storage temperature is vital in maintaining viability (*8, 29, 34*). Three long-term studies confirm results reported for shorter periods by Jones (*14*) and McLemore (*21*). A summary of the three extended studies (*2*) contained recommendations for storing longleaf pine seeds for various periods:

One year.—For storage at temperatures near 34°F, reduce the moisture content of seeds to 10 percent or less. At 0°F, viability is maintained with moisture contents up to 18 percent, although it is safer to store at lower moisture levels.

Two to three years.—Moisture content must be reduced to 8 percent to maintain viability at 34°F. At 0°F moisture contents up to 18 percent are acceptable. Seeds that contain 13 percent moisture store well at 25°F.

Four to seven years.—Do not store at 34°F. Reduce the moisture content to 10 percent for storage at 25°F. Moisture levels up to 15 percent are acceptable at 0°F.

Eight to ten years.—Reduce moisture content to 10 percent or less and hold temperature at 0°F.

Other southern pines stored under similar conditions should retain their viability longer than longleaf seeds. For example, 82 percent of slash and 50 percent of shortleaf seeds germinated after 35 years at 34° to 38°F with a moisture content of 9 percent (*35*).

The dormancy of loblolly pine seeds increases during storage, but the increase is smaller in dry than in moist seeds. Loblolly seeds stored for one to five years at moisture contents below 10 percent were less dormant than those held at moisture contents of 10 to 18 percent (*26*).

Seeds that are damaged or have low vigor can be preserved by lowering storage temperatures (*15, 34*). However, the effect of reducing temperatures far below freezing has been questioned. Apparently there is no problem if seeds have low moisture content. Engstrom (*11*) stored shortleaf seeds in liquid nitrogen (—385°F) for 112 days without reducing viability.

In the absence of humidity controls in the storage area, all storage containers should be tightly sealed to prevent changes in moisture content of seeds.

Treated Seeds

It is often necessary to hold stratified or repellent-coated seeds for a few weeks, and occasionally they must be stored until the following year. Several investigators have stored coated southern pine seeds for short periods (*17, 27, 28, 33*), and seeds coated with anthraquinone were held without damage for a full year (*13*). The effects on storability of stratification and repellent coatings containing Arasan and endrin were measured on longleaf, loblolly, slash, and shortleaf pine seeds (*5, 25*). Four recommendations were presented for storage of treated seeds for up to one year:

1. Repellent-coated, stratified loblolly and shortleaf pine seeds should be stored at 25°F without drying. Restratification is unnecessary. Drying would provide safer storage but would necessitate restratification, which is risky with large quantities of repellent-coated seed.
2. Stratified but uncoated loblolly and shortleaf seeds should be dried to 10 percent moisture content and stored at 25°F. They should be restratified after storage.
3. Stratified slash seed, whether coated or uncoated, should be dried to 10 percent moisture content and stored at 25°F. Restratification is unnecessary.
4. Unstratified, repellent-coated slash and longleaf seed should be stored at 10 percent moisture content and 25°F. Moisture is absorbed during the treating process, so even though the seeds have not been stratified, they require drying.

Weaker seeds may not store as well as the ones on which these recommendations are based, but all lots can probably be stored up to 90 days at 25°F without being dried or restratified. Seeds with more than 25 percent moisture content should not be stored at temperatures below about 25°F.

Conclusions

Viability of all southern pine seeds can be maintained for periods sufficient to meet all practical needs, if collecting, processing, and storage conditions are carefully controlled. Longleaf seeds can be kept highly viable for at least ten years at 0°F with moisture contents of no more than 10 percent. Under these conditions, seeds of other southern pines can probably be stored even longer.

Cone maturity alters germination initially and after storage. The less mature cones are when collected, the poorer initial viability. Most research indicates that immature seeds lose viability rapidly in storage.

Tree age, parent tree, seed source, and fertilization appear to have little influence on storability.

Seeds in slightly immature cones can be ripened by delaying extraction for several weeks, but delays of 60 to 90 days substantially reduce viability of stored longleaf pine seeds. Kilning temperatures exceeding 105°F and damage to seedcoats reduce storability.

Stratified and repellent-coated seeds can be held for one year without loss of viability.

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