United States Department of Agriculture

Forest Service

Southern Forest Experiment Station

Research Note

SO-341
June 1987

Cone Storage and Seed Quality in Longleaf Pine

F.-T. Bonner

SUMMARY

Immature cones of longleaf pine (*Pinus palustris* Mill.) can be stored for at least 5 weeks without adversely affecting extraction or seed quality. Cone moisture should be below 50 percent before using heat to open cones.

INTRODUCTION

Early collection and storage of cones prior to seed extraction is common for all southern pines, including longleaf (*Pinus palustris* Mill.). A study by McLemore (7) found that careful cone storage for up to 5 weeks could increase seed yield of longleaf pine, although germination of seeds from cones collected when cone specific gravity averaged 0.99 was decreased by 5 weeks of storage.

Barnett (2) confirmed that cone storage for 5 weeks would increase longleaf seed yield, but found that germination was decreased if the stored cones were immature when collected. He recommended that cones of longleaf be collected only when mature (specific gravity less than 0.90) to avoid loss of seed quality.

Preliminary tests at our laboratory have indicated that cone storage can be beneficial to seed quality of several pines, including longleaf (4). The previous studies by McLemore (7) and Barnett (2) used unheated indoor storage. Most of the cone storage in the South today is outdoors in unprotected burlap bags or 20-bushel wire-bound boxes. A comparison of these two methods of longleaf pine cone storage seemed warranted.

METHODS

Immature cones of longleaf pine were collected from 5 to 10 trees in southern Mississippi from September 14 to 16, 1984, by a contractor and delivered to the Forestry Sciences Laboratory at Starkville, Mississippi, the following day in a mixed lot. Samples were immediately taken to determine cone specific gravity (10 cones) and moisture content (10 cones). Other samples of 10 cones each were placed in laboratory ovens at 35, 43, or 49 °C to extract seeds for germination tests.

The remaining cones were placed in small burlap bags for storage under the following conditions: (1) outdoors without protection, (2) outdoors with overhead cover, but exposed to blowing rains, and (3) inside small, unheated sheds with complete protection.

There were four replications of each storage condition. Outdoor cones (condition 1) were sprayed with hoses every 3 or 4 days to simulate occasional rainfall when natural rainfall did not occur.

Each week for 5 weeks, 12 cones were removed from each bag. Three were used for specific gravity and cone moisture determinations, and three were dried at each of three extraction temperatures (35, 43, and 49 °C) in forced-draft ovens.

The cones were dried in small trays for 48 hours, then hit against a table top to remove easily extracted seeds. The cones were then carefully torn apart by hand to recover all other seeds. The number of easily extracted seeds were expressed as a percentage of the total seeds for a measure of extraction efficiency.

The seeds were dewinged by hand, and germination

Southern Forest Experiment Station/T-10210 U.S. Postal Services Bldg., 701 Loyola Avenue, New Orleans, La. 70113
Forest Service, U.S. Department of Agriculture.
Serving Alabama, Arkansas, Louisiana, Mississippi, E. Oklahoma, Tennessee, E. Texas, Puerto Rico, U.S. Virgin Islands

was tested according to standard procedures (7). Germination percentages were based on filled seeds only. Analyses of variance were carried out using arcsin transformations of both extraction efficiency and percent normal germination; germination rate was expressed by Peak Value (5).

Cone specific gravity was measured by water displacement (3). Moisture contents were determined by weight loss of cones dried for 24 hours at 105 °C and were expressed as a percentage of fresh weight. Each of these cones was cut into four pieces with a cone cutter for moisture determinations.

RESULTS AND DISCUSSION

The cones were definitely immature when delivered; specific gravity averaged 0.98 ± 0.01, and cone moisture content was 56.3 percent. Seeds immediately extracted also indicated immaturity in their sensitivity to drying temperatures (table 1). Drying at 49 °C yielded seeds with a 14.3 percent germination, while drying at 35 °C yielded seeds with a 66.1 percent germination.

Cones lost moisture at different rates under the three storage conditions (table 2). Moisture loss was slowest in the indoor storage. The two outdoor conditions were about equal in drying rate, except for extended rains during weeks 3 and 5, which raised moisture levels in the outdoor storage without protection.

Extraction efficiency was not significantly influenced by storage condition, storage time, or drying temperature (table 3). Five weeks of storage dropped cone moisture contents as low as 18 percent, but did not improve extraction efficiency. For cones stored indoors, increasing drying temperature from 35 to 49 °C improved extraction efficiency, but this was not true for the other storage conditions. Cones exposed to the weather opened sooner in the ovens than cones from indoor storage, but after 48 hours of drying there was little difference in cone opening. It should be noted that a three-cone sample is small, but drying facilities were limited. Sample size undoubtedly contributed to the variability of the results (table 3).

Table 1 .-Germination of *seeds extracted at three temperatures from immature cones*

Drying temperature	Germination	Peak value
°C	*Percent*	*Percent/day*
35	66.1	3.7
43	48.3	2.2
49	14.3	0.8

Table 2.-*Average cone moisture content during storage under three conditions*

Storage period	Storage condition		
	Outdoors	Outdoors. covered	Indoors
Weeks		*Percent*	
0	56.3	56.3	56.3
1	48.2	47.9	51.7
2	32.4	39.3	41.5
3	29.1	20.8	29.8
4	19.0	17.2	24.3
5	35.5	18.1	19.4

These results suggest that a cone moisture level of 50 percent is the critical point for drying longleaf pine cones. Once cone moisture is below this level, extraction should be successful. Results of previous tests (4) support this conclusion, as do the results of Barnett (2).

Total germination was not affected by any of the storage-extraction treatments (table 4). While the values were not especially high, they were consistent across all treatments.

The most important finding, however, was the effect of cone storage on the rate of germination, normally considered a sensitive index of seed quality. In this study, cone storage significantly increased germination rate (table 4). Peak Value averaged 5.3 after 1 week of cone storage, 6.0 after 3 weeks, and 7.6 after 5 weeks. This leads to the conclusion that the storage conditions stimulated the internal processes leading to germination. Prolonged warm, moist storage environments could also cause germination in the cones, which has been observed after longleaf cone storage for several months in 20-bushel boxes at one southern extractory. Longleaf cones could obviously be held too long before opening, but this study did not determine the limit. McLemore (6) suggested 60 days as a maximum for storage.

Seeds brought close to germination in prolonged cone storage should be used as soon as possible and not stored to carry over to later years. If storage of a portion of the lot is required, then those seeds extracted first should probably be stored. This point is currently under study with samples from all cone storage/extraction treatments.

Drying temperatures also had a significant effect on germination rate (table 4). The lower the temperature, the better the seed quality. This result underscores the danger of using seed yield or percent germination alone to evaluate cone handling and seed extraction procedures. Extraction was equal for all temperatures, but the two higher temperatures damaged seed quality.

F. T. Bonner is supervisory plant physiologist at the Forestry Sciences Laboratory, maintained by the Southern Forest Experiment Station, Forest Service-USDA, Starkville, MS.

Table 3.-Extraction efficiency for longleaf cones stored under different conditions and dried at three temperatures

Storage conditions	Drying temoerature	Weeks of storage 1	2	3	4	5	Mean
	°C			Percent			
Outdoors, Uncovered	35	9	66	24	33	89	44
	43	63	57	42	68	87	64
	49	41	62	42	73	54	55
Mean		36	62	36	58	78	54
Outdoors, Covered	35	75	53	37	19	34	43
	43	13	64	22	24	30	29
	49	37	74	24	46	32	43
Mean		41	64	28	29	32	38
Indoors	35	22	48	52	64	67	50
	43	49	38	50	63	64	53
	49	33	34	76	66	75	57
Mean		34	40	60	64	69	54

Table 4.-Germination of seeds extracted from cones stored under different conditions and dried at three temperatures

Storage condition	Drying temperature	Weeks of storage 1	2	3	4	5	Mean
	°C			Percent			
				Total germination			
Outdoors	35	83.0	74.5	79.3	84.5	80.4	80.4
	43	78.1	75.9	81.8	90.0	82.3	81.9
	49	75.0	85.8	86.4	79.6	82.3	82.0
Mean		78.8	79.0	82.6	85.0	81.7	81.5
Outdoors, Covered	35	82.9	79.5	82.9	81.3	86.3	82.9
	43	88.7	81.2	87.5	83.7	80.8	84.5
	49	76.9	87.2	91.9	84.5	93.0	87.2
Mean		83.5	82.8	87.7	83.2	87.1	84.9
Indoors	35	84.2	68.9	85.9	76.4	93.4	82.6
	43	86.9	90.7	84.4	84.1	85.2	86.4
	49	92.3	80.6	86.5	55.5	80.9	80.4
Mean		88.0	80.9	85.6	72.8	87.0	83.2
				Peak Value			
Outdoors	35	5.9	4.4	5.6	7.4	8.0	6.3
	43	4.0	5.1	5.7	6.2	7.0	5.6
	49	4.1	5.8	5.6	5.8	7.2	5.7
Mean		4.6	5.1	5.6	6.4	7.4	5.8
Outdoors, Covered	35	7.0	6.0	6.0	6.6	7.2	6.6
	43	5.6	5.9	6.7	6.6	7.2	6.4
	49	3.8	5.7	5.8	6.2	7.9	5.9
Mean		5.4	5.9	6.2	6.5	7.4	6.3
Indoors	35	6.1	4.2	6.4	5.1	9.7	6.3
	43	5.6	5.8	6.4	5.4	7.5	6.2
	49	5.6	4.8	5.6	4.5	6.9	5.5
Mean		5.8	4.9	6.2	5.0	8.1	6.0

CONCLUSIONS

Results of this study indicate that immature longleaf pine cones can be stored for at least 5 weeks without adversely affecting extraction or seed germination. The maturation effect during storage actually enhances seed quality as reflected in germination rate. Cone moisture should be below 50 percent (0.80 specific gravity) before drying is begun, and drying should be at temperatures of about 35 "C. Under some conditions, higher temperatures might be useful, but 43 °C should be the maximum. Storage of cones longer than 5 weeks may be possible without seed damage, but extreme care should be used. Extraction efficiency and seed quality were equal for cones stored indoors or outdoors, but cones stored outdoors, which had alternate wetting and drying, seemed to open sooner. If storage for later years is planned, seeds from the earliest extraction (shortest storage), should probably be chosen. Seeds from cones stored the longest should be planted first.

LITERATURE CITED

1. Association of Official Seed Analysts. Rules for testing seeds. Journal of Seed Technology. 6(2):1–126: 1981.
2. Barnett, James P. Cone and seed maturation of southern pines. Res. Pap. SO-122. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station; 1976. 11 p.
3. Barnett, James P. An easy way to measure cone specific gravity. In: Proceedings of the seed collection workshop; 1979 May 16-18; Macon, GA. SA-TP-8. Atlanta, GA: U.S. Department of Agriculture, Forest Service, State and Private Forestry; 1979: 21-23.
4. Bonner, F. T. Effects of seed extraction on the quality of southern pine seeds. Proceedings: 1984 southern nursery conference; 1984 July 24-27; Asheville, NC. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southern Region; 1984:111–120.
5. Czabator, Felix J. Germination value: an index combining speed and completeness of pine seed germination. Forest Science. 8:386–396; 1962.
6. McLemore, B. F. Prolonged storage of longleaf cones weakens seed. Southern Forestry Notes. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station; 1961; 132: 3.
7. McLemore, B. F. Collection date, cone-storage period affect southern pine seed yields, viability. Tree Planters' Notes. 26(1):24–26; 1975.