Longleaf Pine Seed Quality and Preparation for Sowing.

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Abstract:-- The ability to run a highly efficient container nursery is heavily dependent on having excellent seed quality. Longleaf (*Pinus palustris* Mill.) seed quality, although frequently poor, can just as easily be high if care is taken to meet the biological requirements of this species at all steps from seed collection through preparation of seeds for sowing. The necessary actions to take at each step in the seed handling process are described.

INTRODUCTION

“Quality seed does not cost it pays" is a saying known in seed quality circles. It is true in bare root tree nurseries and vitally important to container growers. Every empty cell in the container nursery increases cost without contributing to revenue. Sowing extra cavities might give enough trees but does nothing for cost reduction. Therefore, there are three alternatives. Sowing two or more seeds per cell and thinning out the extra seedlings is one. This option incurs additional labor cost in thinning. In times of short seed supplies, this also becomes too expensive and wasteful in terms of direct seed costs. Sowing extra seeds in a side flat and transplanting them into the empty cells is a second. This also raises labor costs and may not give satisfactory results because the timing of transplanting is very critical for proper growth and timing with the main crop. The final alternative is to use seed of as high a quality as possible and give it maximum care. This option minimizes labor costs and maximizes the number of full cells. This paper covers the steps involved in high quality seed handling from collection through storage to sowing.

CONE COLLECTION

Timing of cone collections

Collection of cones is the first step in producing high quality longleaf pine (*Pinus palustris* Mill.) seed. In the vast majority of cases, longleaf cones must be taken from the tree very close to their natural maturity date. Loblolly (*Pinus taeda* L.) and slash pine (*Pinus elfottii* Engelm.) can be collected early and after ripened artificially. This is not the case for longleaf pine. This has been the finding of formal research (Barnett 1976a, McLemore 1975) and operational work. Hurricanes have blown good cone crops down periodically four to six weeks before natural seed maturity. Seeds from hurricane cones have germinated well at the National Tree Seed Laboratory on only one occasion. Early collected cones can be dried and the seed extracted, however, the seeds are not able to germinate well. Therefore, only mature cones should be picked from the tree.

Determining when the cones are ready for harvest is estimated using specific gravity. This is because the specific gravity is proportional to the water content of the cone, and water content decreases as the cone matures. The specific gravity of any object is defined as the weight of the object divided by the weight of an equal volume of water. For example, a cone weighing 100 grams would displace 100 ml of water. If the volume of this cone were 100 cubic centimeters (also 100 ml) then the specific gravity would be 1.0. The cone would neither sink nor float. Rarely if ever would this be seen. Green cones will sink because their specific gravity is greater than 1.0 and float as they mature because the specific gravity is less than 1.0. When cones just float in water the specific gravity is about 0.98. This means maturity is close.

Wakely (1954) determined that when 19 of 20 cones collected in a stand had specific gravities of 0.89, the harvest should begin in that stand. This measurement must be made within 20 minutes of removing the cone from the tree to give an accurate reading. This quick measurement is required because the cones will be drying, and any delay would cause the specific gravity to be measured below what it actually was on the tree. This specific gravity can be measure with motor oil, but water displacement is more convenient.

Measuring specific gravity

A simple field method of measuring specific gravity is to use a cylinder slightly larger in diameter than the cone. Three-inch pvc pipe works well. A toilet flange with a knock-out plug makes a good base and plug for one end of the pipe. A ¼ to ½ inch drainpipe is installed on the side near the top of the cylinder. Water is put into the cylinder until it flows out of the drainpipe. The cone is then slowly lowered into the water and the overflow caught in a 100 ml graduated cylinder. The volume of water displaced from the cylinder by the floating cone is the weight of the cone. Record this volume. Next, the cone is pushed below the surface of the water displacing more water. This second amount of water equals the volume of the cone (or the weight of "an equal volume of water") that is needed for specific gravity measurement. Dividing the first volume by the second volume gives the specific gravity.

POST HARVEST STORAGE OF CONES

Storage conditions

Freshly harvested cones need to be protected from intense heat and allowed to continue drying. This means that good aeration must be supplied. This can be supplied by keeping the cones in burlap sacks, 20-bushel crates, or on drying racks. If the cones are in burlap sacks, they need to be up

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off the ground and not piled on top of one another. Therefore, they need to be on racks or on pallets where air can circulate completely around the bags. It is important that cones that have begun to open not be left out in the rain because the seeds can easily sprout while in the cone and a very significant loss in quality will result. Freshly picked cones should not be left in vehicles, such as closed trailers or vans that could heat up in the sun. Fresh cones are also high in moisture and still generally green in color. Therefore, they will be respiring and should not be left without ventilation for more than a brief period not to exceed 24 hours.

Length of storage

Finding proper post-harvest cone storage conditions is important but only the first requirement to successful post harvest storage. The second requirement is drying the cones and extracting the seed within 30 days of harvest (Barnett 1996). Some cones have been operationally processed beyond 30 days but not successfully beyond 45 days. In one observed case in the field, the germination dropped from the lower 90's into the upper 80's between day 30 and day 45. A 10 to 15 percent drop in germination is a very large trade off for extending the extraction period. Completing the process in the recommended 30 days is best. All efforts possible need to be placed on extraction. If the 30-day period cannot be met, it is usually better not to collect the cones. The seed quality will be compromised in extending post harvest storage beyond 30 days.

On the other side of the equation is the fact that a two or three week post harvest storage period will increase seed yield (Barnett 1996, McLemore 1975), especially if the cones were collected a bit early. The compromise that must be struck then is one of quality versus yield. The largest differences in quality are manifested apparently after storage of one year or longer. Therefore, to meet current year needs one might decide to hold the cones to increase yields, while for future year needs the cones should be done as soon as possible to maximize storability of the seeds. A dual strategy might be to store the first seed extractions for the future and use the extractions made at 30 to 45 days for current or possibly second year needs.

One factor that has not been examined is the reprocessing of cones that have been closed by moistening. The lower yields from immediately processing twice might increase kilning, and still avoid the decrease in quality that occurs from too long a post-harvest storage period. Yields would be expected to increase, as they are known to do with other conifer species. The effect on seed quality would be totally speculative without research. This concept has not been tested. Once the seed is extracted from the cones, it can be dried and stored in an uncleaned condition until a later time without losing germination.

EXTRACTION OF SEEDS

Drying cones

What are the requirements for drying cones? The main requirements are that the cones be provided enough space that they are able to expand freely and that there be free and even movement of dry air over the cones. This means that they cannot be more than two cones deep in drying trays, and if in bags, the bags cannot be more than half full of green cones. The best device for drying cones or seeds is a pressurized drier. Uniform drying is ensured in this device by forcing air from the bottom up through the seeds or cones. Blowing air over the surface of the cones can also be effective, but the pressurized drier is the preferred method.

What is meant by dry air? Often this has been interpreted to mean hot air. Although it is often easiest to dry air by heating, the question of how hot is not often asked. Table 1 shows how different ambient air conditions will require different amounts of heating. Using the lowest temperature possible is both more economical and better for the seed. To use this table the temperature and relative humidity out-of-doors need to be measured. The temperature is then located in the far left column of the table. Next, follow along that line to the right until the number in the body of the table is larger than the measured relative humidity. Move up that column to the top row. This top number is the temperature that must be obtained in the cone drier to obtain air at 30 percent relative humidity: This is the relative humidity needed to dry cones in 24 to 48 hours. Very little drying will occur when the relative humidity is above 50 or 60 percent. For an outside temperature of 22 °C (72 °C) with 65 percent relative humidity, the drier temperature should be 35 °C (95 °F).

Table- 1. Chart for matching cone and seed drier temperature with ambient temperature and relative humidity.

Ambient Air Temperature °C.	(°F)	Drier Temperature 24 (75)	27 (80)	29 (85)	32 (90)	35 (95)	38 (100)	41 (105)	43 (110)	°C (°F)
4	(40)	100	100	100	100	100	100	100	100	
7	(44)	78	100	100	100	100	100	100	100	
9	(48)	66	86	100	100	100	100	100	100	
8	(52)	57	75	94	100	100	100	100	100	
11	(56)	50	65	77	88	100	100	100	100	Relative
16	(60)	44	58	68	78	94	100	100	100	Humidity
18	(64)	39	51	60	65	84	95	100	100	
20	(68)	31	42	50	58	71	81	95	100	
22	(72)	30	38	45	49	65	69	82	100	
24	(76)	30	31	38	45	55	63	74	87	
27	(80)	30	30	35	38	47	54.	64	75	

Exactly how long it takes to dry cones is also dependent on how moist the cones are when placed into the kiln. Cones kept in 20 bushel crates usually take 48 hours to dry because they are still quite moist. Cones that have been stored in cloth sacks or on drying racks will be partially dried and can usually be dried in 24 hours, sometimes even in as little as 8 hours after prolonged air drying.

Tumbling cones

When the cones are dry, enough they open to release the seeds. Cones are then tumbled in some manner to shake the seed loose from the cones. This step is called extraction. Customarily this extraction step is done in a round cylinder that is perforated to allow the seed to fall free from the cones and the cones then directed away from the seeds. Various shaker tables have also been used with good success. At this step and all subsequent steps, it is very important not to mechanically damage the seeds. Longleaf seeds have very fragile seed coats that crack easily. High quality seed can be reduced to poor quality seeds in just a matter of minutes through poor handling that causes mechanical injury. Actions that rub the seed too hard or too long, drop the seed, pinch the seed between machine parts, or throw it against a hard surface will mechanically damage the seeds. Specific examples of machines that have been found by the NTSL staff to damage seeds are: bucket elevators scooping up the seed too fast, seed dewingers that use brushes or steel paddles and rub the seeds too forcefully, and vacuum conveyance of seeds.

Drying extracted seeds

A second and very important factor to manage at the extraction step is drying the seeds. Longleaf seeds, unlike all other southern pine seeds, are shed from the cones at high moisture content. Seeds should not be stored at high moisture even for a brief time such as overnight. Seed deterioration takes place very rapidly at high moisture and germination and vigor begins to fall. This fact necessitates having a seed dryer immediately available to dry the seeds to a moisture content below 10 percent. Typically, 6 to 8 percent is obtained. Again, this is best done in a pressurized dryer, which was described previously in the paragraph on drying cones. Cones do not pack tightly together and can be dried in thin layers by simply passing air over the cones. It is not optimal, but can be an inexpensive alternative. Seeds on the other hand pack much more tightly together and require a pressurized dryer to dry the seed rapidly enough to prevent deterioration. Therefore, the dryer is indispensable at this stage. Dryer temperatures are selected in the same way as described above for drying cones.

Many requests have come to the National Tree Seed Laboratory over the years from persons who for several days could not dry their seeds. The root cause of the problem was usually that the outside air was too moist for the temperature used in the dryer. A higher temperature was needed to bring the relative humidity in the dryer to 30 percent. The second most common cause was leaking connections that allowed the air to escape from the dryer without going through the seeds.

A moisture test needs to be run on the seed to be sure the seed moisture is at a safe level for storage (below 10%) before drying is stopped. This is best done at the dryer with a moisture meter. Information on the meter and charts to use it are available from the National Tree Seed Laboratory. An oven moisture test should also be requested promptly from a qualified seed laboratory to verify the readings taken with the electronic meter. This is especially true if experience with the meter is limited.

Temporary seed storage

Once the seeds are at safe moisture content for storage they can be sealed in moisture proof containers so they will not absorb moisture from the atmosphere. If there will be more than two weeks before the final cleaning, seeds should be placed in cold storage that is at least 1.7 ^{o}C (35^{o}F) and best if below freezing. If placed at freezing temperatures, the seeds need not be cleaned for several years. Delaying too long, however, increases storage costs because the raw seeds are very bulky because of the wings and takes up two to three times more cold storage space, as do cleaned seeds.

DEWINGING, CLEANING, UPGRADING

Because of the risk of damaging seeds at the cleaning stage and the expense of the necessary equipment, it is best to leave the dewinging and cleaning of seeds to experienced persons. It is good to know, however, what equipment and what steps make for high quality seeds when selecting a contract seed cleaner. The first step is to dewing the seed. This is most often done in a mortar mixer or similar device that stirs the seeds. The mortar mixer is geared to run slower than it would when mixing mortar. The stirring action must be gentle. This requires good experience to know how long to run the seeds and how many seeds to put into the machine. Following the dewining, the seeds must be cleaned to separate them from the detached wings and cone scales. Screening and air separation work well for this step. The final step to high quality seeds is to use the gravity table to remove partially filled seeds, and any remaining cone scales and empty seeds. The gravity table is a shaking inclined table with air blowing through it from the bottom. The poor quality products, bad seeds and cone scales, are slightly raised off the table surface by the blowing air and then they slide over the heavier good seeds that are pushed to the top of the incline by the vibrating table. The best seed then comes off the high end of the table and the trash from the bottom. X-ray analysis is needed to accurately adjust the gravity table and make the maximum improvement. The gravity table alone can produce seed germinating in the upper 80's and possibly lower 90's. By using x-ray analysis, germination can be in the mid to upper 90's. Of course, the gravity table cannot correct for poor handling at earlier stages. Every stage in the handling of the seeds from estimating cone maturity to the gravity table must be done correctly to have the high quality seeds needed in the container nursery. There can be no compromises without lowering seed quality.

TESTING AND SEED STORAGE

The finished seeds need to be placed in moisture proof containers to keep them dry. Metal or plastic can be used. Glass is least used because it is breakable and heavy. Cardboard drums and boxes with foil or plastic liners are most commonly used. Polyethelene liners need to be at least four mils thick. The liner or bag can be closed tightly with string, plastic tie, wire tie, or heat-sealed. The sealed seed container now must be placed into cold storage at about –8 °C (20°F) (Jones 1966). Colder temperatures can be used but are not likely of any value. Storage at –8 °C has been used successfully on an operational scale for decades. As mentioned earlier in this paper, testing the seed moisture content is critical for safe seed storage. A moisture test is inexpensive and, therefore, is cheap insurance to protect seed viability. A moisture test should be taken initially upon sealing the seed for storage, whenever the seed is sampled for viability, and any time there is suspicion that the moisture content might have risen. Times of suspicion are when the container was damaged or opened. Because moisture content is the single most critical factor in maintaining seed viability, it would be ideal to test it annually. This has not proved practical and good seed management has been possible without annual testing as long as the storage container has not been broken open. When sending seed to a laboratory for testing, it must be placed in an unbreakable moisture proof container.

Other tests to do upon packaging the finished seed are germination, seeds per pound and purity. These are all important in determining the value of the seeds for sale and in preparing the correct amount for sowing. Germination and moisture content should be retested every three to five years in storage, within six to nine months before sowing, and before purchasing any seeds. Without testing, the grower simply takes a very big gamble on a crop failure caused by using low viability seeds. The viability needs to be as high as possible to minimize empty cell problems. Seeds per pound and purity can be expected to remain unchanged in storage and would not need to be retested. One exception would be if moisture has increased. Then the seeds per pound would have to be retested. How much water is in the seeds has a strong influence on the weight of the seeds.

PREPARING SEEDS FOR SOWING

How much seed to prepare

How many pounds of seeds to prepare are calculated by dividing the number of seedlings desired by the germination, purity, and seeds per pound. The pounds are further divided by an additional factor called the survival factor. This is an estimate of the number of germinating seedlings that will live. To determine the survival factor, count the exact germination in several trays scattered across the nursery at weekly intervals. Any dead seedlings should be noted and recorded along with living seedlings. The dead seedlings should be removed at every count. Continue counts until no more germination occurs. A final end-of-season count will also be made. Divide the number of surviving seedlings by the number seeds that germinated to obtain the nursery survival factor.

An example of these calculations follows. Germination: 92%, Purity: 99%, Seeds per pound: 5,500, Number of desired seedlings: 10,000, Nursery survival factor: 97%. The pounds of seed to prepare equals: 10,000 seedlings / (.92)(.99)(5,500)(.97) = 2.05 lbs.

Chemical treatment

Treating the seeds with chemicals has been found to improve germination. Benlate was reported (Barnett et. al. 1999, Barnett and Pesacreta 1993) to improve germination by controlling fungal problems. This chemical is not registered at the present outside of North Carolina. Gustafson 42s is another fungicide used as a seed treatment. It is registered for use on southern pine seed. It has been reported by growers that birds are less likely to feed on the seeds if treated with Gustafson. Hydrogen peroxide in 30 percent concentration can also be used as a seed sterilant (Barnett 1976b). However, it was found to be no better than benlate (Barnett et. al. 1999) and is dangerous because it is a very strong oxidant that can cause skin and eye injuries. Whatever chemicals may be used, be sure to use only registered materials and follow the label.

Cold stratification

Cold stratification of the seeds is also reported to improve germination (Karrfalt 1988). As this is not a procedure traditionally used for longleaf seeds, both Karrfalt (1988) and Barnett (1996) advised caution or described damage to germination from stratification. In a desire to improve longleaf seed performance, however, the National Tree Seed Laboratory and numerous growers compared using stratified seeds and unstratified seeds. As a result, most longleaf seed tests done at the NTSL are now stratified because the lab results are higher and there is better correlation between the lab test and the field germination. Hundreds of tests at the NTSL support this practice. Several nurseries are now routinely using stratification to obtain better germination. Adoption of this procedure should be made with caution.

It is very important to do stratification correctly. Longleaf is not a forgiving species and will not tolerate poorly applied procedures. The first step is an overnight water soak. This should be in a cool area. The soak brings the seeds to adequate moisture content to begin preparing to germinate. The next steps are very important to prevent germination. They must be surface dried. This means the removal of all free water around the seeds without drying the seeds themselves. The seed coats will look damp but not shiny when correctly dried. Second, they must be sealed in a moisture proof container to prevent drying. They should not be in layers more than two to three inches deep so that heat of respiration can dissipate. Finally, they must be kept in a well-controlled cooler between 0.6 °C (33 °F) and 3.3 °C (38 °F). They cannot freeze nor be warmer than 3.3 °C (38 °F). A cooler that is frequently opened is not suitable because it will not hold temperature. Caution is advised when beginning to use stratification. It must be done correctly. A small trial section is best done first to learn the technique and be sure it works in your operation. A failure may point out where improvements need to be made or that it is not suitable for your nursery. Success with stratification may on the other hand lead you to a larger trial and to full acceptance of the procedure.

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