Tree Seed Handling and Management--Part I

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Participants in recent nurseryman's conferences around the country have asked for a reference series to help them with their seed handling. The 48 topics they proposed will be covered in a series of articles here in Tree Planters' Notes. Tree Planters' Notes 37:3-7; 1986.

1. Seed moisture--How dry is too dry?

Under most conditions of seed extraction in the South, the moisture of the seed upon arrival at the container is between 9 and 12 percent. However, during humid weather, such as a week of rain, the seed may have a moisture content between 12 and 16 percent when removed from the kiln.

Research has shown that the moisture threshold for the seed of most tree species is around 10 to 12 percent, except for the recalcitrant seed, such as acorns. Seed of the family Fagaceae require moisture contents above 20 percent to maintain viability. These species are considered short lived and usually are stored for no more than one season.

Conifer seed, on the other hand, may be stored for long periods of time, with few exceptions, if the moisture content is below the threshold value of 10 to 12 percent. Seed of most conifers can be stored satisfactorily at 34 °F with an 8 to 10 percent moisture content when the seeds are sealed in moisture-proof containers. This may present a problem, because there is no margin of safety, and seed temperatures could increase rapidly if compressors stop working in the middle of the summer.

Chemical changes that begin at temperatures above 40 °F usually lead to germination or deterioration. Therefore, most nursery managers store their seed at 20 to 25 °F. This range provides a margin of safety for the seed. The typical insulated storage unit will hold seed temperatures below 40 °F for 48 to 72 hours during a power loss. This period is sufficient for emergency repairs. At this temperature range, the moisture content should be held between 6 and 8 percent. Moisture contents close to 10 percent will tend to increase above a safe level because condensation will form on the seed when the lid is removed for repeated sampling. Higher moisture contents also permit chemical changes to progress, even though slowly, at freezing temperatures, resulting in green embryos within the seed.

Some nursery managers store seed in a commercial freezer. These freezers, designed for preservation of food, maintain a temperature of 0 °F. Under these conditions the moisture content of the seed should be reduced to 4 to 6 percent because moisture may crystallize within the cell at or below this temperature. If there is too much moisture, the cell walls will be damaged, thus leading to deterioration.

The drier the conifer seed, the longer it will store. Samples of red pine (*Pinus resinosa* Ait.) and loblolly pine (*P. taeda* L.) were stored at a moisture content of 1 to 2 percent for 5 years, with annual testing. Viability was consistently above 95 percent. Low moisture levels may be detrimental at high temperatures because the cells are unable to repair damage without sufficient moisture for the necessary chemical reactions. However, seeds held at the same low moisture appear to be superior to seeds held at a higher moisture content for long-term storage. How low the moisture is not as important as how the low moisture content was reached. Super-low moisture contents (below 5 percent) must be reached slowly with dry air but without excessive heat. High heat may denature enzymes and kill cells. Relative humidities of 20 to 35 percent will produce very low moisture contents in about 10 days under natural conditions (without artificial heat).

If the seed are dried too fast, the moisture is removed from the seed surface faster than it can be moved to the surface from internal cells. This problem creates a differential pressure between cell layers, which I call a "vapor lock." This vapor lock prevents the seed from germinating until the cell pressure is equalized. This phenomenon can be seen by using microwave drying in a pressure chamber. Seed dried this fast appear to be extremely dormant. They appear to store well but must be hydrated before being stratified. This step is accomplished by placing the seed on a moist surface or in a high-humidity atmosphere for 24 hours.

In summary, the nearer the moisture content of most conifers is to 4 percent, the better for extended storage. Seed stored for 5 years or less may not benefit from the added cost of superdrying the seed. A moisture content of about 9 percent is satisfactory if the seed are frozen. Storage for 1 year or less is possible at a 10-percent moisture content, providing the temperature remains below 40 °F and the moisture content does not increase further.

2. Seed sizing-How much is too much?

The objective of seed sizing is to obtain more uniform sowing and thereby achieve more uniform seedbed densities. Except for Douglas-fir (*Pseudotsuga menziesii*), seed sizing effects have not been found to carry beyond the nursery. Also, in contrast to many articles written on the possible elimination of clones by sizing, there is no possible way to eliminate clones without throwing some of the seed away. At the present value of seed, no one would want to throw away seed, no matter how small or large. However, two problems have led some seed managers to discard seed: the seed were too small to handle or the lot contained too much trash.

Before sizing seed, remove all trash and, if gravity separation is to be used, employ screen sizing first. Gravity can only separate one characteristic at a time. Seed cannot be separated for physical size and density at the same time. Recent studies have shown that physical, sizing (screens) account for 90 percent of the benefit in uniform densities. Therefore, serious evaluations should be made before gravity sizing is considered.

The more sizes obtained, the greater the record-keeping and handling. Increasing the number of the sublots also increases other problems of management. As an example, an 800-pound seedlot of pine seed may be sized into three sizes or into five sizes as indicated below.

Seed sizes (screen holes)	Sublot size (lb)	
	Trial A	Trial B
14		42
16	173	131
18	463	463
22	164	158
24		6

Observe that in separating into five sizes, two sublots were obtained with less than 50 pounds each. The minimum lot size should be that required to fill the planter being used. If the planter required 30 pounds, the 6-pound sublot would be mixed with the next size. We must remember that we are striving for more uniform density, not increased record keeping.

Secondly, the question is raised, "How different are these sizes?" The answer is found by computing the number of seed per pound. An example of the seed per pound on the lots sized above is given in the following table:

	Trial A		Trial B	
Seed sizes	Seed/lb	diff.	Seed/lb	diff.
14			19300	
		—		400
16	19000		18900	
		400		300
18	18600		18600	
		2400		2300
22	16200		16300	
				1800
24			14500	

The question arises, "How much difference is required before the planter makes a difference in seed per foot being planted?" Obviously, the more precise the planter, the smaller the difference that will result in a change in density per square foot of bed. Also, the smaller the seed the greater the difference required between sizes to create a difference on the seedbed.

Data from two planting machines showed that less precise machines like the Oliver planter required differences in seed size of more than 2,500 seed per pound before seedlings per square foot changed. The more precise Love planter provided differences in density with differences in seeds per pound of 1,000 seed.

In the examples above, the three sizes will provide only two different densities when sown because none of the planters used would discern differences in size of 400 seed per pound. Therefore, lot A (for practical reasons) has only two sizes as obtained by the 18- and 22-screen sizes. The 16-size sublot can be recombined with the 18. On lot B, there appear to be three sizes, except that the quantity of sublot from screen 24 was only 6 pounds, whereas size 22 was 158 pounds. Although there is a real difference in seeds per pound, there may be too few seeds to keep separate. If combined with the sublot from screen 22, the planter will discharge one seed of sublot 24 for every 30 seeds of sublot 22. Such large ratios will overshadow any differences that might be seen by seed per pound alone. Thus, lot B also consists of only two sublots.

!n summary, from the standpoint of results in uniform density for the cost involved, no benefit is derived by keeping sized sublots separate if they are like the examples just cited. No benefit is obtained with any sublots that weigh less than 30 pounds, and that differ by less than 1,000 seeds per pound between sublots. These guidelines assume that reasonably precise seeders are being used. The less precise the seeder, the greater the minimum lot size should be, and the greater must be the seed per pound differences between sublots to realize differences in seedbed density.

3. Vigor, the elusive measurement

Vigor, according to Webster, means strength. The ability of a seed to produce a seedling under stress may be classified as vigor. This term differs from germination, which means the actual production of seedlings. Viability is the potential of seed to produce seedlings but does not provide a relationship to the effect of environmental stress on that potential production.

Germination tests are made under optimum and reproducible conditions so that each test relates to the last test. Germination is not determined under specific field conditions because those conditions may change by planting time.. Conversion of germination test results to field expectations is accomplished with a "survival" factor. This factor is based on actual field data collected over time. The factor usually falls between 65 and 80 percent in the South.

"Survival percent" is our attempt to quantify vigor. This term expresses the effect of environmental stress on the potential production of a seedling. According to the International Seed Testing Association, "Vigor cannot be quantified because it is a concept . . . ." This statement is not totally true. Vigor is more than a concept, but few analysts know what they are trying to measure. If you had three lots of seed (A, B, and C) you might want to know which lot will give you the most seedlings.

In humans, we can perhaps understand vigor through the following example. A jogger and a nonjogger start out to walk up a steep hill. Part way up, the nonjogger has to sit down and rest because of exhaustion, while the jogger dances around, eager to go again. It is the effective energy of the jogger that relates to high vigor. There is energy to work against stress and to keep going. The exhausted nonjogger displays low vigor. If stress continues, the nonjogger may not complete the intended objective because of insufficient energy. The capacity for endurance can be increased through exercise and practice in humans, but for seed, germination is a single opportunity.

Seeds in a lot seldom all die at once. Rather, they age and die individually. Each lot or sample of filled seed consists of three components: dead, weak, and vigorous seed. A germination test identifies the percentage of dead seed, but does not identify which of the apparently vigorous seed are really weak, because even the weak seed germinate under optimum conditions. Data from studies and field plantings have shown that the percentage of weak seed in the total seedlot can be calculated by multiplying the percentage of germinating seed in the test by the percentage of dead seed. For example, a seedlot germinating 70 percent has 30 percent dead seed; therefore, 30 percent of the sound seed are weak. This calculation means that 21 percent (30 x 70 percent) of the seedlot is composed of weak seed. Seed in this 21-percent portion possess a broad array of weakness. The weakest seed of this portion will die under even low stress, and more will die as the stress increases. At maximum stress they will all die. At this point, even vigorous seed may be affected by extreme conditions. What we attempt to measure is the portion of the weak category that will die under various stresses such as drought, cold, or fungal infection. The problem is to predict what environmental stresses may occur. Because these potential stresses are not known, we only rate the vigor of a seedlot according to other lots or according to a series of specific stresses such as an array of temperatures.

In summary, many of the so-called vigor tests do not relate to vigor at all but rather are viability estimates. The only true vigor tests are those that either relate lots with similar germination rates to a given stress, or a single seedlot to varying environmental stresses. A measure of vigor to temperature may be quite different from a measure for drought. This complication makes vigor measurements difficult! Thus, there is no direct measurement of vigor; only a relative measure in the comparison of two or more lots or two or more stresses.

4. Impact damage, the quiet death of a seedlot

Tree seed are at their maximum potential viability at maturation. This potential may be reduced by environmental impacts, human intervention, or natural aging.

Viability of seed is affected by many factors. Mechanical damage allows organisms and moisture to readily enter the seed and initiate deterioration. High temperatures may denature enzymes or desiccate tissue, which also leads to a catastrophic death. Elevated moisture contents promote chemical change and support cell division at room temperatures. At cooler temperatures, the heat of respiration usually leads to deterioration. And then there is the natural aging process.

Cell division cannot take place during dry storage. Metabolism is also reduced to a very low level. However, a large amount of cell membrane damage does occur, which leads to a slow death known as aging. The rate of death due to aging is related to seed moisture content and existing temperatures.

Aging is increased by increases in both temperature and seed moisture content.

The least observed--and yet one very common--cause of seed loss is the subtle "quiet death" from impact damage. This kind of damage is similar to the bruise you might experience if you were to trip and fall on a concrete floor. A slight redness immediately gives way to a darkening the next day and eventually a black and blue spot. The bruise on the seed is usually insignificant at the time of processing and will not affect germination at that time. After a short storage period, the extent of damage is observed in abnormal germination. The injury leads to reduced germination, which gets worse with time. The loss in germination is caused by deterioration of individual seeds and can be monitored through germination tests.

Impact damage is very difficult to identify in a single test, but quite easy to recognize in a series of tests over time. The first indication is an increased number of seedlings with endosperm collars.

Impact damage occurs when the seed bounces off elevators and machine parts. Each contact with a solid surface bruises a few cells or a small amount of tissue. Damage is only evident when the bruises are either numerous enough or large enough to affect germination. Impact damage increases as the number of contacts rises and with seeds that have a reduced moisture content. That is, a dry seed is more subject to impact damage than is a moist seed. Increased moisture provides some cushion against the impact.

In summary, seed viability can be improved by not only correction of the visible damages, but also by reducing the "slam-bang" of fast operations. Making seed processing more of a fluid operation, that is, a smooth flow, can increase seed germination by eliminating impact damage.