Producing the Target Seed: Seed Collection, Treatment, and Storage

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Abstract: The role of high quality seeds in producing target seedlings is reviewed. Basic seed handling and upgrading techniques are summarized. Current advances in seed science and technology as well as those on the horizon are discussed.

Keywords: target seeds, seed quality, optimizing seed performance

Introduction

"First the seed" is an old saying among seed workers. It implies that high quality seeds are the first step in producing a good crop and in producing target seedlings. High purity, high germination, and high vigor are basically the targets for high quality seeds. These factors affect seed sowing efficiency, the amount of thinning or transplanting, and the number of empty cells in a container nursery. In other words, these factors affect the quality and cost of seedlings.

Defining High Quality Seeds

High germination is a relative term that depends on such factors as species, seed availability, and seedling production methods. For example, pines (*Pinus* spp.) often have higher germination rates than true fir (*Abies* spp.). Therefore, 95% might be high and 75% low for pine, but 75% might be high for some species of fir. Similarly, 90% might be high in a bareroot nursery, but possibly not in a container nursery. Table 1 illustrates how lower seed germination can affect seedling production costs in a container nursery. If germination is 98% to 100%, there is little wasted production space and no seeds would be wasted. Even at 95% germination, however, a significant number of wasted cells start to occur. Because empty cells cost money and offer no return, their presence reduces nursery profitability and perhaps even the ability to meet production goals. Various strategies exist for dealing with empty cells such as, sowing two seeds per cell, sowing extra cavities, or transplanting germinants into empty cells. These strategies give some relief, but increase costs in seeds, materials, time, and perhaps even quality of seedling. The higher the germination, the better the chances are of producing the desired seedling at the best possible cost (Figure 1).

Vigor is also a relative term and, despite much research, remains difficult to define objectively for native plants. Nevertheless, it is a very useful concept for handling seeds and comparing the performance of seedlots. High vigor can be defined in two ways. The first is the ability of seeds to germinate under adverse conditions or to germinate rapidly. Personal communication with nursery managers indicates these are critical factors in getting a seedling crop through the fragile stage of germination and on to target seedling specifications. The second way to define high vigor is the ability of seeds to perform well after storage. High germination and high vigor often go together, but not always. Low germination could occur due to weak seeds or dormancy. Figure 2 illustrates how, as a seedlot ages, vigor is lost earlier and faster than germination. As a consequence, a seedlot that germinated well a few years ago might suddenly germinate very poorly in the nursery. A current germination test, not more than 6 months old, will help identify seedlots that are losing viability and vigor.

Table 1. Results and consequences of lower seed germination.

Germination	Seeds/cell (#)	Filled cells (%)	Double seedlings (%)	Some consequences
100	1	100	0	Optimal
98	1	98	0	Good
95	1	95	0	5% space lost/cost per seedling up
90	1	90	0	10% of growing space is lost
90	2	99	81	Thinning required; higher seed costs
85	1	85	0	15% space lost/cost per seedling up
85	2	98	72	Thinning required; higher seed costs

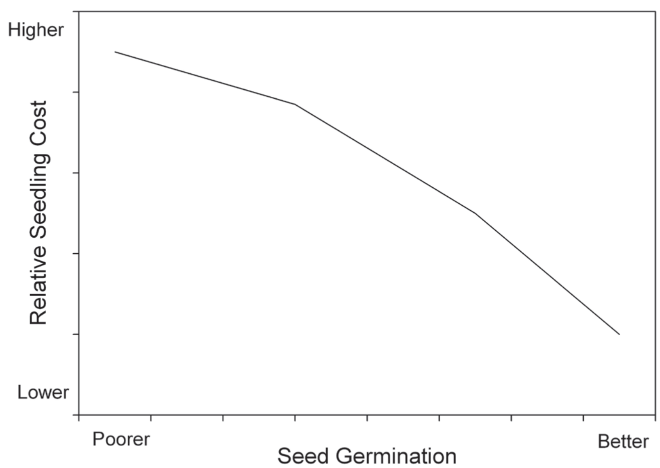

Figure 1. Higher germination gives a better chance of producing the desired seedling at the lowest possible cost.

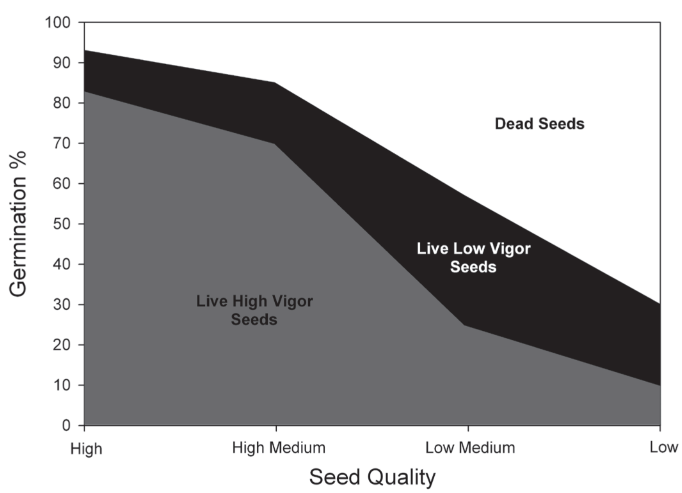

Figure 2. As a seedlot declines in quality, so does total germination and vigor. Vigor is lost quicker than germination.

Obtaining High Quality Seeds ____

High quality seeds are obtained by following basic seed handling procedures and upgrading the seeds as needed. Basic seed handling involves collecting at physiological maturity, handling seeds after harvesting in a manner that does not lead to deterioration, and extracting and cleaning without damaging the seeds but still removing trash and empty seeds. Upgrading seeds involves removing insect or fungus damaged seeds, small amounts of trash, mechanically damaged seeds, and weeds. Both basic cleaning and upgrading require physical differences among the seeds as well as between the seeds and trash; differences can include thickness, length, weight, surface texture, roundness, or color. A detailed discussion on seed cleaning and upgrading machines and techniques can be found in Bonner and Karrfalt (2008).

Cleaning and upgrading seeds can be a multistep process because undesirable seeds and particles can vary in at least two characteristics, weight and size. Fungal or insect damaged seeds (Figure 3 and 4) usually can be removed with air cleaners or gravity tables that separate particles of different weight, but not until the seeds are divided into fractions that are uniform dimensionally. Figure 5 shows that damaged larger seeds can weigh the same as smaller undamaged seeds, and can sort out together by weight until they are separated from each other with screens. Some species with wings do not remove uniformly, so screen sorting prior to weight separation is less effective. As a consequence, these species may not be as thoroughly upgraded. True firs and longleaf pine (*Pinus palustris* Mill.) are two examples of such species.

Some techniques sort seeds using fluids. The Prevac procedure (Simak 1984) (Figure 6) uses water flotation and vacuum to remove mechanically cracked seeds. Seeds are placed in a chamber, such as an Erlenmeyer evacuation flask, on water. A vacuum is then drawn on the chamber to break the surface tension between the water and the seeds, causing the cracked seeds to rapidly take up water and sink, and leaving the uncracked seeds to float. The Imbibe, Dry, Separate (IDS) procedure (Simak 1984) relies on the principal that dead seeds will dry and lose weight faster than alive seeds. By carefully controlling the drying process, dead seeds can be floated away using a chamber similar to Figure 7. These procedures can be used for Sitka spruce (*Picea sitkensis* (Bong.) Carriere), Scotch pine (*Pinus sylvestris* L.), lodgepole pine (*Pinus contorta* Douglas ex Louden), and some white spruce (*Picea glauca* (Moench) Voss).

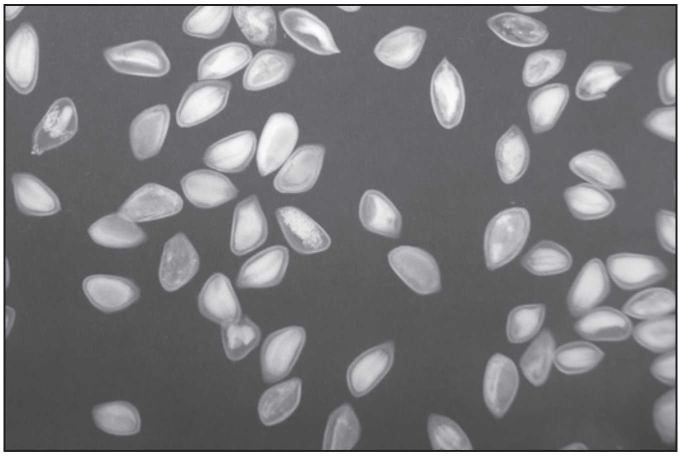

Figure 3. X-ray image of fungal damaged pine seeds.

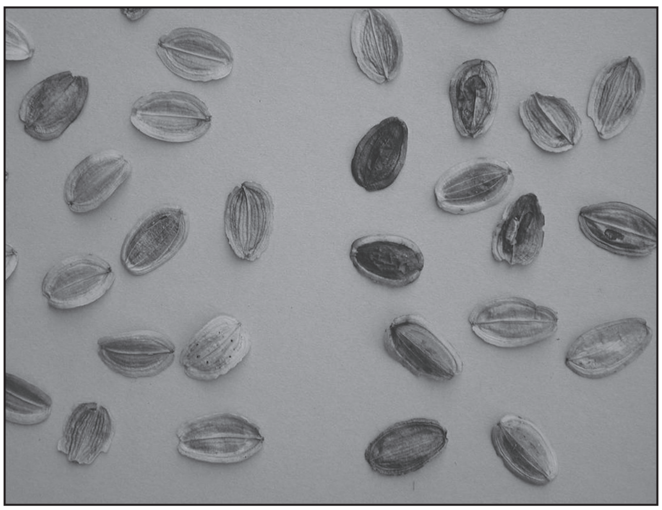

Figure 4. Good (left) and insect-damaged (right) *Lomatium* spp. seeds. Insect holes are visible in damaged seeds.

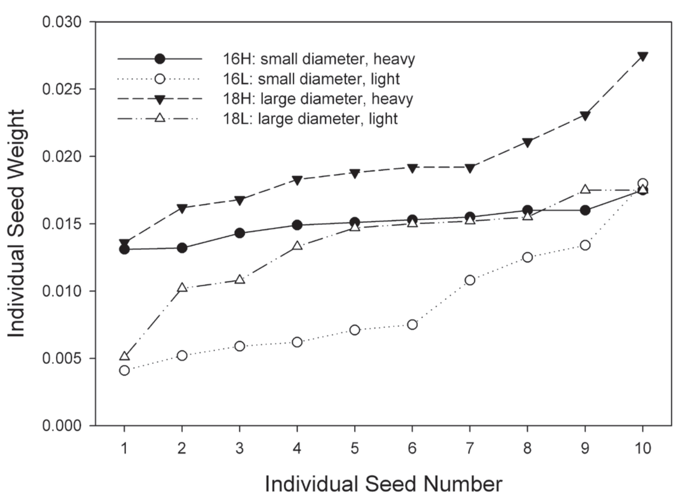

Figure 5. The weight of individual seeds from four seed sizes: number 16 heavy (16H); 16 light (16L); 18 heavy (18H); 18 light (18L).

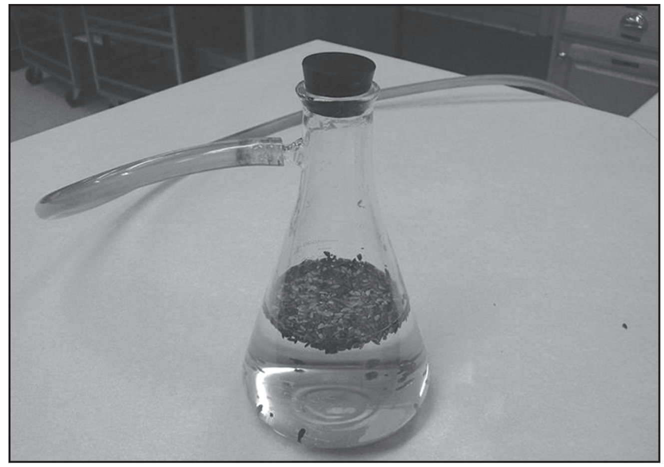

Figure 6. An evacuation flask can be used to perform the Prevac procedure (Simak 1984) to mechanically remove cracked seeds.

Figure 7. A large plastic soda bottle can be used to separate seeds in the Imbibe, Dry, Separate (IDS) procedure.

Optimizing Good Seed Performance

The first step in optimizing seed performance is using good seed. The second step is to use seed wisely. It is important to know the germination requirements for the target species. Seeds have an optimum temperature for germination. Sowing too early might result in temperatures too low for good germination, while sowing too late might result in temperatures being too high for germination. Other factors can also lead to germination problems. For example, in one nursery, the use of irrigation water from a snow-fed stream, with water temperatures near the freezing point, germination was very slow despite using high germination seeds. Apparently the cold water was retarding germination.

Sowing depth is another important factor in optimizing seed performance. Most native plant seeds germinate on or near the surface of the soil. It is usually easiest to obtain a correct planting depth by surface sowing the seeds and mulching to a specified depth. Some species, mountain hemlock for example, require dark to germinate. Some provision must be made, therefore, to exclude light to start the germination process.

In some cases, seed size can ultimately affect seedling size; therefore, using screens to sort seed by size is another tool that optimizes seed performance. Karrfalt (2004) found that acorn size effected oak (*Quercus* spp.) seedling size (Figure 8). Many studies indicate the same is true for other species. A critical factor in sizing seeds for better performance is to establish enough size criteria. Seeds have three dimensions and, therefore, sorting only according to one of them can result in a large amount of weight variation within one size.

Cold stratification has proven to be a very powerful tool to improve seed performance. Extended periods of cold stratification, or the use of cold stratification on non-dormant seeds, have been found to increase the ability of seeds to germinate faster and over a wider range of temperatures. In short, cold stratification increases realized seed vigor. Edwards and El Kassaby (1996) (Figure 9) found stratification improved the speed of germination of mountain hemlock (*Tsuga mertensiana* (Bong.) Carriere). Gosling and Rigg (1990) (Figure 10) showed that extended cold stratification promoted germination at suboptimal temperatures for Sitka spruce. Unpublished data at the National Seed Laboratory showed the same to be true for loblolly (*Pinus taeda* L.), slash (*Pinus elliottii* Engelm.), and longleaf pines.

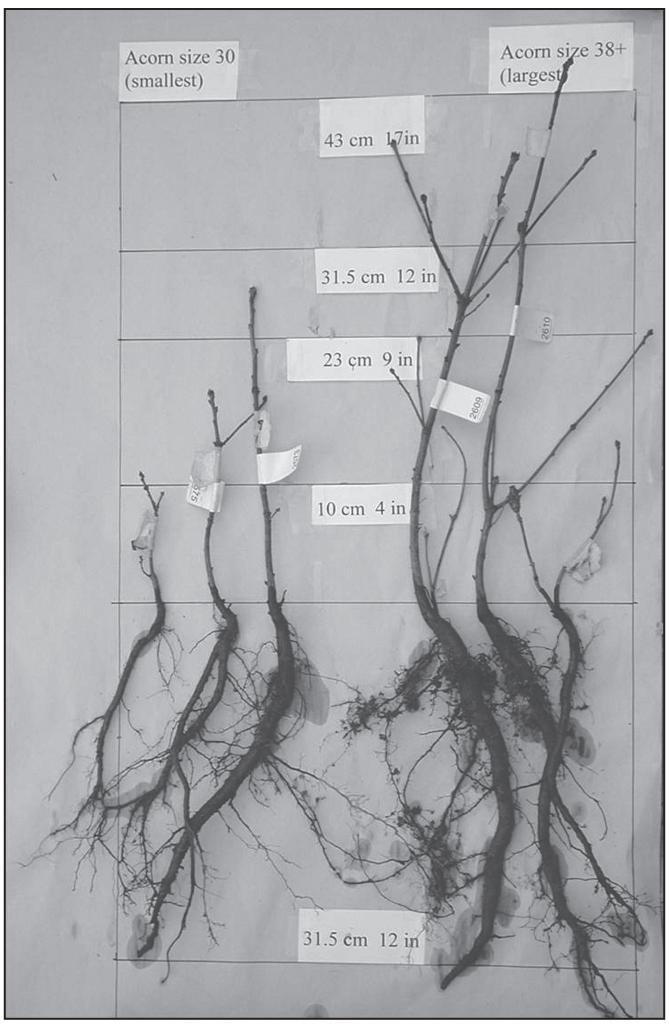

Figure 8. White oak (*Quercus alba*) seedlings produced from a smaller acorn (size 30) and a larger acorn (size 38+).

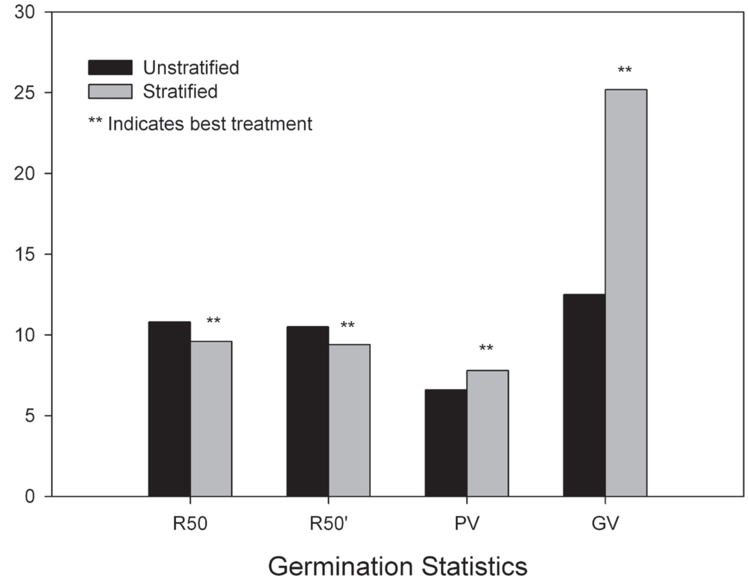

Figure 9. Stratification improves seed vigor for western hemlock (*Tsuga mertensiana*) (Edwards and El Kassaby 1996). Lower values of R50 and R50' indicate high seed vigor, while higher values of PV and GV indicate high seed vigor.

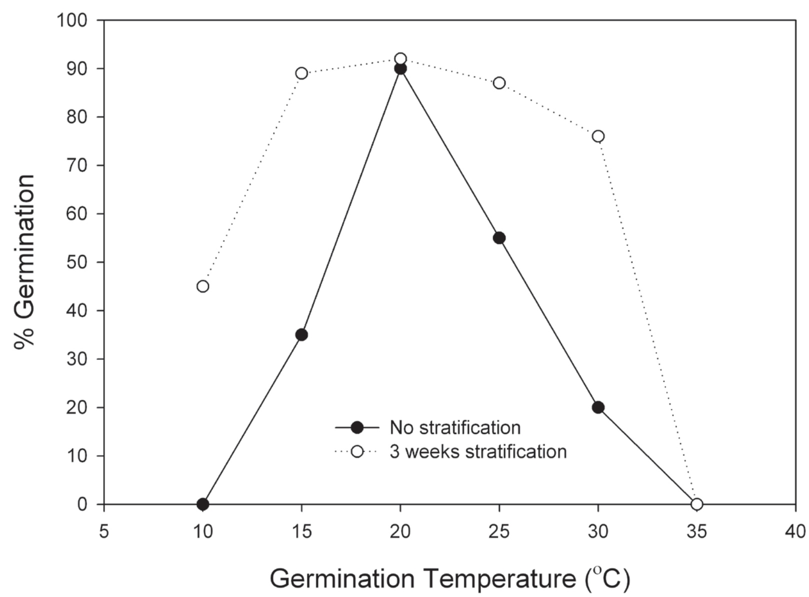

Figure 10. Seed germination occurred over a wider range of temperatures (for example, seed vigor increased) for Sitka spruce following cold stratification (Gosling and Rigg 1990).

Seeds can sometimes germinate in cold stratification, especially if the treatment is extended. However, using a few simple treatment techniques, premature germination can be minimized. When extended stratification times are used, it is necessary to keep temperatures in the 1 to 3 °C (34 to 37 °F) range and restrict the amount of moisture. Prior to stratification, seeds should be soaked to full imbibition (generally overnight) and surface dried to remove free water; the seed coats should look damp. Gosling and Rigg (1990) treated Sitka spruce in this manner and saw no germination up to 20 weeks in cold stratification. Gosling and Rigg (1990) also examined the optimal moisture content for stratification (Figure 11). They found an interaction with moisture content and length of cold treatment. At 25% moisture content, the stratification was effective if held sufficiently long; a 20% moisture content was not as effective. These results are compatible with the work of Edwards (1981) and Leadem (1986) on the stratification re-dry technique for *Abies* spp. In this procedure, seeds are fully imbibed, stratified for 30 days, dried to about 35% moisture content, and returned to stratification at this reduced moisture content for extended periods until a maximum germination is obtained. The germination results are superior to a stratification treatment of fully imbibed seeds for an equal length of time.

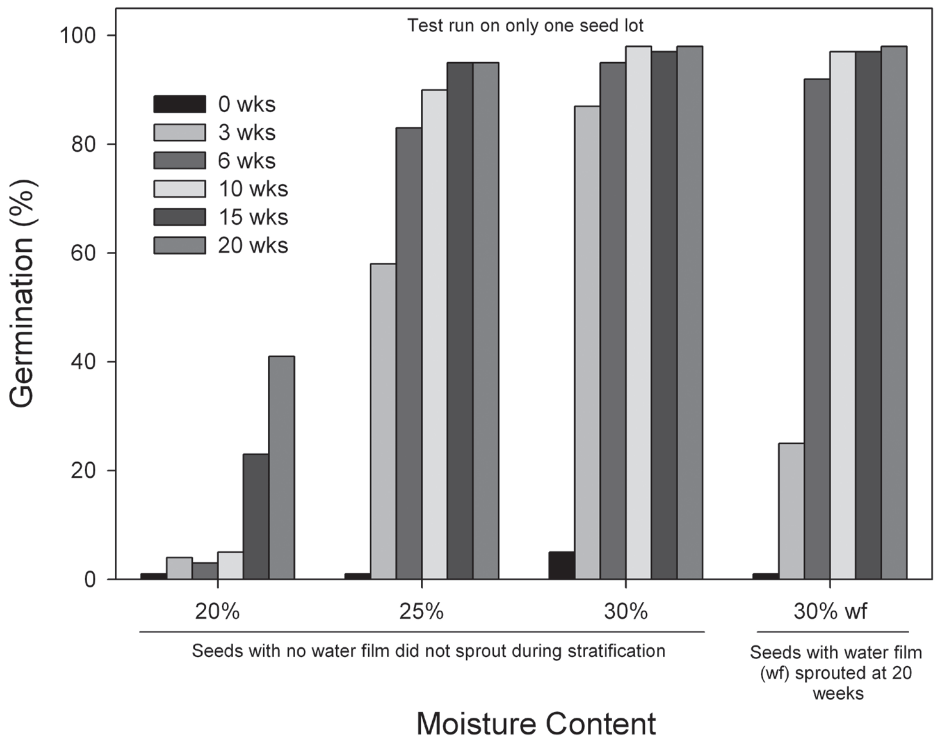

Figure 11. Sitka spruce germination at 10 °C (50 °F); seed moisture content by stratification period interaction.

Edwards (2008) has stated that he is not sure 35% moisture content is optimal because the procedure does not work well for all seedlots. This might be explained in the relationship between moisture content and water activity. Figure 12 shows that seeds with similar moisture contents have different equilibrium relative humidity (ERH). For that reason, ERH more accurately reflects the water status of the highest quality seeds in a seedlot by showing how tightly bound the water is. Equilibrium relative humidity readings, however, do not work well for seeds of high moisture contents, as there is much free water in seeds at or near full imbibition. Another means of accessing the seed moisture status, such as osmometry, might work better for this purpose.

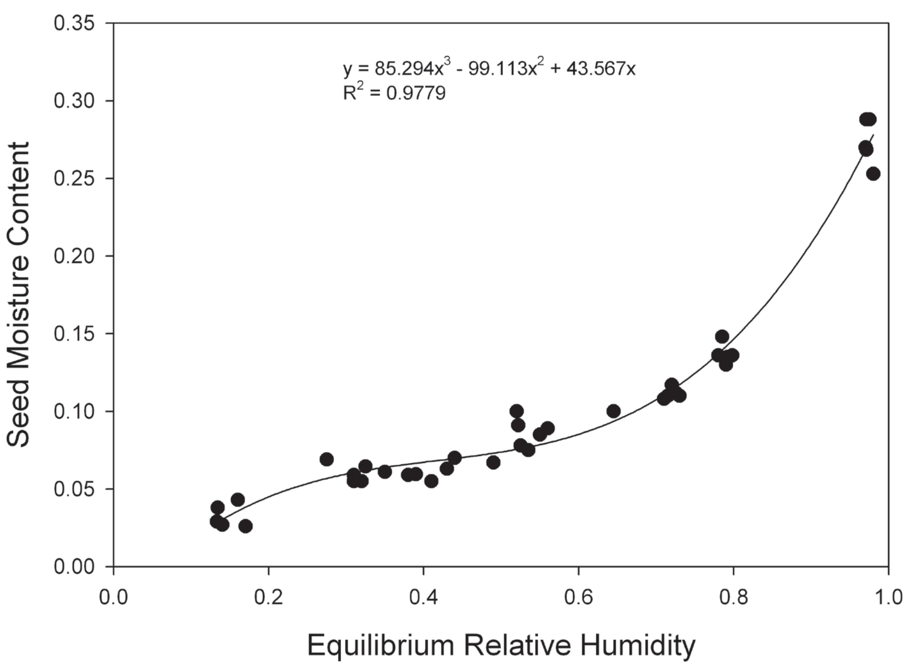

Figure 12. Seed moisture content of green ash seeds plotted against equilibrium relative humidity.

Summary

Producing seedlings economically and efficiently starts with high quality seeds. Defining the characteristics of the target seed is just as important as defining the target seedling. Factors such as nursery production system and species will determine what target seeds will be. Applying good seed handling and upgrading techniques usually will produce target seeds. Once target seeds are acquired, it is necessary to optimize their performance. Prechilling has been the most widely used method to optimize seed germination. Properly applied, prechilling can improve total germination, speed of germination, and the capacity of seeds to germinate in adverse conditions. Seeds must also be planted at the proper depth and at the correct season.

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