Current Practices for Growing Whitebark Pine Seedlings at the U.S. Department of Agriculture, Forest Service, Coeur d'Alene Nursery

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Abstract

The USDA Forest Service, Coeur d'Alene Nursery has produced whitebark pine (*Pinus albicaulus* Engelm.) seedlings for more than 25 years, with 2014 production numbers reaching 214,464 seedlings. Germination remains the largest obstacle in whitebark pine production, due to both the physical and physiological dormancy of the seed. The protocol described in this article outlines the current steps the Coeur d'Alene Nursery uses to break seed dormancy and the growing regime for seedling production. This protocol, which is constantly evolving, serves as a guideline for the production of high-quality plant material for the reforestation and restoration of this important foundation species. This paper was presented at a joint meeting of the Western Forest and Conservation Nursery Association, the Intermountain Container Seedling Growers Association, and the Intertribal Nursery Council (Boise, ID, September 9–11, 2014).

Introduction

Whitebark pine (*Pinus albicaulus* Engelm.) is a high-elevation species found throughout the Western United States and western Canada. It is a foundation species that provides habitat and food for wildlife, including grizzly bear (*Ursus arctos* Linnaeus) and Clark's nutcracker (*Nucifraga columbiana* A. Wilson). Populations of whitebark pine are decreasing due to a nonnative blister rust pathogen (*Cronartium ribicola* A. Dietr.), fire suppression and exclusion practices, mountain pine beetle (*Dendroctonus ponderosae* Hopkins), and wildland fire (Mahalovich and Hipkins 2011). Because of these pressures and the species' importance on the landscape, whitebark pine seedlings are currently grown in nurseries to aid in the reforestation of this species.

The mission of the USDA Forest Service, Coeur d'Alene Nursery is to provide high-quality plant material for restoration and reforestation to the USDA Forest Service's National Forest System, and to other public land management agencies. The Coeur d'Alene Nursery has produced whitebark pine seedlings since 1988, with production numbers increasing to 214,464 seedlings for the 2014–15 planting season. Adequate germination is the largest obstacle in whitebark pine seedling production at the Coeur d'Alene Nursery due, in part, to the complex dormancy of the seeds. Whitebark pine seeds exhibit both physical and physiological dormancy. In 2014, the average germination of nine seed lots was approximately 61 percent, with individual seed lot germination rates ranging from 28 to 90 percent.

The following sections describe the Coeur d'Alene Nursery's current seed preparation and seedling production protocols for whitebark pine. This protocol is an update to the procedures outlined by Burr et al. (2001) and Robertson et al. (2013), but it is a working protocol, meaning that nursery staff are constantly evaluating protocols and changing procedures to incorporate new technologies and streamline production.

Seed Processing

Cleaning and Storage

High-quality seedling production begins with high-quality seed. Whitebark pine cones are hand cleaned in the seed extractory at the Coeur d'Alene Nursery. Throughout the cleaning process, digital x-rays are used to determine percent seed fill. Seed lots are cleaned to a minimum of 95 percent fill and 99 percent purity (figure 1). Seeds are stored at 5.5 to 8 percent moisture and kept in walk-in freezers maintained at 29 ºF (-1 ºC). On average, 2,867 seeds/lb (632 seeds/100 g) are in the 123 seed lots of whitebark pine that are currently stored in the Coeur d'Alene Nursery's seedbank.

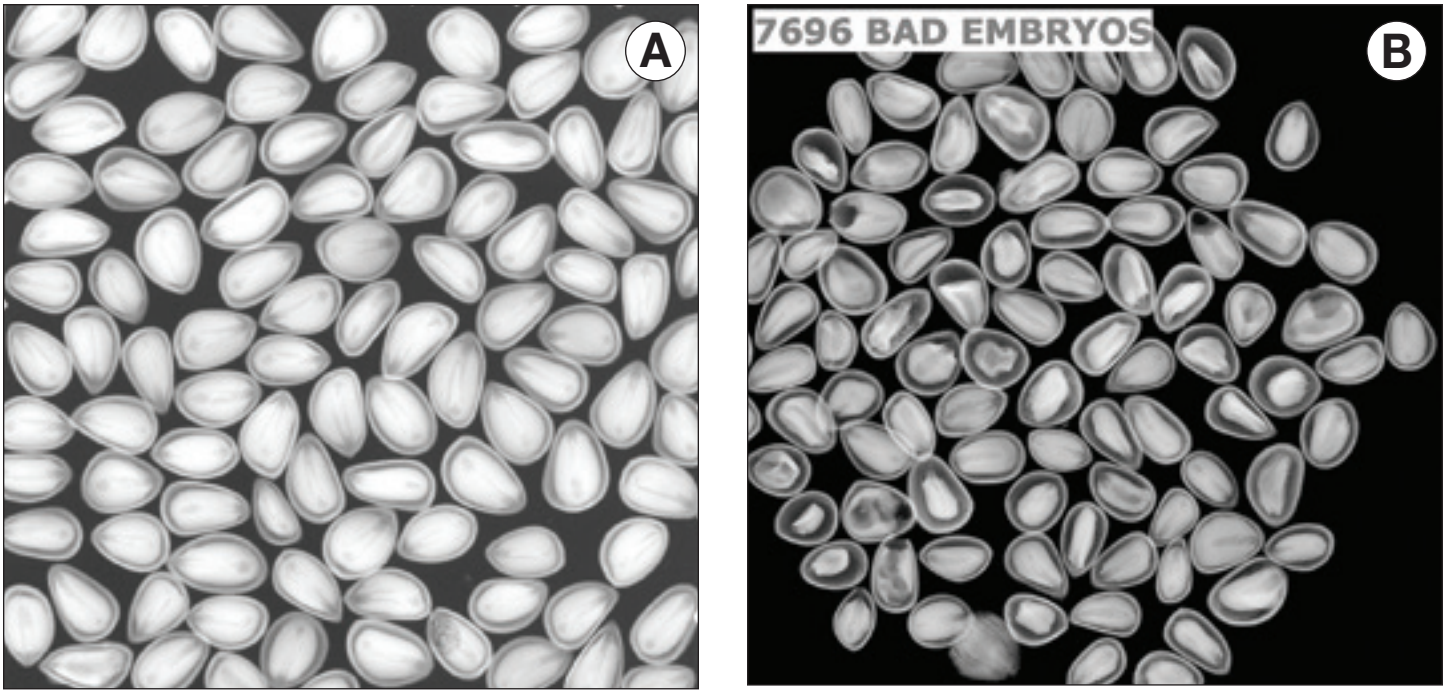

Figure 1. Digital x-rays are a tool used throughout the seed-cleaning process to ensure high-quality seed is stored in the Coeur d'Alene Nursery's seedbank. (a) An x-ray of cleaned seed with at least 95 percent filled embryos and more than 95 percent purity. (b) An x-ray of seed with damaged and underdeveloped embryos that will not be stored. (Photos by Jerri Park)

Treatments

To overcome whitebark pine's physical and physiological seed dormancy mechanisms, seeds are subjected to a 120-day stratification followed by scarification (Burr et al. 2001, Robertson et al. 2013). The stratification process starts with a 48-hour running water treatment in nylon mesh bags. The mesh bags are then placed inside plastic bags that are 1 mil (1000 mil = 1 in, 2.54 cm) in thickness to prevent seed moisture loss and allow for respiration during stratification. The bagged seeds are put into a 30-day warm stratification in germinators set to 86 ºF/68 ºF (30 ºC/20 ºC) day/night, with 12-hour days, and no light. Seeds are taken out every week and rinsed in cold water for 1 hour. Following warm stratification, the plastic bag is changed, and the seeds are moved into cold stratification for 90 days. Cold stratification takes place in a walkin stratification room set to 36 ºF (2.2 ºC) with no light. Every week, the seeds are rinsed for 1 hour in cold water, and every month the plastic bag is changed.

When the 120-day stratification is completed, the seeds are surface dried and placed in a specially designed, rotary-drum sander (USDA Forest Service, Missoula Technology and Development Center, Missoula, MT; Gasvota et al. 2002), consisting of four coffee cans lined with 50-grit sandpaper. The sander spins at 70 revolutions per minute, and the seeds are scarified for 3 hours (figure 2). Following scarification, the seeds are rinsed to remove dust and are placed in a plastic

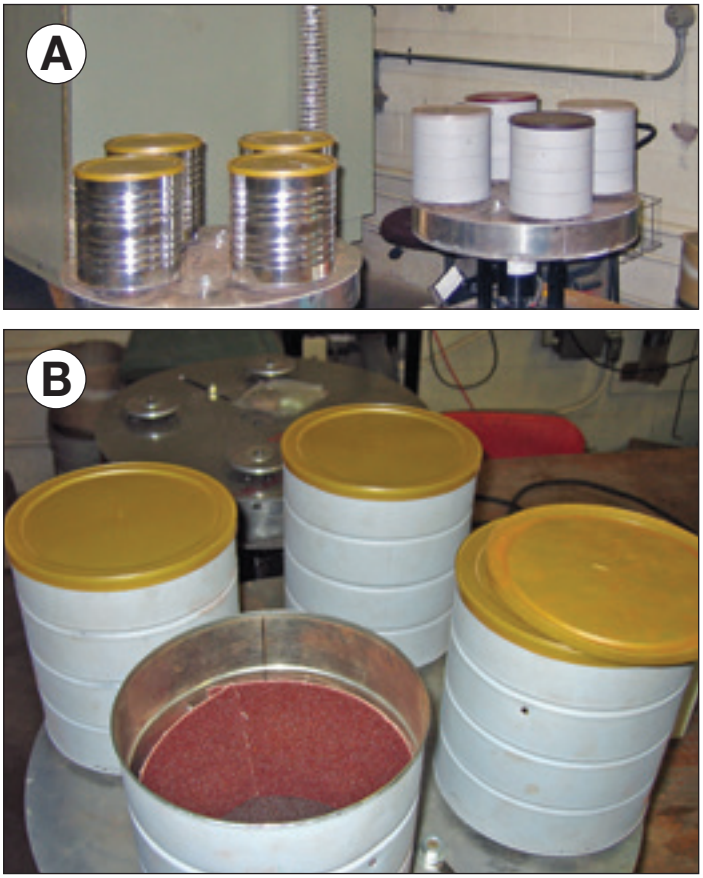

Figure 2. The USDA Forest Service, Missoula Technology and Development Center developed this rotary drum sander to scarify seed (Gasvota et al. 2002). (a) Seed is placed in each coffee can lined with 50-grit sandpaper and (b) seeds are scarified for 3 hours at 70 revolutions per minute. (Photos by Nathan Robertson and Emily Overton)

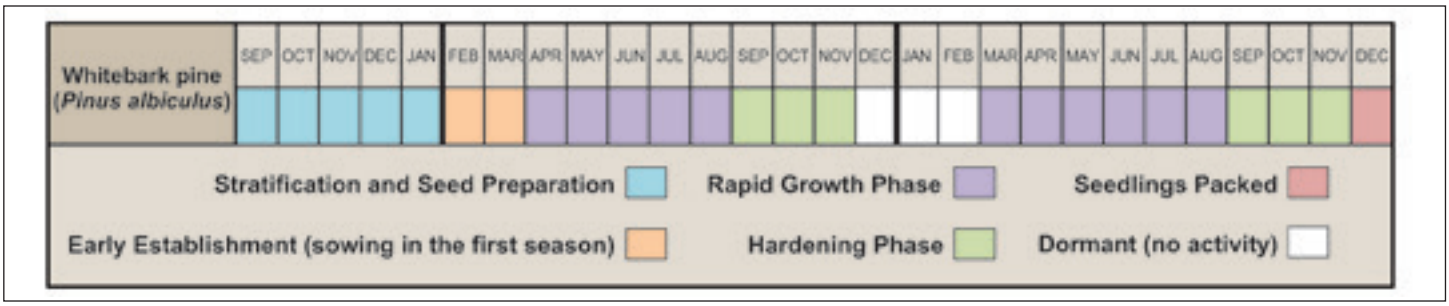

Figure 3. The production schedule for whitebark pine seedlings at the Coeur d'Alene Nursery shows that this species requires a 4-month seed stratification and two complete growing seasons to make packing specifications of 3 in (7.6 cm) heights and 3 mm (0.12 in) root collar diameters.

bag. A recent addition to the Coeur d'Alene Nursery seed preparation protocol includes placing the scarified seeds in a germinator set to 86 ºF (30 ºC) with 24 hours of light. Seeds are kept in the germinator for a minimum of 22 hours until sowing (figure 3).

Seedling Production

The full production cycle for whitebark pine from seed to harvest at the Coeur d'Alene Nursery is shown in figure 3 and is described in detail in the following sections.

Sowing

Whitebark pine seedlings are grown as a 2-year container stocktype at the Coeur d'Alene Nursery. Depending on the depth of soils at the planting site, seeds are hand sown into 10 in^3 (164 ml) or 7 in3 (107 ml) Ray Leach Cone-tainers™ (Steuwe & Sons, Tangent, OR) (figure 4). This container system works well because it allows for consolidation into less growing space in the event of poor germination, has potential to prevent disease issues during production, and prevents root damage at seedling extraction (figure 5). Seeds are planted into a custom blend of 70:30 peat:finely screened composted Douglas-fir bark (Phillips Soil, Canby, OR). The medium is watered to field capacity at the time of sowing. Whitebark pine seed is very valuable because of the difficult and costly cone collection and the lengthy and labor-intensive seed-cleaning and stratification processes. As a result, only one or two seeds are sown per cell (figure 6). Seeds are planted into predibbled holes that are just slightly deeper than the seed, usually about 0.25 in (6.35 mm). Planting depth seems to play an important role in germination success; seeds that are planted too deep often fail to emerge, possibly due to a lack of energy in the seed. The surface of the container is covered with nonporous Styrogrit® (figure 7) (Beaver Plastics, Alberta, Canada) to prevent moisture loss at the medium surface and to discourage growth of weeds and algae. During germination, greenhouse temperatures are maintained at 86 ºF (30 ºC)

Figure 4. Whitebark pine seed that has been stratified, scarified and placed in germinator at 86 ºF (30 ºC) for 24 hours. This seed is now ready to be hand sown into the greenhouses at the USDA Forest Service, Coeur d'Alene Nursery. (Photo by Nathan Robertson, 2010)

Figure 5. The seedlings on the left were hand sown 8 weeks before the seedlings on the right. After full germination, the Ray Leach Cone-tainers™ (Steuwe & Sons, Tangent, OR) were consolidated to reduce greenhouse space due to poor germination. (Photo by Emily Overton, 2014)

Figure 6. Whitebark pine seeds are hand sown into 10 in^3 (164 ml) Ray Leach Cone-tainers™ (Steuwe & Sons, Tangent, OR) at the USDA Forest Service, Coeur d'Alene Nursery. Because of the expense of the seed, only one or two seeds are sown per cell. (Photo by Nathan Robertson, 2012)

Figure 8. Early germination of whitebark pine seedlings at the USDA Forest Service, Coeur d'Alene Nursery. (Photo by Nathan Robertson, 2012)

Figure 7. The USDA Forest Service, Coeur d'Alene Nursery uses a recycled non-porous Styrogrit® product to cover all of our whitebark pine seedlings. This photo compares traditional rock grit (on the left) to two examples (in the middle and on the right) of Styrogrit® products. (Photo by Nathan Robertson, 2012)

maximum and 68 ºF (20 ºC) minimum. The containers are also covered with plastic to maintain humidity and trap heat until germination begins (figure 8).

Fertilization and Irrigation

In the first year of growth, whitebark pine fertilization with a low rate (120 ppm N) of Wil-Sol® Pro-Grower (20N:7P_2O_5:19K_2O, Wilbur-Ellis, Yakima, WA) begins when one-half of the seedcoats are off the cotyledons (figure 8). Approximately 3 weeks later, seedlings are switched to a higher rate (200 ppm N total) of Wil-Sol® Pro-Grower (20N:7P_2O_5:19K_2O, Wilbur-Ellis, Yakima, WA) supplemented with CAN-17 (17N:8.8Ca, Wilbur-Ellis, Yakima, WA) for approximately 20 weeks. High rates of nitrogen are used to promote apical growth in this slow-growing species. Irrigation timing is determined by gravimetric weights (Dumroese et al. 2015) and visual assessment of the root plug. During rapid growth, irrigation occurs when trays reach 75 percent of their field capacity weights. Seedlings are switched to Wil-Sol® Pro-Finisher (4N:25P2O5:35K2O, Wilbur-Ellis, Yakima, WA) at a rate of 40 ppm N during hardening, at which point irrigation schedules are also shifted to 55 to 60 percent of field capacity weights before watering. Supplemental light is added to extend the natural day length to 16 to 18 hours from the time of germination until the end of the rapid-growth phase. After seedling establishment and during rapid growth, greenhouse temperatures are maintained at a minimum of 60 °F (15.5 °C). Seedling mortality increases when daytime temperatures are more than 95 °F (35 °C), so 47 percent shadecloth is added to the greenhouses during the summer months to reduce heat loads.

In the second year of growth, fertilizer and irrigation schedules are similar to those of the first year. Greenhouse systems are turned on between early March and mid-March, with minimum temperatures of 60 °F (15.5 °C), and day lengths extended to 16 to 18 hours using supplemental light. Seedlings are immediately put on 200 ppm N of Wil-Sol® Pro-Grower (20N:7P2O5:19K2O) and CAN-17 (17N: 8.8Ca, Wilbur-Ellis, Yakima, WA) to promote apical growth, and they are irrigated when weights are 75 to 80 percent of field capacity. This regime continues for 20 to 25 weeks. Following the rapid growth phase, supplemental light is removed, seedlings are switched to a hardening fertilizer regime of

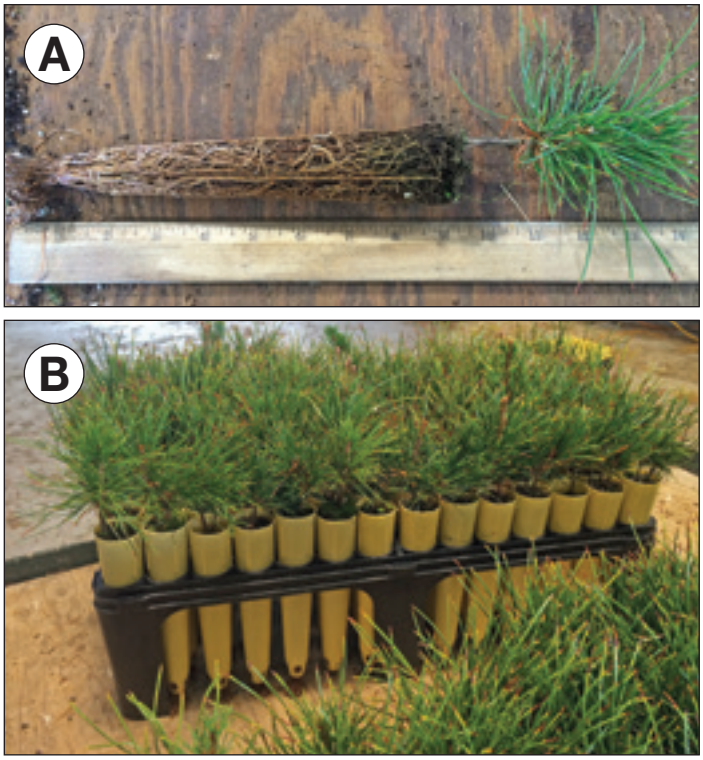

Figure 9. Whitebark pine seedlings ready for extraction and packing in the fall. Seedlings are graded on minimum height (3 in [7.6 cm]) and root collar diameter (0.098 in [2.5 mm]) specifications before shipment. (a) A single seedling extracted from a Ray Leach Cone-tainers™ (Steuwe & Sons, Tangent, OR). (b) A tray of 98 whitebark pine seedlings. (Photos by Emily Overton, 2015)

Wil-Sol® Pro-Finisher (4N:25P2O5:35K2O, 40 ppm N), and irrigation frequency is decreased to watering at 60 to 65 percent of field capacity. Seedling specifications at packing are 3 in (7.63 cm) height minimum and 2.5 mm (0.098 in) root collar diameter (figure 9).

Future Outlook

The Coeur d'Alene Nursery continues to refine and modify the whitebark pine seed and seedling production protocols by participating in small- and large-scale research opportunities. Small studies were conducted in the spring of 2015 to monitor germination rates, following the newest addition to the seed preparation protocol, which involves placing the seeds in a germinator set to 86 °F (30 ºC) postscarification. Trials were also set up to explore if germination would improve when using a lightweight germination fabric on newly sown seeds. A large-scale coordinated research effort among the Coeur d'Alene Nursery, USDA Forest Service, Lucky Peak Nursery, USDA Forest Service, Dorena Genetic Resource Center, and USDA Forest Service, National Seed Laboratory is also under way, which seeks to improve germination by further investigating seed imbibition, stratification lengths, and alternate scarification methods. The results from this study and the trials conducted at the Coeur d'Alene Nursery will help to further streamline the production of this important restoration species.

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