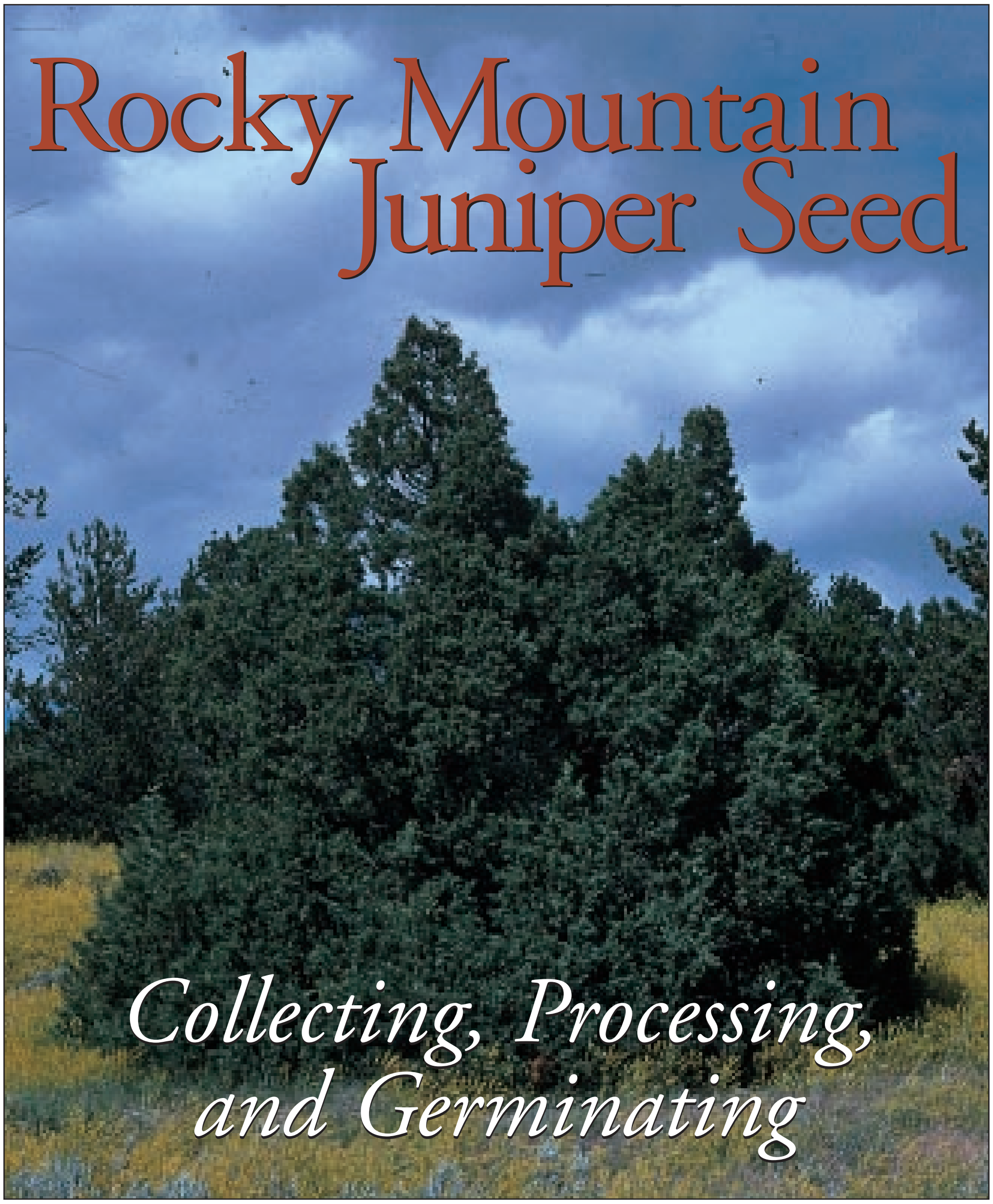
Rocky Mountain Juniper Seed

Collecting, Processing, and Germinating



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ABSTRACT

Propagating Rocky Mountain juniper (*Juniperus scopulorum* Sarg. [Cupressaceae]) from seeds is difficult, but proper collection, cleaning, storage, and dormancy treatment can improve success. Our best results are achieved by: 1) avoiding collection of immature and insect damaged cones; 2) minimizing cone storage or storing surface-dried cones under well-ventilated conditions at 1 to 3 °C (34 to 37 °F) and 80% to 90% humidity; 3) macerating cones in hand-cleaner-amended water; 4) separating light or unfilled seeds from viable seeds with flotation; and 5) treating seeds with a 120-d warm moist stratification in peat moss mix followed by a 150-d cold moist chilling. Establishment and management of cultivated orchards improves seed yield and quality.

KEY WORDS: dormancy, macerator, seed orchard

NOMENCLATURE: (insects) Peck (1963); (plants) USDA NRCS (1995)

At the Bridger Plant Materials Center, we use plants to solve various conservation problems, and Rocky Mountain juniper (*Juniperus scopulorum* Sarg. [Cupressaceae]) is an excellent species for the Intermountain and Northern Plains regions of the US. Hardy, relatively insect and disease resistant, and able to withstand variable and poor soil conditions (Noble 1990; Van Haverbeke and King 1990), it is a relatively low maintenance species useful for windbreaks, shelterbelts, wildlife habitat improvement, mined land reclamation, native range restoration,

Photo by Joseph D Scianna

Figure 1 • Pollen cone (microstrobilus).

xeriscaping, and naturalistic landscaping. Most conservation grade material is currently grown from seeds. Recent advances in asexual propagation of juvenile phase seedlings make propagation by cuttings an increasingly viable production option (Edson and others 1996), although cutting propagation of adult phase tissue remains difficult. Clonal reproduction of numerous ornamental selections is primarily by grafting (Dirr and Heuser 1987, 1990). Although seeds are the favored method of propagation, seedling production in this manner remains challenging given irregular cone production, low seed viability, insect predation, cone processing difficulties, and lengthy and variable dormancy mechanisms. In this article, I provide technical and practical information on growing Rocky Mountain juniper from seeds, and discuss some of the techniques we use at Bridger. Variability among trees, seed sources, and nursery conditions will inevitably result in germination differences over time and among growers. Because alternative and potentially superior techniques may exist, I encourage growers to continue experimentation.

CONE AND SEED COLLECTION

Rocky Mountain juniper has inconspicuous male and female cones (strobili) on separate plants (dioecious). Both cones are borne on the ends of short branchlets from mid-April to mid-June. Seed cones (megastrobili) are greenish-yellowish, becoming more obvious in late summer and opening the following spring before pollination. Pollination is primarily by wind. Pollen cones (microstrobili) are brown and cone-like (Figure 1). The outer covering of the seed cone consists of fleshy, fused scales that create a berry-like appearance (Noble 1990). Maturation requires 2 y, and both first- and second-year seed cones are often found growing simultaneously on the same plant.

Wildland Rocky Mountain juniper begins seed production at about 10 y of age under favorable conditions, but I have observed seed on 3-y-old rooted cuttings taken from mature phase stems. Optimum wildland seed production normally occurs between 50 and 200 y of age. Open grown, stunted, and stressed trees are often prolific seed producers. Rocky Mountain juniper rates as a good to prolific seed producer over most of its natural range, except in parts of Idaho and Montana where it is only fair. Heavy crops occur every 2 to 5 y, but some seeds are usually produced annually (Noble 1990).

We collect mature cones at the optimal time to reduce the chances of picking immature (first-year) seeds. Mature cones are dark blue to nearly black with a glaucous (white waxy) coating; immature cones are green or light blue and covered with bloom. While picking, it is helpful to rub off the waxy coating from cone samples to determine their true color and assure ripeness (Moench 2000). With a 2-y maturation, ripe cones will be found on older growth, as opposed to immature cones found on the more recent season's growth. For efficient harvest, use a cut test to determine percent seed fill prior to collecting cones (Johnsen and Alexander 1974).

Cone collection is a manual labor operation. Our collection crews wear snug fitting, disposable gloves to prevent sap from getting on their hands, aprons with large front pockets, and either sacks or buckets secured with straps around their necks. Mature cones are readily stripped from branches with a rolling and light pulling motion of the fingers, with little or no resultant damage to foliage. Ease of collection appears to be timing (ripeness) and temperature dependent; colder prevailing temperatures seem to improve picking. By reducing the number of immature cones collected, we find that cleaning time and product quality are significantly improved. Cone collection at Bridger, Montana, can occur from mid-October through February, with optimum collection normally in November. Cones ripen as early as mid-September in some locations (Johnsen and Alexander 1974), and may persist until the following spring or early summer. Monitor cone condition and persistence often to minimize losses to birds and animals. It is necessary to collect 1.8 to 4.1 kg (4 to 9 lb) of cones for every 0.45 kg (1 lb) of clean seed (Noble 1990). Cones are processed as soon as possible after collection, but they can be stored for several months under proper environmental conditions. We store surface-dried Rocky Mountain juniper cones in paper sacks in a cooler maintained at 1 to 3 °C (34 to 37 °F) with high humidity (80% to 90%) and avoid conditions that promote heat build-up and molding such as overly-full containers or stacked sacks that reduce air circulation (Moench 2000).

SEED PROCESSING

We use a 31.5-l (8.3-gal) Dybvig™ macerator (Melvin R Dybvig, Portland, Oregon) to extract seeds from cones. Rocky Mountain juniper cones have a leathery outer covering and resinous pulp that make cleaning difficult. Dehydrated cones require presoaking in water or weak lye solution to soften the skin before processing (Johnsen and Alexander 1974). A 24- to 48-h soak in 1.3 ml of lye per liter of water (1 tsp/gal) is the standard recommendation and some nurseries soak cleaned seeds purchased from commercial collectors to assure asepsis. One lye proponent describes its effects as "mystical" (Moench 2000), and it is possible that this product provides some undetermined germination benefits. Most macerators have smooth walls to minimize mechanical damage to seeds during maceration. For this species, however, smooth walls are not abrasive enough to efficiently remove the skin and pulp so the macerator cylinder should be lined with textured rubber, sandpaper, or various types of screening (Justin 2000). At Bridger, we use a light-gauge welded wire with 1.3- by 2.5-cm (0.5- by 1.0-in) openings that does not scarify or damage the seed coat to any degree and is easily removed during the cleaning process (Scianna and Hoffman 2000). Based on our observations, some considerations in the selection of screen material include: 1) screen size should prevent cones and seeds from becoming trapped and not processed properly; 2) screen should remove easily from the macerator for cleaning and access purposes; 3) screen costs—costs vary from less than US $1 for light-duty welded wire to over US $100 for rolled, aluminum deck plating; 4) screen surface—make sure the material does not yield excessive or inadequate abrasion for the species being cleaned; 5) rust proof or resistant materials like plastic, aluminum, stainless or galvanized steel are preferred.

As an alternative to the lye soak, we use citrus-based hand-cleaner containing pumice to clean seeds. Approximately 8 to 12 "squirts" (1 squirt ~ 4.9 ml [1 tsp]) are added to 1.4 kg (3 lb) of cones prior to maceration and again at intervals during processing. For less resinous lots, we reduce costs by thinning the hand-cleaner with up to 50% water prior to application. This non-caustic additive reduces cleaning time and improves product quality. Highly resinous lots require additional cleaner, maceration, and rinsing. Seeds are sufficiently clean when, after squeezing a handful of seeds, your empty hand feels barely sticky when closed and opened. Rinse seeds repeatedly to remove cleaner residue from the seeds and then float off unfilled seeds and stems in a bucket. This method of "floating off" nonviable seeds works well, with less than 5% viable seeds found in discarded material. I have not noted any negative germination effects from the use of the hand-cleaner.

We conducted trials with a "moderately resinous" seed lot comparing the effects of the screen and hand-cleaner on cleaning time (Figure 4) (Scianna and Hoffman 2000). Each sample weighed 1.4 kg (3 lb). The screen plus hand-cleaner substantially reduced cleaning time. Reductions in cleaning time will be less for low resin lots and greater for highly resinous lots. Setup and other factors will lengthen the actual total cleaning time. With our machine, it took approximately the same amount of time to macerate 2.3 kg (5 lb) of cones as 0.45 kg (1 lb). The amount of water needed to rinse the seed slurry during processing in the macerator was reduced up to 30% with the use of the screen and hand-cleaner. Using a screen also improved stem and foliage processing, and reduced the

*We avoid collecting from trees with a high percentage of insect damaged cones. One potentially serious pest is the inconspicuous but common juniper seed chalcid (*Eurytoma juniperina* Marcovitch [Hymenoptera: Eurytomidae]) that makes small (< 1 mm [0.04 in]) exit holes at the base of second-year cones by collection time (Figure 2). Its life cycle and control have not been extensively studied. It is assumed that the adult female, a 2- to 3-mm-long (0.08- to 0.11-in) wasp (Figure 3), oviposits in first-year developing seeds. Eggs or larvae probably over-winter in first-year seeds and emerge as adults the following spring and summer (Stein 2000), early June in Bridger, Montana. Second-year seeds have, therefore, already been damaged by early spring of the second year. It is not known if multiple generations occur each year. I have observed nearly 100% seed mortality on individual trees, and we typically lose 10% to 15% of our annual orchard crop. We currently lack established control protocols, but treatment might include application of contact or ingestion insecticides 5 d before emergence, followed by 1 or more applications at 10-d intervals (Stein 2000). If control proves inadequate, a systemic insecticide in early to mid-spring may be applied, although translocation of systemic chemicals to seed tissues is limited (Rappaport 2000). Current year treatment protects the following years seed crop. Contact your university extension entomologist or county extension agent for chemical recommendations.*

Photos by Joseph D Scianna

Figure 2 • *Exit hole indicating damage by the juniper seed chalcid.*

Figure 3 • *Juniper seed chalcid.*

A viable seed contains an embryo that is alive and capable of germination given proper stimuli. Several measures of viability are used, including direct germination (expressed as percent germination) and tetrazolium (TZ) percentage. Percent germination indicates the percentage of normal seedlings produced by a sample of pure seeds under controlled conditions. This test is used primarily when germination occurs with little or no after-ripening. The TZ test is a biochemical method that detects the presence of living embryo tissue within dormant and non-dormant seed, and is used when extensive after-ripening is needed to overcome dormancy. Tree and shrub seed retailers often report the TZ viability as an indication of potential germination under optimum propagation conditions. Actual nursery germination is usually lower than the TZ viability. When a TZ is available, growers should report germination as a percentage of the TZ value. This expression provides some indication of propagation success relative to the maximum potential for germination. As an example, 10% germination of a 100-seed lot merely indicates that 10 of 100 seeds germinated without an indication of the viability of the non-germinated seed or the true success of the propagation effort. A 10% germination of a 20% TZ viability lot indicates that 50% of all viable seeds germinated (10 of 20 seeds).

amount of hand-cleaner needed by about 20%. Our system works well with our capacity macerator (1.1- to 6.8-l [0.3- to 1.8-gal]) for 0.45- to 2.7-kg (1- to 6-lb) cone lots. Cone lots weighing less than 0.45 kg (1 lb) did not provide enough material for efficient maceration (we macerate small cone lots (< 227 g [0.5 lb]) in a household blender with the impeller blades covered with duct tape to prevent seed damage). Cone lots heavier than 2.7 kg (6 lb) overloaded our 1 hp macerator motor. After thorough rinsing, we dry seeds on kraft paper in a warm, dry location for approximately 48 h and then clean seeds with a Clipper™ fanning mill (AT Ferrell Co Inc, Bluffton, Indiana) to remove inert matter and empty seed. Seed viability (see sidebar page 76) can then be determined with a tetrazolium (TZ) test and additional mill cleaning performed if the percentage is substandard (Moench 2000).

Seed Characteristics

Rocky Mountain juniper seeds are reddish brown, angular, and lightly to prominently grooved. A high proportion of unfilled seeds is common, but varies widely from tree to tree and season to season (Noble 1990). It averages 60,000 seeds per kg (27,000 seeds/lb), but ranges from 39,000 to 93,000 seeds per kg (18,000 to 42,000 seeds/lb) (Johnsen and Alexander 1974). One, two, or even three seeds can be found in each cone. A single seed may contain a single embryo or it may contain 2 embryos in individual chambers separated by a common woody wall. In some cases, 2 seeds, each with an embryo, are lightly fused but can be separated with force to produce 2 distinct seeds. Wildland seed viability is fair, with an average germination capacity of 22% and maximum values seldom exceeding 35%. Seeds can be stored at 10% to 12% moisture content in sealed containers at –7 to 4 °C (20 to 40 °F). A 30% germination level after 3.5 y in storage has been measured for this species (Johnsen and Alexander 1974; Young and Young 1992). Always procure commercial seed on a Pure Live Seed (PLS) basis with a current germination or TZ test to assure viability (see sidebar page 78).

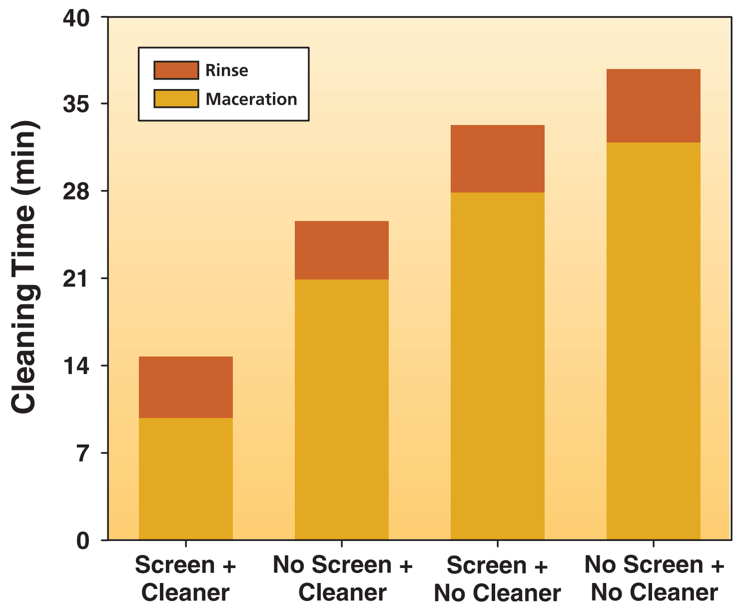

Figure 4 • Placing a screen inside the macerator and adding commercial hand cleaner reduced seed cleaning time by 70%.

SEED GERMINATION

Under natural conditions, Rocky Mountain juniper germinates best on moist sites under partial shade and is unable to establish from seeds on exposed, dry sites. Low and slow germination is common (Noble 1990). Under nursery conditions, germination is erratic and varies widely with seed source (geographic origin), individual seed lot, and nursery practices. Comparing results among growers is difficult because germination is reported in various manners. Johnsen and Alexander (1974) recommended warm moist stratification (20 to 30 °C [68 to 86 °F]) for 45 to 90 d followed by an unspecified period of cold moist chilling (1 to 3 °C [34 to 37 °F]). We consistently have germination that is 40% to 50% of the TZ viability with a similar treatment. We sow fresh seed (<1 y) directly into containers filled with Sunshine Mix #1 (SunGro Horticulture Inc, Bellevue, Washington) and then warm moist stratify for 120 d at 24 to 27 °C (75 to 80 °F) days and 16 to 18 °C (60 to 65 °F) nights, keeping the seeds moist the entire time. Containers are then moved to a cooler for 150 d at 1 to 3 °C (34 to 37 °F). When space is limited, we warm moist stratify and cold moist chill the seeds in sand in cloth sacks or hardware cloth (screen) in the greenhouse or cooler.

Other nurseries report success with various cold–warm–cold sequences (Justin 2000; Laframboise 2000). Generally, imbibed seeds are sown in moist sand and chilled at 1 to 3 °C (34 to 38 °F) in a cooler from January or mid-March until early July (150 to 200 d). Then seeds are either sown directly into seedbeds or buried outdoors in wooden screen boxes or burlap sacks. Seedbeds are covered with an aspen fiber mulch, whereas buried seeds are covered with 2.5- to 5.0-cm (1- to 2-in) of topsoil. Seeds are irrigated regularly until the ground freezes, usually mid-November. Seeds in beds receive their cold moist chilling naturally through the winter. However, buried seeds are uncovered and maintained in a cooler at –4 to –2 °C (25 to 28 °F). The seeds are periodically inspected for early germination until they are sown either in seedbeds (April) or containers (January through March). Optimal germination occurs at 10 to 16 °C (50 to 60 °F) and is delayed above 16 °C (60 °F) (Hartmann and Kester 1983). Justin (2000) reports 80% of seed lots handled this way in recent years had a germination of approximately 50% of the TZ viability.

Hartmann and Kester (1983) recommend treating other juniper seeds with sulfuric acid for 35 to 120 min plus cold moist chilling for 120 d at 4 °C (40 °F). In recent trials with a single seed lot and multiple treatments, we achieved the highest germination (72% of TZ viability) with a 45-min sulfuric acid soak prior to a 116-d warm moist stratification then a 150-d cold moist chilling.

Photo by Joseph D Scianna

Figure 5 • Rocky Mountain juniper seed orchard at Bridger Plant Materials Center.

SEED ORCHARDS

Procedures for establishment, management, and cultivation of seed orchards deserve more review than can be dedicated here, but several points are worth noting. Despite the observation that stressed wildland plants are often prolific seeders, it seems unlikely that long-term seed yield and quality from wildland sources will prove superior to that of comparable cultivated trees. In the Bridger orchard, heavily fruited, 20-y-old trees measuring 2.4 m (8 ft) tall and wide can produce 12,000 g (25 lb) of cones and 1900 g (4.2 lb) of bulk seed. In the 3 y since we began irrigating and fertilizing our orchard, the TZ viability has averaged 61% with a high of 91%. Commercial lots of wildland Rocky Mountain juniper typically measure 30% to 40% TZ viability. Wildland plants are subject to numerous damaging agents (fire, logging, construction, reclamation, and other human activities) that

ROCKY MOUNTAIN JUNIPER SEEDS

Number of seeds per cone:	1, 2, or less frequently 3
Seed maturation:	2 y
Mature cone:	Berry-like, dark blue, approximately 5 to 8 mm (0.2 to 0.3 in.) in diameter, glaucous
Ratio of seeds to cones collected:	1:4 to 1:9; average 1:6.5
Average number of seeds/kg (seeds/lb):	60,000 (27,000)
Range in the number of seeds/kg (seeds/lb):	39,000 to 93,000 (18,000 to 42,000)
Average wildland germination capacity:	22% (seldom > 35%)
Average Bridger PMC orchard germination:	45% of TZ viability
Bridger PMC orchard seed viability (TZ) since irrigation and fertilization begun:	32% to 91%; average 61%
Dormancy breaking:	Acid scarification with or without warm, moist stratification followed by cold, moist stratification. Also a sequence of cold, warm, cold stratifications.
Storage:	30% germination after 3.5 y in sealed containers, 10% to 12% moisture content at –7 to 4 °C (20 to 40 °F)

%PLS = Purity ¥ (Germination [or Viability])
100

The Pure Live Seed (PLS) method designates the percent of a seed lot by weight that will germinate (or is viable). By buying and planting seeds on a PLS basis, you are assured of a certain weight, and hence number, of viable seeds. A 454-g (1-lb) PLS lot of seed contains 454 g (1 lb) of viable seeds, regardless of the total (bulk) weight of the lot. For example, 454 g (1 lb) of Rocky Mountain juniper contains 27,000 seeds. A 454-g (1-lb) PLS lot with an 80% purity and 30% viability would contain 27,000 viable seeds, although its bulk weight would be 1887 g (4.16 lb). In contrast, a 454-g (1-lb) bulk lot weighs 454 g (1 lb), is 24% PLS, and contains only 680 viable seeds. The actual value of 454 g (1 lb) of bulk commercial seeds, therefore, varies widely depending on the purity and viability. Bulk seeds of unknown purity, viability, and/or origin are often a poor value.

are often beyond the control of the grower. Ready access to seed orchard plants facilitates frequent inspection for insect and disease control, supplemental irrigation, fertilization, pruning, weed control, fruit collection, and other cultural treatments and activities (Scianna 1998). Efficient orchard designs isolate closely related trees, minimize inbreeding depression, and allow efficient cross pollination (Figure 5). However, these benefits can be costly to the grower. Adequate spacing for mature trees and equipment access requires a substantial area of land otherwise available for field production. Long-term investments of labor, equipment, and supplies are needed to maintain orchards over time. Growers should evaluate their own nursery operation and product mix to determine if orchard establishment is warranted.

SUMMARY

Nurseries can improve their propagation success with Rocky Mountain juniper by fine tuning their seed collecting, processing, and dormancy breaking techniques. The establishment and proper management of seed orchards should provide additional benefits. Wide variation in seed source performance, nursery operations, and cultural practices provides opportunity for growers to customize propagation methodologies for their specific situation.

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