Propagation of *Juniperus:* Challenges to Propagation and Opportunities for Improvement

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Abstract-Production of *Juniperus* in forest and conservation nurseries is often limited due to poor or erratic seed germination. Poor seed germination of *Juniperus* may be due to several factors, including a high proportion of dead, unfilled, or immature seed, seed-coat dormancy and embryo dormancy. The germination rate of seed sown may be increased through seed quality testing and treating seed to overcome dormancy. We discuss methods to separate seed, and improve seed quality and pre-treatment techniques to overcome dormancy.

INTRODUCTION

Eastern redcedar (*Juniperus virginiana L.*) and Rocky Mountain juniper (*Juniperus scopulorum* Sarg.) are among the most widely planted trees for conservation forestry in the Great Plains. Because they are adapted to a wide range of sites, including dry or rocky soils, both species are planted for windbreaks, shelterbelts, and living snowfences. In 1990, nearly 2.7 million *Juniperus* seedlings were distributed by Great Plains tree nurseries (Moench 1993). However, due to problems associated with dormancy and seed gemination, especially in Rocky Mountain juniper, conservation nursery managers often have difficulty producing a consistent crop of *Juniperus* seedlings. For example, the Oklahoma Department of Agriculture reports that typically only 16% of redcedar seed germinate during the first year after planting and the seed to saleable-seedling ratio is only 0.03 (Porterfield, personal communication). Germination of Rocky Mountain juniper is also low at the Oklahoma nursery and other nurseries in the Great Plains. The low germination rates observed for *Juniperus* indicate that current cultural practices are inadequate to overcome dormancy.

Dormancy is the inability of a seed to germinate, even under conditions that are normally considered favorable for germination. Dormancy can be caused by the seed coat or the embryo. Seed coat imposed dormancy is due to the impermeability of the coat to water and gases which prevents inhibitors from leaving the embryo or the mechanical prevention of radicle extension (Kelly et al., 1992). Embryo dormancy is due to a lack of physiological requirements such as hormonal, temperature or light needed to break dormancy. Seed of *Juniperus* have both types of dormancy. A confounding factor in Rocky Mountain juniper is that the seeds require two years to mature. Therefore, immature seeds can be inadvertently collected with the mature seeds.

Although numerous studies have been conducted on germination of *Juniperus* in the past 70 years, few have yielded consistent results. In the following discussion, we consider three ways to improve germination rates and germination uniformity of *Juniperus* seed. Seed

separation techniques, treatments to overcome seed-coat dormancy and methods to overcome embryo dormancy are the methods we are currently studying, and believe may be useful to nursery growers.

SEED SEPARATION

Low rates of germination in a number of species are due to a large proportion of non-viable or nongerminating seed. Non-viable seed may be hollow, damaged, or immature. In many cases non-viable seed may be separated from viable seed relatively easily, resulting in an immediate increase in germination rates. Simple techniques for separating seed include separation by size or density and the IDS (Incubation, Dehydration, Separation) method.

Density and Size

In general, as seeds mature size and density increase. Therefore, viability and germination are often correlated with seed size and (or) density. Khademi et al. (1993) showed that as the density of *Primula acaulis (L.)* rose, the percent viability and soluble protein contents increased. The densities of the seed ranged from 1. 10 to 1. 18 g/cm^3. The percent viability and soluble protein contents rose from 8 to 90% and from 26 mg/g to 38 mg/g, respectively, as the seed density increased. In addition to increasing germination percentage, selecting for increased size and (or) density may have the additional benefit of improving seedling vigor. Wang et al. (1994) demonstrated that as seed mass rose in black spruce *(Picea inariana* Mill.) seeds, the seedling survival rate also rose.

At an initial seed mass of 0.55 mg, survival rate was approximately 42%, while seed with an initial mass of 1.5 mg had a seedling survival rate of 75%.

A key advantage to separating seed by size or density is that it is relatively simple and straightforward. Laboratories which specialize in seed testing or seed quality improvement use specialized equipment such as density tables and air separators. However, in our current research we have found that *Juniperus* seed can be separated into various size classes using standard soil sieves. We have also found that *Juniperus* seed can be divided into density classes by floating in sucrose solutions of varying specific gravities. Presently, we are conducting trials to correlate germination rates with seed size and density for several seed lots of eastern redcedar and Rocky Mountain juniper from Great Plains nurseries.

IDS

While simple separation by size and (or) density may improve germination by removing empty or immature seeds, IDS separation provides a more physiologically-based indicator to select viable seed. The IDS technique is based on the principle that viable seeds, once hydrated, give up moisture more slowly than unfilled or non-viable seeds. The procedure involves hydrating the seeds (Incubation), drying the seeds for a specified time (Dehydration) and then placing the seeds in water and discarding the seeds that float (Separation).

Singh and Vozzo (1994) found that germination of *Pinus roxburghii* could be enhanced using the IDS technique. By immersing the seeds in solution with a specific gravity of 1.04 for 4 hours, they found that 72% of the seeds sank while 28% of the seeds floated. Of the 72% of seeds that sank, 94% of these seeds germinated. Of the 28% of the seeds that floated in the

solution, only 50% of the seeds germinated. furthermore, Simak (1984) found that for a sample of Lodgepole pine *(Pinus contorta* Dougl.) seeds that typically germinated to a 67% capacity, almost all the 33% that did not germinate were found to be dead using the IDS technique. Increases in germination attributed to the IDS technique have also been reported for lodgepole pine (increased from 37% to 75%) (Downie and Wang 1992), white spruce (increased from 50% to 86%) (Downie and Bergsten 1991), and Scots pine (increased from 33 to 95%) (Bergsten 1988).

OVERCOMING SEED DORMANCY

Although seed separation techniques will remove dead and non-viable seeds, the remaining seeds may still be dormant. As indicated earlier, dormancy may be due to seed-coat dormancy, embryo dormancy or, in the case of *Juniperus*, both.

Seed Coat Dormancy

In order to overcome seed coat dormancy, the seed coat must be broken or conditioned to pen-nit the seed to imbibe water and allow inhibitors to leach out. Seeds may be scarified by soaking in acid or bases, or by mechanical means. Masamba (1994) found that germination of three species of Acacia seeds known to have seed-coat dormancy increased to at least 80% by treating the seeds using a hot wire method. This basically bums the seed coat to scarify the seeds. The best germination from the hot wire method came from a duration of 5- 10 seconds. Cutting the seed bases (hilum) of eastern redcedar and Rocky Mountain Juniper seed resulted in epicotyl development within 3 to 9 days (Djavanshir and Fechner, 1976). Sulfuric acid treatments of 35 minutes for ERC and 120 minutes for RMJ produced a hole in the hilum which led to similar types of germination rates. Seeds of West African Laburnum (*Cassia suberiana* DC.) germinated best when they were immersed in 98% sulfuric acid for 45 minutes, plus a one-hour water soak or nicking, and scarifying the seed coat in a commercial mill for 4 minutes (Todd-Bockarie et a]. 1993). The acid and mechanical scarification resulted in 93% and 85% germination, respectively, as compared to 5% for the untreated controls.

In a separate study done by Todd-Bockarie and Duryea (1992), seeds of velvet tamarind (*Dialium guineense* Willd.) were treated with concentrated sulfuric acid or nicking the seed coat to overcome seed coat dormancy. Nicking the seed coat surface with a scalpel produced the highest germination of 96% while a germination rate of 55% was obtained by soaking seeds in concentrated sulfuric acid for seven minutes. These two treatments are very promising as the germination rate for the control seeds was only 10%. In our current research with Juniperus seed we are investigating the effectiveness of wearing down the seed coat with a rock polisher as a simple method to mechanically scarify seed.

Embryo Dormancy

Embryo dormancy or physiological dormancy in *Juniperus* is controlled by a complex series of hormonal interactions that are poorly understood. Presently the most reliable method of overcoming embryo dormancy is by a combination of warm and cold stratification. Exogenous applications of chemicals, mainly hormones, may also overcome embryo

dormancy.

Stratification

In a study by Young et al. (1988), different stratification techniques were performed on seeds of western Juniper (*Juniperus occidentalis* Hook.) and Utah juniper (*Juniperus osteosperma* [Torr.] Little). Stratification in aqueous solutions with near saturation of the solution with oxygen increased germination of western and Utah juniper to around 50%. Similar treatments using aqueous solutions of 0.289 mol L^{-1} gibberellic acid (GA) improved germination of western juniper to better than 80%. Jones (1989) found that East African pencil cedar (*Juniperus excelsa* M. Bieb.), subjected to cold stratification (5°C) for 60 days increased germination to 63% over controls grown in the greenhouse (53%) and in a growth chamber (47%). Extended H_2SO_4(1 hour) and hot water treatments resulted in very low germination rates. Jones also found that significant differences in germination percentages between seeds from different maternal parents with a final germination percent ranging from 18 to 60%. The most accepted method for breaking dormancy in eastern redcedar and Rocky Mountain juniper is a warm moist stratification (6 weeks) followed by a cool moist stratification (10 weeks) (Van Haverbeke and Comer 1985, Johnson and Alexander 1974).

Chemical Treatments

Soaking spruce (*Picea smithiana* [Wall.] Boiss.) seed in GA_3 increased germination by around 19% (Singh 1989). Applying GA_3 (50 FM) and Ethephon (50 FM) increased germination of eastern redbud (*Cercls canadensis* var. *canadensis L*.) seeds to 28% (±4.8) and 60% (±4.5), respectively, compared to 2% (±1.7) for the untreated controls (Geneve 1991).

In a study done by Persson (1993), seeds of ornamental plants of 16 species were infused with 1FM or 10FM gibberellic acid or with a concentration of 1FM gibberellic acid, 0.5FM kinetin and 1FM Ethrel(2-chloroethanephosphonic acid) dissolved in acetate. Infusion of these growth regulators improved germination in 10 of the experimental species. In all cases, germination rates were increased. Final germination was higher in treated than in control studies. The most effective treatment for increasing germination percentage was gibberellic acid at a concentration of 10FM.

OSMOTIC PRIMING

Osmotic priming using polyethylene glycol (PEG) has been demonstrated to improve seed germination and uniformity of germination in a number of species. Seeds are imbibed in aerated solutions of PEG to a point right before germination occurs. Then the seeds are hydrated with water and the germination process is rapidly initiated. Halgren (1987) found that germination of loblolly pine (Pinus taeda L.) could be enhanced from 53% to 79% for unstratified seeds. In a separate study by Hallgren (1989), it was found that osmotic priming increased final germination and rapidity of germination for loblolly and shortleaf pines (*Pinus echinata* Mill.), but was generally detrimental to germination of slash pine (*Pinus elliottii* Engelm.) seeds with one exception. At 151°C germination temperature, Hallgren found that unprimed slash pine seeds that were not stratified would not germinate but when primed they would germinate to 29%.

SUMMARY
Researchers in the Great Plains and elsewhere have studied the problem of germination in *Juniperus* for over 70 years with limited results. From this research it is clear that poor germination stems from the seeds being doubly dormant (seed coat plus embryo dormancy) and may also be due to a relatively high proportion of immature or otherwise non-viable seed. Given this situation, it seems unlikely that a 'magic bullet' will be found that will dramatically increase germination of eastern redcedar and Rocky Mountain Juniper However, we believe our integrated research approach combining seed quality testing and a combination of stratification, scarification, and, perhaps, chemical treatment may increase rates and uniformity of germination.

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