

# Advanced Techniques to Prepare Seed to Sow

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**Abstract:** This paper reviews research on improving the basic technique of cold stratification for tree and shrub seeds. Advanced stratification techniques include long stratification, stratification re-dry, or multiple cycles of warm-cold stratification. Research demonstrates that careful regulation of moisture levels and lengthening the stratification period have produced a more vigorous response in several species. Advanced stratification techniques have also produced more uniform germination in species that, when treated in the basic manner, have failed to germinate or have germinated erratically. Nursery managers can improve seed germination at their nurseries by carefully and gradually adopting one of the advanced stratification techniques reviewed in this paper.

**Keywords:** cold stratification, warm-cold stratification, germination temperature, seed moisture

## Introduction

For at least the last 60 years, cold stratification has been a primary method for preparing tree and shrub seeds for sowing. Cold stratification was necessary to overcome dormancy factors that prevented seeds from germinating in the fall when they were first shed from the mother tree. The basic technique was to soak seeds overnight, drain off the excess water, bag the seeds in a polythene bag (“polybag”), and place the seeds at temperatures just above freezing for 30 to 60 days. Several researchers explored variations on this basic technique, and there is now enough evidence to support refined practices at production nurseries. These advanced techniques involve:

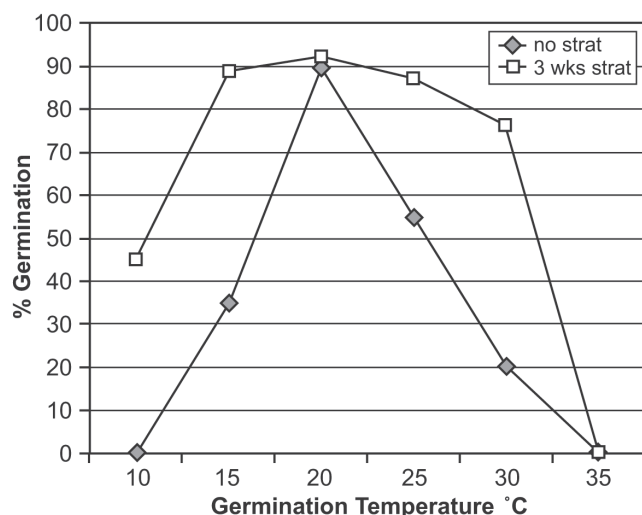
- long stratification periods
- stratification re-dry, or
- multiple cycles of warm-cold stratification.

The one common factor among all these more advanced approaches is a more precise control of moisture levels than was attempted under the basic stratification procedures. The 1974 edition of the Woody Plant Seed Manual (Schopmeyer 1974) stated simply that, “Full imbibition is essential for stratification...” In contrast, all of the advanced techniques make use of specific targeted moisture content.

## Long Stratification and the Stratification of Non-dormant Species

Basic stratification approaches generally work well for moderately dormant species such as most spruce and pine. “Long stratification” means extending the stratification period beyond the basic stratification length. The length of long stratification varies depending on the dormancy of the species. Basic stratification periods for dormant species are mostly 30 to 45 days, extended to 60 days for more dormant species. Long stratification for dormant species therefore involves extending stratification periods beyond the basic 30 to 45 days. Non-dormant species are species that do not require stratification to germinate under favorable conditions. Therefore a general definition of long stratification for non-dormant species is the use of 14 to 28 days or longer of stratification than would be used with basic seed treatments.

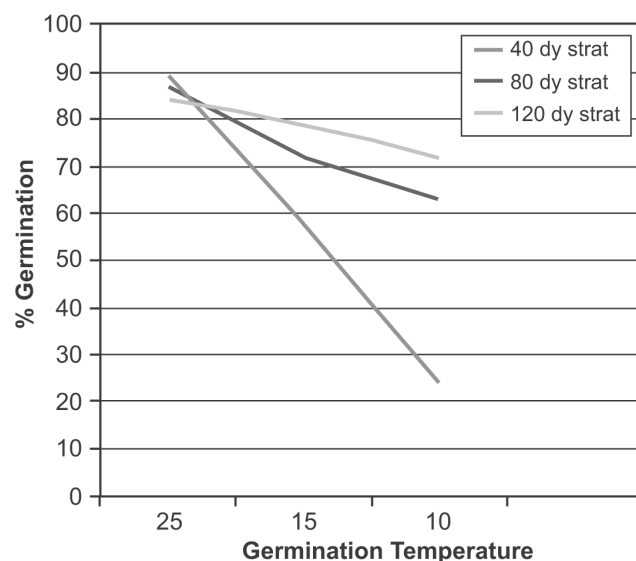
Sitka spruce (*Picea sitchensis* (Bong.) Carrière) is a non-dormant species. Gosling and Rigg (1990) showed that unstratified Sitka spruce seeds germinated best at 20 °C and that germination dropped dramatically when the temperature was increased to 25 °C or decreased to 15 °C. Following 21 days of stratification, the seeds were able to germinate equally well at all three temperatures (Figure 1). Stratification also increased germination percentages and speed of germination for longleaf pine (*Pinus palustris* Mill) another non-dormant species (Karrfalt, 1988).



**Figure 1.** Stratification makes Sitka spruce seeds able to germinate well over a range of temperatures (Gosling 1990).

Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) is a moderately dormant species. Allen (1962) tested germination on 26 seed lots using 40, 80, and 120 days of stratification and germination temperatures of 25, 15, and 10 °C. Germination was best at 25 °C following all stratification periods, but the longer stratification time sharply improved the germination at the lower germination temperatures (Figure 2) just as occurred with the non-dormant Sitka spruce.

In basic stratification, there usually is a film of capillary water on at least some of the seeds. This is excess water that can lead to sprouting as the stratification period is extended. This is formally demonstrated by Gosling and Riggs (1990) with Sitka spruce. Seeds at 30% moisture content and no water film never sprouted even when the stratification period was extended to 140 days (20 weeks). Seeds that had a water film did begin sprouting in stratification (Figure 3). Therefore, removal of the water film is a mandatory requirement for long stratification because protruding radicles are usually damaged during sowing resulting in lost or stunted seedlings.

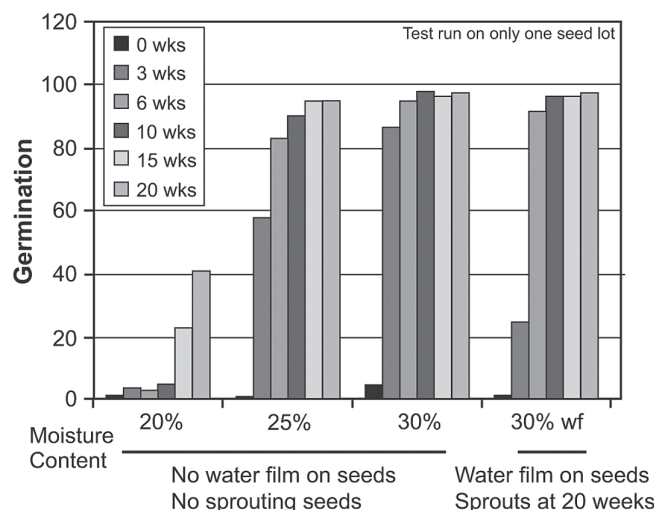


**Figure 2.** Long stratification makes Douglas fir seeds germinate better at cooler temperatures (Allen 1962).

Removal of the water film can be accomplished in several ways after draining the soaked seeds. The first is to simply spread the seeds out in thin layers for air drying. This takes a large flat area and continuous monitoring and turning of the seeds until the film of water is gone. A quicker way to do this is to use a pressurized drier (Karrfalt 2012). After draining the seeds, the seeds are placed in the drying tray and gently stirred continuously until the surface water is removed. Stirring is necessary or else seeds on the bottom of the tray might get too dry. A third way is to place bags of soaked seeds in a laundry spinner (Gosling and others 1994). When properly surfaced dried, the seeds will look damp but no longer have the shiny film of water.

Identifying the best length of stratification is done by simply testing different periods to determine which ones give the best germination responses. A qualified seed laboratory can run a series of tests using varying stratification lengths and even possibly germination temperatures to assist in identifying optimal stratification periods.

As with any new procedure at a nursery, a careful transition should be made when adopting longer stratification periods. The right balance must be found between removing the excess film of moisture that can cause sprouting and keeping the seed moist enough for effective stratification.



**Figure 3.** A film of water is not needed for effective stratification of Sitka spruce but can eventually lead to sprouted seeds in stratification (Gosling 1990).

## Stratification-redry

The stratification-redry used with true firs (*Abies* spp.) (Edwards 1981; Leadem 1986) is similar to the long stratifications already discussed with two differences. First the initial 30 days of stratification is conducted in the basic manner with some surplus water with the seeds. This initial 30 days gives more complete imbibition of water. Following the initial 30 days, the seed is surface dried as described in long stratification above. Secondly, the length of the stratification is measured for each lot by pulling small samples from the stratification bag and running a small germination test. Once a good germination is obtained the stratification is terminated. To determine when the best germination has been obtained it would be useful to have had an estimate of viability made with a tetrazolium test. In a tetrazolium test, the chemical tetrazolium chloride stains the viable seeds a light pink so they can be distinguished from the non-viable seeds. When the tetrazolium estimate is close to the germination then a good germination in the nursery would be expected.

## Multiple Cycles of Warm and Cold Stratification

This approach holds promise for species of deep and variable dormancy such as rocky mountain juniper (*Juniperus scopulorum*) and cherries (*Prunus* spp.). Suszka and others (1996) describe methods employing multiple cycles of warm and cold stratification to achieve complete and uniform germination. These multiple cycles presumably mimic several cycles of growing and dormant seasons. Those species requiring this treatment would be ones that use a regeneration strategy of being able to germinate seeds from one seed crop over a period of years.

In the Suszka procedure, seeds are first imbibed to a moisture content of 35%, slightly less than full imbibition. Next the seeds are generally put through cycles of approximately 30 days at 20 °C and 60 days at 2 or 3 °C. How many such cycles depends on the species. The length of the final cold cycle is determined similarly to the stratification-redry. A small sample of seeds is placed in germination and when a good germination is obtained, the cold stratification is terminated and the seed can be sown. Just as with the stratification-redry procedure, a tetrazolium test is useful to estimate the viability of the seed for comparison to the germination.

Typically species of deep and variable dormancy, when kept completely in cold stratification with a little excess moisture, will germinate in stratification over an extended period of time. In the nursery bed they can germinate over two, sometimes three growing seasons. Reducing the moisture content to 35% prevents germination but allows the dormancy breaking process to continue until all seeds are non-dormant.

## Storing Non-dormant Seeds

With careful drying of treated seeds, some authors stated that storing seeds in a stratified condition without re-inducing dormancy appears to be possible. Drying stratified seeds generally puts seeds back into dormancy requiring a second stratification. Suszka and others (1996) reported that by slowly drying the seeds they could be stored in a non-dormant condition. This would be a great help to nurseries planning seedling production and responding to late orders. Allen (1962) reported a similar response in Douglas-fir. More research on how to conduct this procedure of bringing seed to low enough moisture status for storage and yet not inducing dormancy needs to be conducted before recommendations can be made for nurseries.

## Summary

All of the more advanced approaches of preparing seed to sow involve a more precise control of moisture levels than the basic stratification procedures. The main key is to control the moisture content of the seeds by surface drying the seeds after they are fully imbibed. This allows for the stratification process to proceed and apparently reach an optimal state of preparation without starting germination.

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