plants by treatment with rhizobacteria. *Phytopathology* 71:914 (Abstr.).

40. Zavaleta, E. Mejia, and S.D. Van Gundy. 1982. Effects of rhizobacteria on meloidogyne infection. 21st Annual Meeting of the Society of Nematologists, Knoxville, TN, USA, July 26-30, 1982. *Jour. Nematology* 14:475A-475B.

CUSTOM SEED PREPARATION FOR OPTIMUM CONIFER PRODUCTION

SHARON K. DELONG

Brown Seed Company
P.O. Box 1792
Vancouver, Washington 98668

I would first like to describe how we test and stratify conifer seed at Brown Seed Company and then discuss some of the different methods which can be used for handling the more difficult species.

The germination possible for a seed lot is determined by the basic soundness of the seed and the care given that seed during collection, processing, and storage. After the seed comes out of freezer storage we then attempt to design or "customize" our treatment procedures for each lot to obtain this maximum possible germination.

SEED TESTING

In order for any program of so-called custom stratification to work, the seed handler needs as much information as possible about the seed lot. This includes:

1. *Purity Test.* This test determines the percentage of pure seed in a sample. For container sowing the seed should be as clean as possible and handpicking is available to bring the seed to 100% purity. A purity test is also necessary to calculate with accuracy the amount of seed needed for sowing.

2. *Seed Count.* The seed count determines the number of seeds found in a pound or gram of pure seed in a lot. The number of seeds/lb. can vary widely within a species and this information is essential to calculating seed needs.

3. *Standard Germination Test.* This test compares the actual germination of chilled with non-chilled seed. The results are especially useful if two different chill periods are used (Table 1). Besides being the best tool for deciding the optimum period of stratification, the standard germination test will also usually indicate if a customer is likely to have mold problems with his seed.

Table 1. Typical standard germination test results using two different chill *periods.*

COMPLETED GERMINATION TEST RESULTS

Test # 2894 Date May 4, 1984

Ownership	Check No. Chill			14 Day Chill			28 Day Chill		
	Day	G%	Firm	Day	G%	Firm	Day	G%	Firm
Sp. grand fir	7	0		7	4		7	20	
Lot ID CWD-35-83	14	22		14	63		14	53	
Processing Lot #B-101	21	61		21	70		21	54	
Strat. Began 3/9/84	28	66		28	70		28	54	
Seed C/T or VAS 80/69									

Optional Information:
(By request only)
Purity
Seed Count/lb. 18,000
Moisture
Sizing: Reg. S M L
Other Info. 50.0 Lbs.

When there is no time for a standard germination test, or a further test is wanted after seeing the results, two quick tests for seed viability are also available.

1. The *tetrazolium chloride* (TZ) test is based on the fact that respiring seeds give off hydrogen which reacts with the colorless triphenyl tetrazolium chloride to give the red colored, triphenyl formazan. Essentially the test determines if there is a living embryo. Some nurseries use only TZ tests and claim they give the best correlation with field results. In our experience, while the TZ test predicts the average and better than average lot quite well, very poor lots, particularly in the true firs, will sometimes give excellent TZ readings. The TZ test takes about 48 hours.

2. The *hydrogen peroxide* (H_2O_2) test is based on the observed elongation of the radicle of a viable seed in response to a 1% solution of hydrogen peroxide. The H_2O_2 apparently overcomes dormancy by stimulating the early stages of respiration. While in general we have had pretty good correlation between hydrogen peroxide tests and standard germination tests, an occasional lot of ungerminable seed, usually true fir, will give positive results with this test. The H_2O_2 test takes about 10 days.

STRATIFICATION

At Brown Seed Company seed is stratified "naked" in plastic bags rather than being mixed with a moisture holding material such as peat or sand.

1. The seed is weighed and placed into 4 ml. clear plastic bags. A maximum of 5.0 lbs. of seed is put in a 26 × 26 in. bag.

Smaller amounts of seed are put in proportionately smaller bags.

2. The open end of the bag is gathered around a "breather tube", a short piece of plastic pipe 5 × 1½ in. (smaller for smaller bags). The bag is fastened to the tube with a wire tie by means of a tie pulling device. The loop remaining at the end of the wire is used for attaching the identification tag and for hanging the bag during soaking and stratification.

3. Cold tap water is added to the plastic bag to at least double the volume of seed. The seed is soaked for 40 to 48 hours. At least once during this period the seed is agitated by hand to ensure that the seed is uniformly moistened.

4. After soaking, the water is *thoroughly* drained from the bag by punching several small holes with a nail in the bottom and bottom corners of the plastic bag. After tilting the bag and allowing water to run out the corner holes, there should be *no* standing water in the bag. The seed is soaked and drained in a greenhouse at a temperature of 40° to 65°F.

5. The bag with the moist, drained seed is hung in the cooler at 36°F. Because of the clear plastic the seed can easily be checked periodically for mold or signs of germination. The breather tube helps provide adequate aeration and can also be used to add water during stratification, although this is usually not necessary, except perhaps with ponderosa pine.

6. After stratification is complete, the seed is surface dried in shallow layers of newspaper at room temperature in front of fans. Stirring the seed occasionally helps insure even drying. When the seed is dry enough to be handled easily, it is placed in clean *cloth* bags and returned to the cooler immediately. The seed is kept refrigerated until it is sown and it can be stored in the cloth bags for several months, if mold is not present. When shipping stratified seed to customers, the seed is packed in "Blue Ice" and express service is used to ensure delivery within 24 hours.

While it is preferable to have specific germination information on each seed lot, this is not always possible and at Brown Seed Company we use some general guidelines when stratifying various species of seed. (Table 2) When using these guidelines one must remember to check the seed periodically for signs of seed deterioration, such as mold or odor, and for signs of germination, such as cracking of the seed coat or beginning emergence of the radicle.

While most of our conifer seed is stratified as described above, there are other techniques which can be used to speed up germination or to increase the total germination in those species which do not respond well to conventional methods.

Table 2. General guidelines for stratification for various conifers

Species	Approximate Length of Stratification (Days)
Abies concolor (white fir)	14-21
A. grandis (grand fir)	14
A. magnifica var. shastenis (Shasta red fir)	21-28
A. procera (noble fir)	28-35
Thuja plicata (western red cedar)	28
Picea engelmannii (Engelmann spruce)	21-28
P. pungens (blue spruce)	7
P. sitchensis (Sitka spruce)	21-28
Pinus monticola (western white pine)	120
P. mugo (mugo pine)	14-21
P. contorta murrayana (lodgepole pine)	42
P. nigra (Austrian pine)	7-14
P. ponderosa (ponderosa pine)	42-56
P. strobus (eastern white pine)	60-90
P. sylvestris (Scotch pine)	14-21
Pseudotsuga menziesii (Douglas fir)	35
Tsuga heterophylla (western hemlock)	28-42

1. Aeration *(Pinus monticola).* We use either medical oxygen from a tank or air from an aquarium type air pump during the soak and 2 or 3 times during the stratification period. With this method we have gotten much more consistent results, and results closer to germination test predictions than by layering with peat or naked stratification alone.

2. Warm-Cold *(Juniperus scopulorum).* Soaked juniper seed is kept at room temperature for 2 months then given a normal moist chill for another 2 months.

3. Post-stratification (true firs, particularly *Abies procera*). Seed is given a normal period of regular stratification and then surface dried to 30-35% moisture. The seed is put in a cloth bag and returned to the cooler for approximately 2 months. For some lots this process seems to even out variations in dormancy within the seed lot allowing very dormant seeds to catch up while preventing the germination of less dormant seeds until the lot is sown.

4. Double stratification (*Abies procera, Pseudotsuga menziesii).* In this procedure seed is soaked and stratified as usual then either surface dried *or* dried to storage levels (ca 8%) and then returned to the cooler *or* the freezer for a specified period. The seed is then resoaked and restratified. In our experience this does not increase overall germination but it greatly speeds up the time it takes for the seed to sprout. (Table 3) In fact the length of the second stratification period should probably be shortened for some species to prevent pregermination in the cooler.

Table 3. Results of double stratification treatments on *Pseudotsuga menziesii* and *Abies procera*.

Final Germination Test - Percent germination based on 200 seeds.

Abies procera (noble fir)

Treatment		Days in Germinator 7	14	21	28
Normal strat. only	A	29.5	62.0	63.0	63.0
Strat. + post-strat.	B	27.0	62.5	63.0	63.0
Strat. + post-strat. + strat.	C	*63.0	63.0	63.0	63.0
Strat. + dry-freeze + strat.	D	41.0	52.5	53.0	53.0

Pseudotsuga menziesii (Douglas fir)

Treatment		Days in Germinator 7	14	21	28
Normal strat. only	A	33.0	76.5	83.0	86.0
Strat. + post-strat.	B	56.0	79.0	81.0	82.0
Strat. + post-strat. + strat.	C	70.5	84.5	84.5	84.5
Strat. + dry-freeze + strat.	D	66.0	85.5	86.0	86.5

* Approximately 0.5% of the seed germinated in the cooler and was removed before the seed was tested.

REFERENCES

1. Danielson, H.R. 1972. Quick-tests for determining viability of Douglas fir seed. Presented to the Joint Meeting of the Western Forest Nursery Council and the Intermountain Forest Nurseryman's Association, Olympia, Washington, August 8-10-1972.
2. DeLong, S.K. 1982. Stratification of seed at Brown Seed Company. Unpublished.
3. DeLong, S.K. 1984. Double stratification of Douglas fir and noble fir seed. Unpublished.
4. Edwards, D.G.W. 1980. A new prechilling method for true fir seeds. 1980. Paper presented at Joint Meeting of Intermountain Nurseryman's Association and Western Forest Nursery Council. Boise, Idaho, August 1980.

NEW IDEAS IN THE USE OF PLUG SYSTEMS

GARY P. HARTNETT

Skagit Gardens
1719 Old Highway 99 South
Mount Vernon, Washington 98273

The development of the seedling plug is one of the major advances in the bedding plant industry in the last decade. As more growers have recognized the potential of plugs, demand has been created for improved seeding equipment, higher quality seed, and more advanced environmental controls, as well as more efficient methods of handling plug flats and plugs. This is a brief overview of those advances.