Seed Germination of Giant Sequoia

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Germination trials with giant sequoia seed samples show that long stratification periods (≥ 60 days) and an overnight soak in distilled water prior to stratification promote rapid germination at relatively high rates.

Giant sequoia trees *(Sequoiadendron giganteum* (Lindl.) Buch.) were "officially discovered" in the mid-1850's. Since then, their awesome beauty, massive size, and extreme old age (Only bristlecone pine is known to live longer.) have inspired hundreds of writers and planters in many parts of the world.

The species is little used for wood products, but sequoias are widely planted as ornamentals. In fact, they are some of the largest trees in Europe *(6).* Sequoias are grown to a limited extent for Christmas trees in the United States, and recently, favorable reports on wood quality (*4*) and growth rate (*3, 8, 10*) have sparked new interest in their potential use for timber. Since 1974, I have sent sequoia seed to foresters in Germany, New Zealand, Canada, China, Yugoslavia, and many places in the United States. In most cases, those foresters were unfamiliar with procedures for handling sequoia seed. Some information is available, but some of it is conflicting, and little, if any, mention is made of source-related differences. For example, Beetham (*1*) found 22.54 percent average germination with seeds from ground collections in 42 natural giant sequoia populations. Hartesveldt and others (*7*) considered 35 percent to be a representative figure. Schubert (*9*) reported 8 percent and 46 percent germination for giant sequoia seeds that had been stored at 5° C for 14 and 13 years respectively, stratified in a mixture of moist sand and peat moss for 60 days at 2.2° C, and germinated in a greenhouse at temperatures from 12.8 to 23.9° C. Beetham (1) reported that "exposure of Sequoia seeds to temperatures of +1.6° C for several months does not damage the seeds," but noted that no conclusion on stratification requirements could be made because many seeds were exposed to winter conditions in the green cones after they mature. Johnson[2] suggested stratifying the seeds for 7 days.

In our own early germination trials, using samples from 26 populations, we used no stratification. The first germinants appeared after approximately 2 weeks and continued steadily for about 1 month. In some samples, new germinants appeared even after 4 months. Seven-day stratification produced similar results.

For experimental and/or production purposes, such a wide spread in germination time and wide variation in germination percents are unacceptable. We felt it was important to develop reliable procedures for achieving rapid and high germination.

The main purposes of the work reported here were to compare the effects of short and long stratification periods on germination rates and percent germination, and to determine the extent to which population differences contribute to variability in seed germination.

Collections

In the summer and fall of 1974, 1975, and 1976, we collected squirrel-cut cones in 34 of the approximately 73 natural populations of giant sequoia. A total of 434 single-cone collections were used for studies of population variation (*5*). Larger bulked collections from some of those populations were used in the germination studies reported here.

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[2]Personal communication. LeRoy Johnson, U.S. Department of Agriculture, Forest Service, Institute of Forest Genetics, Placerville, Calif.

Materials and Methods

Seeds were placed in Seedboro germination blotters on fine sand in petri dishes, moistened with distilled water or with a solution of Captan[3] at 1 tablespoon per gallon of water, and stratified at 2.2 to 2.8° C. A seed was considered germinated if the radicle extended beyond the seedcoat by 1 millimeter or more. Numbers of germinants were recorded at 2- to 3-day intervals. All percent data were transformed to arcsine for the analysis of variance.

Stratification Test

This experiment was designed as a three-way factorial using eight stratification periods (0 to 91 days), two population samples (Mountain Home and Garfield), and a Captan and no-Captan treatment, with two replications of 100 seeds each per treatment. All seeds were parceled at the beginning of the experiment, randomly assigned to different stratification periods, and kept in dry cold storage, until they were sequentially stratified. just prior to stratification, packets of seeds were soaked overnight in distilled aerated water. All seeds were removed from stratification on the same day, and incubated at 22.5° C with 12 hours of fluorescent light and 12 hours of darkness (*2*).

Results. Average germination after 5 weeks was 37.8 percent (table 1). The two population samples were significantly different from one another in final germination percent, but the effects of Captan and of different stratification periods were not statistically significant (table 2). There were clear differences, however, in rates of germination among treatment groups, with 0- and 7-day stratifications resulting in slower germination rates than the longer stratification periods (figs. 1 and 2). Captan treatments appeared to slow germination slightly, but final germination percents were not affected (figs. 1 and 2).

Bubbler Experiment

Samples of 100 seeds from each of five populations were soaked overnight in aerated water. A second set of 100 seeds from each of the populations was not soaked. Both groups were treated with Captan and stratified at 2.8° C for 25 days, after which they were moved to a laboratory bench, covered with a burlap cloth, and incubated at ambient air temperature.

Results. Average germination after 5 weeks was 22.9 percent (table 3). Differences between populations were significant (table 4, P = .005). Average germination of the soaked seeds was 127 percent of the controls. For each of the five samples tested, the soaked seeds germinated faster and in higher percentages than the nonsoaked seeds (fig. 3). The near, but nonsignificant P-value (P = .059) for these differences between the groups suggests a real effect.

Relationship Between Seed Weight and Germination Percent

Beetham (*1*) reported that exceptionally large seeds germinated 154.13 percent of the controls (random seeds from five seed sources) while smaller ones germinated 6.9 percent of the controls. Our samples were similar to Beetham's in that light-seeded samples germinated at 43 percent of the average and heavy-seeded samples germinated at 109 percent of the average in 284 samples from 26 populations. However, the most successful germination occurred with seed samples whose weight was close to the overall mean.

Recommendations

The studies presented here suggest that fast and relatively high germination percents may be obtained with giant sequoia seeds with an overnight soak in aerated water followed by a long stratification period (at least 60 days). Treatment with Captan may slow germination slightly, but does not seem to affect final

[3]Captan 50-W, Stauffer Chemicals. Active ingredients: 50 percent Captan (N-(trichloromethyl)thio)-4-cyclohexene-1, 2-dicarboximide), 50 percent inert. Microfine wettable powder.

Table 1.—*Stratification test—average percent germination after 5 weeks by population sample, stratification period, and Captan treatment*

		Population sample		
Stratification period (days)	Captan treatment	Mountain Home	Garfield	$\bar{X}$
0	Captan	39.5	28.0	33.8
	No Captan	38.0	33.5	35.8
7	Captan	42.0	38.0	40.0
	No Captan	36.0	30.0	33.0
49	Captan	39.5	36.0	37.8
	No Captan	38.0	41.0	39.5
56	Captan	39.5	37.5	38.5
	No Captan	45.0	39.0	42.0
63	Captan	37.5	34.5	36.0
	No Captan	43.0	34.5	38.8
70	Captan	35.5	32.0	33.8
	No Captan	43.5	36.0	39.8
77	Captan	41.0	38.0	39.5
	No Captan	47.0	29.0	38.0
91	Captan	45.0	31.5	38.3
	No Captan	41.5	40.5	41.0
Mean	Captan	39.9	34.4	37.2
	No Captan	41.5	35.4	38.8
Overall average		40.7	34.9	37.8

Table 2.—*Analysis of variance 1: Stratification test*

Source	df	MS	F	P
Main effects				
Stratif. period	7	9.4	0.8	.54
Population samples	1	189.7	17.6	.0002
Captan	1	9.5	0.9	.35
First order interactions				
Stratif. x samples	7	6.5	0.6	.75
Stratif. x Captan	7	11.3	1.1	.42
Samples x Captan	1	0.5	0.04	.84
Second order interactions				
Stratif. x sample x Captan	7	13.7	1.3	.29
Within	32	10.8		

germination percent of seeds stratified for long periods. Large differences in germination percents can be expected between populations. Seeds may be sorted by weight, and light seeds should be sown at twice the sowing rate of the average-weight seeds to compensate for their expected lower germination percent.

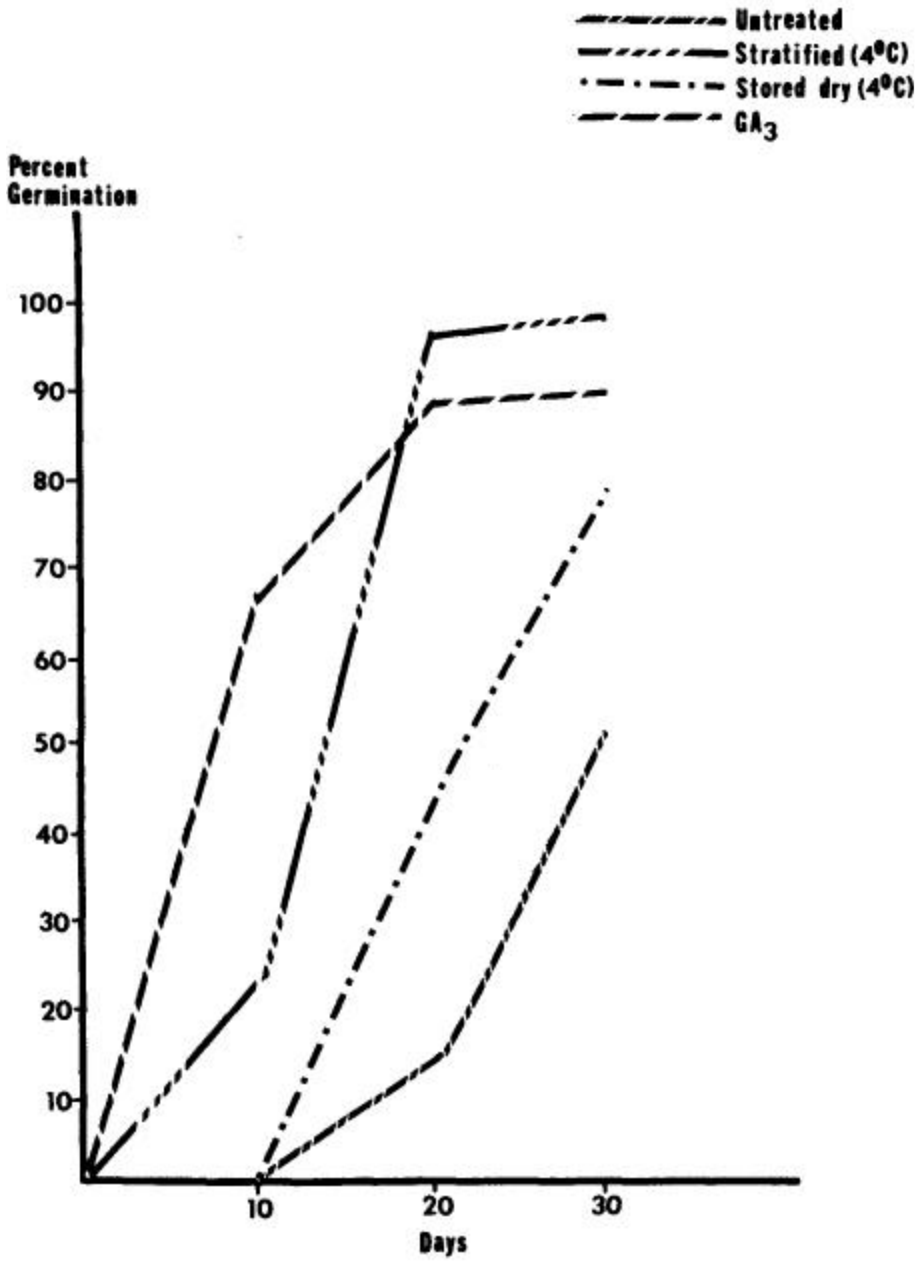

Figure 1.—*Stratification test-average percent germination of two population samples over time by stratification period. Captan-treated.*

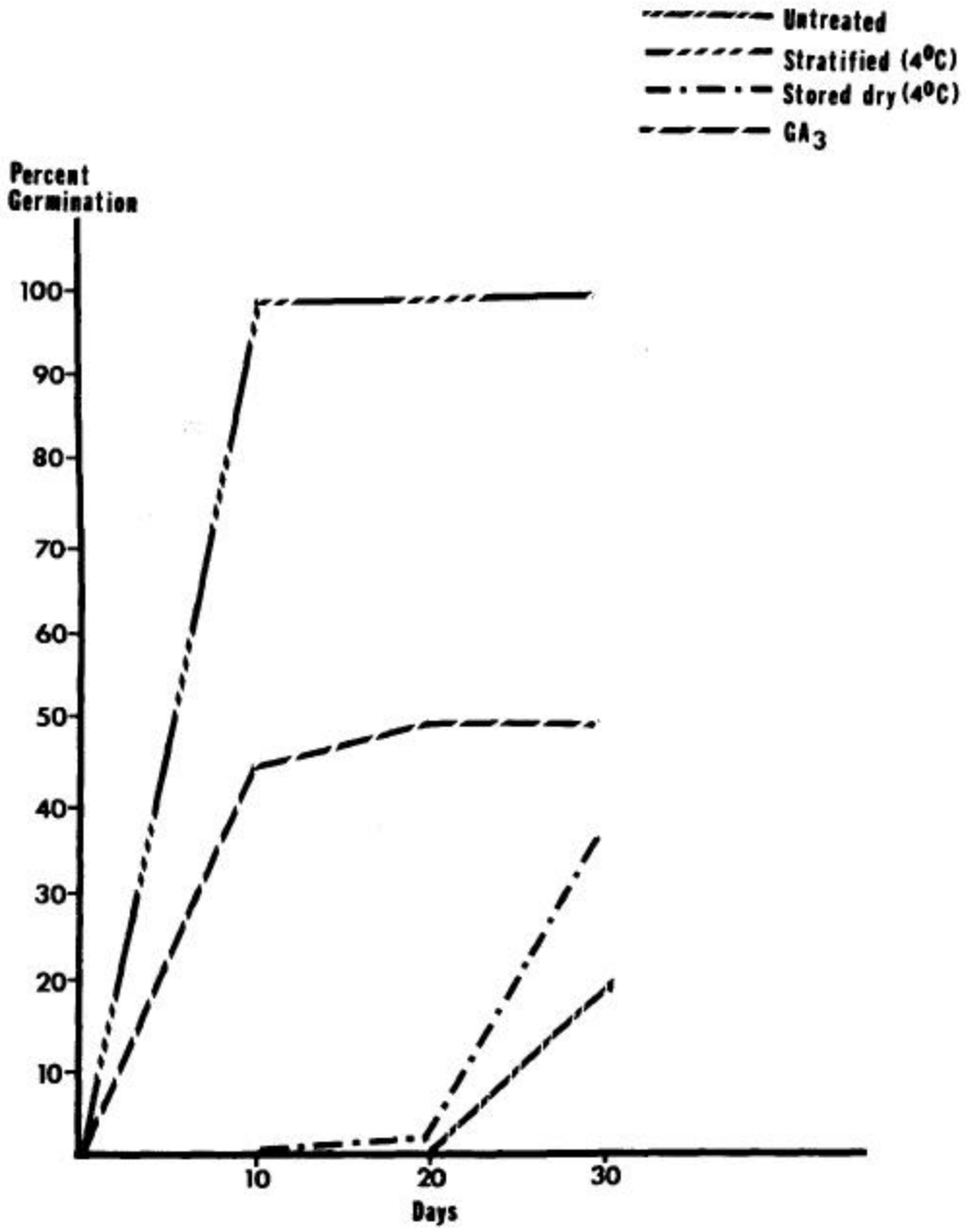

Figure 2.—*Stratification test—average percent germination of two population samples over time by stratification period. Without Captan.*

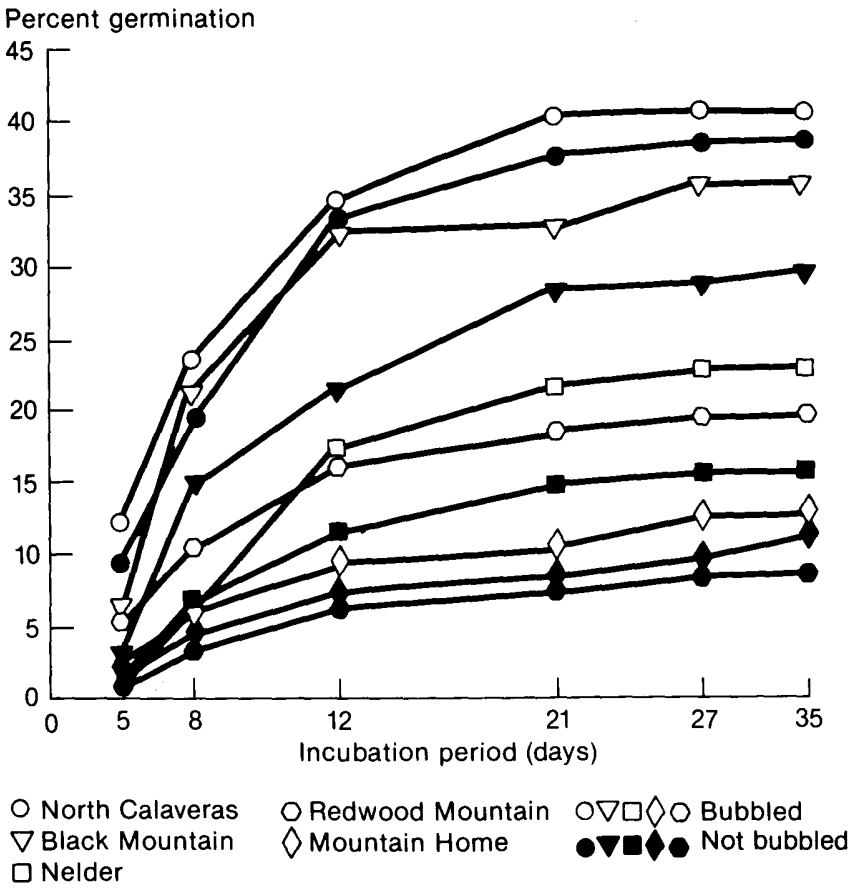

Figure 3.—*Bubbler experiment—percent germination by population samples for bub- bled and nonbubbled seeds.*

Table 3.—*Bubbler experiment-percent germination after 5 weeks by population sample and by bubbler treatment*

Population sample	Bubbled	Not bubbled	Mean
Black Mountain	35	29	32.0
Mountain Home	12	11	11.5
North Calaveras	40	38	39.0
Nelder	22	15	18.5
Redwood Mountain	19	8	13.5
Average	25.6	20.2	22.9

Table 4.—*Analysis of variance 2: Bubbler experiment*

Source	df	MS	F	P
Bubbler treatment	1	41.4	6.9	.059
Population samples	4	137.7	22.8	.005
Residual	4	6.0		

Literature Cited

1. Beetham, N. M. 1962. The ecological tolerance range of the seedling stage of Sequoia gigantea. Ph.D. thesis. Duke Univ., 135 p. Univ. Microfilms, Inc., Ann Arbor, Mich.
2. Boe, K. N. 1974. *Sequoiadendron giganteum* (Lindl.) Buch. Giant Sequoia. In Seeds of Woody Plants in the United States. U.S. Dep. Agric., Agric. Handb. 450.
3. Burns, T., Jr. 1970. Man and the Giant Sequoia in the Willamette Valley of Oregon. Proc. of the Oreg. Acad. of Sci., 1970. p. 37-45. Univ. Oreg.
4. Cockrell, R. A., R. M. Knudson, and A. G. Stangenberger. 1971. Mechanical properties of southern Sierra old- and second-growth giant sequoia. Calif. Agric. Exp. Stat. Bull. 854.
5. Fins, L. 1979. Genetic architecture of giant sequoia. Ph.D. dissertation. Dep. For. and Conserv., Univ. of Calif., Berkeley.
6. Hartesveldt, R. J. 1969. Sequoias in Europe. Final contract rep. to the Natl. Park Serv. Contract no. 14-10-0434-3364.
7. Hartesveldt, R. J., H. G. Harvey, H. S. Shellharnmer, and R. V. Stecker. 1975. The giant sequoia of the Sierra Nevada. U.S. Gov. Print. Off. 180 p.
8. Huth, H. 1976. Sequoias in Germany. J. For. Hist. 20(3):143-148.
9. Schubert, G. H. 1952. Germination of various coniferous seeds after cold storage. U.S. Dep. Agric., For. Serv., Pac. Southwest For. and Range Exp. Stn., Res. Note 83.
10. Cook, N.W., and D.T. Dulitz. 1978. Growth of young sierra redwood stands on Mountain Home State Forest. Calif. Dep. For., State For. Notes 72, 5 p.