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Substrate and Temperature Tests for Germination of Atlantic White-Cedar Seeds

A. Bianchetti, R. C. Kellison, and K. O. Summerville

Seed technologist/visiting scholar, North Carolina State University; professor of forestry, North Carolina State University; and staff forester, Technical Development and Planning, North Carolina Division of Forest Resources, Raleigh, North Carolina

Experiments were conducted to evaluate temperatures and substrates for Atlantic white-cedar— Chamaecyparis thyoides *(L.) B.S.P.— seed germination. Seeds placed in petri dishes kept in germination chamber were tested at constant temperatures of 23 ºC (73 ºF) and 26 ºC (79 ºF) and at alternating temperatures of 20/30 ºC (68/86 ºF). Substrates tested were sand, vermiculite, and blue blotter. Best results were obtained with blue blotter under an alternating temperature regime*. Tree Planters' Notes 45(4):125-127; 1994.

Atlantic white-cedar— *Chamaecyparis thyoides* (L.) B.S.P— is an evergreen conifer usually found in small, dense stands in freshwater swamps, bogs, bays, and pocosins, on stream banks, and along lake shores. Although Atlantic white-cedar occurs primarily on the lower Coastal Plain, its range extends from Maine to Florida and west to Mississippi. It has been extensively logged, and its habitat has been so altered by human intervention that the species has lost much of its former abundance (Laderman 1989). Efforts to recolonize Atlantic white-cedar have only partly succeeded because of its poor seed germination and variable seedling development. To help overcome these obstacles, different temperatures and substrates were tested for germination of white-cedar seeds.

Materials and Methods

A bulked sample of Atlantic white-cedar seeds was furnished for the tests by the North Carolina Division of Forest Resources in Raleigh, North Carolina. Seeds in the sample were taken from 5 trees in each of 10 stands covering the range of Atlantic white-cedar in North Carolina. The seeds (including inert material) had been cold-stored for 15 months in a room at 3 to 5 ºC (37 to 41 ºF). The seedlot was manually cleaned, and light seeds were separated from heavy ones using a Dakota blower. Separation produced a 20% yield of heavy (viable) seed, a typical yield for the species. Light (nonviable) seeds were discarded, and heavy ones were pre-imbibed in water at room temperature (20 ºC, or 68 ºF) for 18 hours before treatment was begun.

Experiments were conducted with warm/ cold stratification to break seed dormancy, and without stratification (as a control). Tests with and without stratification were run separately, because the germination chamber was too small to accommodate all treatment combinations. Stratification was performed by placing petri dishes containing wet seeds in the germination chamber at 20 ºC (68 ºF) for 7 days, and then transferring them to another chamber at 5 ºC (41 ºF) for 7 days.

The treatments used for the trials consisted of combinations of three substrates (vermiculite, sand, and blue blotter) with two constant temperature regimes (23 ºC, or 73 ºF, and 26 ºC, or 79 ºF) and one alternating temperature regime (20/30 ºC, or 68/86 ºF). Under the alternating temperature regime, seeds were kept at 20 ºC (68 ºF) for 16 hours during the night, and at 30 ºC (86 ºF) for 8 hours during the day.

Four replications of 50 seeds per treatment were used for the germination trials. The experimental design was a completely randomized block containing 9 plots each for the stratified and nonstratified treatments, arranged in a 3-by-3 factorial (3 substrates x 3 temperature regimes), for a total of 18 treatments. Differences among means were determined by the Tukey test.

The germination period was determined to be 28 days, with counting done at 7-day intervals beginning on day 14, when the first germinants were observed. For a seed to be counted as a germinant, its cotyledon had to completely emerge above the substrate.

Results and Discussion

No stratification. Results from the trial without stratification (table 1) show that blue blotter was the best substrate at both 23 ºC (73 ºF) and 26 ºC (79 ºF), producing significantly ($P < 0.05$) higher germination than either sand or vermiculite. Under the alternating

Table 1 -*Germination of nonstratified Atlantic white-cedar seeds under three temperature regimes on three substrates*

	Percentage germination		
Temp.(°C)	Blue blotter	Vermiculite	Sand
23	11 Ba	8 Bbc	10 Bb
26	13 Ba	6 Bb	6 Cb
20/30	34 Aa	35 Aa	33 Aa

Note: Values followed by the same letter do not differ significantly ($P < 0.05$), according to the Tukey test. Uppercase letters (A, B, C) compare values by substrate (within columns); lowercase letters (a, b, c) compare values by temperature regime (within rows).

temperature regime, there was no significant ($P < 0.05$) difference in germination rates among substrates, but alternating temperatures produced much higher germination rates than either of the constant temperature regimes. Similar results were found by Okoro (1976) for *Terminalia ivorensis* seeds, which are similar in size to white-cedar seeds.

Stratification. Results from the trial with stratification (table 2) show no significant ($P < 0.05$) difference in germination rates among substrates under any given temperature regime, and no significant ($P < 0.05$) difference in germination rates under the two constant temperature regimes, regardless of substrate. But for all three substrates, alternating temperatures produced much higher germination rates than the constant temperature regimes.

In both experiments, an alternating temperature regime and (to some degree) a higher constant temperature increased seed germination on the blue blotter. Moreover, warm/ cold stratification produced about 10% more germination (averaged across all substrates and temperatures) than did nonstratification. Similar results were found by Bianchetti and others (1993) when white-cedar seeds were pretreated in water at 40, 60, 80, and 100 ºC (104, 140, 176, and 212 ºF) for 18 hours and then prechilled at 5 ºC (41 ºF) for 14 days, or warm-stratified at 20 ºC (68 ºF) for 7 days and then prechilled for an additional 7 days. These results suggest that white-cedar seeds respond promptly to temperature changes. Although all three substrates produced about the same rate of germination under the alternating temperature regime, blue blotter is recommended because it is inexpensive, requires no covering layer of substrate over the seeds, and contrasts with the dark brown color of the seeds, allowing them to be easily counted and spaced. Sand and vermiculite are more difficult to handle and usually require a thin covering layer of substrate over the seeds. Sand is preferable to vermiculite because it contrasts with the seeds in color, causing fewer mistakes in, assessing germination and spacing seeds in the germinator box.

Table 2 -*Germination of stratified Atlantic white-cedar seeds under three temperature regimes on three substrates*

	Percentage germination		
Temp. (°C)	Blue blotter	Vermiculite	Sand
23	16 Ba	16 Ba	16 Ba
26	19 Ba	20 Ba	19 Ba
20/30	41 Aa	38 Aa	41 Aa

Note: Values followed by the same letter do not differ significantly ($P < 0.05$) according to the Tukey test. Uppercase letters (A, B, C) compare values by substrate (within columns); lowercase letters (a, b, c) compare values by temperature regime (within rows).

Conclusions

This study found that:

- Poor germination of Atlantic white-cedar seeds is linked to the high proportion of empty seeds and inert material found in seedlots. The 80:20 ratio of nonviable to viable seeds found here is typical of the species.
- Stratification improves germination, regardless of temperature and substrate, but improvement is only marginal.
- Different substrates (sand, vermiculite, and blue blotter) produce no significant differences in germination, but blue blotter is recommended because it is less expensive and easier to use.
- For both stratified and nonstratified seeds, alternating temperatures of 20 / 30 ºC (68 / 86 ºF) produce higher germination rates than constant temperatures of 23 ºC (73 ºF) and 26 ºC (79 ºF). A higher constant temperature produces marginally better results than a lower constant temperature.

Further studies are needed to determine how to accelerate and increase seed germination using alternating temperature regimes.

Address correspondence to Robert Kellison, North Carolina State University, Hardwood Research Cooperative, Box 8002, Raleigh, NC 27695.

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