Soaking in Cold Water Replaces the Stratification Requirement of True Cedar Seeds

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There is an increasing demand from growers for seeds to be of the highest vigor possible, with the ability to emerge rapidly, uniformly, and to a high level. Seed priming (soaking in salt, osmoticum, or water solutions) can accelerate germination and seedling establishment. This technique is a well-established practice for some horticultural crops (Parera and Cantliffe, 1994) and forest trees (Struve et al., 1991). True cedars (*Cedrus* sp.) are common forest trees in the Mediterranean basin and are also widely used as ornamental trees in Europe, the United States, and other countries. Seeds of true cedars usually require stratification for 2 weeks to improve germination (Heit, 1968). Since the stratification period must be accompanied by adequate water uptake (Bonner et al., 1989), we examined whether soaking true cedar seeds in cold water could reduce or replace their stratification requirement.

Fresh seeds (one lot) of *Cedrus deodara* (D. Don.) were obtained from Setropa Ltd., Bussum, The Netherlands. Seeds were stored dry at 4 °C and used for the experiments within 4 months after collection. Seeds were soaked in aerated water solutions in 9-L polystyrene containers; an airstone placed on the bottom of the containers supplied air at a rate of 1.5 L·min⁻¹. The rate of airflow was controlled by flowmeters. One hundred seeds were placed in a net bag floating in the water and were soaked in the dark for 2 d at 4 or 19 °C. Additional seeds were stratified in moist vermiculite at 4 °C for 2 weeks. To determine emergence, seeds were sown in vermiculite in germination trays placed in a growth chamber under the following con-

ditions: 16 h light (130 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ at the surface of the medium) and temperature of 22 °C light/18 °C dark.

Soaking seeds in water at 4 °C for 2 d accelerated seedling emergence and somewhat increased the final percent emergence as compared with stratification (Fig. 1). Of particular interest is the more uniform emergence obtained by cold soaking; maximum emergence was obtained after 19 d, whereas emergence of seedlings from stratified seeds increased gradually during the entire experimental period (28 d). The response to cold soaking probably reflected the combined effects of low temperature and uptake of water, as soaking was much more effective at 4 °C than at 19 °C. Aeration of the treatment solutions was essential, since without aeration emergence was low (data not presented).

The data show that soaking *C. deodara* seeds in aerated water at low temperature

mainly improved the uniformity of seedling emergence. Uniform emergence is necessary to reduce the period of susceptibility to certain diseases, improve crop uniformity, and increase seedling size. Cold soaking increased the final emergence percentage only slightly above that of stratified seeds. However, this effect was consistent in all the experiments performed (Fig. 1 and two additional experiments not presented), and may also be beneficial due to the low germination rates ($\approx 50\%$) of true cedars, primarily because of low viability (Bonner et al., 1989). Cold soaking also stimulates germination of *C. atlantica* seeds (Siaki, 1999). Results in this and previous studies suggest that cold soaking can replace stratification completely in seeds that require a short period of stratification, but only partly in seeds with longer stratification periods (Janerette, 1979).

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Fig. 1. The effect of seed pretreatment on the emergence of *C. deodara* seeds. The pretreatments were: aerated solution for 2 d at 4 °C (■), aerated solution for 2 d at 19 °C (□), stratification for 14 d at 2 °C (▲), no pretreatment (△). Mean separation by chi square at $P \leq 0.05$ is presented for the final emergence percentage.

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