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Seedling cold hardiness, bud set, and bud break in nine provenances of *Pinus greggii* Engelm.

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Abstract

Cold hardiness and timing of bud set and bud break are important processes that provide protection of nursery seedlings against low temperatures. Seedlings of 9 provenances of *Pinus greggii* from two different regions of Mexico were tested to determine cold hardiness, bud set, and bud break timing differences. Needle sections were exposed to freezing temperatures to determine an injury index of each provenance. In addition, bud set and bud break timing were recorded through the fall, winter and spring. There were significant differences in cold hardiness between seedlings from northern and southern provenances. At the maximum cold hardiness, the index of injury (LT_{50}) for northern provenances was $LT_{50} = -18$ °C, compared to -12 °C for southern provenances. There was a considerable variation among the provenances in the proportion of seedlings that set terminal buds. Seedlings from northern provenances had greater proportions of seedlings that set a terminal bud than seedlings from southern provenances. There were also significant differences in the bud break timing in the following spring among the 9 provenances. Seedlings from northern provenances broke bud earlier than southern provenances. Cold hardiness, bud set, and bud break timing results may be useful to determine how far a specific seed source can be moved from its natural environment.

Keywords: Frost tolerance; Nursery production; Reforestation; Phenology; Genotypic variation

1. Introduction

Differences in susceptibility to cold temperatures are often present in species that show a wide geographic distribution (Flint, 1972; Kuser and Ching, 1980; Alexander et al., 1984; McCamant and Black, 2000). Seedlings from northern provenances or higher elevation typically tolerate low temperatures better than seedlings from southern provenances or low elevation (Kuser and Ching, 1980; Thomas and Lester, 1992). Cold hardiness is an important factor related to the physiological condition of the seedlings (Johnson and Cline, 1991). Knowledge of seedling cold hardiness status can be valuable when protecting seedlings against low temperatures not only in the nursery but also after outplanting (Mexal et al., 1979; Glerum, 1985).

Cold hardiness also has been found to be related to bud set and bud break of some conifers (Kuser and Ching, 1980; Burr et al., 1989). Bud set and bud break are two precise phenological events in conifers (Hannerz, 1999) in response to the environmental conditions and this response is under strong genetic control (Ekberg et al., 1991). Both bud set and bud break can be used for screening clones and progenies in tree breeding programs (Hannerz, 1999).

Pinus greggii Engelm. occurs in natural stands in two widely separated regions of Mexico. These northern and southern populations of *P. greggii* are exposed to different environmental conditions. Trees from northern populations grow above 2200 m a.s.l., receive less than 800 mm in average annual precipitation, while the average annual temperature is about 14 °C. On the other hand, the southern populations usually grow at elevations below 1900 m a.s.l., receive more than 800 mm/yr, and in some places greater than 1200 mm, with an average annual temperature near 17 °C. Northern populations usually grow on sites with neutral to slightly alkaline pH while southern populations prosper in more acidic soils (Donahue,

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