

# 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  $LT_{50} = -18^{\circ}\text{C}$ , compared to  $-12^{\circ}\text{C}$  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.

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## 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  $14^{\circ}\text{C}$ . 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  $17^{\circ}\text{C}$ . 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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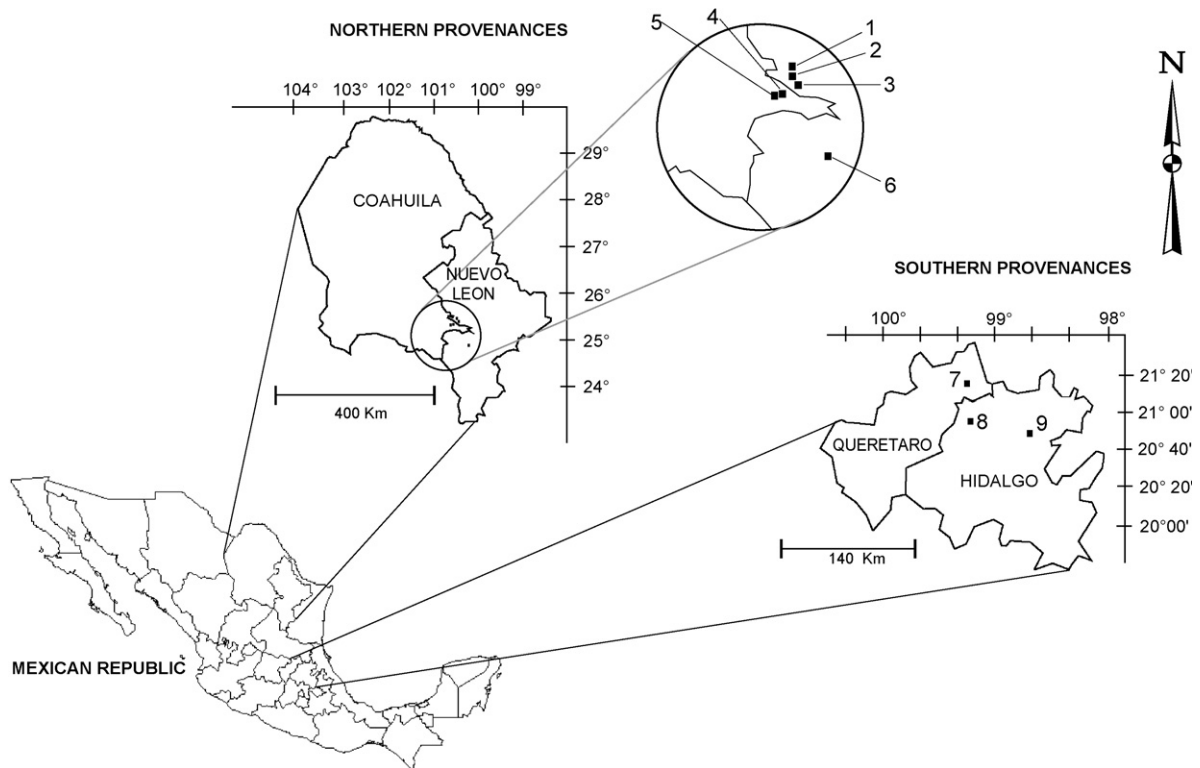


Fig. 1. Geographic location of the northern region (states of Coahuila and Nuevo Leon) provenances (1: Jamé, 2: Los Lirios, 3: San Juan, 4: Santa Anita, 5: El Conejo, and 6: Las Placetas) and southern region (states of Hidalgo and Querétaro) provenances (7: El Madroño, 8: El Piñon, and 9: Xochicoatlán).

1993). The great difference in environmental growing conditions between the two regions has influenced some morphological, physiological, and phenological traits in this species not only in adult trees but also in seedlings (Dvorak et al., 1996). The overall objectives of this study were to evaluate the variation of cold hardiness, bud set, and bud break in seedlings from 9 different provenances of *P. greggii*.

## 2. Materials and methods

### 2.1. Seed sources

*P. greggii* seed was collected in 1995 from two different regions of Mexico and stored for 3 years at 4 °C. The first region was located in the northern part of Mexico in the states of

Coahuila and Nuevo Leon, while the other is in the southern part in the states of Querétaro and Hidalgo (Fig. 1). The northern region included six provenances (Jamé, Los Lirios, San Juan, Santa Anita, El Conejo, and Las Placetas) while the southern region included three provenances (Xochicoatlán, El Piñon, and El Madroño) (Table 1).

### 2.2. Seedling production

Seedlings were produced at the Fabian Garcia Science Center at New Mexico State University (latitude 32°22', longitude 106°43'). The experiment was established in a greenhouse where 9 provenances were compared. Seedlings were grown in plastic propagation trays (Tray Master TM 060, The Lerio Corp, Mobile, Alabama), and each plastic tray

Table 1  
Geographic location, elevation, and annual precipitation of the 9 provenances of *Pinus greggii* included in the study

Provenance	Code	State	Latitude	Longitude	Elevation (m a.s.l.)	Precipitation (mm)
<b>Northern</b>						
Jamé	1	Coahuila	25°21'N	100°36'W	2500–2600	<800
Los Lirios	2	Coahuila	25°22'N	100°32'W	2300–2600	<800
San Juan	3	Coahuila/N.L.	25°25'N	100°32'W	2450–2650	<800
Santa Anita	4	Coahuila/N.L.	25°27'N	100°34'W	2500–2600	<800
El Conejo	5	Coahuila/N.L.	25°28'N	100°34'W	2500–2600	<800
Las Placetas	6	Nuevo Leon	24°54'N	100°12'W	2400–2500	<800
<b>Southern</b>						
Xochicoatlán	7	Hidalgo	20°45'N	98°40'W	1800	1200
El Piñon	8	Hidalgo	20°54'N	99°11'W	1800–1900	800
El Madroño	9	Querétaro	21°14'N	99°13'W	1650–1840	1200

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