From Forest Nursery Notes, Winter 2009

92. © Genetic variation in frost damage and seed zone delineation within an altitudinal transect of *Pinus devoniana* (*P. michoacana*) in Mexico. Saenz-Romero, C. and Tapia-Olivares, B. L. Silvae Genetica 57(3):165-170. 2008.

Genetic Variation in Frost Damage and Seed Zone Delineation within an Altitudinal Transect of *Pinus devoniana* (*P. michoacana*) in Mexico

By C. SÁENZ-ROMERO[1)] and B. L. TAPIA-OLIVARES

Instituto de Investigaciones Agropecuarias y Forestales,
Universidad Michoacana de San Nicolás de Hidalgo (IIAF-UMSNH)
Km 9.5 Carr. Morelia-Zinapecuaro, Tarimbaro Michoacan 58880, Mexico

(Received 18th January 2007)

Abstract

We explored the patterning of genetic variation among *Pinus devoniana* Lindl. (also known as *P. michoacana* Martínez) populations to develop guidelines for seed and seedling movements, intended for improving the matching between genotypes and environments regarding frost tolerance, in reforestation programs. Open-pollinated seed from 16 populations along an altitudinal transect (1600 to 2450 m) were collected near Morelia, State of Michoacán, México. A common-garden provenance test, established with 2.5-year-old seedlings, was assessed for frost resistance conducting a laboratory frost damage test (–9 °C). Results indicate that there were significant differences among provenances ($P = 0.0261$) for frost damage. Variation among provenances was structured as an altitudinal cline, with populations from lower altitudes being the least tolerant to frost. Linear regression statistics suggest that for each increment of 100 m of provenance altitude, there will be a 5.2% decrease in frost damage. We suggest the use of two provisional altitudinal seed zones of 400 m breadth each (lower and upper limits for zone 1: 1600 m and 2000 m of altitude; for zone 2: 2000 and 2400 m, respectively), and for reforestation of a given site, the use of seedlings originated from seed of the same seed zone or within ±200 m of altitude from the elevation of the reforestation site.

Key words: Pinus devoniana, Pinus michoacana, altitudinal genetic variation, provenances, frost damage, frost hardiness, seed zoning, seed and seedling movement guidelines.

Introduction

Frost damage is one of the main causes of poor growth and mortality of seedlings in reforestations using pine species in México (BELLO-LARA and CIBRIÁN-TOVAR, 2000; SÁENZ-ROMERO *et al.,* 2003). Frost damage accounts for the 14% of mortality in reforestations in the Mexican western State of Michoacán (SÁENZ-ROMERO and LINDIG-CISNEROS, 2004). Frost damage also causes reduced growth and poor stem form (ANEKONDA and ADAMS, 2000). Occurrence of frost damage in provenance tests or field plantings is an indication of lack of compatibility between the genotype of the tree and the climate of the planting site (development is out of phase with the environment). Thus, prevention of frost damage requires better matching between genotypes and environments.

Studies on conifer species in the Rocky Mountains have shown that populations are genetically differentiated along altitudinal gradients, with populations from lower altitudes having less frost hardiness than populations from higher altitudes (CAMPBELL, 1979; REHFELDT, 1985, 1988, 1989, 1991). It is expected that such patterns will occur in Mexican pines distributed along mountain systems. However, such patterns are generally unknown for Mexican pines. In order to appropriately match seedling genotypes (regarding frost hardiness) and environmental conditions of the sites to be reforested, and thus to increase survival and seedling growth in the reforestation zones, one needs to know the patterning of genetic variation among populations along altitudinal gradients for Mexican pine species. If such pattern is known, then it is possible to delineate seed zones, as guidelines for deciding seed and seedling movements within and among regions in reforestation programs, and thus to improve the matching between genotypes and environments (REHFELDT, 1983a, 1983b; SÁENZ-ROMERO, 2004a; SÁENZ-ROMERO, 2004b; SÁENZ-ROMERO *et al.,* 2006). At present, the patterns of variation in *P. devoniana* are not known and empirically based seed zones do not exist in Mexico.

There is evidence of correlation between seedling response to artificially-induced frost damage in laboratory conditions and seedling response to frost damage in field conditions, with an average genetic correlation of 0.85 (AITKEN and ADAMS, 1997; O'NEILL, 1999). Also, there are strong correlations ($r^2 > 0.90$) between results using visual injury scoring (a technique with an unavoidable component of subjectivity) and results using more objective techniques for injury assessments, such as electrolytic conductivity (SHORTT *et al.,* 1996) or chlorophyll fluorescence (BINDER *et al.,* 1997).

Pinus devoniana Lindley (also known as *Pinus michoacana* Martínez) has a natural distribution confined mostly to México (the states of Nayarit, Zacatecas, Jalisco, Colima, Michoacán, Hidalgo, Mexico, Puebla, Morelos, Guanajuato, Tlaxcala, Guerrero, Oaxaca, Veracruz, and Chiapas), and in Guatemala (the departments of Totonicapán, Quiche, Quetzaltenango, Chimaltenango, Sacatepequez, and Guatemala), in pine-oak and pine forest, in pure stands or mixed with *Pinus montezumae*, *P. pseudostrobus* and *P. oocarpa* (PERRY, 1991; FARJON and STYLES, 1997). Near Morelia, capital of the State of Michoacán, western México, the species occurs between 1600 m to 2450 m of altitude on the Neovolcanic Axis slopes, mixing with *P. oocarpa* at the lower limit of the altitudinal distribution and with *P. pseudostrobus* at the higher altitudes.

[1)] Corresponding author: Phone/Fax +(52)(443) 295-8323 and 295-8324. E-mail: csaenz@umich.mx.