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Growth and frost damage variation among *Pinus pseudostrobus*, *P. montezumae* and *P. hartwegii* tested in Michoacán, México

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Abstract

To study the variation in growth traits, survival, and frost damage between four taxa, *Pinus pseudostrobus* typical (represented by four provenances) and its variety *P. pseudostrobus* var. *apulcensis* (two provenances), *Pinus montezumae* (two provenances) and *Pinus hartwegii* (one provenance), seeds of stands of natural distribution were obtained in the States of Michoacan, Puebla, Hidalgo and Veracruz, Mexico. Provenances were evaluated at two field sites located in forests of the Native Indian Community of Nuevo San Juan Parangaricutiro, Michoacan, at contrasting altitudes of 2200 and 2800 m. Evaluations made when seedlings were between 15 and 27 months old, indicate that there were large differences in initial growth and in frost damage between the taxa: typical *P. pseudostrobus* was the species with the largest growth although also the one of the largest percentage of frost damage; *P. pseudostrobus* var. *apulcensis* shows both intermediate total height and frost damage with respect to typical variety and to *P. montezumae* and *P. hartwegii*. Height growth of *P. montezumae* and *P. hartwegii* was lower than the growth of typical *P. pseudostrobus* and the *apulcensis* variety, although they presented the lowest percentage of frost damages. In order to reforest sites at Purépecha Plateau in Michoacan, it is suggested to use typical *P. pseudostrobus* on sites relatively free from frost occurrence, and to use *P. montezumae* on sites with frost occurrence. It is not recommendable to use *P. pseudostrobus* var. *apulcensis* (susceptible to frost occurrence and not having the best growth rate) or *P. hartwegii* (with the lowest survival rate). *P. pseudostrobus* var. *apulcensis* is a distinguishable taxon of *P. pseudostrobus*, due to its growth characteristics, which support the taxonomic classification according to some authors.

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1. Introduction

Frost damage is one of the main causes of seedling mortality in restoration ecology reforestation made in Mexico (Sáenz-Romero et al., 2003; Bello-Lara and Cibrián-Tovar, 2000). Pine seedling mortality after 1 year of plantation has an average of 62% in the State of Michoacan, western Mexico, and frost damage causes 14% of it; the combined effect of inadequate species selection, drought stress and frost damage causes 46% of mortality (Sáenz-Romero and Lindig-Cisneros, 2004). Frost

damage also causes growth reduction, loss of stem straightness, and increases susceptibility to fungi and other pathogen infections (Alden and Hermann, 1971; Anekonda and Adams, 2000). Thus, the selection of appropriate species and provenances adapted to frost occurrence is a relevant factor to increase seedling survival and growth in reforestation programs. However, it is necessary to select species and provenances adapted to the plantation sites finding an appropriate balance between growth potential and frost resistance, because it has been demonstrated that provenances with greater frost resistance also have less growth potential (Rehfeldt, 1983, 1985; Jonsson et al., 1986).

Pinus pseudostrobus Lindl., *Pinus montezumae* Lamb., and *Pinus hartwegii* Lindl. are three ecologically and economically very important species in the Neovolcanic Axis of central Mexico, due to their relatively large distribution and extended

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