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Original article

Seed germination of montane forest species in response to ash, smoke and heat shock in Mexico

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ABSTRACT

In many fire-prone ecosystems, seed germination is triggered by heat shock, smoke, ash and charred wood. However, few studies concerning the effect of these fire products on the germination of tropical and subtropical species exist. We assessed the effect of fire products and their interactions on seed germination in 12 species that frequently grow in burned areas of pine–oak and mixed forest in a mountainous subtropical area. Each species was exposed to a predetermined treatment of heat shock, which was optimised in accordance with a previous study. For smoke treatments, seeds were immersed in smoke water, whereas for ash treatments, 1.5 g of ash was added to the incubation medium. Germination increased in 92% of the species in response to the products of fire. Both the smoke water and the ash treatments promoted germination in four species that had permeable seed covers and physiological dormancy. Six species with physical dormancy required both heat shock and smoke water or ash to break dormancy. Our results indicate that seed germination response to fire products depends on the species and/or dormancy type. The germination response to the fire products varied between species; therefore, fire products may influence the species composition in post-fire regeneration.

1. Introduction

Environmental disturbances that modify conditions such as light, moisture, temperature and the chemical environment affect seed germination in many ecosystems (Baskin and Baskin, 2001; Fenner and Thompson, 2005). Because fire modifies all these factors, it frequently affects germination, especially in the seasonal environments of Mediterranean areas and temperate forests (Whelan, 1995; Keeley and Fotheringham, 2000). In fire-prone areas, germination is triggered by fire products such as high temperatures, plant-derived smoke, ash and charred wood (Keeley and Fotheringham, 2000; Van Standen et al., 2000). Combinations of these fire products influence germination, and their effects on seeds can be internal (chemical) or external (physical) (Van Standen et al., 2000). For example, heat disrupts the impermeable seed covers, thereby facilitating water uptake in the seed and promoting subsequent germination (Keeley and Fotheringham, 2000). Fire breaks physical dormancy, which is the most common type of dormancy in the soil seed bank (Baskin and Baskin, 1989; Keeley and Fotheringham, 2000). Most species in fire-prone plant communities display increased germination percentages after seed exposure to heat shock treatments between 80 and 120 °C for short periods of time, but higher temperatures and/or long exposure times can be lethal (Auld and O'Connell, 1991; Rivas et al., 2006; Zuloaga-Aguilar et al., 2010).

Seed germination induced by smoke is common in plants (Keeley and Fotheringham, 2000; Van Standen et al., 2000; Adkins and Peters, 2001). The positive effect of fire products on germination is an important tool for the conservation and restoration of plant communities (Read et al., 2000; Flematti et al., 2004) because fire products favour high seedling establishment and may increase species diversity (Read et al., 2000; Wills and Read, 2002; Enright and Kintrup, 2001). However, high smoke concentrations can inhibit germination for some species (Dixon et al., 1995; Wills and Read, 2002). The effect of smoke on seed germination is internal; Keeley and Fotheringham (1997) propose that smoke may modify the semipermeable cuticles by increasing their permeability to solutes. It is not yet clear which smoke-active component stimulates germination. Studies have proposed that the active component is either NO_x (Keeley and Fotheringham, 1997; Preston et al., 2004; Flematti et al., 2004; Kulkarni et al., 2007) or the butenolide 3 methyl-2H-furo (2,3-c) pyran-2-one (Flematti et al., 2005). In

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