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Germination of Three Native *Lupinus* Species in Response to Temperature

Abstract

Understanding germination requirements of native species is an important component of restoration in south Puget Lowland prairies (Washington, USA). We conducted an experiment to determine the effects of pre-germination treatment and germination temperature conditions on the proportional germination of three species of *Lupinus*. For one species, *Lupinus lepidus*, germination was highest following heat shock treatments to the dormant seed, suggesting adaptation to the high temperatures associated with wildfire. For a more widespread species, *Lupinus polyphyllus*, high heat treatments had no effect, and germination was mildly higher in a temperature sequence simulating winter chilling followed by cool, diurnally alternating temperatures. For a final intermediate species, *Lupinus albicaulis*, responses to germination temperatures were dependent on high-heat treatments. These data suggest interspecific variation in germination cues where these *Lupinus* species are influenced differentially by environmental conditions in both breaking of physical dormancy and the promotion of germination. Our results have the potential to improve the establishment of these species from seed in restoration. Specifically, there may be implications for the timing of manual seed sowing and the efficacy of seed establishment following exposure to fire in south Puget Lowland prairies.

Introduction

Studies that identify environmental limitations to seed germination in ecologically important native plants have the potential to significantly improve efficacy of ecological restoration in disturbed ecosystems (Primack 1996, Baskin and Baskin 1998, Seabloom et al. 2003, Corbin and D'Antonio 2004, MacDougall and Turkington 2006). In grassland ecosystems in particular, seed limitations may be important in controlling native species abundance (Turnbull et al. 2000, Foster and Tilman 2003, Zeiter et al. 2006, Clark et al. 2007, Stanley et al. 2011). Therefore, determining germination response cues for native species may be especially important in developing holistic restoration strategies in prairie ecosystems.

Restoration efforts in south Puget Lowland prairies (WA, USA) have taken a number of steps to re-establish native flora in a landscape heavily invaded by non-native plants (Stanley et al. 2008). However, plans to significantly expand the scale of restoration efforts highlight the need to test seed germination requirements of native plants under simulated natural conditions (Thomas and Carey 1996, Dunwiddie et al. 2006). Useful germination protocols have already been established for some important taxa native to these prairie ecosystems (Drake et al. 1998, Kaye and Kuykendall 2001). However, species in the genus *Lupinus* (Fabaceae) remain poorly understood in terms of germination cues.

Members of the genus *Lupinus* are especially important to restoration efforts because they have symbiotic associations with nitrogen-fixing bacteria. This allows them to play unique roles as arbiters of soil nitrogen dynamics in native plant communities following disturbance. For example, *Lupinus lepidus* Dougl. ex Lindl. represents the most abundant herbaceous plant on new volcanic substrates following the eruption of Mount St. Helens where it plays a major role in shaping plant community structure (del Moral and Rozzell 2005). Species in the genus *Lupinus* are also known for unique pollinator relationships with arthropods (especially Hymenoptera and Lepidoptera) and they have been vital in the conservation of endangered species in western Oregon and Washington prairies (e.g., Wilson et al. 2003, Schultz et al. 2011).

The conditions inducing germination in hard-seeded native plants in the genus *Lupinus* can be complex. Germination in the family Fabaceae is often a two-stage process starting with the breaking of physical dormancy followed by actual germination. Physical dormancy is dormancy provided by hard seed coats that do not allow the seed to absorb water and is especially common in Fabaceae. Van Assche et al. (2003) found that temperature fluctuations involving a chilling to 5 to 10 °C for six weeks followed by alternating day/night temperatures of 15 °C and 7 °C increased germination

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