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RESEARCH PAPER

Effects of smoke, heat, darkness and cold stratification on seed germination of 40 species in a cool temperate zone in northern Japan

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ABSTRACT

The effects of smoke, heat, darkness and cold stratification on seed germination were examined for 40 species with various life history attributes. These species establish in early successional stages on a volcano and are distributed in cool temperate zones of northern Japan. Smoke decreased seed germination in 11 species and increased it in one species, *Leucothoe grayana.* Germination of *Polygonum longisetum* was enhanced by a combination of smoke and cold, and that of *Aralia elata* by smoke and heat. Heat increased germination for three species and decreased it for one. Cold stratification broke dormancy in seeds of 11 species. Continuous darkness decreased germination of 22 species and did not increase germination for any species, showing that approximately half of the species require light for maximum germination. Although most species are sun plants that establish in early stages of succession and/or in disturbed areas, smoke and heat do not enhance germination of these species after disturbance, even when the disturbance is fire. Germination of slender and/or large seeds tends to be decreased more by smoke, probably because of their larger surface area. Light is more important than smoke and heat for detection of disturbance and for seed germination in this region. However, despite the low fire frequency in the region, germination of a few species was increased by fire-derived stimuli.

INTRODUCTION

Plants are negatively affected by many types of stress and disturbance at every life history stage, but particularly at the seed to seedling stage (Silvertown & Lovett Doust 1993). Therefore, several seed dormancy and germination strategies have evolved that optimise plant establishment. Of the evolutionary strategies, seed dormancy is stimulated or released by diverse exogenous and endogenous factors such as light, chilling, warm stratification, temperature fluctuation, gibberellins and other hormones (Baskin & Baskin 1998; Finch-Savage & Leubner-Metzger 2006). Furthermore, smoke-induced seed germination, which was first reported from the South African fynbos in 1990 (Lange de & Boucher 1990), has now been reported from other Mediterranean climate regions subject to frequent wildfires, that is, South Africa, Western and Southern Australia (Dixon *et al.* 1995; Merritt *et al.* 2006), California (Keeley & Fotheringham 1998), and the central Mediterranean area (Perez-Fernandez & Rodriguez-Echeverria 2003). Prior to the discovery of smoke-induced seed germination, heat had been considered the primary factor influencing seed germination in fire-prone regions. In fact, heat and smoke are important triggers of seed germination in fire-prone regions (Enright & Kintrup 2001; Tieu *et al.* 2001). In contrast, smoke-induced germination has not been reported from cold, cool or warm temperate regions where natural wildfires are also common, for example, Alaska and Siberia.

In 2006, on the island of Hokkaido, northern Japan, which is in a cool temperate zone, there were 31 wildfires that affected a total of 75 ha (HGJ 2007); most of these were extinguished by fire fighters. One of the fires resulted from a lightening strike, 16 were from human