Prairie Seed Response to Smoke Cues

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Abstract

It is well known that fire plays a large role in the maintenance of the tallgrass prairie ecosystem. Fire helps maintain species richness and discourages the growth of invasive species. Many species of prairie plants are adapted to periodic fire. Heat is required for the germination of seeds of some prairie species such as *Iliamna remota* (Chasan and Hart 1996) as well as for seeds in other fire-prone ecosystems. Smoke stimulates germination in California chaparral, the South African fynbos, and Western Australian scrub (Brown et al. 2003; Keeley and Foteringham 1998; Morris 2000), but the effect of smoke on prairie seeds had not previously been investigated. This study treated the seed of 23 prairie species with aerosol smoke for varying lengths of time to identify which species were stimulated by smoke. The results were mixed; some species experienced increased or decreased germination percentages and others were unaffected. The results of this study may benefit conservation and restoration efforts, as well as, the horticultural trade.

Introduction

During pre-European settlement, the predominant ecosystem in Illinois was tallgrass prairie. Today, less than 0.07 percent of the prairie remains in the state (Bowles et al. 2002). Most losses are due to development and agriculture, but some prairie has been lost because of fire suppression. The tallgrass prairie in Illinois was historically maintained by periodic burning. Fire plays an important role in the prairie ecosystem because it maintains species diversity, keeps out invasive cool season grasses, changes nutrient cycling and pH, and increases net primary productivity (Bowles et al. 2002; Seastedt 1988).

Seeds of chaparral species from Australia, South Africa, and California that also experience frequent burning and periods of drought have been shown to respond to smoke with increased germination percentages (Keeley and Foteringham 1998; Thomas et al. 2003). Recently, the bioactive compound in smoke that promotes germination in responsive taxa was isolated and determined to be butenolide (Flematti et al. 2004). The purpose of this study was to investigate whether smoke inhibited, stimulated, or had no effect on the germination of prairie species.

Methods

Seeds of 23 native prairie species from the Asteraceae, Asclepidaceae, Caryophyllaceae, Commelinaceae, Fabaceae, Laminaceae, Onograceae and Poaceae families were exposed to aerosol smoke for periods of 0, 1, 10, and 60 minutes. Dried prairie vegetation was burned to generate smoke using a beekeeper's smoker (Figure 1). Smoke was pumped through a plastic hose into a 20 gallon glass container.

Four replicates of 25 seeds were then sown in a pre-moistened soil-less germination mix, covered with vermiculite, and grown under ambient light. Water was provided by a mist sprinkler system. The seedlings were counted every 2-3 days for three weeks and seedlings were removed after each count to facilitate future counts.

Seed viability was determined using the cut test on 100 seeds of each species. Filled seeds with healthy, white endosperm were considered viable. Viability adjusted germination (VAG) was determined as follows:

VAG = (total number of seedlings per treatment*4) / mean percentage of viable seed

Data Analysis

The data were arcsine transformed to ensure normality. Differences in VAG between smoke treatments were analyzed using one-way ANOVA. Tukey's test was employed to determine differences between means.

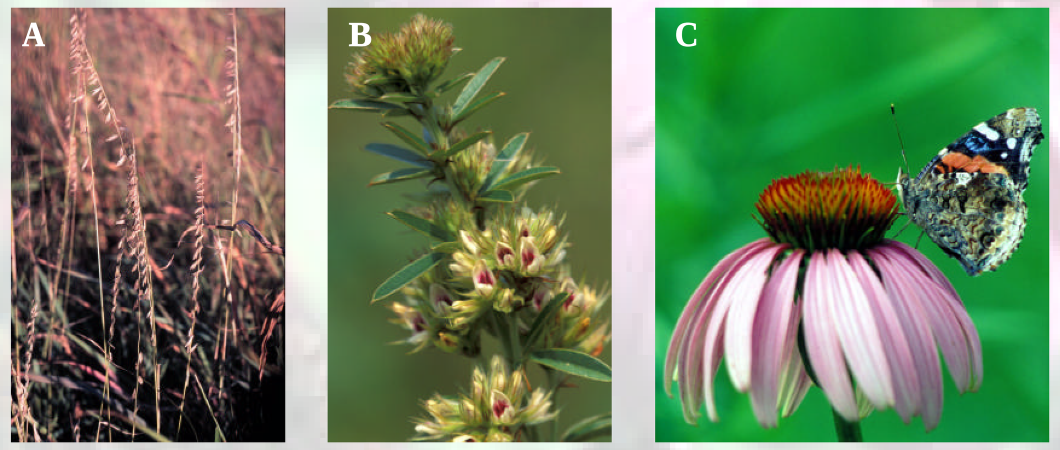
Figure 1. Smoke set-up (A) and germination trays (B).

Results

Twelve of the 23 species tested showed significant differences among treatments (Table 1; Figure 2). Five of the six Echinacea species showed significant increases in germination after being exposed to smoke (Fig. 2A). Two other taxa in the Asteraceae family also responded positively to smoke: *Coreopsis lanceolata* and *Solidago rigida* (Fig. 2A). In addition, *Lespedeza capitata* (Fabaceae; Fig. 2B) and *Bouteloua curtipendula* (Poaceae; Fig. 2C) showed significant increases in germination after being exposed to smoke. *Silene regia* (Caryophyllaceae), *Monarda fistulosa* (Laminaceae) and *Epilobium glandulosum* (Onograceae) experienced a significant decrease in germination in response to smoke (Fig. 2D).

Table 1. Response of species to smoke treatment.

Family	Species	Response	P value (Sig.)
Asclepiadaceae	*Aclepias tuberosa*	0	0.14
Asteraceae	*Coreopsis lanceolata*	+	**0.01**
Asteraceae	*Echinacea angustifolia*	+	**0.01**
Asteraceae	*Echinacea atrorubens*	0	0.09
Asteraceae	*Echinacea pallida*	+	**0.01**
Asteraceae	*Echinacea paradoxa*	+	**0.02**
Asteraceae	*Echinacea purpurea*	+	**0.002**
Asteraceae	*Echinacea tennesseensis*	+	**<0.001**
Asteraceae	*Rudbeckia hirta*	0	0.34
Asteraceae	*Solidago rigida*	+	**<0.001**
Caryophyllaceae	*Silene regia*	-	**0.01**
Commelinaceae	*Tradescantia ohiensis*	0	0.46
Fabaceae	*Amorpha canescens*	0	0.56
Fabaceae	*Baptisia australis*	0	0.28
Fabaceae	*Dalea purpurea*	0	0.66
Fabaceae	*Lespedeza capatata*	+	**<0.001**
Laminaceae	*Monarda fistulosa*	-	**0.04**
Laminaceae	*Pycnanthemum pilosum*	0	0.22
Onograceae	*Epilobium glandulosum*	-	**0.002**
Poaceae	*Andropogon gerardi*	0	0.26
Poaceae	*Bouteloua curtipendula*	+	**0.03**
Poaceae	*Hystrix patula*	0	0.57
Poaceae	*Sorghastrum nutans*	0	0.08



Bouteloua curtipendula (A), *Lespedeza capatata* (B), and *Echinacea angustifolia* (C), all respond positively to smoke.

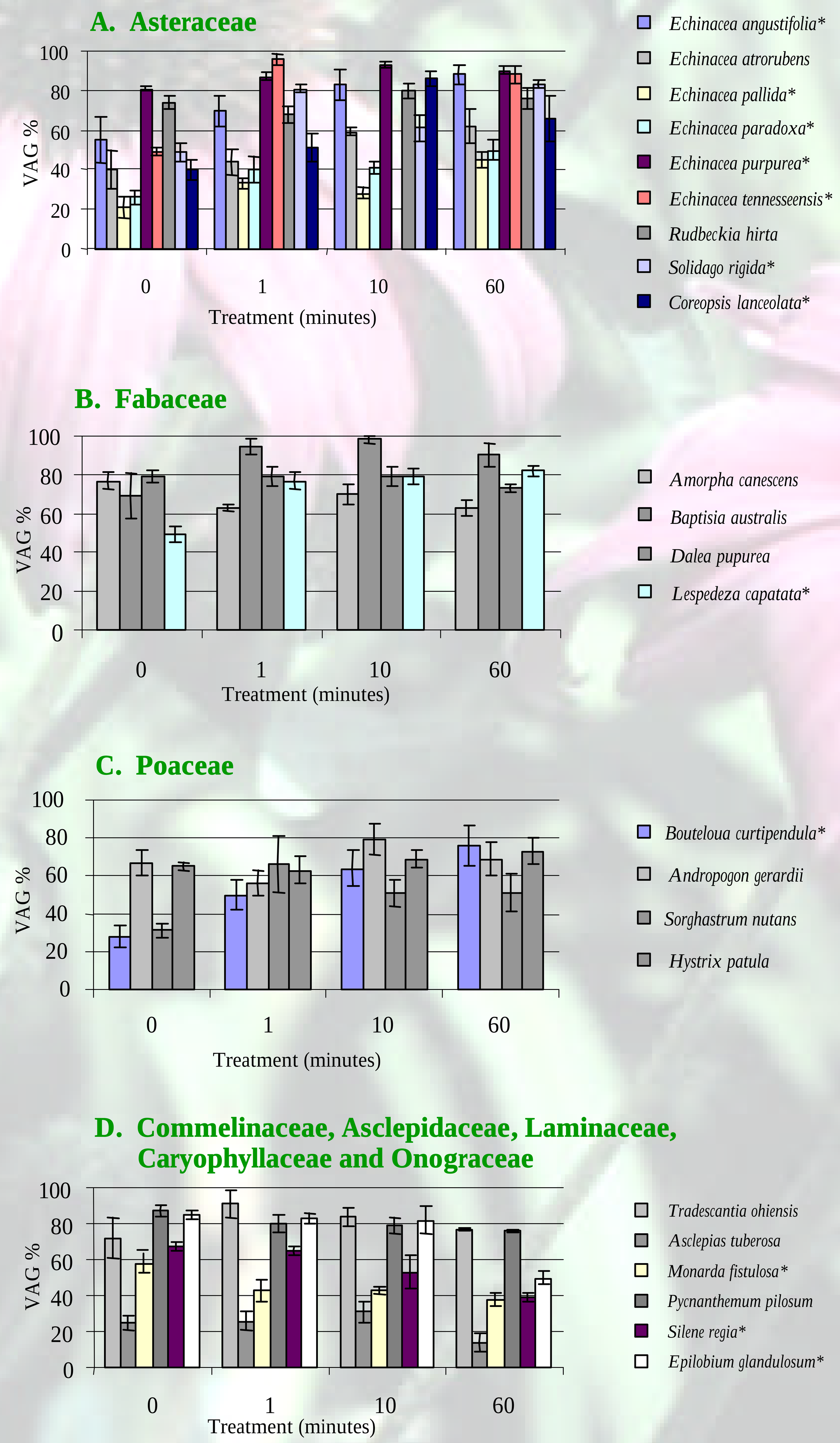


Figure 2. Mean viability adjusted germination (VAG) of taxa from Asteraceae (A), Fabaceae (B), Poaceae (C), and Commelinaceae, Asclepidaceae, Laminaceae, Caryophyllaceae and Onograceae (D) after aerosol smoke treatment over periods of 0, 1, 10, and 60 minutes. Bars represent standard error. Star (*) indicates a significant response to smoke.

Discussion

It has long been assumed that the only kind of stratification prairie seeds require for germination is cold stratification because prairie plants are adapted to long, cold winters. However, our results showed a clear connection between the presence of smoke and germination success for some prairie species. There were differing results among families and genera which makes broad generalizations about a smoke response impossible. We found nine species that were positively affected by the addition of smoke. Prairie species may have adapted to germinating after fire because of the advantage of germinating with less competition. Germinating after a fire ensures seedlings have access to sunlight as perennials recover and the litter is removed (Bowles et al 2002).

There are several distinct prairie types that are subject to different natural fire regimes. Prairie types that experience frequent high-intensity fires may have more species that are smoke responsive. We are continuing to investigate the relationship of community fire regime and species smoke responsiveness.

The results of this study have implications for prairie restoration efforts as well as the horticulture trade. Restoration seeding projects would be more effective and reliable with the increased seed germination. Economically, nurseries would benefit because more plants could be grown for sale with the same amount of seed.

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