Effects of Smoke on Prairie Seed Germination

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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 10 species and 3 hybrid cultivars of prairie plants with aerosol smoke for varying lengths of time to identify species 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 both restoration efforts and the horticultural trade.

Introduction

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). The effects of heat on seed germination have been well studied and it has been known to stimulate germination of some prairie species by cracking the seed coat. One by-product of fire that has not been studied in the prairie is the effect of smoke on seed germination. 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 is 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 seeds.

Methods

Seeds of 10 native prairie species from the Asteraceae, Asclepidaceae, Commelinaceae, Fabaceae, and Poaceae families and 3 *Echinacea* hybrids 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. Treatment times started when the seeds were covered with a thick, dark layer of smoke and could no longer be seen from the outside of the glass container. The hose from the smoker was over a meter long to ensure the smoke cooled before reaching the seeds.

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

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 to avoid washing smoke from the seeds. 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)/predicted germination from viability tests

The data were arcsin 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.

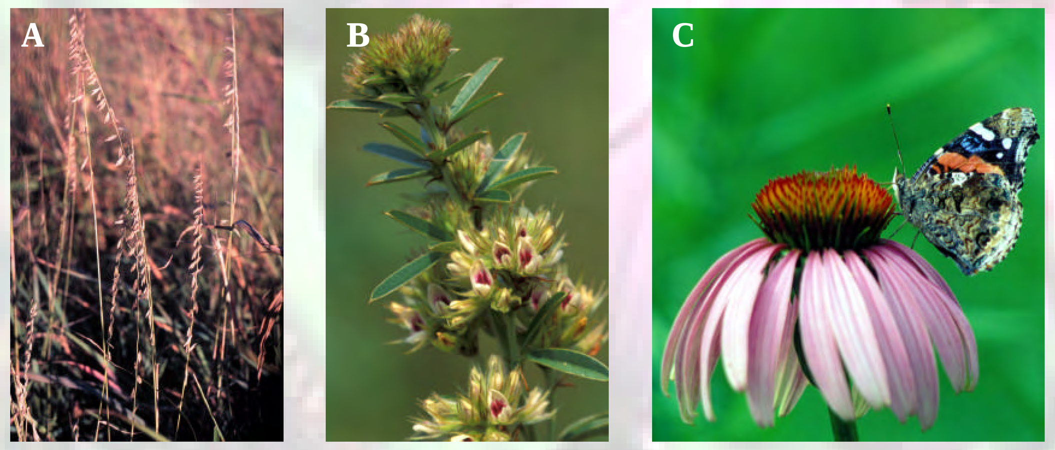
Table 1. Response of species to smoke treatment.

Family	Species	Response	P value (sig.)
Asclepiadaceae	*Aclepias tuberosa*	-	0.14
Asteraceae	*Echinacea* hybrid 1*	+	0.13
Asteraceae	*Echinacea* hybrid 2**	-	**<0.001**
Asteraceae	*Echinacea* hybrid 3***	+	**0.02**
Asteraceae	*Echinacea angustifolia*	+	0.06
Commelinaceae	*Tradescantia ohiensis*	0	0.46
Fabaceae	*Amorpha canescens*	-	0.56
Fabaceae	*Baptisia australis*	+	**0.05**
Fabaceae	*Dalea purpurea*	0	0.66
Fabaceae	*Lespedeza capatata*	+	**<0.001**
Poaceae	*Andropogon gerardi*	+/-	0.26
Poaceae	*Bouteloua curtipendula*	+	**0.03**
Poaceae	*Sorghastrum nutans*	+	0.17

*Hybrid 1 = E. purpurea x [[purpurea 'White Swan' x "White Flowered"] x paradoxa]

**Hybrid 2 = [E. purpurea x [purpurea x laevigata hybrid]] x [[purpurea x laevigata hybrid] x E. purpurea]

***Hybrid 3 = [E. purpurea x [purpurea x laevigata hybrid]] x [[purpurea 'White Swan' x "White Flowered"] x paradoxa]



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

Results

Five of the 13 species tested showed significant differences among treatments and five additional species showed definite trends in germination. (Table 1; Figure 2). *Lespedeza capitata, Echinacea* hybrid 3, *Baptisia australis*, and *Bouteloua curtipendula* showed significant increases in germination after being exposed to smoke. *Echinacea* hybrid 2 experienced a significant decrease in germination in response to smoke. While not statistically significant, the germination of several species increased with shorter exposure to smoke but decreased after extended exposure.

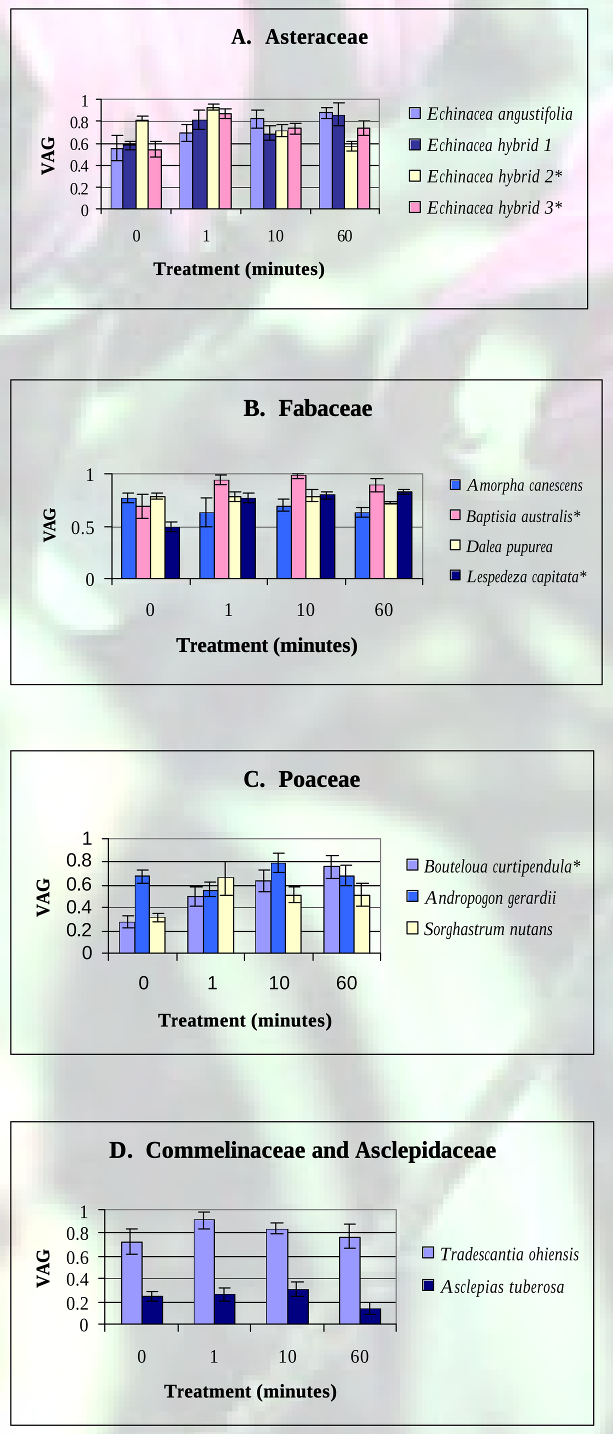


Figure 2. Mean viability adjusted germination (VAG) of taxa from Asteraceae (A), Fabaceae (B), Poaceae (C), and Commelinaceae and Asclepidaceae (D) after aerosol smoke treatment over periods of 0, 1, 10, and 60 minutes. Bars represent standard error. Star (*) indicates a significant response to smoke.

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 three species that were positively affected by the addition of smoke. An additional five species showed a positive trend in germination. 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. For example, in a similar study we found germination of *Echinacea purpurea* (a woodland edge species) decreased while germination of *Echinacea pallida* and *E. paradoxa* (characteristic of mesic and dry prairies) increased in response to smoke (Forsberg et al. unpublished data). 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.

Acknowledgements

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