Effects of plant derived smoke solutions on seed germination of forages

Y. Abu, J.T. Romo, Y. Bai

Department of Plant Sciences, College of Agriculture and Bioresources, University of Saskatchewan, 51 Campus Drive, Saskatoon, SK, S7N 5A8

Key Words: smoke solutions, forages, germination, dormancy breaking, wheat straw

Abstract

The effects of aqueous plant-derived smoke solutions on the germination of 10 native and tame forages were tested under laboratory conditions. Smoke solutions were produced by slowly burning wheat straw or prairie hay and bubbling the smoke generated through distilled water. Smoke dilution alone had a neutral effect on the germination of *Astralagus cicer* when compared to the control ,but it reduced germination of *Trifolium ambiguum.*Smoke dilution interacted with light on the germination of *Elymus angustus, Stipa comata, Festuca hallii, Stipa viridula, Dactylis glomerata, Agropyron dasystachyum,* and *Agropyron smithii.* Smoke dilution also interacted with temperature to affect germination in *Festuca hallii, Stipa viridula, Dactylis glomerata, Elymus junceus, Agropyron dasystachyum, and Agropyron smithii.* The interaction of temperature and light suggests that smoke may stimulate germination in dormant seeds over a wide range of temperatures and light conditions. Exposing seeds to smoke solutions either partially or fully substituted a light requirement for dormancy breaking in four species and three species respectively. The observed responses in germination provides a better understanding of fire ecology and the role it could play in shaping the structure, composition and restoration of prairies and degraded habitats.

Introduction

Seeds of many grasses and legumes from the Canadian Prairies have dormancy which prevents the germination of viable seeds in otherwise favorable conditions. Smoke can either promote or inhibit germination in plants of fire and non-fire prone ecosystems (Jager et al., 1996; Kulkarni *et al.*, 2007). The active compounds in smoke interact with temperature and light (Brown *et al.*, 1994). The study of smoke as a potential germination stimulant using Canadian species has received inadequate attention. The objective of this study is to evaluate the effects of smoke dilutions on seed germination of selected forages and to determine if such effects depend on fuel type.

Materials and Methods

Seeds of ten forage species were selected for this study because they are known to show seed dormancy and poor seedling vigor. Seeds were stored at 4^{o}C until when needed. Seeds were incubated at $10/0^{\circ}$C and $25/15^{\circ}$C under light/dark (12:12h) and dark (24h) conditions in a randomized complete block factorial experiment. Germinated seeds were counted at defined intervals over a 49 d period. Seed viability was tested by laterally cutting seeds and staining with

0.1% Tetrazolium Chloride (TZ) solution (Grabe, 1970) for 18 hours at room temperature. Staining patterns and intensity of coloration were observed upon which viability was interpreted (Hampton *et al.*, 1999). Seeds were assumed viable if they stained evenly. Smoke solutions were prepared by burning 1.6kg of wheat straw (*Triticum aestivum* cv. Unity) or fescue hay (*Festuca hallii*) in a 75L smoke generator. Air was forced into the can at a pressure of 10-20 psi (KPa) to allow for smoldering and the smoke produced was continuously bubbled into 4L of distilled via a cooling pipe for 30 minutes (Fig.1). Using the stock solution produced, test dilutions were made.

Fig.1: Experiment set up used in the production of aqueous smoke water. Wheat straw or prairie hay (1.6kg) was smouldered in a 75L smoke generator fitted with a ring heater and lid . Air at 10-20 psi was forced into the smoke smoke generator and the smoke produced was passed through a cooling pipe and was bubbled for 30 mins in 4L of distilled water.

Data Collection and Analysis

Germinated seeds were counted at defined intervals over a 49 d period. Data was analysed using factorial ANOVA at $P \leq 0.05$ significance level. Contrast matrix approach was used to compare treatment effects. The mixed model procedure on R statistical software was used.

Results

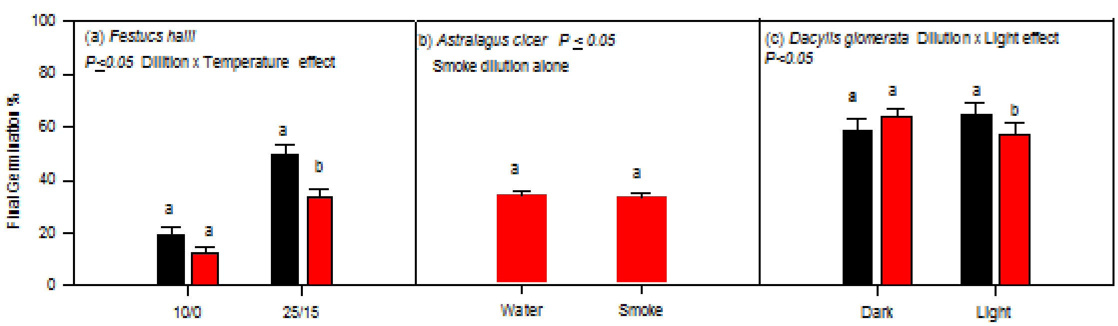

Fig 2: (A) Effects of smoke x temperature interaction on the germination of *Festuca halli* (B) Effects of smoke dilutions alone on the germination of *Astralagus cicer* (C). Effects of smoke x light interaction on the germination of *Dactylis glomerta*..* Dark and red bars in (a) and (c)represent water and smoke treatments respectively . Values are mean ± SE of 4 replicates of 50 seeds each

Discussions

Smoke dilution alone performed at par with distilled water control in *Astralagus cicer* (Fig.2b). This suggests that smoke may have a neutral effect on seed germination. Brown *et al.,* (2003) reported that smoke treatment had no effect on the germination of species of the Amaryllidaceae family.

Smoke interacted with light in *Dactylis glomerata* (Fig 2a). Smoke also interacted with temperature in *Festuca hallii* (Fig 2c) affecting germination and partially substituting for a light requirement in dormancy breaking. The interaction of smoke with light and temperature suggests that smoke may stimulate germination in dormant seeds over a wide range of temperatures and light conditions. The active compounds in smoke interact with temperature and light (Brown *et al.,* 1994).

Exposing seeds to smoke fully substituted for a light requirement in dormancy breaking in *Dactylis glomerata* (shown), *Stipa comata*, *Festuca hallii and Agropyron smithii* and partially substituted for a light requirement in dormancy breaking in *Elymus angustus,Stipa viridula* and *Agropyron dasystachyum.* In a similar study, smoke or butenolide partially replaced the light requirement for germination of seeds of five species of Australian *Asteraceae (*Merritt *et. al.,* 2006).

Conclusions

Smoke effect was not dependent on the two fuel types studied. Smoke has the potential to break seed dormancy and stimulate germination in a species dependent manner. Smoke treatment may promote, inhibit or have a neutral effect on germination. Smoke interacted with light (7 species) and temperature (6 species) to either promote or inhibit germination.

References

Brown, N.A.C., Jamieson, H. and Botha, P.A. (1994) *Plant Growth Regulation* **15**, 93-100.
Brown, N.A.C., Van Staden, J, Daws, M.I., Johnson, T. (2003) South Africa J. Bot **69**, 514–525
Jager, A.K., Rabe, T. and Van staden, J. (1996) *South African J. of Botany* **62**, 282-284
Kulkarni, M.G., Sparg, S.G. and Van staden, J. (2007) *J. of Arid Environments* **69**, 177-187.
Merritt, D.J.,Kristiansen, M., Flematti, G.R., Turner,S.R. and Ghisalberti, E.L,Trengove, R.D. and Dixon, K.W. (2003) *Seed Science Research* **16**, 29 – 35