Enhancing Germination with Liquid Smoke©

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INTRODUCTION

Exposure to smoke has been shown to improve germination of species previously thought to be difficult or impossible to germinate (Dixon et al., 1995). Kings Park and Botanic Gardens in Western Australia have used exposure to smoke to increase the germination of at least 23 native species that do not germinate easily. These include species that had been described as being fire-responsive, suggesting that germination would only occur after exposure to heat from a fire. However, there is evidence that the products of fire rather than the effects of heat may be an important germination stimulatory factor. Keeley and Bond (1997) observed that of 57 species of South African natives from fire-prone areas 44% had increased germination in response to being treated with the products of fire while heat treatments increased germination of only 16% of these species. Only one species, *Heliophila* pinnata, responded positively to both stimuli.

The search for the causal agent has been elusive (Minorsky, 2002; Van Staden et al., 2004). Flematti et al. (2004) reported the discovery of the causal agent, butenolide 3-methyl-2*H*-furo[2,3-*c*]pyran-2-one, as a by-product of combustion. Using the species *Syncarpha vestita* L. (cape everlasting), *Emmenanthe penduliflora* Benth. (whispering bells), and *Lactuca sativa* L. 'Grand Rapids' (Grand Rapids lettuce) each responded with demonstrated activity at very low concentrations, <1 ppb (10^{-9}) of the butenolide compound. Research has confirmed the activity and presence of the butenolide compound in liquid smoke formulations (Goubitz et al., 2003; Perez-Fernandez and Rodriguez-Echeverria, 2003; Kulkarni et al., 2007; Sparg et al., 2006).

Since many of our herbaceous perennial species are native plants and may have been subjected to occasional exposure to wild fire during evolutionary development, perhaps these species would also respond to treatment with liquid smoke. Producing many perennials from seed can be difficult and techniques that may enhance or improve erratic germination of some herbaceous species would be useful to the grower. This is a summary of work to evaluate the use of liquid smoke on the germination of a herbaceous perennial species having erratic germination. Two experiments were conducted in which *Echinacea*, a herbaceous flowering perennial genus exhibiting erratic germination characteristics (7 to more than 21 days) was chosen as the model plant.

Experiment 1. A liquid smoke product was applied using a hand sprayer at the following rates 0 (control), 50, 100, 200, or 400 ml/m^2 to *Echinacea purpurea* seeds sown into 128-cell plug trays. After treatment application, the four replicates were placed under mist. Germination was recorded 7, 9, 12, 16, 19, and 21 days after treatment.

Experiment 2. This experiment examined effect of liquid smoke and/or cold stratification on germination of four *Echinacea* species, *E. pallida*, *E. angustifolia*, *E. tennesseensis*, and *E. purpurea*. Seed treatments included: 1) control (CON), 2) cold stratification (STRAT), 3) liquid smoke application (LS), and 4) cold stratification/liquid smoke application (STRAT+LS). Cold stratification consisted of 20 days at 2 °C (36 °F). Liquid smoke was applied at 100 ml/m^2 as previously described. Germination was recorded daily beginning 8 until 21 days after treatment (DAT) for all species.

Both experiments were repeated and resulting data pooled within each experiment. All data were analyzed using analysis of variance (ANOVA) and if significant means were separated using least significant difference (LSD), *P*=0.05.

RESULTS AND DISCUSSION

Experiment 1. *Echinacea purpurea* germination was positively influenced with liquid smoke treatment. Beginning nine days after treatment (DAT) application, germination was greatest in the 100 ml/m^2 treatment. The 50 and 200 ml/m^2 treatments were similar to both the control and 400 ml/m^2 treatments as well as the optimum 100 ml/m^2 treatment (Table 1).

Experiment 2. *Echinacea purpurea*: Treatments receiving cold stratification had the greatest effect on stimulating germination during the first 11 days of the study. The liquid smoke treatment was similar after 11 days and all treatments were similar after 15 days (Table 1).

Echinacea tennesseensis: Cold stratification treatments produced the fastest germination through the first 17 days. Liquid smoke treatment was similar after 19 days. All treatments produced greater germination percentages when compared to the untreated control (Table 1).

Echinacea pallida: all treatments were similar through day 9. The untreated control and liquid smoke treatments had the greatest germination percentages through the remainder of the study. Cold stratification treatments had an inhibitory effect on germination regardless of liquid smoke treatment (Table 1).

Echinacea angustifolia: There was no differences between treatments throughout the study (Table 1).

In the first experiment the 100 ml/m^2 application rate produced the greatest germination percentages. While the 50 and 200 ml/m^2 treatments were statistically similar, the overall germination rates of these treatments were lower through the first 12 days of the study.

Germination enhancements resulting from liquid smoke application were species dependent for *Echinacea* evaluated in the second study. This result is affirmed through the literature. Roche et al. (1997) reported that germination response to smoke treatment was species specific for 181 native Australian species, while Bachman and Davis (2003) reported species effects among 45 different species of herbaceous ornamentals plants. Freshly collected and aged seed responded positively to liquid smoke application in 70% and 60%, respectively, for studied species (Roche et al., 1997). The high percentage of species responding positively to liquid smoke treatment suggests that the germination stimulant (butenolide 3-methyl-2*H*-furo[2,3-*c*]pyran-2-one) produced during fires may be of a general nature (Keeley and Pizzorno, 1986). This general nature of the germination stimulant could make liquid smoke a valuable tool for the horticultural industry.

The use of liquid smoke has the potential to be a powerful tool for growers to use to enhance the germination of herbaceous perennials having erratic or inconsistent germination. More species screening is required to fully evaluate the use of liquid smoke in the production of herbaceous perennials.

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Table 1. Germination response of *Echinacea purpurea* 'Bravado' to liquid smoke applied at five different rates (ml/m^2) (Kidwell et al., 2001).

	Days After Treatment (DAT)					
	7	9	12	16	19	21
Liquid Smoke Treatment	Germination Percentage (%)					
Control	29a[z]	47b	55b	58b	61ab	61b
50 ml/m^2	40a	57ab	68ab	68ab	71a	71ab
100 ml/m^2	40a	64a	73a	73a	73a	75a
200 ml/m^2	38a	52ab	64ab	65ab	66ab	66ab
400 ml/m^2	34a	45b	56b	56b	57b	59b

[z]Mean separation within columns by Least Significant Difference (LSD), P=0.05.

Table 2. Germination of *Echinacea purpurea* 'Bravado', *E. pallida*, *E. tennesseensis,* and *E. angustifolia* in response to application of liquid smoke and/or cold stratification treatments (Thompson et al., 2002).

	Days After Treatment (DAT)						
Treatment[z]	9	11	13	15	17	19	21
E. purpurea							
Bravado							
Control	6c[y]	25b	45b	62b	75a	78a	85a
LS	16c	69a	75a	76a	78a	81a	82a
Strat+LS	51b	62a	67a	69a	71a	71a	74a
Strat	65a	73a	75a	76a	78a	79a	79a
E. pallida							
Control	46a	78a	85a	88a	88a	92a	94a
LS	45a	78a	88a	88a	89a	89a	90a
Strat+LS	53a	65b	69b	70b	72b	72b	75b
Strat	50a	68b	70b	73b	73b	73b	73b
E. tennesseensis							
Control	2b	20c	33b	41b	47b	49b	51b
LS	4b	24c	44b	61b	73b	80a	82a
Strat+LS	11a	46b	66a	73a	77a	77a	78a
Strat	24a	69a	75a	78a	80a	80a	80a
E. angustifolia							
Control	53a	71a	74a	74a	75a	75a	76a

LS	62a	69a	72a	75a	75a	76a	78a
Strat+LS	66a	74a	73a	74a	75a	75a	78a
Strat	65a	68a	70a	70a	71a	71a	71a

[z]LS, liquid smoke treatment, Strat+LS, cold stratification and liquid smoke treatment, Strat, cold stratification treatment

[y]Mean separation within column and by species by Least Significant Difference (LSD), P=0.05.