PRELIMINARY WORK WITH THE USE OF FIRE TO BREAK SEED DORMANCY IN NATIVE RANGE GRASSES

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Introduction

Seed dormancy may be caused by several factors, including seed coats that limit movement of moisture and or oxygen into the seed, inhibitors that block the germination process, and immature seed that must develop further (after-ripen) before it can germinate. It may be that the seed is designed to survive passage through the digestive tract of some animal, or to age for a long period (overwinter, or over several years), or to be exposed to the effects of fire, before germinating (Copeland and McDonald 1985). Recent work with fire effects on germination have shown increased germination in response to trace gases in smoke, burned soil, and aqueous smoke extracts among several plant species native to areas where fires are part of the ecosystem (e.g., Brown and van Staden 1997, Keeley and Fotheringham 1998). However, overexposure of seed to smoke also can inhibit germination (Brown et al. 1993). Blank and Young (1998) reported enhanced germination of Indian ricegrass and increased rate of leaf expansion in Great Basin wildrye exposed to smoke in a laboratory environment.

Trials conducted in 1999 at the Madras station and at Warm Springs (Sexton et al. 2000) suggested that field burning occurring after the first postplanting irrigation would promote germination of Great Basin wildrye, Indian ricegrass, and needle-and-thread grass. From these trials it also appeared that an ethylene seed treatment had a positive effect on germination of Indian Ricegrass independent of the bum effect. Kentucky bluegrass straw was used as a fuel for the 1999 bum studies and the plots contained a very high number of volunteer bluegrass seedlings, which made counting the desired grasses difficult and contributed to large variation in the data. For this reason the trial was repeated in 2000 using wheat straw rather than bluegrass straw. In the follow-up trial, Idaho fescue replaced Needle-and-thread grass, and a treatment where the seed was exposed to smoke before planting was added to the study. Also a preliminary trial was run where dry seeds were exposed to smoke before from three different fuels to see how smoke from different plant materials would differ in effect on germination enhancement.

Methods

Exposure of seed to smoke

In order to test the efficacy of exposing seed to smoke to promote germination, seeds of Great Basin wildrye and Indian ricegrass were counted out into seedlots of 50 seeds each and subjected to different smoke treatments. A commercial meat/fish smoker (model "Little Chief' Home- Smoker, Luhr-Jensen Inc.) was used to generate smoke from different air-dry plant fuels with the seed placed on a screen at the top of the smoker. Temperature at the point of seed placement was monitored with a data logger (Hobo data logger, Onset Computer Corp., Bourne, MA) and ranged from 86 to 90 ^{o}F. Three different fuels tested were:

1. wheat straw at 0.5, 1.0, 2.0, and 4.0 minutes exposure to smoke;

2. alfalfa hay at 0.5, 1.0, 2.0, and 4 0 minutes exposure to smoke;
3. sage collected from nearby range sites at 0.5, 1.0, 2.0, 4.0, 8.0, 16.0, and 32.0 minutes exposure to smoke.

There were four replicates for each treatment. After the above treatments, the various seedlots, along with an untreated control seedlot, were placed on moist blotter paper in germination trays and put in a germination chamber set at day/night temperatures of 20/10° C. Germination counts were made at 7, 11, 15, 18, 22, 25, and 32 days later. In addition to germination percent, a coefficient of germination speed was calculated (Young and Evans 1977 using the following equation.

$$\text{Coefficient of germination speed} = \sum^{n} ([g_n - g(n\_1)]/n)$$

Where g_n is the accumulated germination on a given day minus the germination percentage of the previous day divided by the total number of incubation days. Data on germination percent were square-root transformed prior to statistical analysis. In order to keep the treatments balanced, the 8-16- and 32-minute exposures for sage were excluded in the analysis of variance, although the means are reported in the table for the reader's information. Initial analysis was conducted as a factorial with both fuel and time of exposure included as main effects. Since there was no interaction of fuel by time, in order to simplify the analysis, the data were reanalyzed with time removed to allow a direct comparison of the fuels used.

Field burning experiment

Seeds of Great Basin wildrye, Indian ricegrass, and Idaho fescue were planted at seeding rates of 45, 90, and 45 seeds/row ft., respectively, on 6 June 2000. Planting depth was 0.25 inches with a row spacing of two feet using a four-row cone planter (Almaco Inc., Nevada, IA). Single row plots, 40 feet long, were used for the experiment. Plots were irrigated with 0.5 inch of water the day after planting and were kept moist for 2 wks after planting.

Two different seed treatments were tested under five different field burning regimes in a factorial design for a total of 15 treatments for each of the three grasses. Seed treatments were:

1. control-no seed treatment;
2. smoke-exposure to wheat straw smoke for 1.0 minutes;
3. ethephon-1 mM.

The ethephon treatment was imposed by placing seed in a beaker and adding a solution of 1 mM ethephon sufficient to cover the seed, immediately removing the seed, and allowing seed to dry overnight before planting the next day. Burn treatments were as follows:

1. control (no burn);
2. burn before planting;
3. burn after planting, before irrigating;
4. burn after first irrigation;
5. propane flame after first irrigation.

Burn treatments were imposed using wheat straw that was evenly spread (approximately 5.4 kg/plot) over the plot and ignited using a propane torch. Propane flaming was done with a hand-held propane torch held 1.5 inches over the row at a slow walking speed. Plots consisted of nine rows 40-ft-long. Burn treatments were imposed on 8 ft. strips of row. The trial was laid out in a randomized complete block design with four replications at the Madras experiment station. Emergence counts were made by hand along 3 ft. of row within each plot at 24 days after planting. Data for each grass were subjected to analysis of variance using the PROC GLM procedure in the SAS statistical package (SAS Institute, Cary, NC).

Results and Discussion

Smoke treatments using different fuels and times of exposure

Germination of Great Basin wildrye was not significantly affected by any of the smoke treatments (Tables 1 and 2). Germination was fairly high for all the treatments (mean of 68 percent), and there were no apparent trends favoring any of the three fuels, nor did time of exposure affect germination, with the possible exception that long exposure (32 min.) to sage smoke might have decreased germination (Tables 2 and 3).

Germination, and speed of germination of Indian ricegrass showed a response to smoke treatment; however, overall germination rates were so low (mean of 3.9 percent) that while of biological significance on a practical level it has little benefit (Tables 1 and 2, Fig. **1).** The coefficient for speed of germination for seed exposed to sage smoke was almost six-times greater than for the untreated seed (Table 3). While this is of interest, and may be part of a practical solution to breaking seed dormancy in Indian ricegrass, by itself it is not enough to be useful. It remains a matter of conjecture why sage smoke increased speed of germination more than did wheat straw or alfalfa. Sage is a natural component of rangelands and a competitor of Indian ricegrass (Clint Jacks, personal communication), whereas wheat and alfalfa are not. It appears that there must be some unique component(s) of sage smoke that Indian ricegrass is sensitive to.

Effect of field burning

Contrary to last year's results (Sexton et al. 2000), there was little if any benefit from field burning on germination (Tables 5 and 6). The reason for the discrepancy is unclear. One factor may be that last year we used kentucky bluegrass hay, whereas this year wheat straw was used as a fuel. The wheat straw appeared to burn hotter and quicker than did the bluegrass. The bluegrass would have had a cooler burn, longer exposure time to smoke, and probably smoldered more-meaning the smoke itself would have had different components. Obviously, the effect of smoke on germination enhancement needs to be investigated further. The variable results suggest that fuel, time of exposure, and temperature of burn may **all need** to be studied and taken into account before consistent, practical results are obtained.

Literature

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Table 1. Analysis of variation table on significance of main effects (fuel and time) and interactions on germination and coefficient of rate of germination of two native range grasses.

	Great Basin wildrye		Indian ricegrass	
Source of Variation	Germination	Coefficient of rate of germination'	Germination	Coefficient of rate of germination
Fuel	NS	NS	+[2]	**[3]
Time	NS	NS	NS	
Fuel by time	NS	NS	NS	NS

'Coefficient of rate of germination is the function of speed of germination. See methods for further detail.

[2] A+ indicates statistical significance at the 0.10 level.

[3]** indicates statistical significance at the 0.01 level.

Table 2. Germination and coeffient of rate of germination of Great Basin wildrye and Indian ricegrass to exposure of several fuel sources over time.

Source of fuel	Length of exposure	Great Basin Wildrye Germination	Great Basin Wildrye Coefficient of rate of germination'	Indian Ricegrass Germination	Indian Ricegrass Coefficient of rate of germination'
	(minutes)	(%)		(%)	
Control	0.0	69.5	7.83	2.0	0.11
Alfalfa	0.5	68.5	7.40	3.5	0.30
Alfalfa	1.0	66.5	7.10	4.5	0.38
Alfalfa	2.0	69.0	7.70	3.5	0.31
Alfalfa	4.0	67.5	7.01	4.5	0.43
Straw	0.5	79.0	8.42	2.0	0.18
Straw	1.0	70.0	7.40	5.5	0.38
Straw	2.0	69.0	7.25	4.5	0.34
Straw	4.0	64.5	6.83	6.5	0.62
Sage	0.5	64.5	7.02	5.5	0.53
Sage	1.0	76.5	8.22	3.5	0.29
Sage	2.0	69.0	7.25	10.0	0.90
Sage	4.0	64.0	6.17	8.5	0.86
Sage	8.0[2]	66.0	6.56	5.0	0.58
Sage	16.0[2]	68.0	7.02	12.0	1.02
Sage	32.0[2]	59.0	6.22	2.5	0.23
Mean		68	7.35	3.9	0.43
LSD (0.10)		NS	NS	NS	0.35
CV (%)		6	15	49	69

'Coefficient of rate of germination is the function of speed of germination. See methods for further detail.

[2]8-16-and 32-minute exposures were excluded to keep the statistical analysis balanced.

Table 3. Average germination and coefficient of rate of germination of Great Basin wildrye over 0-4 minutes of exposure of fuel.

Grass	Fuel source	Germination	Coefficient of rate of germination'
		(%)	
Great Basin Wildrye	Straw	70.6	7.47
	Control	69.5	7.83
	Sage	68.5	7.16
	Alfalfa	67.9	7.30
Mean		68.7	7.35
LSD (0.10)		NS	NS
CV (%)		6	15

'Coefficient of rate of germination is the function of speed of germination. See methods for further detail.

Table 4. Average germination and coefficient of rate of germination of Indian ricegrass over 0-4 minutes of exposure of fuel.

Grass	Fuel source	Germination	Coefficient of rate of germination'
		(%)	
Indian Ricegrass	Sage	6.9 a	0.65 a
	Straw	4.6 ab	0.38 b
	Alfalfa	4.0 b	0.35 b
	Control	2.0 b	0.11 b
Mean		3.9	0.43
CV (%)		50	74

'Coefficient of rate of germination is the function of speed of germination. See methods for further detail.

Table 5. Analysis of variance table on significance of main effects (burn and seed treatment) and interactions on emergence of three native range grasses from a field study conducted at Madras, Oregon.

Source of variation	Great Basin Wildrye	Idaho Fescue	Indian Ricegrass
		Emergence	
Burn	NS	NS	[2]
Seed Treatment	NS	1	NS
Burn by Seed treatment	NS	NS	NS

[1]indicates statistical significance at the 0.05 level.
[2]indicates statistical significance at the 0.01 level.

Table 6. Emergence of three different native range grasses based on bum treatment applied to • small plots in a field study conducted at Central Oregon Agricultural Research Center, Madras, Oregon, in the spring of 2000.

	Emergence of plants (no./3 ft. of row)		
Treatment	Great Basin Wildrye	Idaho Fescue	Indian Ricegrass
Control	31.8	39.3	41.9
Burn before planting	32.4	39.6	32.2
Burn after planting	29.8	29.6	28.1
Burn after first irrigation	26.8	35.4	38.0
Propane flame after first irrigation	27.1	42.3	49.4
Mean	29.6	37.2	37.9
LSD (0.05)	NS	NS	10.2
CV (%)	32.8	32.5	28.3

Table 7. Emergence of three different native range grasses based on seed treatments conducted at Central Oregon Agricultural Research Center, Madras, Oregon, 2000.

Treatment	Emergence of plants (no./3 ft.of row)		
	Great Basin Wildrye	Idaho Fescue	Indian Ricegrass
Ethylene	32.7	42.4	35.7
Smoke	29.7	38.8	36.5
Control	26.1	30.5	41.6
Mean	29.6	37.2	37.9
LSD (0.05)	NS	8.5	NS
CV (%)	31.6	31.0	33.8

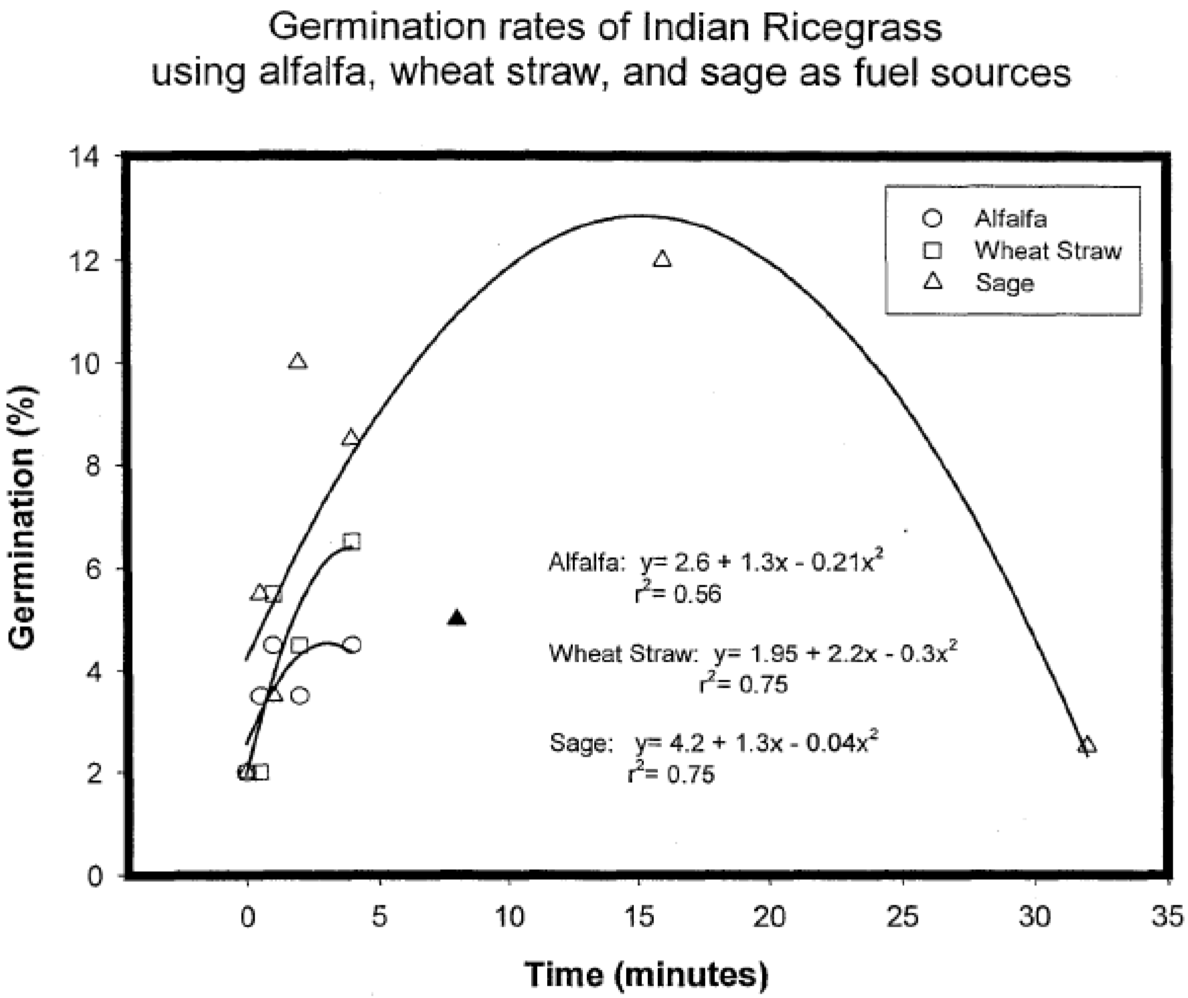

Figure 1. Germination percentage versus time of exposure to smoke from three different fuels (alfalfa, wheat straw, and sage) for Indian ricegrass. Dry seed was exposed to smoke in a commercial smoker for various periods and then germinated under controlled conditions in a germination cabinet.