

# Effect of Temperature and Postharvest Field Burning of Kentucky Bluegrass on Germination of Sclerotia of *Claviceps purpurea*

W. J. Johnston, C. T. Golob, and J. W. Sitton, Department of Crop and Soil Sciences, Washington State University, Pullman 99164-6420; and T. R. Schultz, Washington State University Cooperative Extension, 2525 Merryfield St., Friday Harbor 99250

## ABSTRACT

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Sclerotia of *Claviceps purpurea* were collected from Kentucky bluegrass (*Poa pratensis*) seed fields and exposed to various temperature regimes in a kiln. Sclerotia lost their ability to germinate when exposed to 200°C for 116 s, 300°C for 48 s, or 400°C for 15 s. Exposures of 240 s at 100 and 50°C produced only a slight reduction in germination compared to controls. The effect of temperatures produced by open-field and machine burning of residues also was determined. Peak soil-surface temperatures produced by open-field burning of Kentucky bluegrass postharvest residue were 120°C in 1990 and 240°C in 1991 at Rockford, WA. An experimental machine burner produced soil-surface temperatures of 280°C in 1990 and 320°C in 1991. Temperatures at 1 and 3 cm below the soil surface did not significantly change with any field treatment. Machine and open-field burning, compared to the nonburn control, significantly lowered (1990) or eliminated (1991) germination of sclerotia on the soil surface. None of the treatments significantly altered germination of sclerotia buried at 1 and 3 cm. These results indicate that the higher the temperature from burning residue, the greater the reduction in sclerotial viability.

Additional keyword: ergot

The Pacific Northwest grass seed industry has used open-field grass burning for 50 years as a simple, inexpensive, and effective means to control a broad spectrum of diseases (6,7,9,12), weeds (13), and nematodes (2). Burning Kentucky bluegrass (*Poa pratensis* L.) postharvest residue increases seed yields (6,7) and removes plant debris that shade new plant growth (8). Boubel et al. (3) reported soil-surface temperatures of 232°C and unburned hydrocarbons of 135 ppm in bluegrass field burns in the Willamette Valley of Oregon. The smoke released into the air during the burning of grass fields has caused concern from an increasingly, environmentally sensitive public (12).

Ergot, caused by *Claviceps purpurea* (Fr.: Fr.), Tul. is one of the most serious disease problems in Kentucky bluegrass, reducing seed yield. The sclerotia of the fungus, which contaminates the harvested seed and gleanings, are a health hazard to animals and, therefore, a problem for foreign shipment

of seed. Many investigators have reported that postharvest burning of grass residue will reduce ergot (5,10,12,14), whereas others have not reported this effect (1). The heat generated by cereal grain fires does reduce sclerotia viability (5). Preliminary work by Alderman and Young (2) showed that bluegrass sclerotia on the soil surface lose viability during field burning. The objective of

this investigation was to study the effect of temperature on the germination of sclerotia of *C. purpurea* in the laboratory and field.

## MATERIALS AND METHODS

**Kiln experiment.** Sclerotia of *C. purpurea* were collected from a 'Plush' Kentucky bluegrass seed field at Post Falls, ID, in 1990 and 1991. Twenty sclerotia were placed in 30-ml nickel (high form) crucibles. Crucibles, with sclerotia, were placed in a furnace (Thermolyne Type 30400, Barnstead/Thermolyne, Dubuque, IA) at 50, 100, 200, 300 (omitted in 1990), or 400°C for 0, 15, 30, 60, 120, or 240 s. The crucibles, one for each temperature-time regime, were removed rapidly from the kiln, and the sclerotia were immediately transferred into crucibles at room temperature (23°C). Approximately 16 h after exposure, sclerotia were transferred to a 0.5% sodium hypochlorite solution for 2 min, followed by two rinses (15 ml) with sterile deionized water. Sclerotia were placed on three layers of sterile 8.5-cm-diameter Whatman #1 filter paper moistened with 4 ml of sterile deionized water in sterile glass petri plates. The plates were sealed with Parafilm and stratified in the dark for 10 weeks at 5°C. Following stratification, germination of sclerotia (percent sclerotia bearing apothecial stalks) was assessed weekly dur-

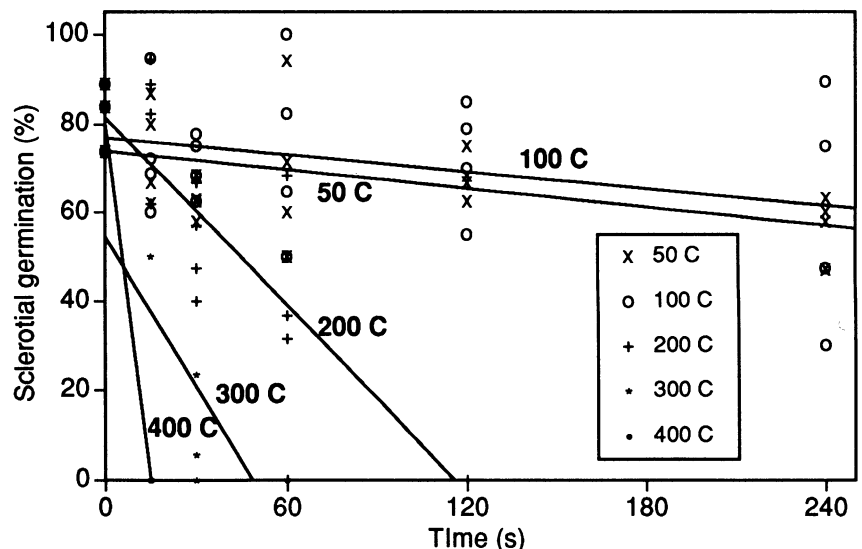


Fig. 1. Germination of *Claviceps purpurea* sclerotia heated in a kiln at 50, 100, 200, 300, or 400°C for 15, 30, 60, 120, 180, or 240 s. Regression equations for curves are: 50°C:  $Y = -0.0700X + 73.91$ ,  $R^2 = 0.25$ ; 100°C:  $Y = -0.0639X + 76.93$ ,  $R^2 = 0.11$ ; 200°C:  $Y = -0.7044X + 81.49$ ,  $R^2 = 0.80$ ; 300°C:  $Y = -1.1252X + 54.50$ ,  $R^2 = 0.53$ ; and 400°C:  $Y = -5.3383X + 80.08$ ,  $R^2 = 0.99$ .

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Corresponding author: W. J. Johnston  
E-mail: wjohnston@wsuedu

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ing incubation for 8 weeks at 20°C in the dark.

The experimental design was a randomized complete block with four replications and nonheated controls. The data were analyzed with regression analysis (percent germination versus exposure time at a specific temperature). The 1990 kiln experiment was repeated in 1991.

**Field experiments.** Twenty sclerotia were placed in 4.5 × 7.5-cm, 40-mesh stainless steel packets (2). Fiberglass-insulated chromel-alumel thermocouples attached to a micrologger (Campbell Scientific 21X, Pullman, WA) were placed inside the packets. The packets were crimped to prevent movement of the sclerotia and thermocouples. Packets were placed on the soil surface (under bluegrass residue) and 1 and 3 cm below the soil surface. Field sites were located near Rockford, WA, in 1990 and 1991, on Kentucky bluegrass seed fields of 'Garfield' and 'South Dakota Common,' respectively.

The treatments were not burned, open-field burned, or machine burned during September of each year. An experimental, mobile field burner was used for machine burning (11). The mobile field burner was pulled with a tractor at 0.5 km h<sup>-1</sup> in 1990 and 1.5 km h<sup>-1</sup> in 1991. Open-field burn treatments were done at the same time as the machine burn treatments. Individual plots were 2 × 5 m.

Immediately preceding treatments, air temperature was measured 0.3 m above the soil surface, wind velocity was measured at 1.5 m above the soil surface with a hand-held anemometer, and relative humidity was measured with a hygrometer. Four 75-g plant residue samples were taken at random from the plot area, sealed in plastic bags, and refrigerated on ice for transportation to the laboratory for moisture analysis. In addition, four 200-g soil samples were taken from the plot area and put into preweighed soil-moisture tins. The moisture content of the residue was determined after drying in an oven for 1 week at 60°C. Soil moisture was determined after drying in an oven for 2 days at 105°C.

After all treatments, sclerotia were surface-disinfected inside the wire-mesh packets by dipping in a 0.5% NaOCl solution for 3 min, followed by three 60-s rinses in sterile deionized water and blotting dry on sterile paper. The sclerotia were removed from the packets and germinated by the same procedure as in the kiln experiments.

The temperatures of the open-field- and machine-burned plots were plotted over time. Sclerotial germination (percent apothecial stalks) was analyzed as a two-factor randomized complete-block design, consisting of three soil depths and three burn treatments with four replications. Fisher's protected least significant difference (LSD) ( $P = 0.05$ ) was used to separate the means.

## RESULTS

In laboratory tests, germination of non-burned sclerotia was 80%. In the kiln experiment, results from 1990 and 1991 were similar, and only 1991 results, which included exposures at 300°C, are presented. Sclerotia exposed to 50 or 100°C in a kiln for up to 240 s showed only a slight, probably biologically insignificant, decrease in percent germination (Fig. 1). At 200, 300, and 400°C, a linear equation best fit the data, with germination reduced to 0 at 116, 48, and 15 s of exposure, respectively.

Postharvest residue cover was 6,063 kg ha<sup>-1</sup> in 1990 and 4,042 kg ha<sup>-1</sup> in 1991. The weather preceding grass burning was drier during 1991 than 1990; hence, the moisture content of the residue preceding

the burns was 22% in 1990 and 9% in 1991. In 1990, the conditions during burning were: wind velocity at 16 to 32 km h<sup>-1</sup>; relative humidity at 54%; and air temperature at 25°C. In 1991, the burn conditions were: wind velocity at 5 to 10 km h<sup>-1</sup>; relative humidity at 27%; and air temperature at 31°C.

The peak surface temperatures generated by open-field burning were 120 and 240°C in 1990 and 1991, respectively (Fig. 2). Machine-burn peak temperatures at the soil surface were 280°C in 1990 and 320°C in 1991. In 1990, mean peak temperatures at the 1 cm soil depth were 29 and 25°C, and at 3 cm were 21 and 17°C for machine and open-field burn, respectively. The nonburn surface temperature was 20°C. In 1991, mean

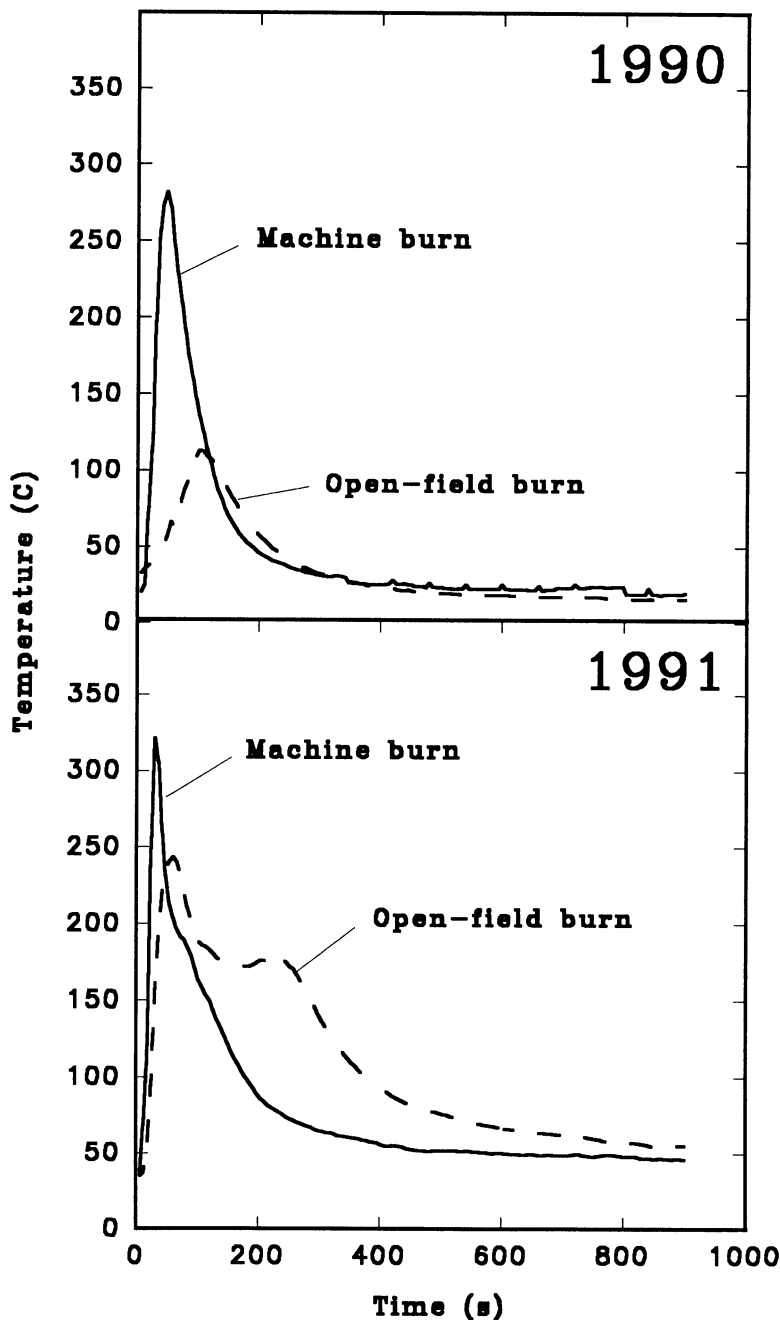


Fig. 2. Temperature measured on the soil surface during open-field and machine burning of Kentucky bluegrass postharvest residue at Rockford, WA, in 1990 and 1991.

peak temperatures at the 1 cm soil depth were 38 and 35°C for machine and open-field burn, respectively. Temperatures at the 3 cm depth were 33 and 27°C for machine and open-field burn, respectively. The non-burn surface temperature was 34°C.

In the hotter burn of 1991, both open-field and machine burning totally eliminated the germination ability of sclerotia (Table 1). Sclerotial germination was significantly reduced, but not eliminated, by open-field (9.8%) and machine burning (1%) compared to nonburned controls (51.6%) in 1990. There was no significant reduction in germination of buried sclerotia regardless of which treatment was used during burning.

## DISCUSSION

In both the laboratory and field tests, temperatures of 200 to 300°C killed the *C. purpurea* sclerotia. Laboratory exposures of 116 and 48 s at 200 and 300°C, respectively, reduced sclerotial germination to 0. Laboratory, and presumably field, tem-

peratures of 100 to 200°C reduced germination, but small numbers of sclerotia may still be capable of germinating and infecting future crops. Use of a machine burner provided higher, more consistent temperatures and killed more sclerotia, even with higher moisture in residue. It cannot be assumed that open-field burning will provide absolute ergot control, especially in situations in which "cooler" burns take place, e.g., in wet coastal areas or during wet years in normally drier areas on the east side of the Cascade Mountain Range of the Pacific Northwest. This may explain why Alderman (1), when examining seed samples from 218 Willamette Valley burned and nonburned grass fields, failed to detect significant differences in ergot infection. Boubel et al. (3) measured the temperatures of grass burns in the Willamette Valley and found open-field burns to be relatively cool and smoky. This type of burn, presumably, would not control ergot.

A shallow covering of soil, approximately 1 cm, provides enough insulation to protect sclerotia from damage. Presumably, some sclerotia would fall into naturally occurring crevices in the soil or be covered by the action of farm implements, e.g., during swathing or combining, and remain viable to potentially infect future bluegrass crops. However, there is evidence that burying sclerotia also reduces their viability (4).

Results from these studies indicate that "hot burns" (more than 200°C for 116 s) reduce germination of sclerotia of *C. purpurea*, and cool burns or shallow (1 cm) burial in the soil may not kill bluegrass ergot sclerotia. Research is needed to study options other than postharvest field burning to control ergot in bluegrass seed production.

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**Table 1.** Effect of nonburning, machine burning, and open-field burning of Kentucky bluegrass postharvest residue on germination of sclerotia of *Claviceps purpurea* on the soil surface and buried at 1 and 3 cm at Rockford, WA, in 1990 and 1991

	Germination of sclerotia (%) <sup>y</sup>		
	Surface	1 cm	3 cm
1990			
Nonburn	51.6	52.1	50.2
Open-field burn	9.8	40.2	41.6
Machine burn	1.0	44.2	52.3
LSD <sup>z</sup> (P = 0.05)	17.4	17.5	15.0
1991			
Nonburn	68.7	64.6	62.2
Open-field burn	0.0	72.8	67.9
Machine burn	0.0	59.1	64.5
LSD <sup>z</sup> (P = 0.05)	4.2	15.7	13.8

<sup>y</sup> Mean of 20 sclerotia in four replicates.

<sup>z</sup> Fisher's protected least significant difference (P = 0.05).