Burning System to Collect Water Soluble Compounds from the Smoke of Plant Materials

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Abstract

Fire plays a crucial role in maintaining the natural landscape of tallgrass prairie habitats. Past studies show that smoke produced by fires in the prairie habitat can break seed dormancy for some tallgrass species. More recent studies show that water soluble butenolides released in the smoke are involved with breaking seed dormancy. However, it is not clear if the release of these compounds varies with different species. Our objective was to design a system to collect compounds in the smoke that dissolve in water. A 10 x 23.5 cm stainless steel bee smoker (model 15239, GloryBee Foods, Inc., Eugene, OR) was filled with dried plant material—totaling 200 g burned in two 100 g portions. After the plant material was ignited with a butane torch, the bellows were used to force a consistent flow of smoke from the smoker, through a 77.5 cm long by 2.7 cm (inside diameter) heat resistant tubing, into water (300 mL) contained in a 1,000 mL sidearm flask. One end of the tube was clamped to the open end (2 cm diameter) of the funnel-shaped bee smoker top and the other end was placed just below the water surface in the sidearm flask. To pull the smoke through the tube into the water, a water aspirator—acting as a vacuum—was connected to the arm of the flask. The burning process for 200 g of plant material required approximately five hours. The proper assembly of this system will allow successful creation of smoke-water solutions for analysis of smoke compounds.

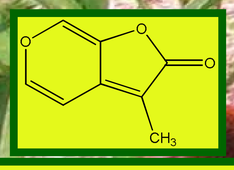
Introduction

Prior to European settlement, the most prominent ecosystem in Illinois was tallgrass prairie—covering around 60% of the state. In tallgrass prairies, fire plays a crucial role in defining the natural landscape (Jefferson *et al.*, 2008). Over the last 20 years, smoke from burning plant material has shown to play an important role in seed germination of species from fire prone habitats around the world. The chemical compound present in smoke that induced seed germination was identified as the butenolide, 3-methyl-2H-furo[2,3-*c*]pyran-2-one, which is a water-soluble compound that is active at a wide range of concentrations and stable at high temperatures. Butenolide may be produced by the combustion of cellulose (Flematti *et al.*, 2004). Different plant materials such as sawdust, fresh or aged grass tissue, brush, and trees of native species are considered the best combustion materials to create the smoke that induces seed germination (Landis, 2000).

When fire engulfs a tallgrass prairie, all of the plants burn and contribute to the smoke produced. Because of this collective smoke, it is hard to determine exactly which species, if not all, are actively releasing the butenolide when burned. Thus, the overall purpose of this project was to compare production of butenolide and other compounds in smoke of twelve native Illinois species (10 prairie and 2 woody) when burned. The crucial first step was to develop a system to collect smoke from individual species so that they could be analyzed separately.

Objective

Design a system to produce smoke-water solutions from the burning of dried plant material.



Butenolide: 3-methyl-2H-furo[2, 3- *c*]pyran- 2- one

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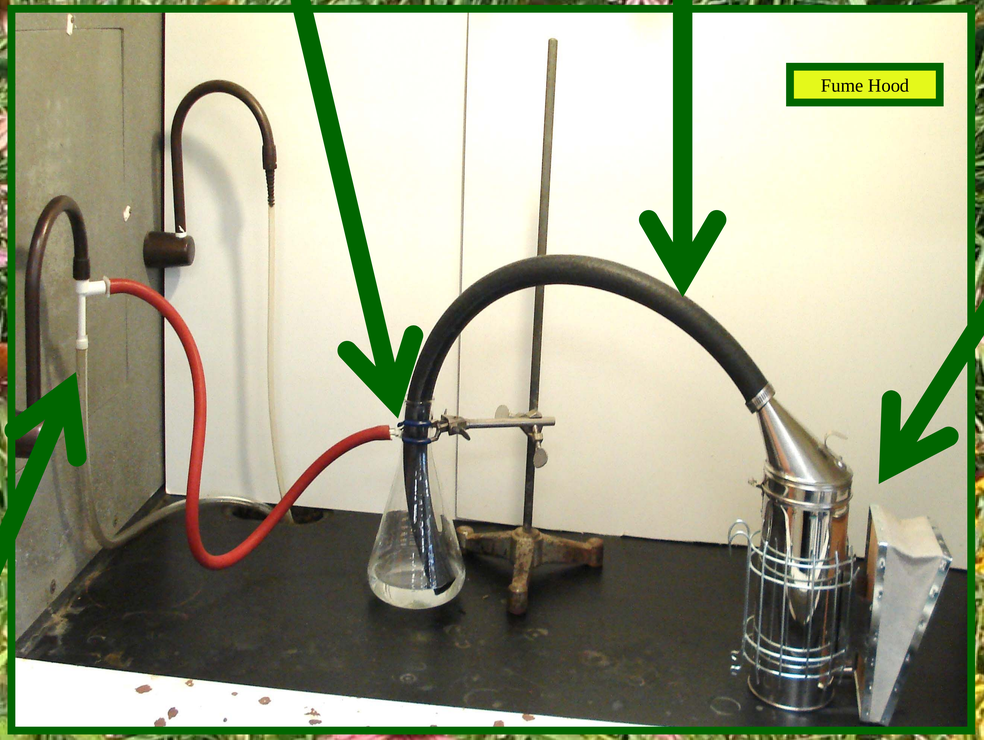

The completed burning system including: bee smoker with bellows, tubing, sidearm flask, & water aspirator. The working system was stored and used in a fume hood.

Fire at Mnoke Prairie, Indiana Dunes National Lakeshore, 4/5/05

Plant material from left to right: prior to chopping , after chopping, ash after burning, smoke solution

Materials & Methods

Plant Materials
- Harvested in October 2009 from Eastern Illinois University Native Prairie Garden
- Stored in paper lawn/leaf bags
- Plant materials were air dried and finely chopped
- 200 g weighed and stored in small paper bags until burning

Burning System Construction
- Stainless steel bee smoker model 15239 (10 x 23.5 cm), GloryBee Foods, Inc., Eugene, OR
- Rubber tubing- heat resistant heater hose, length- 77.5 cm with 2.7 cm inner diameter
- 1,000 mL sidearm flask containing 300 mL distilled water
- One end of rubber tubing placed over opening of the funnel shape top of the bee smoker, the other end of tubing placed into the sidearm flask into the 300 mL of water
- Water aspirator/ vacuum connected to sidearm flask

Creation of Smoke Solutions
- 200 g of plant material for each species was ignited in the bee smoker using a butane torch and lid was closed
- Bellows used to provide oxygen to the burning plant material and to push the smoke through the tubing and into the water
- Each burning lasted 2 – 6 hours
- Once the burn completed, ash cooled and weighed
- Smoke water solution transferred to a clean glass jar with lid and frozen

Species Collected	
Herbaceous Tallgrass Prairie Species	
Scientific Name	**Common Name**
Monarda fistulosa	Wild Bergamot
Silphium terebinthinaceum	Prairie Dock
Ratibida pinnata	Yellow Coneflower
Schizachyrium scoparium	Little Bluestem
Andropogon gerardii	Big Bluestem
Liatras spicata	Prairie Blazing Star
Ruellia humilis	Wild Petunia
Eryngium yuccifolium	Rattlesnake Master
Asclepias tuberosa	Butterfly Milkweed
Baptisia alba	White Wild Indigo
Woody Species	
Scientific Name	**Common Name**
Carya ovata	Shagbark Hickory
Quercus alba	White Oak

Stainless Steel Bee Smoker with Attached Bellows (10 x 23.5 cm) model 15239, GloryBee Foods, Inc., Eugene, OR)

Literature Cited

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