Fungal Fumes Clear Out Crop Pests

PEGGY GREB (K11933-1)

A codling moth larva crawls out of an apple it infested.

Isolated from the bark of a Honduran cinnamon tree 12 years ago by Montana State University professor Gary A. Strobel, the fungus *Muscodor albus* today continues to impress with its potential as a biobased fumigant.

Indeed, in studies at laboratories in Aberdeen, Idaho; Wapato, Washington; and Parlier, California, ARS scientists have reported success in pitting *Muscodor* against some top agricultural foes: *Tilletia* fungi that cause bunt diseases of wheat; potato tuber moths and apple codling moths; and the gray mold fungus *Botrytis cinerea,* which attacks grapes.

Although the scientists—Blair J. Goates, Lawrence A. Lacey, and Joseph L. Smilanick—are conducting separate investigations of *Muscodor,* they share a common goal. They all seek to determine whether a cocktail of natural compounds emitted by the fungus could replace or diminish use of synthetic pesticides. *Muscodor's* blend of volatile organic compounds (VOCs) naturally kills or inhibits fungal and bacterial pathogens, parasitic nematodes, and some insect pests. Neither *Muscodor* (federally registered by AgraQuest, Inc. of Davis, California, in 2005) nor its fumes harm humans or other mammals, and it leaves behind little or no residue on treated crops or in the environment.

Safeguarding Seedbeds

In May 2009, Goates and Julien Mercier, formerly with AgraQuest, began the third of a 3-year field study evaluating *Muscodor's* ability to control common bunt disease caused by the fungus *T. tritici,* which harms wheat by reducing the yield and quality of its grains, often imparting a foul, fishy odor to them.

Chemical fungicide seed treatments have kept common bunt outbreaks to a minimum, but alternative controls are nonetheless worth exploring should, for example, the chemical lose its effectiveness or be discontinued.

"We've become reliant on chemical seed treatments to control the disease," says Goates, a plant pathologist in ARS's Small Grains and Potato Germplasm Research Unit, in Aberdeen. "Without them, growers in many areas of the United States face the potential for significant yield losses." Such dependence underscores the need for alternatives. Organic wheat growers would benefit too, because they can't use synthetic pesticides and have limited means of fighting the disease.

In lab tests, *Muscodor* VOC's were found to kill 100 percent of *Tilletia* spores. In field trials conducted since 2006, treating seed or soil with a ground-rye-grain formulation of *Muscodor* completely prevented common bunt under moderate disease conditions.

"The dry formulation resembles granola with white frosting," Goates says. Adding water causes that frosting—in actuality, a twisted mass of *Muscodor* fungal fibers called "mycelia"—to begin growing and emit the VOCs, which in turn, fumigate the seed and surrounding soil where *Tilletia* spores lay waiting to germinate and infect plants.

Results from 2009 tests, conducted in naturally infested soils, are pending.

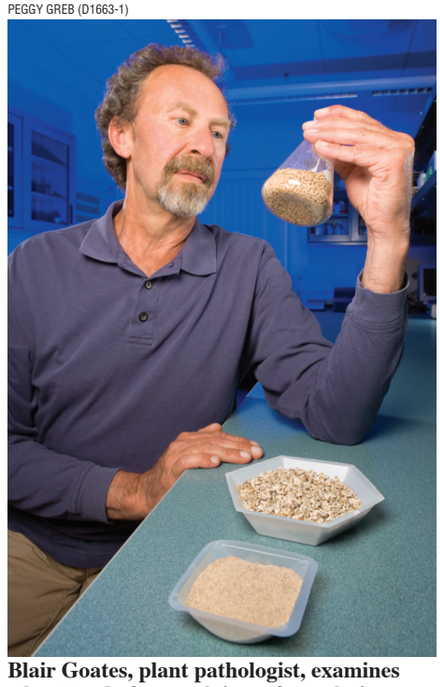
Pest-Proofing Stored Spuds

In Wapato, Lacey and colleagues have pitted *Muscodor* against the potato tuber moth, *Phthorimaea operculella*. In its larval stage, the pest feeds on the crop plant's leaves and tubers, tunneling deep inside the tubers until it's time to emerge and spin a cocoon elsewhere.

Some of the broad-spectrum pesticides growers use to keep the pest at bay cannot be applied within 2 weeks of harvest. That's often enough time for surviving moths to lay their eggs on the tubers before they're harvested and trucked off for storage or sale.

Fumigating the tubers with *Muscodor* during storage could offer a safe, biobased way to finish off those survivors, says Lacey, an entomologist with ARS's Yakima Agricultural Research Laboratory, in Wapato. In fumigation-chamber tests there, 85 to 91 percent of adult moths died when exposed to *Muscodor* fumes, and

PEGGY GREB (D1663-1)



Blair Goates, plant pathologist, examines wheat seed after applying a formulation of the biocontrol fungus *Muscodor albus,* shown in the foreground.

Muscodor's compounds killed 100 percent of *Tilletia* spores in lab tests.

JOSEPH SMILANICK (D1666-1)

Gray mold, *Botrytis cinerea,* on grapes.

between 62 and 73 percent of larvae died or failed to pupate.

In a different study, *Muscodor* overcame the codling moth, *Cydia pomonella*. In its larval stage, the insect bores into apples to feed. In storage tests, a 14-day exposure killed 100 percent of the moths in their overwintering stage—cocooned larvae—when they are the most difficult to control.

"Though our *Muscodor* evaluations have been conducted in laboratory conditions, I am very encouraged by the results," says Lacey, who's collaborated with David R. Horton, Dana C. Jones, Heather L. Headrick, and Lisa Neven—all with ARS.

Most recently, they've been testing *Muscodor's* effectiveness in biofumigating sealed cartons of apples stored at various temperatures. "We've seen no effect on their color and firmness so far," Lacey reports.

Botrytis: Friend—and Foe—to Grape Growers

For those who love grapes, *Botrytis* is both hero and arch-enemy. Some vintners treasure *B. cinerea* because it causes winegrapes to sweeten to perfection, creating memorable dessert wines that have earned this fungus the accolade "noble rot."

But to growers of fresh-market grapes—the kind you buy in bunches to eat out of hand—the microbe is the big-time bad-guy cause of gray mold.

For organic growers, *Botrytis* is especially troublesome because these producers can't use the typical treatment, sulfur dioxide, to quell it. That's why *Muscodor* studies—by plant pathologist Smilanick and visiting scientist Franka M. Gabler, both at the ARS San Joaquin Valley Agricultural Sciences Center near Parlier, along with Mercier, Jorge J. Jiménez from AgraQuest, and Robert Fassel from Visalia-based PACE International LLC—should benefit conventional and organic growers alike.

For experiments with Thompson Seedless grapes, the researchers placed tea bags filled with *Muscodor* in either of two common types of fresh-grape packaging: vented polystyrene bags or hinged-lid "clamshell" boxes. *Muscodor* reduced the natural incidence of *Botrytis*-infected grapes by up to 85 percent. Factors affecting the infection rate included the concentration of the fumigant, the number of days that had elapsed since the harvested grapes were first exposed to the mold—without prior *Muscodor* protection—and the temperature of the grapes (the fruit, harvested from vineyards that sometimes exceed 100°F, must be cooled).

PEGGY GREB (D1665-1)

Plant pathologist Joe Smilanick places a clamshell box full of table grapes inside an ozone gas chamber. The "tea bags" inside the boxes contain the biocontrol fungus *Muscodor albus.*

In a test designed with conventional growers in mind, Smilanick, Gabler, Jiménez, and Mercier tried pairing *Muscodor* with sulfur dioxide. "As expected, sulfur dioxide killed a lot of the *Muscodor,*" Smilanick reports. "So we tried using *Muscodor* with ozone instead."

The researchers fumigated Autumn Seedless and Thompson Seedless grapes for 1 hour with 5,000 parts per million of ozone and then stored the grapes with the *Muscodor* tea bags for 1 month.

"Even though it wasn't as effective as the standard sulfur dioxide treatment," notes Smilanick, "the ozone-*Muscodor* combination controlled *Botrytis* significantly."

ARS and the California Table Grape Commission funded the research.

If developed commercially, *Muscodor* could offer a powerful new tool for protecting a host of valuable crops and ensuring their quality.—By **Jan Suszkiw** and **Marcia Wood,** ARS.

This research is part of Plant Genetic Resources, Genomics, and Genetic Improvement (#301), Plant Diseases (#303), Crop Protection and Quarantine (#304), and Quality and Utilization of Agricultural Products (#306), four ARS national programs described at www.nps.ars.usda.gov.

To reach scientists featured in this article, contact Jan Suszkiw or Marcia Wood, USDA-ARS Information Staff, 5601 Sunnyside Ave., Beltsville, MD 20705-5129; (301) 504-1630 [Suszkiw], (301) 504-1662 [Wood], jan.suszkiw@ars.usda.gov, marcia.wood@ars.usda.gov. ✷