MUSCODOR: A NEW BIOFUMIGANT AS AN ALTERNATIVE TO METHYL BROMIDE

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Muscodor albus is and endophytic fungus isolated from a cinnamon tree (*Cinnamomum zeylanicum*) from Honduras. It was isolated and identified by Professor Gary Strobel of Montana State University and licensed to AgraQuest, Inc. According to Professor Strobel: "This xylariaceaous fungus effectively inhibits and kills certain other fungi, and bacteria, by virtue of a mixture of volatile compounds that it produces. The majority of these compounds were identified by gas chromatography/mass spectrometry and then made into an artificial mixture that mimicked the antibiotic effects of the mixture of volatile compounds given off by the fungus. Each of the five classes of volatile compounds produced by the fungus (alcohols, esters, ketones, acids and lipids) had some inhibitory effect against the test fungi and bacteria, but none was lethal. However, collectively they acted synergistically to kill a broad range of plant- and human-pathogenic fungi and bacteria. The most effective class of inhibitory compounds was the esters, of which 1-butanol, 3-methyl-, acetate was the most active biologically".

M. albus lacks a sexual stage. It is cultured on autoclaved rye grits and air dried and milled to achieve a relatively uniform particle size. The rye grits act as a food source for *M. albus*. From *M. albus*, a suite of products is being developed that have activity on many, important soil borne and postharvest pathogens. In practice the formulation is re-hydrated to activate the fungus and begin its production of volatiles. In the soil environment, material is uniformly mixed with soil and watered. In postharvest situations the formulation is placed in sachets which are re-hydrated and placed directly in cartons of fruit or vegetables. Upon consumption of its food source the fungus dies.

In greenhouse and tests Muscodor volatiles have been found to effectively control *Rhizoctonia solani, Pythium ultimum, Pythium aphanadermatum, Verticillium dahliae, Fusarium aveneaceum, Phytophthora capsici, Phytophthora palmivora, Phytopthtora nicotianae, Sclerotinia minor, Sclerotium rolfsii.* Recent trials have also shown the product to have excellent activity on *Meloidogyne incognita* and *Pratylenchus spp.* In these trials Muscodor has effectively protected crops such as tomatoes, peppers, strawberries from disease. In the field *M. incognita* and *Pratylenchus* nematodes were effectively controlled in tomatoes and lilies, respectively. Work continues to optimize the formulation and adjust rates for disease severity and soil types.

In the soil, Muscodor must be uniformly incorporated since the volatiles do not move far from their point origin. Further, sufficient irrigation must be applied to activate the product. An advantage of Muscodor, however, is that it effectively fumigates the soil without the need for tarping.

In the postharvest environment work is underway in crops such as cherries, peaches, pears, apples, strawberries and grapes. Muscodor has been found to effectively control diseases such as *Botrytis cinerea, Colletotrichum acutatum, Geotrichum candida, Monolinia fructicola, Mucor piriformis, Penicillium expansum* and *Penicillium digitatum.* Initial work focused on the weigh of Muscodor sachets to carton volume and fruit weight, time of fumigation and temperature limitations.

Research suggests that at a rate of 1:100 of Muscodor to fruit weight provides effective disease protection for up to 8 weeks in cold storage. Placing sachets near the top of the carton allows the volatiles to spill over the fruits and vegetables for several weeks. An advantage of *M. albus*, as a biological control agent, in postharvest situations is that it is active at temperatures as low as 31^{o}F. For fumigation at low temperatures a short incubation period at room temperature following re-hydration enhances antifungal activity and VOC production as opposed to re-hydration directly at low temperatures. The release of iso-butyric acid is a good indicator of antifungal activity for Biofumigation formulations.

The registration package for Muscodor was submitted to the U. S. EPA in June of 2004.

A sampling of results is provided below:

Table 1 – Percent decay of Thompson Seedless grapes after 8 weeks in cold storage at 31°F.

Treatment	% decay after cold storage	% decay after 24 h at room temp.
Untreated	7.5 a	14.0 a
SO2 (10 ppm once)	5.1 ab	5.1 b
Muscodor, 24 g/carton	3.6 ab	3.6 b
Muscodor, 86 g	2.3 b	2.7 b

Table 2 – Percent decay of Ruby Seedless grapes after 9 weeks in cold storage at 31°F.

Treatment	% decay after cold storage
Untreated	20.4 c
SO2 (10 ppm weekly)	0.1 a
Muscodor, 24 g	19.9 c
Muscodor, 86 g	7.5 b

Figure 1 - Muscodor for control of Root Knot Nematode in Fresh Market Tomatoes, (J. Noling, University of Florida, Lake Alfred, FL-2005)