Back to Pathogens Table of Contents

Metarhizium
(Order: Hypocreales, Family: Clavicipitaceae)

by Todd Ugine

Metarhizium species (Metschnikoff) Sorokin, also known as green muscardine fungi, have long been recognized for their biological control potential against arthropods. As early as 1879, fungi from this genus were being evaluated for control of wheat chafer beetles, *Anisoplia austriaca*, and sugar beet curculio, *Cleonus punctiventris*, in Ukraine. The species level name of one of the more widely researched *Metarhizium* species (*M. anisopliae*) was derived from this beetle. Morphological features for identifying *Metarhizium* species can be imprecise as there can often be overlap of characters among species. Molecular techniques have shown that what used to be called *M. anisopliae* represents a complex of nine species (Bischoff et al. 2009).

PHOTO: Todd A. Ugine

Appearance

Infections of arthropods by *Metarhizium* species are easily recognized a few days after death, when the fungus grows out of the arthropod integument and forms reproductive structures. Initially, one only sees fungal hyphae that appear white, but, as conidia form and mature they often take on a characteristic olive green color (see photo 1). However, depending on the species and strain of *Metarhizium*, spores can range in color from white to yellow to brown and green (Tanada and Kaya 1993).

Habitat (Crops)

Metarhizium species are commonly thought of as soil saprophytes and are most frequently found in disturbed habitats like agricultural fields as compared to forest ecosystems (Meyling and Eilenberg 2007). Additionally, recent findings suggest that these fungi form associations with plant roots in the rhizosphere (Hu and St. Leger 2002) and survive better in that environment than in surrounding potting soil over extended periods of time (Bruck 2005).

Pests Attacked

Metarhizium species are known to attack a wide range of arthropods: greater than 200 species in over 50 families. These include many species of agricultural, medical and veterinary importance. Some insect hosts included on two active product labels in the U.S. (as of 2011) [Met52, Novozyme Biologicals, Salem, Virginia] include “various ticks and beetles; root weevils, flies, gnats, thrips,” and locusts and grasshoppers (Green Muscle, Becker Underwood, Ames, Iowa). Additionally, *Metarhizium* species have

been developed in other countries for use against cockchafers, spittlebugs, grubs, borers, and for control of mosquitoes that vector malaria.

Life Cycle

Our discussion of the life cycle of species within this genus will be restricted to their activity as arthropod pathogens. Generally, the development of a lethal arthropod infection can be separated into three stages. First, asexual conidia (singular=conidium) come into contact with the arthropod integument as the arthropod travels through the environment. The conidia stick to the arthropod's exoskeleton, germinate and grow a germ tube, which eventually ends in an appressorium, the flattened and thickened tip of a germ tube. A penetration peg grows under the appressorium, pierces the integument and enters the hemocoel. The penetration of the fungus is achieved by the production of a cocktail of hydrolytic enzymes including proteases, lipases, chitinases, and mechanical pressure. Second, single cells of the fungus, blastospores, bud off of the penetration structure, circulate in the insect hemocoel and multiply, thereby depleting host nutrients. *Metarhizium* species are also known to produce compounds that are toxic to arthropods and presumably aid in killing the host, suppressing host immune defenses and fending off potential microbial competitors. Finally, after the host dies due to mycosis, the fungus will penetrate out of the integument and grow conidiophores, on which environmentally stable aerial conidia are produced. These conidia are passively disseminated into the environment and eventually infect new hosts.

Pesticide susceptibility

The effect of fungicides on *Metarhizium* species can be variable and needs to be assessed on a case-by-case basis. If there is any doubt as to the effect of a fungicide or insecticide on the viability of *Metarhizium* species products, users should err on the side of caution and not use tank mixes. Bruck (2009) reported on the persistence of *M. anisopliae* conidia in Petri dishes, bulk soil and in the rhizosphere, when in contact with several fungicides commonly used in greenhouses and nurseries. While a large number of fungicides negatively impacted conidial germination and mycelial growth in Petri dishes, there was little effect in the rhizosphere following two applications of some fungicides. The fungicides with the largest detrimental impact were Captan and triflumizole.

Commercial Availability

Between October-2005 and May-2006, Faria and Wraight (2007) determined that there were 47 different commercially-available *Metarhizium*-based products available around the world. Because of recent taxonomic changes to the genus *Metarhizium* (Bischoff et al. 2009) it is not possible to determine the exact species composition of that list. However, as of 2007 many of the different products were listed as either *Metarhizium anisopliae* or *Metarhizium anisopliae var. acridum*, which Green Muscle is based on. This strain is active against locusts and grasshoppers and is now recognized as its own species *M. acridum*. The strain of *M. anisopliae* that is the basis for Met52 (Novozyme Biologicals) is now recognized as M. brunneum.

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Back to Pathogens Table of Contents

BACK TO TOP