Pathogen One Day, Mutualist Another: The double life of *Metarhizium robertsii*

What we know, and what we aim to find out about this fascinating microbe

By Hannah Peterson

The rhizosphere, or soil area where the roots of a plant population live in, is a biological hotspot of diversity for microbial populations. A single handful of soil can contain over 50 billion individual life forms—about 7 times the number of humans on Earth. This incredible amount brings with it a richness of benefits, the product of billions of years of coevolution. A considerable number of these microbes have evolved to live between and within the cells of host plants, classifying them as endophytes. Endophytes are not technically beneficial to their host—the word just refers to a microbe which does not appear to have any adverse effects on its host (anything that is not a pathogen, is an endophyte).

Among this large class of soil-dwelling microbes, is a fascinating microbial fungus called *Metarhizium robertsii. Metarhizium* species have been known to scientists for centuries, due to the obvious symptoms it elicits when it infects insects. As an entomopathogen, *Metarhizium* has the fun reputation as an “insect-mummifying fungus”—infecting its victims via physical contact with the cuticle and quickly penetrating it, then using the insect to reproduce at a lightning-fast rate. The result is a crumbly, green shell of the arthropod it once was. *Metarhizium* species have been used as a biological control worldwide, both as generalist control () and targeted control (). However, in 2014, it was discovered to engage in an alternative lifestyle as an endophyte, preferring to colonize grasslands and agroecosystems. Interestingly, it changes its functionality completely in this new role, conferring plant growth promoting benefits and upregulating plant defense genes.

While this new information is quite fascinating, it does little to help our understanding of this relationship between *Metarhizium* and the plants it colonizes. Research so far has primarily focused on results under ideal planting conditions, which is not realistic for agricultural research. This is especially true when one considers context-dependent effects, which are extremely prevalent in environmental microbiology. There are many examples of environmental effects drastically changing the role of microbes in an environment and the relationships it has with other plants, insects and animals. The threat of climate change makes this even more important, as the consequences of exposing *Metarhizium* to crops via biological control efforts should be completely known to stakeholders. If environmental factors make *Metarhizium* and antagonist of crop growth, this would change its value as a biological control for growers.

Increases in the frequency and severity of drought and flooding are two of the most costly consequences of climate change to the agricultural industry. For every 1 degree C increase in global climate, there will be an estimated 7% increase in yearly precipitation, primarily through flash flooding followed by long dry periods. So when examining the effects of abiotic stressors on the relationship between *Metarhizium* and plant hosts, water stress is a relevant and important stressor that affects

For this study, I designed groups based on a factorial design with three levels of water stress: deficit, excess, and adequate watering (control), and two levels of *Metarhizium* treatment: *Metarhizium*-inoculated and not inoculated. Plants were grown and inoculated after a controlled growth period, then all treatments were applied at the same time. Water stress was applied for three weeks, then