Summary: Managing Mycorrhizas on Your Agricultural Operation

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AMF: Arbuscular Mycorrhizal Fungi

Arbuscular Mycorrhizal Fungi are not your average fungi (Figure 1).They are not decomposers and they do not form mushrooms. So what are Arbuscular Mycorrhizal Fungi (AMF)? AMF are fungi that are over one hundred million years old and which can form a mutual relationship with plants. Why are AMF important? This mutual relationship between AMF and plants, if present on your agricultural operation, can increase nutrient and water uptake of your crops.

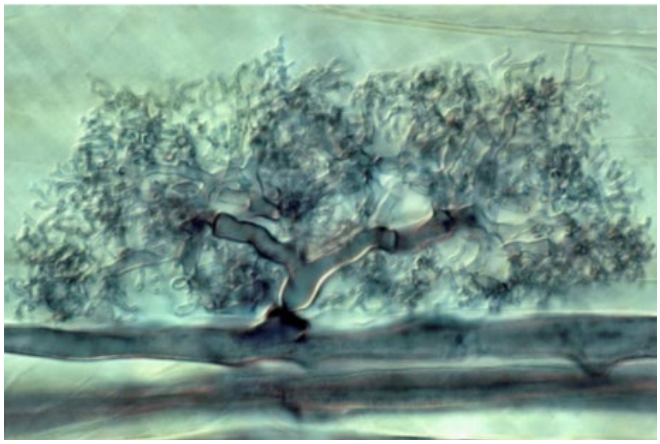

Figure 1: Arbuscule representation in a root, tree-like structure that acts as the site for resource exchange between plant and fungi. Image property of Brundrett MC. 2008. Mycorrhizal Associations: The Web Resource. mycorrhizas.info.

Structure of AMF

There are three different ways that AMF can form and reproduce in the soil (Figure 2, 3). These 3 sources or ways for AMF to perpetuate in soils are through:

1. **Spores:** Spores are reproductive strucutres of the fungi and they germinate to form hyphae which branch out to form an arbuscule, these of which help the plant uptake water and nutrients.
2. **Root fragments:** AMF can be found inside root fragments and can colonize the plant and form more AMF within the plants roots.
3. **Intact hyphal networks:** Hyphae act as a site for transport of resources within the fungus. They are able to extend more than root fragments which allows for more AMF colonization because they have a greater radius of influence and therefore more opportunities for AMF to be present in a soil system.

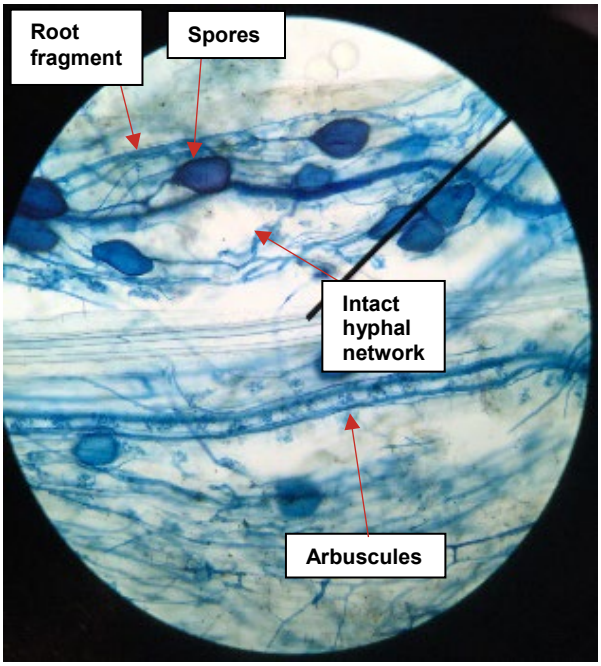

Figure 2: AMF presence in a strawberry root cell. Image property of Aidee Guzman, PhD. August, 2016.

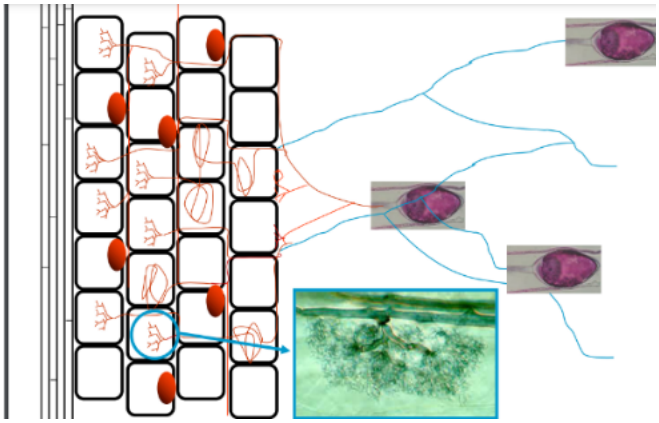

Figure 3: Structure of AMF as seen on a plant cell: spores, hyphae and arbuscules. Image modified from Dickson, *et al.*

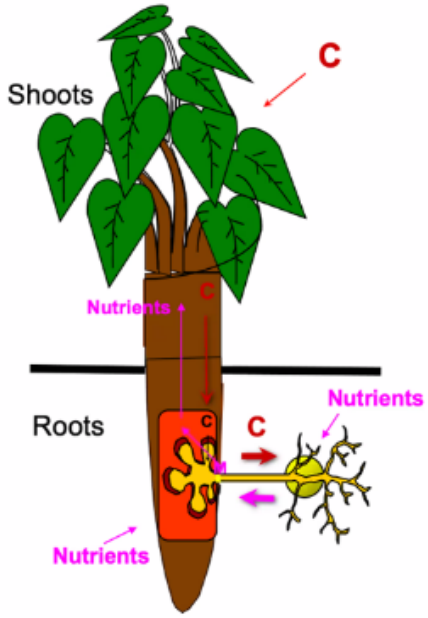

Figure 4: An overview of mycorrhizal symbiosis and how it affects the nutrient uptake of a plant. Image property of Brundrett MC. 2008. Mycorrhizal Associations: The Web Resource. mycorrhizas.info.

How mycorrhizal symbiosis works

AMF are considered obligate biotrophs, in other words they require living roots to reproduce. By having access to living roots, a symbiosis occurs between the plant and the fungus. In this symbiosis, a nutrient and energy trade occurs between the plant and the fungus (Figure 4). This trade allows for sugars (e.g. carbon) to move from the plant to the fungus while inorganic nutrients move from the fungus to the plant (e.g. iron and calcium). Evenmore, this symbiosis between plant and fungus can affect plant water relations—symbiosis with AMF can increase a crop's water use efficiency.

However, it is crucial to understand that AMF are not always mutual symbionts. This is to say, there are costs and benefits to this symbiosis. A plant may not always benefit from the nutrients provided by AMF or the AMF may not always provide nutrients. For example, AMF are not beneficial in a phosphorus rich environment.

There are advantages and disadvantages to AMF depending on the context: such as your soil, your crops, your inputs (fertilizers, pesticides, fungicides, herbicides, etc), your soil practices (tilling vs. no tilling, conventional or organic, etc.). Key advantages and disadvantages of AMF are listed in Table 1.

Table 1: Advantages and Disadvantages of AMF

Advantages	Disadvantages
Can increase nutrient uptake	You need to know your soil's cropping history
Can increase water use efficiency	You will need to know your soil's nutrient levels
Can increase soil resiliency	Will require soil testing and possible changes to your practices
Can allow for control over how you manage your soil system (e.g. decrease fertilizer use, water use)	There are chances that AMF is not present or not as successful in your soil system due to various factors and your setting

Factors that may decrease AMF

There are many factors that may decrease the presence of AMF in your soil system. These are listed in Table 2. By understanding the effects of these factors, you can promote the presence and or

viability of AMF in your soil system. However, please be aware that AMF is context specific and therefore may not be present in your soil and or will be affected by the practices you apply in your soil system.

Table 2: Practices that can affect AMF

Practices that can decrease AMF presence in your soil system
Loss of native vegetation
Monoculture systems
Fallow fields
Soil disturbances such as intense tillage
Applications such as fertilizers, fungicide, insecticides, herbicides, can all reduce and affect AMF presence

Possible ways to promote AMF in your agricultural operation

Keeping in mind that AMF is context and site specific, there are some possible ways to promote its presence in your agricultural operation. One of the most popular methods is the use of AMF inoculum. AMF inoculum is a soil amendment that attempts to release and promote AMF colonization in your soil system. Inoculum is a novel method that has mixed results—sometimes effective and sometimes not, depending on multiple factors such as your soil management, with the note that sometimes soil management is not the reason. Therefore, if you'd like to manage mycorrhizas on your agricultural operation, be mindful of your soil's nutrient properties, the practices you implement, and your cropping history. The best way to manage mycorrhizas is to understand the soil in your agricultural operation—one way to do so is to identify where your plants are stressed because this site may not have AMF presence and may benefit from AMF inoculation. Proceed with caution and remember AMF presence and viability is specific!

Definitions and take-home messages to consider for your lingering AMF related questions

- **AMF**: Arbuscular Mycorrhizal Fungi
- **Arbuscule**: tree-like structure that acts as the site for resource exchange between plant and fungus
- **Mycorrhiza**: symbiotic relationship between fungus and plant
- **Spore**: reproductive structure for AMF
- **Hyphae**: structure for AMF colonization, allows for resource transportation inside fungus
- **AMF presence is context and site specific:** AMF presence and inoculation may be successful in one stressed plant site and may be un-successful in one stressed plant site
- **Tillage, Cover Cropping, and AMF**: Even if you have a tilled system, you can still have AMF in your soil—note that reduced tillage can increase AMF presence. Also, by having a cover crop you can promote and boost AMF populations. For example, if you have an intensely tilled system, you can implement cover crops and may possibly still have AMF presence and success.
- **Amendments and AMF:** AMF benefits tend to decrease in phosphorus rich soils, therefore be cautious with your use of amendments with low N: P.
- **Curious about experimenting with AMF inoculation?** Begin your inoculation with plants that are stressed (e.g. water stress or nutrient stress, such as Phosphorus limited soil systems), but remember that AMF presence as well as success is context and site specific.