Arbuscular mycorrhizal fungi (AMF) are just one of numerous fungal groups that live in the soil and associate with plant hosts. Plant roots colonized by AMF greatly expand the volume of soil from which to draw water and nutrients; in fact, research has shown that AMF often make their plant host grow more vigorously, particularly under challenging conditions such as drought, low soil nutrients and pest pressure.

Harnessing AMF in Crop Production Systems

Although plants and AMF have been partners for nearly 500 million years, our understanding of these relationships is relatively immature and rapidly changing as new research studies are published. What we do know is that AMF can greatly enhance plant health and crop yields.

The arbuscule is designed to maximize the surface area available for nutrient exchanges, similar to how a lung or kidney functions in higher organisms.

How AMF Work in the Soil

There are many different species of arbuscular mycorrhizal fungi (AMF), including strains or types with unique characteristics that live in specific geographical regions. Multiple AMF species are often present in a single soil sample.

AMF are obligate plant symbionts. The term obligate means AMF cannot reproduce without a plant host. The term symbiont means AMF live very closely with their plant host. This living arrangement is considered mutually beneficial under many conditions. What makes AMF distinct from other types of fungi is the arbuscule structure (Figure 1), which is constructed inside the plant’s root cells and is the site for physical exchange of materials between the plant and AMF. The arbuscule is designed to maximize the surface area available for nutrient exchanges, similar to how a lung or kidney functions in higher organisms.

Arbuscular mycorrhizae exist in soil as spores during the resistant resting stage in their growth cycle. When a nearby plant root begins growing, it sends a chemical signal to the AMF spore, which responds by germinating and producing fungal hyphae, filamentous threads that travel through the soil and make contact with the plant root. At this stage, additional plant-to-AMF communication occurs, and the AMF thread is allowed to enter the root and, ultimately, a root cortical cell in which the arbuscule is constructed. Multiple species of AMF can simultaneously colonize a single plant host.

Through the arbuscule, a host plant provides simple sugars – produced by photosynthesis – to the AMF. Unlike many other soil fungi, AMF are not able to take up simple sugars from the soil and are therefore dependent on their plant host for food. Research has discovered, however, that the plant does not just provide food in the form of sugar to the AMF; it also provides pre-made fatty acids that are used by AMF to assemble their own lipids. Meanwhile, using the food provided by the plant, AMF busily extend their filamentous hyphae out into the soil to explore surrounding plant roots. The AMF filaments transport water, macronutrients (N, P) and micronutrients (Cu, Zn, etc.) and provide them to the plant through the arbuscule. AMF also protect crop plants from pathogens and pests.

Remember, AMF cannot complete their life cycles without their plant host. Roughly 90% of agricultural crops form associations with mycorrhizae; notable exceptions are brassicas such as canola, radishes, mustard and turnips.
is that many agricultural practices reduce the number and diversity of AMF in soils and alter the nature of the plant–AMF relationship. For example, aggressive tillage breaks up the AMF network of filaments, the lack of plant roots eliminates AMF reproduction and high fertility levels often diminish the importance of the plant–AMF relationship.

Scientific research has not yielded many solid answers for practical questions regarding AMF in crop production systems, including the best way to measure AMF. There are a number of laboratory techniques for measuring the number and diversity of AMF and for identifying specific species, but each technique has its own limitations and most are very labor intensive. Some of the difficulties in measuring and identifying AMF are due to the fungi’s microscopic size, complex and varied life cycles, evolutionary history and their need for a plant to reproduce, which prevents them from being grown and studied independently. However, research has shown that reducing tillage, moderating fertility levels, adding cover crops or diversifying crop rotation should enhance the numbers and diversity of native AMF, which in turn will emphasize this ancient partnership and the benefits received by the plant.

The emphasis on native AMF is an important consideration. It is highly likely that some AMF species or strains have adapted to local soil and climatic conditions and possess differing characteristics than AMF in other geographical regions. Therefore, it is important to encourage the multiplication of locally adapted, native AMF. Even if the numbers of native AMF have been greatly reduced by prior farming practices, the remaining organisms can be multiplied under positive conditions and augmented by new colonizers arriving through wind, water and animals.

New research is rapidly improving our understanding of these enigmatic soil organisms, and the future is certain to hold new answers on how to promote the plant–AMF partnership in agricultural production systems.