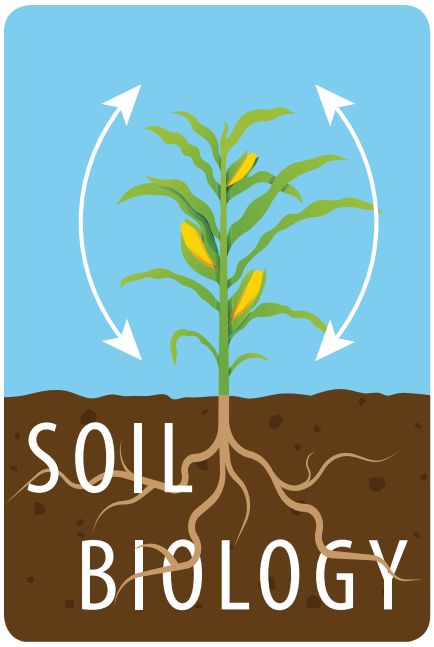
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The value of arbuscular mycorrhizal fungi for field crops

Geoffrey Siemering, Matthew Ruark, Francisco Arriaga, Erin Silva, and Heidi Johnson

The name arbuscular mycorrhizal fungi translates directly from Latin as:

LITTLE TREE (ARBUSCULUM)+ FUNGUS (MYCO)+ROOT (RHIZA).

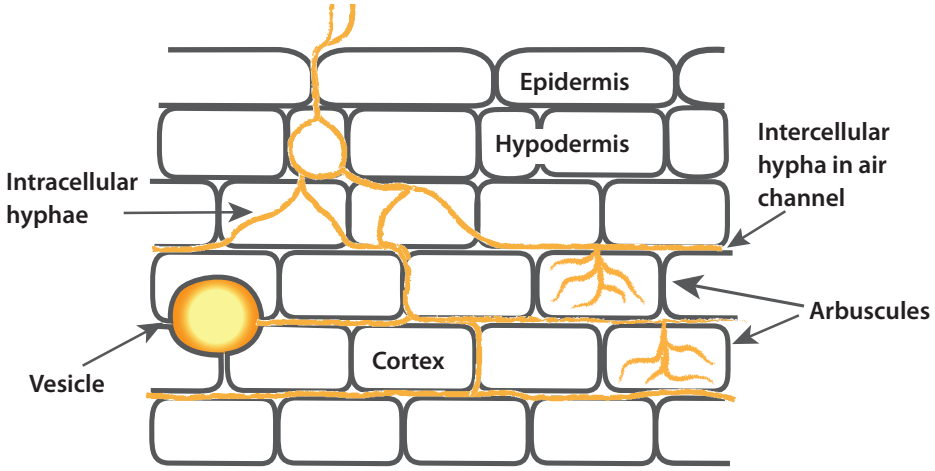
Key facts

- Arbuscular mycorrhizal fungi (AMF) are soil organisms that form symbiotic associations with most vascular plants. Exceptions include spinach, sugar beets, lupins, and brassicas (e.g., radish, canola, cauliflower, cabbage, and turnip).
- Robust AMF development increases the capacity of plant roots to take up nutrients and water, and can lead to improved plant health and yield.
- Tillage reduces the growth of AMF.
- Long fallow periods or cropping of non-AMF supporting plants reduces AMF, which can result in reduced yield for AMF-associated crops.
- These soil organisms are often referred to as "mycorrhizae" or "vesicular arbuscular mycorrhizae" (VAM).

What are arbuscular mycorrhizal fungi?

AMF are specialized soil fungi that benefit many important crops and require an association with vascular plants to survive. Plants allow AMF to live within their roots and provide the fungi with sugars (carbohydrates) that enable them to grow (figure 1). In exchange, the fungi provide the plant with additional water and nutrients that the plant could not otherwise extract from the soil. To accomplish this, the fungi develop tree branch-patterned "root" structures (arbuscules) within plant root cells and grow "threads" (hyphae) from the plant. These threads act as an extended root system, pulling nutrients and water from the soil and storing them in small swellings (vesicles) in the roots' upper cell layers. The plant can then use the water and nutrients stored in these swellings to supplement those absorbed directly by the plant roots.

FIGURE 1. Cross section of AMF plant root colonization.



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Where do AMF come from?

AMF are present in most soils worldwide, and are readily transported by wind, soil, and animals. Local climate and soil type determine which AMF species grow best at a particular location.[1]

Why should I manage my fields to increase AMF growth?

The association of AMF with a crop increases the crop's capacity to take up phosphorus (P), zinc (Zn), copper (Cu) and water (figure 2).[2] This increased capacity usually results in more robust plant growth, especially under stress conditions such as drought or limited nutrient availability. AMF also help increase plant resistance against pathogens and make plants generally healthier.[3]



FIGURE 2. Mycorrhizal threads (hyphae) assist this pine tree's root system to absorb additional nutrients. *Image courtesy of Professor Sir David Read, FRS.*

From a soil health perspective, AMF help stabilize soils by producing a glue-like compound called glomalin. Glomalin coats and protects the fungal threads as they grow from the plant's roots. Furthermore, glomalin glues surrounding soil particles together, which increases soil aggregate size and stability. The glomalin itself is an important source of soil organic matter—estimates of glomalin deposition range from hundreds to thousands of pounds of carbon per acre per year.[4]

How do my soil management practices impact AMF growth?

Soil tillage

Strip till or no-till enhances AMF growth.

- Tillage inhibits AMF development by physically tearing apart fungal threads, disrupting AMF growth, and decreasing glomalin production.[5]
- AMF colonize crop roots earlier in the season in no-till versus tilled fields.[6] Early colonization increases spring P and Zn uptake, which may improve yield and reduce the need for additional P-containing fertilizer. Glomalin added by AMF helps with soil aggregation, which can also increase yield over time.[7]

Crop rotation

Regular crop rotation, reducing the use of crops that do not form AMF associations, and avoiding long fallow periods increase AMF abundance.

- In fields with regularly rotated crops, the AMF community is typically healthier and more diverse than communities found under monocultures.[8]
- In fallow soil or in soils planted with non-mycorrhizal crops, the number of AMF spores and threads are low and AMF are largely dormant.[9]

Cover crops

Non-brassica cover crops (e.g., rye, oat, clover, and vetch) maintain continuous AMF colonies between growing seasons.

- AMF colonize cash crops more rapidly in the spring if fields are planted with non-brassica cover crops rather than left fallow over winter.[10] Early AMF colonization helps crops to better utilize nutrients and can result in increased crop yield.
- Brassica cover crops (e.g., radish, turnip, and mustard) can be used in cover crop rotation plans or mixtures without long-term AMF impact.[11]

Pest management

Fumigants wipe out AMF in the short-term, but pesticides have little to modest effect on AMF.

- Soil fumigants are very damaging to AMF populations and temporarily eliminate them from the upper soil layer.[12]
- Herbicide effects on AMF are variable depending on a range of conditions, but are generally modest.[13]
- Insecticides and nematicides generally have little adverse impact on AMF.[14]
- Fungicide impacts on AMF are also variable.[15] Systemic fungicides have been shown to reduce AMF growth or change AMF species composition.[16] Foliar fungicides have little impact on AMF because of their limited soil contact.
- Limited research has shown that healthy AMF populations under corn can suppress some weed species.[17]

Fertilizer inputs

Robust AMF growth may mean reduced need for P fertilizer.

- AMF improve P plant uptake and shifts the maximum cost–benefit on P application to lower application rates (figure 3).[18]
- When available P is above optimum for a crop, AMF growth is suppressed.[19]
- Organic fertilizers such as animal and green manures may increase AMF growth and species diversity.[20]

Does inoculating the soil with AMF help?

While AMF inoculants are commercially available, independent research has not yet verified that the use of these products will definitively increase either short- or long-term production yield. Although AMF is present in all soils, AMF inoculation may be beneficial when soils have limited P availability, fields have been frequently tilled, or non-AMF supporting plants have been grown in continuous or frequent rotation.[21] It is prudent to first try small-scale testing before widespread use to make sure you see benefits from inoculating your fields.

Further reading

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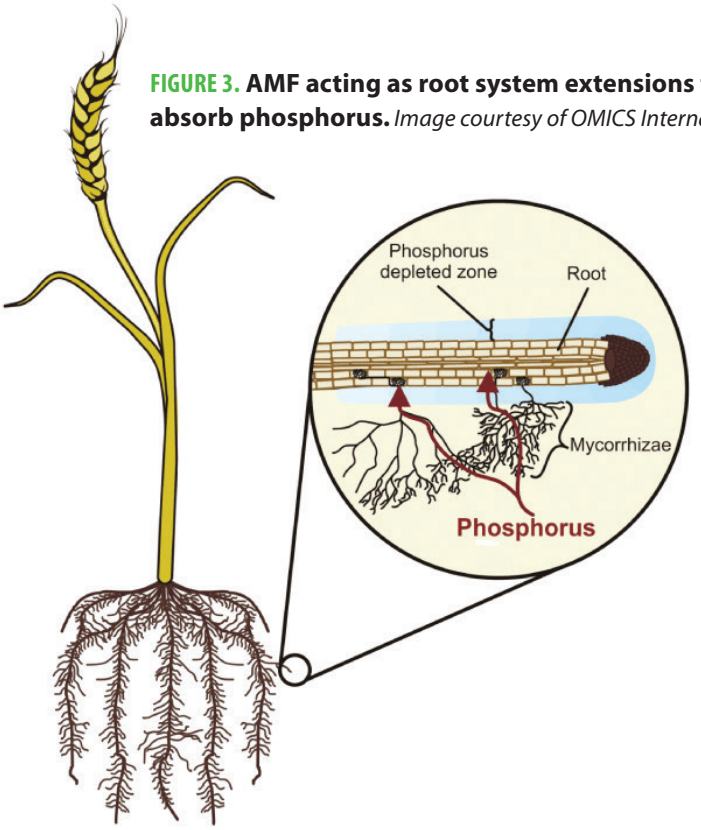


FIGURE 3. AMF acting as root system extensions to absorb phosphorus. *Image courtesy of OMICS International.*

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The Value of Arbuscular Mycorrhizal Fungi for Field Crops (A4114-01) I-06-2016