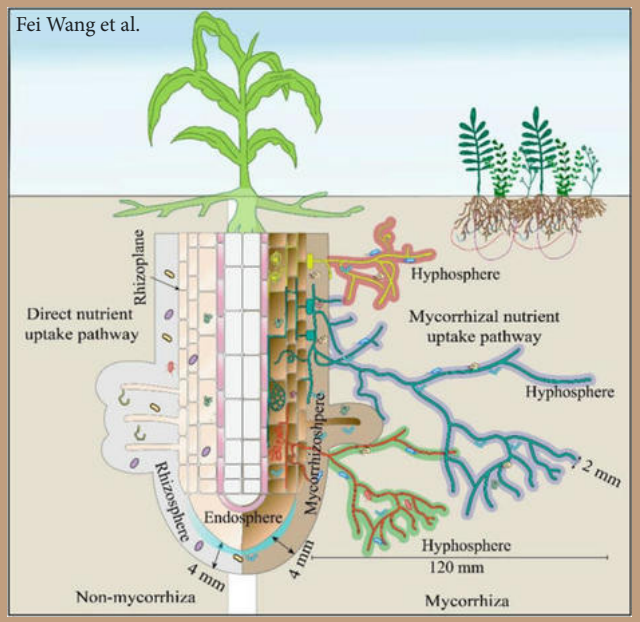
Ectomycorrhizal Fungi (EMF)

Ectomycorrhizal fungi (EMF) are fungal species that live outside plant root cell walls, while Endomycorrhizal fungi (Arbuscular mycorrhizal fungi or AMF) are fungal species that penetrate plant root walls. Both EMF and AMF function extend root coverage area, access to water, and nutrient absorption for the host plant roots. [17]

EMF can also form an interconnected communication system between nearby trees and other woody plants: improving plant tissue regeneration and sapling survival during environmental disturbances (changes) within forests. [10, 31, 33]

Benefits of Arbuscular Mycorrhizal Fungi (AMF) on a Healthy Microbiome

Endemic (native) rhizobacteria and mycorrhizal fungi can decrease nutrient loss, promote nutrient availability for plant roots, and improve soil quality and water retention. The soil microbiome may also break down pesticides, heavy metals, organic contaminants, and other harmful substances to benefit plant growth. [2, 3, 5, 21, 25, 32]



Water (H_2O)

A study from Oecologia found that seedlings with AMF had higher drought resistance, biomass, and water use efficiency than plants without AMF during drought periods. AMF can absorb and preserve accessible water over an extended range and may also increase a plant's ability to balance water and excess salt (road salts). [5, 8, 14, 20, 33]

Bio-defense

AMF activate plant defense systems against parasites and bacteria. AMF also attack nematodes that cause root-knot disease and protect plant roots from harmful external bacteria. [2, 23, 34]

Macronutrient Absorption

Nitrogen (N)

Symbiotic relationships with AMF increase nitrogen absorption and fixation (conversion) through a relationship with specialized beneficial bacteria known as rhizobacteria. Soil-bound rhizobacteria can also aid in reducing nitrogen runoff (loss). [4, 18, 21, 24, 26]

Phosphorus (P)

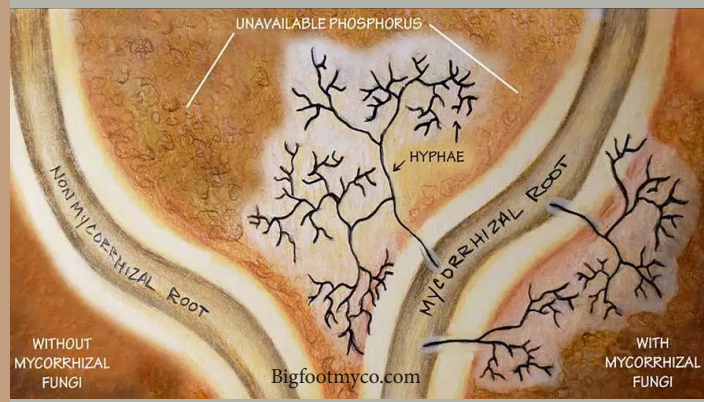
Phosphorus abundance may vary within the soil, and fertilizer may be necessary to increase nutrient concentrations. Even where soil phosphorus is plentiful, it may not be accessible in a form plants can readily use. Rhizobacteria associated with AMF contribute to the breakdown of phosphorus into plant-dependent forms: reducing fertilizer needs. AMF with rhizobacteria may also contribute to maintaining soil pH levels to an appropriate range for phosphorus and calcium availability. [4, 11, 13, 16, 17, 19, 22, 29]

Calcium (Ca)

Calcium may be abundant within the soil but is limited in forms inaccessible for plant uptake. AMF increase phosphate solubilizing bacteria which may increase soil calcium-phosphate for plants. [4, 22]

Potassium (K)

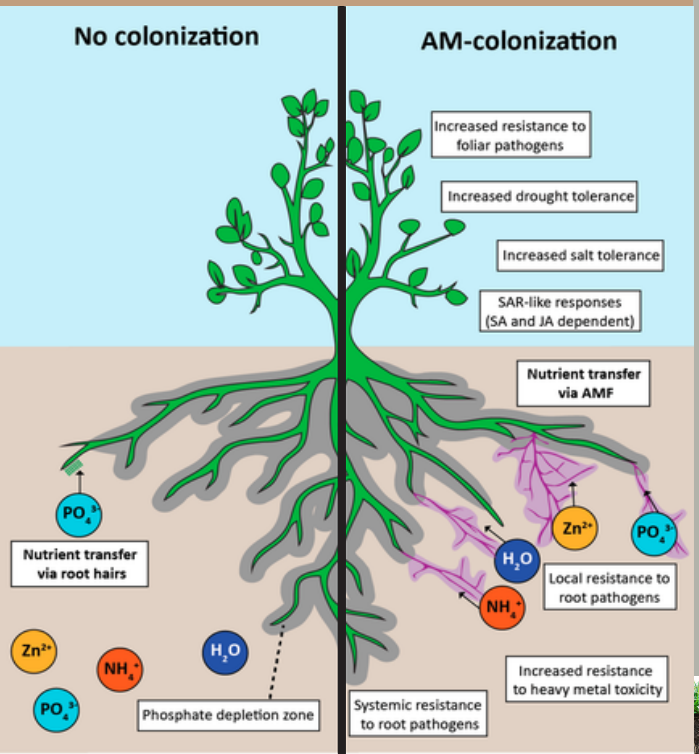
Symbiotic relationships with AMF increase mineral potassium breakdown and potassium absorption into the plant roots with rhizobacteria. [5, 17, 29]



Arbuscular Mycorrhizal Fungi (AMF)

Comprised of thousands of cell-sized strands, the AMF hyphae extend the host plant biomass, expanding outwards into the soil for hard-to-reach nutrients and water sources. The AMF hyphae may also increase beneficial soil microorganisms, contributing to a healthy root biota. Tilling, soil compaction, and pesticide use negatively impact AMF colonization: reducing the potential benefits to plant and soil health. [2, 3, 5, 24]

About 80% of all herbaceous plant species can form a symbiotic relationship with AMF. AM Fungi enter plant root tissues to exchange water and essential nutrients such as nitrogen (N), phosphorus (P), and potassium (K) for photosynthesis-derived carbon, acting as a carbon sink. Mycorrhizae contribute to healthy soil systems by converting nutrients for plant root uptake. [9]



Jacott, 2017

Study Evidence for AMF Benefits in Soil

Six studies show inoculating plant fields with endemic AMF may increase:

- Growth Rate
- Yield (Harvest Size)
- Water Retention
- Efficiency of Resources

Links and References at NWCD.org

- Potato fields with compost and fertilizer showed a 45% increase in yield in year 1 with the inoculation of AMF and a 10-20% increase in year 2, compared to non-AMF fields (USDA). [12]
- Welsh Onions were grown in superphosphate (P_2O_5) concentrations ranging from 300 to 1500 mg. AMF-inoculated onions had a similar yield at 300 mg P_2O_5 compared to non-inoculated onions at 1000 mg P_2O_5. The production cost per hectare decreased by half with AMF inoculation (Yamagata University). [30]
- Tomato fields inoculated with AMF showed increased yield, water absorption, and efficiency during low water conditions compared to non-AMF tomatoes (Institut de Recerca). [7, 22, 25]
- Corn fields inoculated with AMF and a 50% nutrient fertilizer blend showed an increased yield compared to non-AMF corn with 50% and 100% nutrient blends. AMF reduced the chemical fertilizer use on corn by 50% (Cheikh Anta Diop University). [15, 25]
- Squash fields inoculated with AMF showed effective plant growth in low-phosphorus soils without excess phosphate additives (Alexandria University). [1]
- Apple trees inoculated with AMF showed increased growth and a decreased effect from drought stress compared to non-AMF apple trees (University of Sheffield). [6]

The Plant Sidekick

Mycorrhizal Fungi Analysis

By: Coleman Pushlar

Fungi are ubiquitous in the environment. The earth beneath our feet contains many beneficial microorganisms that improve the health of plants in forests and agriculture. Almost 95% of all seed-producing herbaceous plant, woody shrub, and tree species have a symbiotic relationship with mycorrhizal fungi. These fungi live in and around the roots of these plants, increasing nutrient retention, drought resistance, and pathogen protection. [3, 9]

Michael Rothman

Plants require macro and micronutrients for growth and survival. These nutrients may become limited in the soil, negatively affecting the plant and potentially benefiting tolerant weeds. [3, 4]

Macronutrients	Micronutrients
Carbon	Iron
Hydrogen	Manganese
Oxygen	Boron
Nitrogen	Molybdenum
Phosphorous	Copper
Potassium	Zinc
Calcium	Chlorine
Magnesium	Nickel
Sulfur	Cobalt
	Sodium
	Silicon