FACT SHEET
Agriculture and Natural Resources

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Mycorrhizae in Urban Landscapes

Nathan M. Kleczewski, Dennis Lewandowski, and **Pierluigi (Enrico) Bonello**
Department of Plant Pathology
The Ohio State University

Introduction

Mycorrhizae are relationships between specific fungi and the roots of numerous plant genera. Mycorrhizae are essential for ecosystem functioning and the survival of plants, with estimates of 80–90% of all plant life believed to engage in at least one of the seven types of mycorrhizae. The arbuscular mycorrhizae (AM) and ectomycorrhizae (EM) are probably the most important forms of mycorrhizae in the urban setting due to their prominence on many economically important garden and landscape plants and known benefits to their associated plant hosts.

Basics of the Mycorrhizal Relationship

In AM and EM associations, the fungus colonizes the roots of an appropriate plant host and develops threads of fungal material (emanating, or extramatrical hyphae) into the surrounding soil, which vastly increase the absorptive area of the root system and access to water and limiting nutrients such as phosphorus and nitrogen. Some of the water and nutrients are transported through the hyphae into the roots, where they are exchanged with the plant for sugars derived from photosynthesis. These plant-derived sugars are essential for the survival and development of most mycorrhizal fungi. This kind of two-way beneficial interaction is called a "mutualistic association." In nature, this relationship helps plants establish in resource-poor areas and improves the ability of the host to compete with soil microbes and other plants for limiting nutrients such as nitrogen and phosphorus. Mycorrhizal plants typically have higher rates of survival, increased growth and productivity, and increased nutrient status when compared to non-mycorrhizal plants.

Arbuscular Mycorrhizae

AM occur in the roots of herbaceous plants and trees such as sweetgum and maple (**Table 1**). The fungi forming AM typically produce large resting spores, which can be used to identify AM fungal species (**Figure 1**). AM produce organs of nutrient transfer (generally known as haustoria) within root cells. These organs are technically called arbuscules (from the Latin word for "tiny tree") (**Figure 2**). Sometimes AM fungi also produce storage organs (vesicles) between root cells, a feature that led them to be called vesicular-arbuscular mycorrhizal (VAM) fungi in the past.

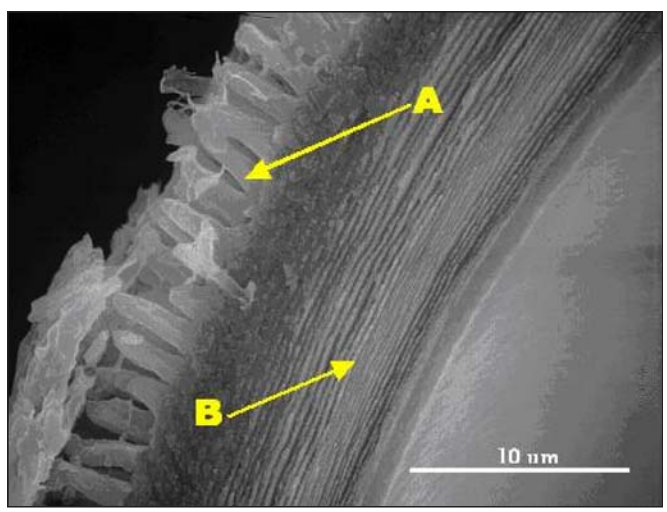

Figure 1. AM fungal spore walls can be complex.
A: outer spines; B: laminated inner wall.
Photo by Nathan Kleczewski.

Figure 2. An arbuscule of a AM fungus.
Photo by M. Brundrett (with permission).

Table 1. Examples of plants forming AM

Ailanthus	Apple	Arborvitae
Barberry	Blackberry	Boxelder
Buckeye	Butternut	Catalpa
Chamaecyparis	Cherry	Chinaberry
Coffeetree	Crabapple	Cryptomeria
Cucumber tree	Dogwood	Elm
Gingko	Grapevine	Hawthorn
Hibiscus	Holly	Horse chestnut
Juniper	Leyland cypress	Ligustrum
Lily	London plane	Magnolia
Maple	Melaleuca	Olive
Palms	Paulownia	Persimmon
Raintree	Redbud	Redwood
Rose	Sequoia	Serviceberry
Silverbell	Sourgum	Sweetgum
Viburnum	Walnut	Yellow Poplar

Table 2. Examples of trees forming EM

Alder	Aspen	Basswood
Beech	Birch	Chestnut
Chinquapin	Douglas Fir	Eucalyptus
True Firs	Hazelnut	Hickory
Ironwood	Linden	Oak
Pine	Poplar	Spruce

Ectomycorrhizae

EM occur on numerous tree genera, including those commonly found in the nursery and landscape (**Table 2**). Unlike the large resting spores formed by AM fungi, EM fungal spores are often small and wind dispersed from fleshy fruiting bodies we call mushrooms. EM fungi produce a sheath of fungal material on the root known as the mantle, and an intercellular organ of nutrient transfer called the "Hartig net." In contrast to AM arbuscules, the Hartig net is found between, not within root cells (**Figure 3**). Colonized root tips may be brightly colored, and are often swollen and highly branched (**Figure 4**). Some EM fungi produce enzymes that allow for access to nutrients from organic sources such as proteins or DNA in the soil that would not normally be available to trees, improving their competitive abilities. (See **Figure 5** for a diagrammatic representation of a tree colonized by EM fungi and structures associated with the interaction.)

Host Range of Mycorrhizae

AM and EM fungi vary in their levels of host species specificity. While most individual EM fungal species tend to form associations with specific host plant species, individual AM fungal species are "generalists" and can associate with hundreds of different host plant species. This characteristic is reflected in the number of recognized mycorrhizal fungal species: thousands of EM vs. about 200 AM fungal species.

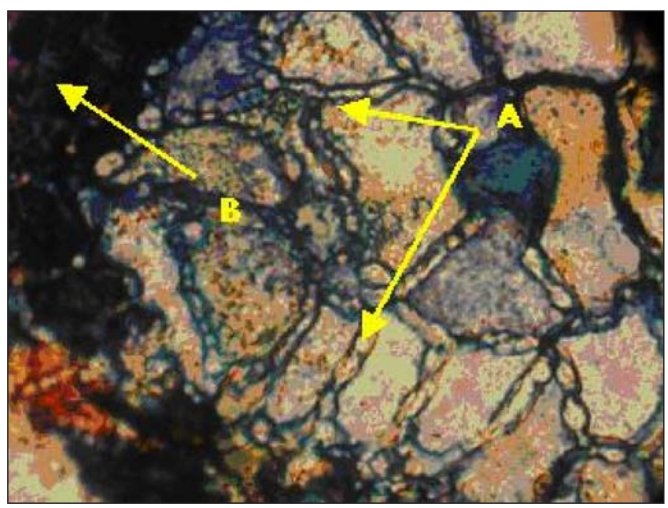

Figure 3. A cross section of an EM root tip.
A: Hartig net surrounding individual root cells; B: mantle.
Photo by Nathan Kleczewski.

Figure 4. An example of a highly branched EM root tip. *Photo by Nathan Kleczewski.*

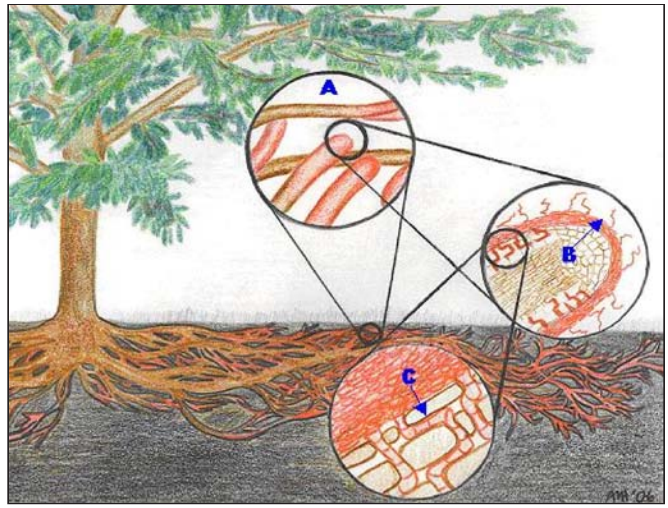

Figure 5. Diagrammatic representation of the EM relationship at various anatomical levels. A: EM root tips; B: mantle and emanating hyphae; C: Hartig net. *Drawing by Ashley Hughes.*

Artificial Inoculation of Urban Plants

Artificial mycorrhizal inoculation may benefit plants when there is no natural and appropriate mycorrhizal inoculum in the soil, the inoculum level is low, or species present are less efficient at aiding the plant host than those being introduced. This situation is most commonly found in disturbed, depleted soils such as mine spoils. In principle, highly compacted, organic nutrient-poor soils in urban environments may also be prime candidates for artificial mycorrhizal inoculation. However, success of the treatment and benefit to the plant cannot be guaranteed for three main reasons: (1) the target host may not be completely receptive to the introduced fungi, due to imperfect host specificity; (2) the urban soil may already contain spores of native mycorrhizal fungi that can outcompete the newly introduced species. Recent studies by Ohio State researchers demonstrate that urban soils are rapidly colonized by competitive, native EM fungi, and inoculum loads of subsoils may be quite similar to fertile soils; and (3) the soil environment may not be conducive to the establishment of the introduced mycorrhizal fungi. Studies show that slight alterations in soil characteristics such as pH, temperature, organic matter content, overall fertility, and moisture may significantly alter colonization by mycorrhizal fungi or may favor colonization by certain fungi over others. In all of these cases, while application of these treatments is not injurious to the plant, it may result in no net benefits to the host (and the customer).

At present, there is very limited, unbiased scientific evidence demonstrating that mycorrhizal inoculations of urban soils with commercial preparations make plant establishment more successful or that the inoculated plants grow better and remain healthier over time. In fact, the available evidence is very inconsistent. These inconsistencies may result from improper preparation, storage, and/or application of the commercial products, or an inability of the mycorrhizal fungi to establish on root systems as highlighted above. For all these reasons, treatment of trees with mycorrhizal preparations should not be viewed as the miraculous panacea presented in commercial advertisements, but rather as one potentially beneficial tool in the wider context of integrated tree health management.