Native Forests and the Urban Landscape: Don't treat your soil like dirt

By Mike Amaranthus, Ph.D.

Today's modern urban landscape is a far cry from the native forests that once spread widely across our continent. Urban landscapes face many threats to the health of trees. Shortage of organic matter in the soil, compaction, poor soil drainage, disease, erosion, unstable pH and impermeable crusted soil surface are definitely not the conditions that trees faced in their native forest habitats. (Table 1).

How do trees in the forest primeval attain great ages, heights and diameters without irrigation, fertilizers and pesticides? The answer is that soils in undisturbed native forests contain a wide range of beneficial organisms that soils in the urban landscape lack. Probably the most important of these, and the most studied group of beneficial soil organisms, are the mycorrhizal fungi. Mycorrhizae literally means fungus-root and is a symbiotic (mutually beneficial) relationship between plant roots and certain specialized soil fungi. All known tree species form the mycorrhizal relationship in their native habitats.

For the last 20 years, scientists have been intensely studying these tiny soil organisms that are changing the way tree care professionals think about planting and managing trees.

A healthy Deodar cedar (Cedrus deodara) after treatment with a mycorrhizal inoculant.

Mother's ancient history

Our landscape has not always been alive. Back 460 million years ago, no plants covered the earth's land surface. Compared to today, the land was a barren, lifeless surface. Plants only existed in lakes and seas and lacked the elaborate root structure they needed to conquer the harsh conditions on the land.

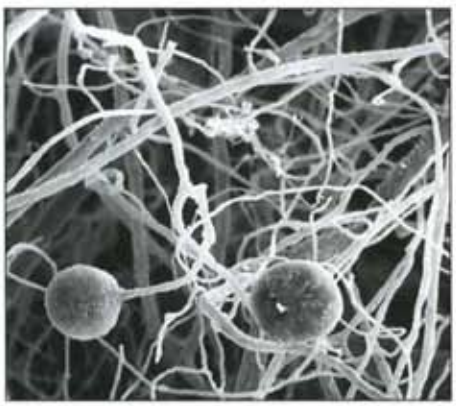

Figure 1. Mycorrhizal filaments in the soil.

Then the specialized fungus entered the primitive root of the aquatic plant. The fungal thread secured its energy source from the plant and, in return, the fungal filaments explored and mined the harsh earth's surface. (Figure 1). The plant acquired the needed nutrients and water to sustain life from the fungus. The resulting evolutionary leap allowed plants to inhabit the land surface and has shaped life as we know it today.

The mycorrhizal-plant relationship not only still exists today, but has also become one of the most successful relationships on earth. Today, approximately 90 percent of the world's plant species form the mycor-

Figure 3. Too much turf grass, water and fertilizer are not conditions that favor trees and mycorrhizal fungi.

planting and are subject to greater levels of stress and mortality.

We now know that mycorrhizal populations have been lost following construction activities. Vegetation removal, compaction, erosion, grading, topsoil removal, paving, pollution, over watering and the use of certain chemicals are just some of the practices that adversely affect mycorrhizal fungi (Figure 4). These conditions are definitely not the conditions that plants faced in their natural forest environments.

Re-establishing a living earth

How do you re-establish mycorrhizal fungi once they have been lost from a site?

Recent advancements in our understanding of mycorrhizal fungi and their requirements have led to the production of high-quality, economical mycorrhizal inoculums at affordable prices. Mycorrhizal inoculums are currently available in granular, powder, liquid and even tablet forms (Figure 5).

The most important factor for re-integrating mycorrrhizae is to get the mycorrhizal propagules near the root systems of target plants. Inoculum can be incorporated into the planting hole at the time of transplanting, watered into porous soils, mixed into soil mixes or directly dipped on root systems using gels. The

Undisturbed Forest Soil vs Disturbed, Intensively Managed Urban Soil

Loose, well aggregated	vs	Compacted, massive
Fungal dominated	vs	Bacteria dominated
Low to moderate fertility	vs	High fertility
High levels of mycorrhizal fungi	vs	Low levels of mycorrhizal fungi
Seasonal moisture inputs, well drained	vs	High levels of irrigation, poorly drained
High levels of organic matter inputs	vs	Low levels of organic matter inputs
Low, stable pH and temperature	vs	High, variable pH and temperature
Low levels of surface erosion	vs	High levels of surface erosion
Low salt concentrations	vs	High salt concentration
Low levels of soil borne diseases	vs	High levels of soil borne diseases

Table 1

rhizal-plant relationship in varied natural habitats all over the world.

How do mycorrrhizae work?

Mycorrhizal spores (seeds) germinate in response to root activity and penetrate in or around the inside of the root cells (Figure 2). Then they send their filaments (called mycelium) into the surrounding soil, effectively extending the plant's roots and root absorbing capacity from 10 to several thousand times – far beyond what the plant can do alone and thus improving plant establishment and productivity.

Several miles of these ultra-fine filaments can be present in less than a thimbleful of soil. Mycorrhizal fungi supply the water and nutrients needed by the plant for establishment and survival, and, in return, receive from the plant roots sugars and other compounds needed by the fungus. Mycorrhizal filaments are much smaller than roots, so they can easily penetrate into smaller spaces between soil particles.

In the small nooks and crannies of the soil, these tiny filaments release powerful enzymes that dissolve tightly bound minerals such as phosphorus, sulfur, iron and all the major and minor nutrients used by plants. The nutrients are organically assimilated by the mycorrhizae and become readily available for use by the plants.

Mycorrhizae provide many other benefits to plants. The fungal filaments take up and store water, decreasing drought stress during dry periods. Plant roots are too thick to access the small pores that retain large amounts of water in the soil. The much thinner mycorrhizal hyphae easily penetrate into smaller spaces between soil particles and supply essential water during periods of moisture deficit.

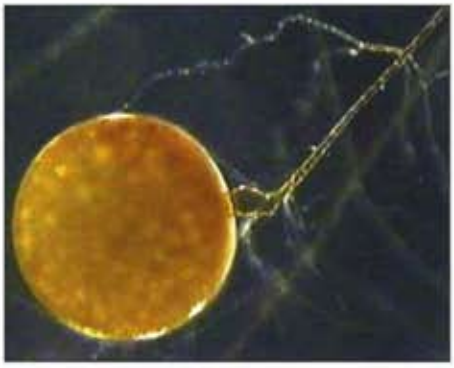

Figure 2. Mycorrhizal spore.

The fungal filaments also bind soil particles into larger aggregates with organic glues such as humic compounds; the resulting soil structure allows air and water movement into the soil, encouraging root growth and distribution.

Mycorrhizal benefits include:

- Improved transplant survival, growth
- More effective rooting
- Improved soil structure
- Increased fertilizer utilization
- Decreased drought stress
- Tolerance of environmental extremes
- Reduced off-site pollution of surface and groundwater

When do we apply mycorrhizae?

Natural, undisturbed areas are teeming with a wide variety of mycorrhizal fungi. These areas have reached tremendous productivity and stability without chemical fertilizers, irrigation and pesticides. Healthy living soils conserve water and nutrients and protect the plants against stress and environmental extremes.

To achieve the benefits of the mycorrhizal relationship, they need to be present on your site. Most of our man-made environments were built using practices that destroy the soil conditions supportive of beneficial soil organisms. (Figure 3) Studies have documented that in highly disturbed environments, trees have not formed mycorrhizal relationships after

form and application of the mycorrhizal inoculum depends upon the needs of the applicator. What is clear is that on disturbed construction and stressed sites, inoculation is highly effective.

If you are planning to add mycorrhizal fungi back to areas where they have been lost, make sure you use products that have a diverse array of species. Not all are created equal. Mycorrhizal fungi have different capacities and tolerances. For example, some have differing abilities to protect plants from drought. Still others are better at producing enzymes that facilitate mineral uptake such as phosphorous, iron and others. Some mycorrhizal fungi can access organic forms of nitrogen. Mycorrhizal diversity ensures a range of benefits to the plant not found with only one species.

Don't treat soil like dirt

Disturbance activities and the widespread use of conventional fertilizers and pesticides have resulted in detrimental effects on our soils and environment. Impacts include high levels of run-off, erosion, compaction, contamination of lakes, streams and groundwater, salt accumulation and loss of soil structure. On large areas of the planet, we have treated soil like dirt.

An attractive tool to diminish the environmental and dollar costs of these activities is to use mycorrhizal fungi as a natural tree growth stimulant. Using mycorrhizal fungi to establish and grow trees is borrowing from nature's template. Natural, undisturbed areas are teeming with a wide variety. Many of these natural forest ecosystems are the most stable and productive on earth, achieving great plant productivity and longevity without irrigation, fertilization or the use of pesticides. How do they do it? A healthy, robust, living soil conserves, transforms and utilizes soil nutrients and water and protects plants from unhealthy soils and environmental extremes. The key for the tree care specialist is to recognize that soil is alive and deserving to be treated like the precious resource it is.

Granular mycorrhizal inoculum. Mycorrhizal inoculums are currently available in granular, powder, liquid and even tablet forms.

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Mike Amaranthus, Ph.D., is adjunct associate professor of Forest Science at Oregon State University and president of Mycorrhizal Applications Inc. This article was excerpted from his presentation on the same subject at TCI EXPO 2006. He will be presenting at TCI EXPO 2007 this November in Hartford, Conn., on Maintaining Soil Fertility.