The Real Dirt on Soil:

www.mycoapply.com
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Does my soil already contain mycorrhizal fungi?

Mycorrhizal fungi are present in most undisturbed soil ecosystems, along with innumerable amounts of bacteria, protozoa, actinomycetes, worms, insects, etc. Mycorrhizal populations are particularly low, and many times non existent, in agricultural soils that have been altered by certain pesticides, chemical fertilizers, tilliage, compaction, organic matter loss, erosion, and fallow periods. Once lost from a farm, endomycorrhizal populations are slow to recolonize. Endomycorrhizal fungi form their spores or "seeds" below the soil surface. Because these spores do not readily move in the air, they do not move long distances from natural areas back to the farm.

Nursery grown crop plants available to farmers are often deficient in mycorrhizae. Plants raised in most nurseries receive intensive care and feeding. These artificial conditions, such as high levels of water, nutrients and sterile soil-less mixes at the nursery produce large quantities of plants for sale. Unfortunately, the high levels of water and nutrients and the lack of mycorrhizae discourage the plant from producing the extensive root system it will need for successful transplantation. Thus these plants are poorly adapted to the eventual outplanted condition and must be weaned from intensive care systems and begin to fend for themselves. Application of mycorrhizal inoculum before, or during, transplantation can encourage plant establishment and set the plant on track to feed for itself. Research studies document the need of plants to generate a mycorrhizal roots system in order to quickly become established.

Mycorrhizal colonization can also be reduced by high rates of available phosphorous. Studies have documented a decline in mycorrhizal colonization when available P rates exceed 80 ppm. On many farms there is an adequate supply of soil phosphorous but it is tied up in the soil and not available to plants. Mycorrhizal fungi such as Glomus mosseae, Glomus intraradices and Glomus etunicatum species produce a high level of phosphotase enzymes that specifically extract tightly bound phosphorous from clay particles and make P immediately available to the plant. Since mycorrhizal fungi are important to accessing P in soil, a healthy mycorrhizal population eliminates the need for high levels of P fertilization. Some scientific studies have shown that following mycorrhizal inoculation growers can decrease their P fertilization by 20-30 percent without any loss of plant productivity. In fact most studies have documented large increases in P uptake when mycorrhiza are present. This has significant implications to agricultural production because phosphorous is second only to nitrogen in terms of its importance to crop growth and development.

While some fungicides reduce or eliminate mycorrhizal fungi other research indicates that certain types of fungicides do not adversely affect mycorrhizae. A list of fungicides and their effects on mycorrhizae can be accessed at www.mycorrhizae.com. In addition, mycorrhizal inoculants can be used 4 to 6 weeks before applying fungicides allowing the mycorrhizae to firmly establish within the plant root.. Mycorrhizal inoculum can also be added following the use of a fungicide. Follow the manufacturers' guidelines for the time in which the fungicide "clears" the soil media.

How to use mycorrhizal fungi

Agricultural markets are already benefiting from the use of mycorrhizal inoculum and use has increased dramatically in recent years. New developments in the growing of mycorrhizal inoculum has made using mycorrhizae on the farm more cost effective, easy and affordable. High quality, concentrated mycorrhizal inoculum containing diverse species is the best choice. Because of the wide variety of crops, soils, and climatic conditions characterizing farm environments a diverse species mix of mycorrhizae assures the best response. Endomycorrhizal inoculum used to form the mycorrhizal relationship, can contain several selected mycorrhizal species. Glomus intraradices is one of the most studied and known to form the mycorrhizal association over a wide range of crop conditions. Glomus intraradices has been shown to be critical for nutrient and water uptake as well as in the control of parasitic nematodes. Glomus mosseae and Glomus etunicatum produce a superior crop yield response by stimulating root development, protecting against drought, and increasing P uptake.

What types of mycorrhizal products are available? Mycorrhizal inoculum can be applied in a powder, granular or liquid form. Treating seed, either before or during sowing, produces excellent results. For example, one pound of the concentrated 4 species, MycoApply® mycorrhizal seed inoculant can treat enough seed to sow one acre(figure 6). Del Gates a farmer in North Dakota was able to increase flax yields from 22 to 28 bushels/acre. Ron Miller a wheat farmer in Nebraska increased his organic wheat yield from 12 to 17 bushels/acre using the same mycorrhizal seed inoculum. In Visalia, California, studies by United Agricultural Products documented a 20% increase in the yield of sorgum sudan grass at 4 different seeding rates following MycoApply® inoculation. Other studies with MycoApply® mycorrhizal inoculants have shown significant improvement in the yield of strawberries, tomatoes, potatoes and many other crops.

Conclusions

It is easy to forget about soil organisms. After all, most of the creatures living in the soil are out of sight. However, farmers clearly know the look and feel of a productive soil that is the product of the living soil environment. Managing for beneficial soil organisms can create and maintain healthy and profitable soil conditions. The “real dirt” on soil is this: it's much more than minerals, air, water and decaying organic matter. The soil has life and this life supports a productive farm. "Dirt is dead, but soil is alive".

A healthy profitable soil is alive

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The Real Dirt on Soil:

Soils are more than minerals, air, water and decaying organic matter

Ask any farmer what good soil looks, feels and smells like. Their criteria will likely include certain features:

- It has soft and crumbly structure
- It drains well
- It soaks up rains without runoff
- It's not compacted or has a hardpan
- It doesn't require increasing expenditures for high yields
- It produces healthy, high quality plants
- It has a rich, earthy smell
- It supports an abundant array of beneficial soil organisms

It is this last feature of good soil that is the most difficult to see and understand. Yet soil organisms are vital to the development and maintenance of many of the characteristics that we attribute to healthy soils.

The living soil, the "Real Dirt"

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The real dirt www.mycorrhizae.com

Figure 1. Del Gates, North Dakota farmer treated several thousand acres and increased yields of wheat and flax using a mycorrhizal inoculant.

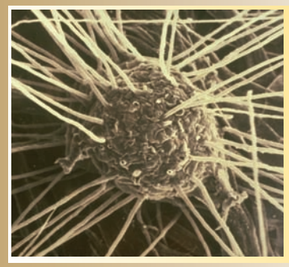

Figure 2. Filaments of mycorrhizal fungi extract moisture and nutrients from the soil.

Figure 3. Onion field. Left area inoculated with mycorrhizal fungi. Right area not inoculated.

Understanding native soils

How do soils function in their natural condition? How do native grasslands and forests produce an abundance of plants and animals in the complete absence of irrigation, fertilizer and tillage? The answer lies in understanding certain principles by which native soils function. We have been taught that soils are comprised of four basic components: minerals, air, water and decaying organic matter. What we haven't been told is that there is another major component of soil. It is the web of life, the "living soil" that supports plant health and growth (figure 2). Take a look at the amount of soil organisms present in an acre of healthy topsoil:

* 1000 pounds of earthworms
* 1500 pounds of bacteria
* 900 pounds of arthropods
* 130 pounds of protozoa
* 1000 pounds of actinomycetes
* 2500 pounds of fungi
* Thousands of miles of mycorrhizal fungal filaments

The living soil can help farmers develop and maintain productive and profitable soil conditions for today and for future generations. Dr. Arden Andersen, a physician and leader in the field of sustainable agriculture says, "The health of the living soil effects the health of the crop and ultimately humans. Using sustainable technologies, such as mycorrhizal fungi, works with nature and outperforms conventional agriculture" (figure 3).

When the soil is healthy, alive and managed in a sustainable manner, several positive features emerge:

* Reliance on expensive additives declines
* Land value increases
* Income potential increases
* Natural processes can replace artificial intervention
* Crops are more productive and less susceptible to disease

The real dirt

The living soil, the "real dirt" should be viewed as a living community and not an inert body. What do beneficial soil organisms do in natural areas that can also benefit the farm? Native prairies and forests functioned for decades and centuries without artificial inputs. The soils are tilled by soil organisms, not by machinery. They are fertilized too, microscopic bacteria fix nitrogen from the atmosphere and convert it to a form readily available to plants. In the natural soil system, fertility is used over and over again and nutrients are not lost to runoff, ground water or by erosion. Jim Trappe, Ph.D professor emeritas at Oregon State University has studied the living soil for 45 years and published over 250 scientific papers on the subject. Says Jim, "Beneficial soil organisms such as mycorrhizal fungi conserve, process and transport bound up minerals directly to the plants via a microscopic web of fungal filaments. The original "world wide web" of mycorrhizal filaments beneath the soil surface will work for the farmer's benefit if simply managed for their survival". There are over 50,000 thousand scientific studies on mycorrhizal fungi. The following paragraphs briefly describe what mycorrhizae are, where they are and how to use them. More detailed information on mycorrhizae and their uses can be accessed at www.mycorrhizae.com.

Reliance on expensive additives declines

What are mycorrhizal fungi?

"Mycor" - "rhiza" literally means "fungus" - "root" and defines the mutually beneficial relationship between the plant root and fungus. These specialized soil fungi colonize plant roots and extend far into the soil resource. Mycorrhizal fungal filaments in the soil are truly extensions of root systems and more effective in nutrient and water absorption than the roots themselves. A thimble full of healthy soil can contain several miles of fungal filaments that direct soil resources back to the plant roots.

Nearly all agriculturally important plants form endomycorrhizae. Here is a list of some commercially important agricultural plants that research has shown benefit from endomycorrhizae:

Alfalfa	Barley	Coconut	Fig	Leek	Onion	Plum	Strawberry
Almond	Bean	Coffee	Flax	Lettuce	Papaya	Potato	Sugarcane
Apple	Blackberry	Corn	Garlic	Lentil	Passion Fruit	Raspberry	Sunflower
Apricot	Cacao	Cotton	Ginseng	Mango	Peach	Rice	Tea
Artichoke	Carrot	Cowpea	Grape table	Millet	Peanut	Rosemary	Tobacco
Asparagus	Celery	Cucumber	Grape wine	Mint	Pecan	Sorghum	Tomato
Avocado	Cherry	Currant	Hemp	Oats	Pepper	Soybean	Wheat
Banana	Citrus	Eggplant	Kiwi	Olive	Pistachio	Squash	

*beets, broccoli, cabbage, spinach and canola do not respond to mycorrhizal inoculation

Endomycorrhizal fungi penetrate into and around root cells and form specialized cells in the roots for the storage and transfer of materials between the plant and fungus. Endomycorrhizal species form individual spores which are the"seeds" that form the next colony of mycorrhizal fungi (figure 4). These spores are formed beneath the soil surface and do not readily disperse and recolonize an area once they have been lost from a site. Research studies of important agricultural plants that respond to mycorrhizal colonization can be found at www.mycorrhizae.com.

Over the past 400 million years, this association of mycorrhizae with plant has evolved to a level where, in addition to sourcing food and moisture, the mycorrhiza has taken on other properties that assure plant health and vigor. As the fungi infects or colonizes spots along the root system, it restricts access by various pathogenic organisms and produces antibiotics to retard their growth. The thousands of miles of mycorrhizal filament present in a acre of healthy soil provides access to water or act as miners, excreting specific enzymes, converting tightly bound nutrients such as phosphorous from mineral soils into forms that can be used by plants.

Specific benefits

Mycorrhizal fungi are the most researched aspect of the living soil. Mycorrhizal fungi can produce increased growth because they improve the absorption of soil phosphorus, zinc, iron, calcium, magnesium, manganese and sulfur. Research indicates mycorrhizal colonization increases a crops ability to absorb water from the soil and withstand extended periods of drought. Improved photosynthesis capacity resulting from colonization has also been cited in reducing negative effects of salt and toxic elements. Mycorrhizae produce hormones that stimulate root growth. Mycorrhizae can also produce synergistic effects in legume crops when the inoculants of fungi and nitrogen fixing bacteria are combined. Roots colonized by mycorrhizal fungi are less likely to be affected by root feeding nematodes. And finally, mycorrhizal plants are more resistant to many soil borne pathogens. Specific scientific abstracts regarding mycorrhizal fungi and these benefits can be accessed through www.mycorrhizae.com.

Soil tilth and mycorrhizal fungi

A soil that drains well, does not crust and takes in water and oxygen is said to have good tilth. Soil tilth influences the ease of tillage, root penetration and seedling emergence. Soil with good tilth is said to be well-aggregated. Well-aggregated conditions occur when individual soil particles are joined together in stable clusters that improve the infiltration and porosity of the soil. USDA soil microbiologist Sara Wright named the glue that holds aggregates together "glomalin" after the common Glomales group of endomycorrhizal fungi that form with most agricultural corps. These mycorrhizal fungi secrete this gooey protein though their tiny filaments. This sticky glue holds individual soil particles in water-stable aggregates that encourages the flow of both moisture and oxygen through the root zone. Glomalin levels are high in healthy well-aggregated soils. Figure 5 is a picture of healthy well aggregated soil.

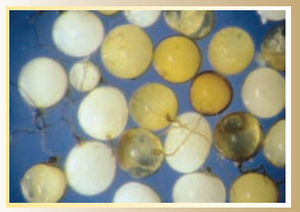

Figure 4. Endomycorrhizal spores.

Figure 5. Roots penetrate deep into well aggregated soil following inoculation with mycorrhizal fungi on a farm in Manitoba, Canada.

Figure 6. Tiny mycorrhizal filaments radiate from the young roots of mycorrhizal coated seed.

Mycorrhizal filaments act as miners providing nutrients