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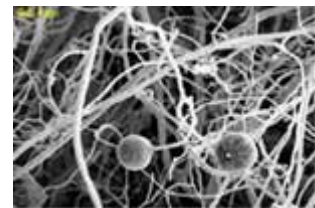
## **An easy and cost effective way to improve yields using Mycorrhizal fungi.**

Mycorrhizal fungi form symbiotic associations with over 90% of the world's plant species. The relationship is particularly important for agricultural plants that have large requirements for nutrients and water to achieve optimum yields. The mycorrhizal fungi excrete powerful chemicals that dissolve mineral nutrients, absorb water, retard soil pathogens, and glue soil particles together into porous structure. In return, the mycorrhizal fungi receive sugars and other compounds from plants to fuel mycorrhizal activities. Both agricultural plant and fungus benefit from the "symbiotic relationship". Research has documented improved plant nutrient and water uptake and resistance to a wide range of environmental extremes. Plants establish and yield more abundantly and require less intensive care. This is a major reason why plants from natural undisturbed areas can thrive without irrigation, fertilizer and pesticides. Over 50 thousand University studies have highlighted the benefits of mycorrhizal colonization on the health and yield of plants. Mycorrhizal seed inoculants are a concentrated low-cost mycorrhizal seed coating for agriculture that combines multiple mycorrhizal species with a patented mycorrhizal stimulant and proven biostimulant.

### **Agricultural Soils Need Mycorrhizae**

Modern agricultural practices can greatly reduce the biological activity in soil. Certain pesticides, chemical fertilizers, extensive cultivation, organic matter loss, and erosion adversely effect beneficial mycorrhizal fungi. Mycorrhizal fungi significantly increase the absorbing area available to the plants root system, improving the plant's ability to absorb water and nutrients, maintain soil structure and increase resistance to stress and pathogens.

### **The mycorrhizal network is the original world wide web.**



### **Increased yield**

A recent scientific breakthrough has led to the development of a cost effective mycorrhizal seed inoculant. Mycorrhizal seed inoculants are an environmental friendly product that increases yields while decreasing reliance on fertilizers and pesticides. This concentrated powder coats the seed delivering the benefits of the mycorrhizal relationship to the field crop. Yields increased 26 bushels an acre in a recent study of Kansas dryland wheat seed coated with mycorrhizal seed inoculant. An organic wheat farm in Nebraska increased yields 43% with the addition of a mycorrhizal seed inoculant. Flax yield was increased 27% in North Dakota with a 10-fold increase in mycorrhizal colonization following application of a mycorrhizal seed inoculant. Numerous University studies with wheat have documented increased nutrient uptake and yields (Khare et al. 1998; Thompson et al. 2002; Al-Karaki and Al-Omouh 2002). The mycorrhizal relationship enhances phosphorous accumulation and grain production over a wide variety of soil

and climatic conditions (Mohammad et al. 1998; Brito et al. 2001; Talukdar and Germida 1993). Dryland winter wheat yields have been increased over 100% in eroded and water stressed areas (Pan et al. 1992). Increased yields have been documented for a variety of agricultural crops including alfalfa, barley, corn, flax and potatoes.

In **soybeans**, inoculation with mycorrhizal fungi increased the amount of biological-fixed nitrogen and stimulated phosphorous uptake, soybean growth and yield (Shabayex et al. 1996; Goss and deVarenes 2002). Yield increases of 30% or greater have been realized for **corn and soybeans** with savings of 160 and 213 lb/acre phosphorous respectively (Kelly et al. 2001; Plenchette and Morel 1996). Increases in yield are not only related to improved phosphorous nutrition but more extensive soil water extraction. (Busse and Ellis 1985; Auge et al. 1992; 2001). Phosphorous content increased 35 to 98% in corn root tissue following mycorrhizal inoculation (Shnyreva and Kulaev 1994). Mycorrhizal colonization of corn shortly after germination is important to phosphorous nutrition and initial corn growth (Jayson et al. 1993).

How to apply: One pound of mycorrhizal seed inoculant will treat enough seed to sow one acre. It can be applied as a dry powder or with a spray coat. Apply before or during sowing. a Mycorrhizal seed inoculant can be stored dry at room temperature for 2 years without loss of viability.

Most agriculturally important plants form this mutually beneficial relationship with a specific group of “good fungi” called arbuscular mycorrhizal fungi (AMF). The plant-AMF relationship is of high interest as it has been shown to improve plant nutrient uptake, crop yield, and resistance to pathogens and drought. Thus, a source of AMF inoculum provides farmers with an efficient, cost-effective, and ecologically improved agricultural practice.

Either powder or granular mycorrhizal materials are added directly into the surrounding soil of seeds and plantlets to form the mycorrhizal relationship. The primary goal always being to get the product in close contact with the seed and the emerging root system to be most effective.

AMF filaments are much smaller than roots, so they can easily penetrate into smaller spaces between soil particles, where they release powerful enzymes that dissolve tightly bound minerals like phosphorus, iron, and absorb all the major and minor nutrients used by plants (Figure 4 – “Mycorrhizal Filaments”). The nutrients are absorbed by the mycorrhizae and transported back to the plants themselves. Recent research by the Agricultural Research Service has also documented the importance of mycorrhizae for the uptake of nitrogen.

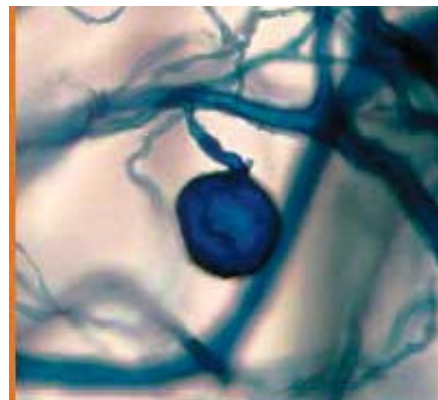


Figure 4 Mycorrhizal filaments and spore emanating from root.

AMF provide many other benefits to plants. The fungal Filaments take up and store water, decreasing drought stress during dry periods (see Figure 5 picture of “Corn Treated and Untreated”). They also bind soil particles and Untreated”). They 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.



Figure 5 Mycorrhizal inoculated corn tolerates drought.

## Results

Bill Miller used “nature’s good fungi”, to raise his organic flax yield from 3 to 6 bushels per acre. What impressed Bill even more was the additional revenue he reaped with those extra bushels. With organic prices at \$14-19 per bushel and an increase of 3-6 bushels of flax per acre, Bill’s initial investment in mycorrhizal seed inoculant typically resulted in an extra \$50-100 per acre. Bill’s experience is based on replicated plots for the North Dakota Crop Improvement Organization, but other farmers are learning how “nature’s good fungi” can boost alfalfa, corn, wheat, potato and onion yields as well.

Bob Pylman’s alfalfa price jumped from \$80 per ton to \$130 per ton in a test conducted in California by United Agricultural Products. In the hot summer period, he found hay quality remained high when treated with a mycorrhizal seed inoculant compared to the untreated fields where quality continued to decline. Research trials with alfalfa have also documented improved alfalfa seed germination.



Figure 2 Alfalfa germination trial. The pot on the left was treated with a mycorrhizal seed inoculant.

Jerry Miller at Agritech tested mycorrhizal seed inoculant with **corn** and bumped up his average yield from 60-70 bushels per acre in non-treated North Dakota fields to 100 bushels/acre. In Canada, Acres Research found increased yields in all 8 out of 8 mycorrhizal seed inoculant treated plots in Manitoba, Canada.

Mycorrhizal seed inoculant has also been found to stimulate production of Grasses. Lonny Warfel in Halsey, Oregon used it when sowing his tall fescue in 2005 and has seen significant improvement in plant vigor (see Figure 3).

Figure 3 Top, control group. Bottom, Fescue after a mycorrhizal seed inoculant treatment.



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Product	#'s	Cost	\$Acre	#acre
Soluble13 Endo/Ecto+19Bac+Tric+BioStim+Vit	1	\$55.93	\$55.93	1
Soluble Ultrafine Endo Powder	20	\$375.20	\$18.76	1
Seed Inoculant Powder+Tric+BioStim	20	\$386.40	\$19.32	1
Endo Granular (Gandy Box)	20	\$201.60	\$20.16	2

<http://www.cottoninc.com/Engineering/ConservationTillageConference2005/>

Practical Soil Microbiology and Biochemistry for Con-Tillers

Presented by Dr. Al Knauf

*Technical Consultant, Ag Spectrum Co.*

The soil ecosystem is a complex and dynamic community that requires the same things that we require: respiration, water, food, shelter, and acceptable temperatures. The degree to which we provide these essentials determines our success with this, a community vital to the cycle of life on earth.

Tillage and agricultural chemicals reduce the kind and numbers of soil residents as we process forests and grasslands into cropland and pasture. As soil diversity changes, so does productivity. Monoculture requires unnatural inputs and puts strains on the crop of microbes and worms, arthropods, mites, and predators that are the grower's below-ground crop.

Given the necessities, the soil community will decompose residues and release fertility from them for the next crop. This forms humic materials which improve a soil's ability to aggregate, hold and drain excess water, and retain applied fertility. Acids and growth factors are also produced, which release nutrients from unavailable soil minerals and stimulate plant growth. Some microbes even fix nitrogen, form special symbiotic relationships with crop roots, and antagonize plant pathogens. The chart shown below illustrates what just 25 ppm of phosphorus and a mycorrhizal association can do for the nutritional balance in corn. Note how all aspects of mineral nutrition improve when we feed the system. When soil life goes to work, far more than absorption of a single nutrient is affected.

<b>Effect of Inoculation with Mycorrhiza and of Added Phosphorus on the Content of Different Elements in the Shoots of Corn</b>				
<b>Nutr.</b>	<b>No Phosphorus</b>		<b>25 mg/kg Phosphorus</b>	
	<b>No Mycorrhiza</b>	<b>Mycorrhiza</b>	<b>No Mycorrhiza</b>	<b>Mycorrhiza</b>
<b>P</b>	750	1,340	2,970	5,910
<b>K</b>	6,000	9,700	17,500	19,900
<b>Ca</b>	1,200	1,600	2,700	3,500
<b>Mg</b>	430	630	990	1,750
<b>Zn</b>	28	95	48	169
<b>Cu</b>	7	14	12	30
<b>Mn</b>	72	101	159	238
<b>Fe</b>	80	147	161	277

In each case above the addition of mycorrhiza plus phosphorus significantly increased the level of other nutrients in corn as expressed in micrograms per plant.

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In short, management of this resource can improve soil tilth, drainage, nutrient holding capacity, and lower chemical and fertilizer bills.

<http://aggie-horticulture.tamu.edu/faculty/davies/research/mycorrhizae.html>

**Benefits of Mycorrhiza:**

1. Enhanced plant efficiency in absorbing water and nutrients from the soil.
2. Reducing fertility and irrigation requirements.
3. Increased drought resistance
4. Increased pathogen resistance/protection.
5. Enhancing plant health and vigor, and minimizing stress.
6. Enhanced seedling growth.
7. Enhanced rooting of cuttings.
8. Enhanced plant transplant establishment.