Why Should You Consider Using Mycorrhizae?

Change Your World

www.mycorrhizae.com
Mycorrhizal Symbiosis

A mutually beneficial relationship, which is characterized by movement of carbon flows to the fungus and inorganic nutrients move to the plant, thereby providing a critical linkage between the plant root and soil/media/substrate.

Mycorrhizae provide better absorption of nutrients and increased water uptake to the plant in exchange for carbon supply.
TYPES OF MYCORRHIZAE

- ECTOMYCORRHIZAE
- ENDOMYCORRHIZAE - ARBUSCULAR MYCORRHIZAE
- ECTENDO-MYCORRHIZAE
- MONOTROPOID MYCORRHIZAE
- ERICOID MYCORRHIZAE
- ARBUTOID MYCORRHIZAE
- ORCHID MYCORRHIZAE
Ecto vs. Endo Colonization of Plant Roots

Endomycorrhizae
(Arbuscular Mycorrhizal Fungi)

Arbuscular Mycorrhizal Fungi (AMF) colonize plant roots intracellularly (inside the root cell) and are dependent upon a living plant for growth.

General Life Cycle of Arbuscular Mycorrhizal Fungi (AMF)

1. **Chlamydospores (spores)** form at the end of fungal hyphae either within the plant root or outside in the soil.
2. Upon receiving **Strigolactones** signal from plant root, the spores germinate, penetrate & colonize plant roots.
   a. **Hyphae** - Each of the branching filaments (fungal roots) that make up the mycelium of a fungus.
   b. **Arbuscules** - Hyphal structures with many branches within the plant roots that serve as the site of nutrient exchange.
   c. **Vesicles** - Mycorrhizal storage structures within the roots.

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Figure 6
Schematic showing the difference between ectomycorrhizae and endomycorrhizae colonization of plant roots.
© 2013 Nature Education Bonfante, P. & Genre, A. Mechanisms underlying beneficial plant-fungus interactions in mycorrhizal symbiosis. Nature communications 1 doi:10.1038/ncomms1045. All rights reserved.
Mycorrhizal Propagules

Entities which can re-establish the mycorrhizal hyphal network with host plant roots:

**COLONIZED ROOT FRAGMENTS**

Fungal hyphae network within root tissues. Provide a fast fungal hyphae (re-)growth and quick colonization of target plants.

**FUNGAL SPORES**

Spores are normally dormant and germinate slower than root fragments. Very resilient structures.

**FUNGAL HYPHAE**

Extra-radical fungal hyphae can colonize plant roots quickly but have a very limited shelf-life (<2 years).
MYCORRHIZAL PRODUCT FORMULATIONS

Mycorrhizal inoculants come in a number of different formulation types. Many contain mycorrhizae only, some contain additional beneficial ingredients.

Granular Formulations
- Ideal for media incorporation

Suspendable Powders
- Can be highly concentrated
- Most versatile

Liquids
- Aqueous - Limited Shelf Life
Primary Benefit of Mycorrhizae

• Expanded Root Mass
  – As much as 50 times over time, up to 2 more ft.
  – Nutrient and water absorption occurs along the entire length of the hyphae
  – Mineral nutrient uptake from the soluble and insoluble pool
  – More efficient nutrient uptake (greater nutrient inflow)
  – Better roots lead to better plants
ROOT HAIR vs. MYCORRHIZAL FUNGAL HYphae

**Root hair:**
- Maximum length is a few millimeters
- Cation absorption occurs only at the tips
- Mineral nutrient uptake from available (soluble) pool only
- The rate of nutrient inflow is lower

**Mycorrhizal fungi:**
- Maximum length 20-25”
- Nutrient and water absorption occurs along the entire length of the hyphae
- Mineral nutrient uptake from the soluble and insoluble pools
- The rate of nutrient inflow is greater
Expanded Root Mass

CAST 2017

Full Fertilizer, MycoApply Treatment on Right

1/3 Less Fertilizer, MycoApply Treatment on Right
Expanded Root Mass

Cultivate 2018

Full Fertilizer, MycoApply Treatment on Right

Full Fertilizer, MycoApply Treatment on Right
Secondary Benefits of Mycorrhizae

• Efficiency in Nutrient Uptake
  – Reduced Nitrogen & Phosphorus run off
  – Nutrient buffer
  – Ability to modify nutrients into a form plants can use
  – Reduced plant stress
  – Reduce high EC stress
Less Fertilizer, More Plant

40% Less Fert. No Mycorrhizae

40% Less Fert. With Mycorrhizae

Full Fertilizer No Mycorrhizae

Full Fertilizer With Mycorrhizae
Secondary Benefits of Mycorrhizae

- Improved extraction of water
  - Enhanced in ground performance
  - Reduced plant stress
  - Water buffer
  - More efficient utilization of irrigation
  - Storage of water and lipids for periods of drought
Nutrient and Water Uptake
Drought Tolerance/Shelf Life

California Spring Trials 2017:
Coreopsis Wilt Trial

- Full Fertilizer + Soluble MAXX
- Full Fertilizer + Ultrafine Endo
- Reduced Fertilizer + No MycoApply
- Reduced Fertilizer + Soluble MAXX
- Reduced Fertilizer + Ultrafine Endo
- Full Fertilizer + No MycoApply
Study: “The effect of inoculation with the mycorrhizal fungus *Glomus intraradices* and extended drought on transplant survival of perennial herbaceous plants.”

- Survival without mycorrhizae AVERAGE: 41%
- Survival with mycorrhizae AVERAGE: 90%

-Klironomos, et al 2008 University of Guelph, Ontario, Canada
Benefits of Mycorrhizae

• Increased transplant success – both as a liner/plug and in the landscape
• Improved flowering – can be earlier, more prolific and more uniform
• Increased fruiting – can be earlier and have higher yield
• Enhanced plant habit – more lateral branching, darker foliage, higher plant grade out
Pay it Forward

• Mycorrhizal treatment benefits everyone in the customer channel after the treatment
  – Grower
  – Retailer
    • Pay by Scan
    • Guaranteed plant material
  – Landscaper
  – Home Gardener
COST OF TREATMENT

• $0.10/tray for drench treatment
  – Divided by number of cells...
    • Ex: $0.10 / 72 cells = $0.0014 per plant

• Production benefits
  – higher plant grade out, improved plant health, reduced production costs

• Retail benefits
  – reduced stress during shipment, improved shelf life, less customer returns
FOUR SPECIES PERFORMANCE

• MycoApply products contain a four species consortium (at a minimum).
  – Glomus mosseae
  – Glomus aggregatum
  – Glomus intraradices
  – Glomus etunicatum
Specificity of Endomycorrhizae

• Great deal of variability
• One fungal species may form association with many different plant species – low specificity
• One host plant can have mycorrhizal associations with a number of different fungal species (even at the same time)
• Each species colonizes roots at different speeds
• Each species colonizes different plant species to a different extent
Specificity of Endo Mycorrhizae

- Different species are responsible for different functional benefits

- Seasonal changes of rhizosphere microbial communities – “One does not fit all”
  - Soil microclimate (e.g., changes in soil moisture, phosphate availability)
  - Plant phenology
  - Plant physiology
  - Ecological conditions

- Diversity in microbial inoculants is important, because the species complement each other
## SINGLE VS. FOUR SPECIES PERFORMANCE

### Beneficial Factors Attributed to 4-Species

**MycoApply Endomycorrhizal Fungi and Their Relationships with Plants**

<table>
<thead>
<tr>
<th>Plant Nutrition Attributes</th>
<th>Glomus mosseae</th>
<th>Glomus aggregatum</th>
<th>Glomus intraradices</th>
<th>Glomus etunicatum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased Nitrogen (N) uptake</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Increased Phosphorus (P) uptake</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Can access organic forms of N and P</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Increases mineral uptake</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Effective root colonization with time-release fertilizers</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Tolerant of high fertility levels</strong> (Phosphorus)</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>High levels of enzyme activity benefiting nutrient and micronutrient acquisition</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>
## SINGLE VS. FOUR SPECIES PERFORMANCE

### Beneficial Factors Attributed to 4-Species MycoApply Endomycorrhizal Fungi and Their Relationships with Plants

<table>
<thead>
<tr>
<th>Plant Growth and Establishment</th>
<th>Glomus mosseae</th>
<th>Glomus aggregatum</th>
<th>Glomus intraradices</th>
<th>Glomus etunicatum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved performance of woody perennials</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Increases fruiting and flowering</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Improves plant performance in sandy soils</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Improves performance of palms and fruit trees</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Increases crop yields</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Improves growth and performance of turf grasses, agricultural crops and nursery stock</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Very effective in agricultural soils</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Improved plant establishment</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Well adapted to a wide variety of plants and soil conditions</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Improved growth of grain crops</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Increases production of vegetable crops</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Improved growth of tropical and subtropical fruits</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>
SINGLE VS. FOUR SPECIES PERFORMANCE

<table>
<thead>
<tr>
<th>Beneficial Factors Attributed to 4-Species MycoApply Endomycorrhizal Fungi and Their Relationships with Plants</th>
<th>Endomycorrhizal Fungi</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Glomus mosseae</td>
</tr>
<tr>
<td>Heat and Drought Tolerance</td>
<td></td>
</tr>
<tr>
<td>Drought protection</td>
<td>X</td>
</tr>
<tr>
<td>Greatly improves drought tolerance</td>
<td>X</td>
</tr>
<tr>
<td>Active during periods of low water availability</td>
<td>X</td>
</tr>
<tr>
<td>Suppression of plant pathogens and root diseases</td>
<td></td>
</tr>
<tr>
<td>Stimulates root development</td>
<td>X</td>
</tr>
<tr>
<td>Keeps root systems healthier</td>
<td>X</td>
</tr>
<tr>
<td>Nematode protection of roots</td>
<td>X</td>
</tr>
<tr>
<td>Promotes disease suppression</td>
<td>X</td>
</tr>
<tr>
<td>Effectively suppressed Verticillium wilt</td>
<td></td>
</tr>
<tr>
<td>Soil Physical and Chemical Conditions</td>
<td></td>
</tr>
<tr>
<td>Salt tolerance</td>
<td>X</td>
</tr>
<tr>
<td>Effective in mine reclamation</td>
<td>X</td>
</tr>
<tr>
<td>Protects against heavy metal toxicity</td>
<td>X</td>
</tr>
</tbody>
</table>
MYCORRHIZA FAQ

• What is the best application method?
  – An application that gets good contact with the roots will produce great results. Growers can choose the application method that best fits into their growing practices.
    • Soil/media incorporation
    • Plug dip
    • Direct application to roots at transplant
    • Traditional drench
      – Not via large scale horticulture injection systems, until early 2019
MYCORRHIZA FAQ

• How many applications are recommended?
  – Once treated, mycorrhizae remain in a symbiotic relationship with the plant for the plant’s entire life. When a plant is transplanted, the mycorrhizae join the soil ecosystem and change as it changes.
  – In most cases only once!
  – You can not overdose.
MYCORRHIZAE FAQ

• When will I start to see a difference after applying mycorrhizae?
  – Benefits can start within four weeks, visible benefits can be seen within eight weeks.
  – Crop time can include time as a plug and/or cutting.
  – Once propagation material is planted in a larger container, benefits start to become more visible.
MYCORRHIZAE FAQ

• Can I use fungicides if I grow with mycorrhizae?
  – Yes. A detailed list of fungicide compatibility is available from Mycorrhizal Applications.
  – Most fungicides can be used with mycorrhizae without negative impact.
  – The longer you wait to apply an “avoid use” fungicide after mycorrhizal inoculation, the better it will be for the mycorrhizal establishment and development.
MYCORRHIZAE FAQ

• Can mycorrhizae be used with other biological products?
  – Yes. Mycorrhizae work well with other biological products, such as beneficial bacteria (Actinovate®) and Trichoderma (RootShield®).
MYCORRHIZAE FAQ

• Can mycorrhizae be used with beneficial insects and mites?
  – Yes. Mycorrhizae do not interfere with these natural pest predators. In fact, mycorrhizal inoculation reduces plant stress, which in turn can reduce pest insect infestations.
MYCORRHIZAE FAQ

• How do mycorrhizae differ from other microbes?
  – Without the plant, they cannot live
  – They provide a long-term impact
  – They thrive in a diverse range of conditions
  – Mycorrhizal structures store nutrients and water for later use by the plant
• What is the recommended fertility program if I use mycorrhizae?
  – For best results, we recommend keeping N levels at 200 ppm (EC 0.4) or lower and P$_2$O$_5$ levels at 100 ppm (EC 0.2) or lower while using mycorrhizae.
  – Higher levels of fertility during inoculation can reduce the ability of the mycorrhizal inoculum to form the symbiotic relationship with the root system.
MYCORRHIZAE FAQ

• Are there any plants that will not benefit from mycorrhizal inoculants?
  – Brassicas – non-mycorrhizal
  – Mustards – non-mycorrhizal
  – Carnation/Dianthus – non-mycorrhizal
  – Orchids & Ericaceous – special mycorrhizae
  – It does not hurt a non-mycorrhizal if you treat it
MYCORRHIZAE FAQ

• What are the application options?
  – Soil Incorporation – lbs. per yard
  – Drench – volume per container
  – Plug Dip – 15 second absorption
  – Bareroot Dip – wetting agent, 15 second absorption
MYCORRHIZAE FAQ

• Can mycorrhizae reduce plant diseases?
  – Not an EPA registered pesticide
  – University Research has shown the benefits
  – Improved plant health by producing stronger root system
  – Life of mycorrhizae connected to life of plant
  – Research shows other mechanisms exist
  – Think of it as a good secondary defense
  – Potential to reduce need for fungicidal treatments
Who is Mycorrhizal Applications?

• 1995 – company established in Dr. Mike Amaranthus’ garage

• 1999 – MA branched out beyond the forestry industry, and added endomycorrhizae into its product mix, establishing the MycoApply® brand.

• 2015 – Mycorrhizal Applications became a wholly owned subsidiary of Valent BioSciences, a Sumitomo Chemical Company
MycoApply® Mycorrhizal Inoculants

Granulars

Suspendable Powders
MycoApply® Mycorrhizae

- OMRI Listed and CDFA
- Two year shelf life
- Can be stored under normal warehouse conditions, under 140°F
- Products registered in all 50 states, considered a soil amendment
Please stop by our booth and say hello!

Booth 48, 49
Questions/Technical Support

What questions do you have?
Blair Busenbark
425-429-1492 (PST)
Blair.Busenbark@mycorrhizae.com