Welcome!

- Session Title: Mighty Mycorrhizae: Nutrient Management Using Friendly Fungi
- Speaker(s): Blair Busenbark, Dr. Leonardo Casieri
- Session Sponsor: Mycorrhizal Applications LLC

**SESSION EVALUATION**

WEBSITE ADDRESS: cultivate.cnf.io

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**HORTICULTURE HAS CHANGED**

- Mycorrhizal Applications was founded in 1995.
- Grower Practices in 1995:
  - 20-20-20 was a fertilizer standard
    - Urea and Ammonia were the dominate nitrogen sources.
  - 400 ppm or more nitrogen was the norm
  - Plants were constantly fed
- Big Box Growers were paid 30 days after delivery.
HORTICULTURE HAS CHANGED

• Production Culture in 1995:
  – Plugs were starting to become popular.
  – Seed produced plants were the most popular product offering.
  – Vegetative plants were less common, Proven Winners had only been in business three years.
  – Container sizes were different - typically smaller, the cell pack was standard for consumer sales.

TIME IS NOW FOR MYCORRHIZAE

• MycoApply® sold through Horticultural Distribution in the United States and Canada.
  – 15-5-15 or a variant is the fertilizer standard
  • Nitrate fertilizers are the standard nitrogen source
  – 200 ppm or less nitrogen is the norm
  – Plants are not always constantly fed
• Big Box Growers now paid via pay-by-scan.

• Production Culture in 2019:
  – Liner and plug production are industry standards.
  – Vegetative propagation has flourished. Multiple companies have been created to fill market needs.
  – Propagation specialists have been created. Medium and small growers buy plugs and liners.
  – Cost of plant material has increased.
  – Larger containers have become more common. Four inch and gallon production is part of most growers’ product offerings.
WHAT ARE MYCORRHIZAL FUNGI?
- Mycorrhizal fungi form symbiosis with ≈95% of land plants.
- They live in the soil and colonize plant roots.
- Mycorrhizae provide better absorption of nutrients and increased water uptake to the plant in exchange for carbon supply.
- Mycorrhizal fungi cannot function without living plants. (Obligate symbionts)
- Plants or mycorrhizae can initiate the symbiosis; root exudates trigger spore germination.
- Increase effective root surface area for absorption.
- Increase tolerance to various stressors (drought, nutrient deficiency, heavy metal toxicity, etc.).
- Different types of mycorrhizae. Most plants Endo.

ENDOMYCORRHIZAE
- Form symbiotic association with ≈85% of plant species on earth.
- Colonize plants inside root cortical cells.
- Root is not altered in morphology – difficult to determine when roots are colonized – must clear and stain followed by microscopic examination.
- Form hyphae ("fungal roots") in the soil and within root tissues.
- Reproductive structures (spores) either within the plant root or outside in the soil.
- Environmental conditions and root exudates trigger spores to germinate in the soil.

ECTOMYCORRHIZAE
- Associate with ≈10% of plant species on earth.
- Major hosts are coniferous and select deciduous trees.
- Form fruiting bodies (carpophores = mushrooms).
- Root is altered in morphology – easily recognized.
- Roots become thicker and repeatedly branched after colonization.
- Hyphae penetrate within the first layer of root cortical cells and form a network of hyphae around root tips.
**CONTAINER – GROWN PLANTS**

- **Increased Root Mass:**
  - Endo mycorrhizae do not increase rooting to the point that the container is root bound.
  - Most of the increase in the root mass comes from the development and growth of mycorrhizal hyphal filaments.
  - Increased root mass can help transplant into a larger container more quickly root.
  - Less plant loss and reduced transplant shock.

- **Increase Water Uptake:**
  - Water absorption occurs along the entire length of the hyphae.
  - In times of excess, water is stored in hyphae for use when needed by the plant.
  - Increases water availability without increasing moisture in the soil.
  - An increase in drought resistance of approximately 36-48 hours.
  - Allows a grower to grow dry and not stress out their plants.
**CONTAINER – GROWN PLANTS**

- Increased Nutrient Uptake:
  - Produces enzymes that convert nutrients into bioavailable forms.
  - Increases the production of solubilizing enzymes by plant roots.
  - Working together with other microorganisms to convert insoluble minerals into soluble forms.
  - Increases overall nutrient uptake efficiency.
  - Reduces nutrient leaching from pots and plant containers.

**PLANT’S NEEDS DRIVE SYMBIOSIS**

- What causes the plant to be less interested?
  - Fertilizer Overabundance
    - When nutrients are readily available, the plant does not need to connect with the mycorrhizae.
  - Growing Wet
    - When water is readily available, the plant does need to connect with the mycorrhizae.

*Why Put Forth The Energy To Establish The Relationship?*

**MULTIPLE MYCORRHIZAL SPECIES**

- Different species are responsible for different functional benefits.
- Seasonal changes of rhizosphere microbial communities – “One species does not fit all”
  - Soil microclimate (e.g., changes in soil moisture, phosphate availability)
  - Plant phenology (seasonality)
- Different species dominate under different ecological conditions (e.g., soil type, nutrient content).
- Multiple mycorrhizal fungi species increase the speed to providing benefits and extent of symbiotic colonization.
- Multiple species also increase the capabilities of extracting a broader nutritional offering for the plant.
MULTIPLE MYCORRHIZAL SPECIES

• Higher levels of phosphorus reduce the mycorrhizal colonization of most mycorrhizal species.
• Multiple mycorrhizal fungi species allows for nutritional performance under a wider range of growing conditions.
• Multiple species allows for continued mycorrhizal benefits even when phosphorus level are high.
• In nature, plants have relationships with multiple mycorrhizal species to optimize the symbiotic relationship. Why would you want to limit your benefits by relying on a single species mycorrhizal offering?

PRODUCTION PARADIGM

• Growing with higher water and feed
  – Softer/larger/lusher growth – increased insect and disease susceptibility, and PGR usage
  – Higher fertilization costs – Not Desirable
• Growing with less water and feed
  – Smaller plant size – often requires less PGRs
  – Better toned growth – reduced insect and disease issues
  – Lower fertilization costs – Increased Profitability

PLANTS NEEDS DRIVE SYMBIOSIS

• What causes the plant to be more interested?
  – Lower Fertilizer Availability
    • Leaner growing induces stress that encourages the development of the mycorrhizal relationship.
    • Lower application rates and/or not using constant feed.
  – Dryer Cultural Practices
    • Growing dryer induces stress that encourages the development of the mycorrhizal relationship.
    • Allowing the plant to dry down forces the plant to search for more water, increases need for mycorrhizae.
TIMING IS EVERYTHING
• Inoculation process requires one month to establish symbiosis with benefits going to the plant.
• Growers typically start to see benefits from within two months from inoculation.
• Some mycorrhizal species are quicker to establish the symbiotic relationship.
• Application during propagation offers lowest costs and starts the benefits clock sooner.

EVERYONE LIKES OPTIONS
• Purchase a soil manufacturer growing media with mycorrhizae added.
• Growers can add mycorrhizae to growing media through soil incorporation.
• Applying a drench either in propagation or in production.
• Using a plug/liner dip to treat small quantities.
• Spraying a drench on bare root plants.

MYCORRHIZAL ECONOMICS
• Cost to treat
  – Impacted by soil volume.
  – Treatment transfers when the plant is moved to a larger container.
  – Cost per tray to treat a plug/liner tray $0.05-0.06.
  – Cost per plant to treat - $0.0008 per 72 cell liner.
  – Cost per plant to treat - $0.0002 per 392 cell plug.
  – One treatment is all that is needed for most plants.
### MYCORRHIZAL ECONOMICS

- **Lower Production Costs**
  - Greater utilization by the plant, less fertilizer.
  - Less fungicides, insecticides and PGRs.
  - Less labor – irrigation, applications.
  - Less dump – more saleable plants.

- **Increased Sales**
  - Better retail sell through, less returns.
  - Increased customer satisfaction – improved gardening experience, more secondary sales.

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**Mighty Mycorrhizae:**

**Nutrient Management Using Friendly Fungi**

Blair Busenbark and Dr. Leonardo Casieri

[www.mycorrhizae.com]
AMF: Improving Nutrient and Water uptake efficiency

Mycorrhizal interaction: complex interaction between plant and AMF

1) Functionality of mycorrhizal fungi with the plant
   i. Role of arbuscules and vesicles
   ii. Hyphae function nutrient and water uptake

Time

Before contact

After contact

Spore

Hyphal branching

Plant exudates

Fungal arbuscules

Hyphopodium

Calcium uptake

Arbuscule

Before contact

After contact

Time
Arbuscules: Symbiotic marketplace where nutrients are exchanged

Nutrient exchange - the Plant side...

- **Loading**: symplastic • apoplastic
  - Species dependant

- **Unloading**: Organ dependant
Nutrient exchange - the Plant side...

Arbuscular mycorrhiza-specific enzymes FmtW and RAA:\nFine-tune lipid biosynthesis to promote development of
arbuscular mycorrhiza.

Nutrient exchange - the AMF side...

S uptake pathways in plants
AMF:
Helping plants in soil-less media and in mineral soil

- Overcoming the chemical and/or physical root uptake limitations
- Improving Nutrients and Water availability
- Ameliorating plant growth and stresses' resistance

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Questions/Technical Support
What questions do you have?
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