MYCORRHIZAL INOCULATION OF NURSERY TREES: BENEFITS FOR ARBORISTS

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Mycorrhizae are specialized fungi that live on plant roots in a mutually beneficial relationship. The host plant supplies carbohydrates produced during photosynthesis. In return, the fungus grows an extensive network into the soil, transferring water and nutrients to the roots.

Mycorrhizal fungi are very common in natural soils. They are less common in urban soils or in nursery potting mixes. Over the past 3 years, we have tested commercial formulations of mycorrhizal products in different nursery and greenhouse settings. This presentation will review some results from controlled trials at Byland's Nurseries Ltd., in British Columbia.

I. BENEFITS OF MYCORRHIZAE

Nutrient uptake: mycorrhizal roots usually grow faster, are much larger, and are more physiologically active than non-mycorrhizal roots. The improved nutrient uptake, especially of phosphorus, is more obvious in low fertility soils, "tired" land, and disturbed landscape sites.

Stress tolerance: mycorrhizal plants show higher survival under drought conditions than non-mycorrhizal plants. Mycorrhizal plants also exhibit higher survival in cold temperatures and more tolerance of soil problems such as low pH or high salt content.

Disease tolerance: mycorrhizal roots have an increased tolerance to infection by soil-borne diseases. One level of protection comes from the physical barrier created by the fungus mantle on the root. Another level of protection comes from the secretion of antibiotics by some fungi.

TYPES OF MYCORRHIZAE

Endomycorrhizae: the most widely distributed in nature, they are associated with turfgrasses, vegetables, flowers, fruit trees, and many ornamental shrubs and trees. "Endo" refers to the fungi penetrating into the root. It cannot be seen except for some hyphae growing near feeder roots.

Rhododendron, cranberry, blueberry and orchids have specialized endomycorrhizal associations.

Ectomycorrhizae: they are found in late succession plants including forest conifer trees and some hardwoods such as oak, beech, birch, willow and hickory. "Ecto" refers to the fungal growth forming a thick sheath around feeder roots. Many ectomycorrhizae can be seen with the naked eye and some species will produce mushrooms or puffballs, including the gourmet truffles.

No mycorrhizal association is a situation found on a few plants typical of early-succession, mostly weeds such as Shepherd's-purse, stinkweed, bitter cress, bindweed and buckwheat.

Above: Ecto-mycorrhizal fungi is clearly visible on the roots of many plants.
The white netting (mycelium) is from the fungus foraging the soil for water and nutrients.
There is a symbiotic relationship between the plant and the fungus as they exchange food.

Below: Plants colonised by mycorrhizal fungi have a better tolerance to environmental stresses.
The pepper plant at left was grown in regular soil, the plant at right with mycorrhizal fungi.
When watering is stopped, the "regular" plant is wilting, the mycorrhizal plant is functioning.
Picture from Dr. F.T. Davies, Texas A&M University, 2002

II. TRIALS IN NURSERY PRODUCTION

In July 2001, we potted shrub liners in 1-gallon containers with different potting mixes. One potting mix was augmented with "Myke Pro Endo" from Premier Tech, at label rate. The plants, 20 in each treatment, were managed following standard nursery practices.

In September 2002, fourteen months after potting, root samples were collected for an independent laboratory analysis. Plants grown in the potting mix containing mycorrhizae had 42% of roots colonized, compared to 1% for plants grown in the regular potting mix.

Mycorrhizal colonization of roots, Cornus alba 'Bailhalo', fourteen months after potting

Treatment	Number of samples	Average root colonization (rating scale 1 to 5)
Regular mix (control)	8	0.13
Regular + Endomycorrhizae	8	2.13 *

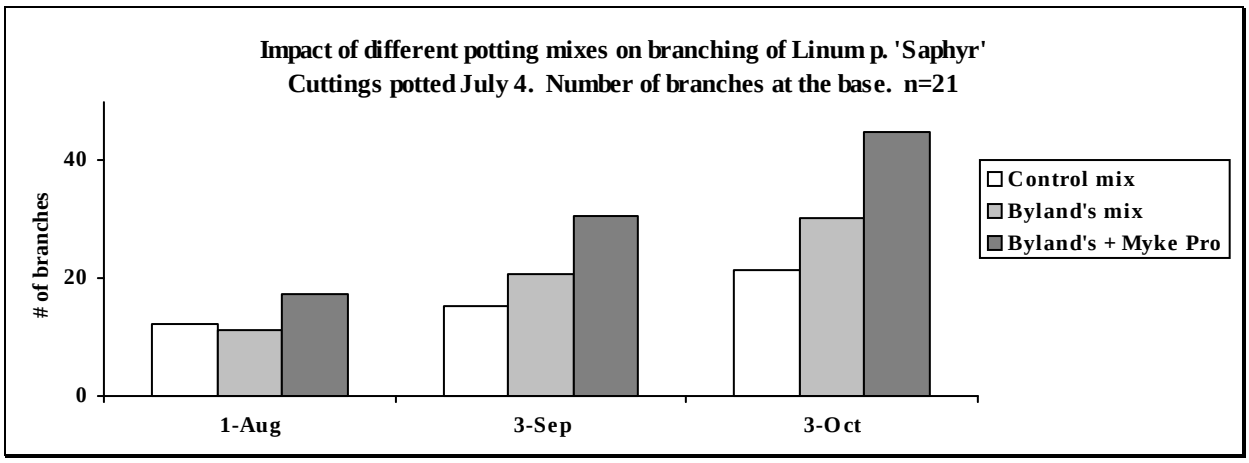
Number followed by an asterix is statistically different than control at p=0.05, Tukey HSD Multiple Comparisons.

Plants were cut at the soil line and dried at 105^{o}C for 24 hours. Top dry weight was not different for plants grown with mycorrhizae when compared to plants grown in the regular mix. The same results were observed with *Spireae* 'Froebeli' and *Juniperus* 'Calgary Carpet'.

If we can achieve successful root colonization but there is no impact on top growth, what is the point of adding mycorrhizal products during nursery production? As many nursery growers already know, many factors other than top growth are important to plant health.

Impact on branching

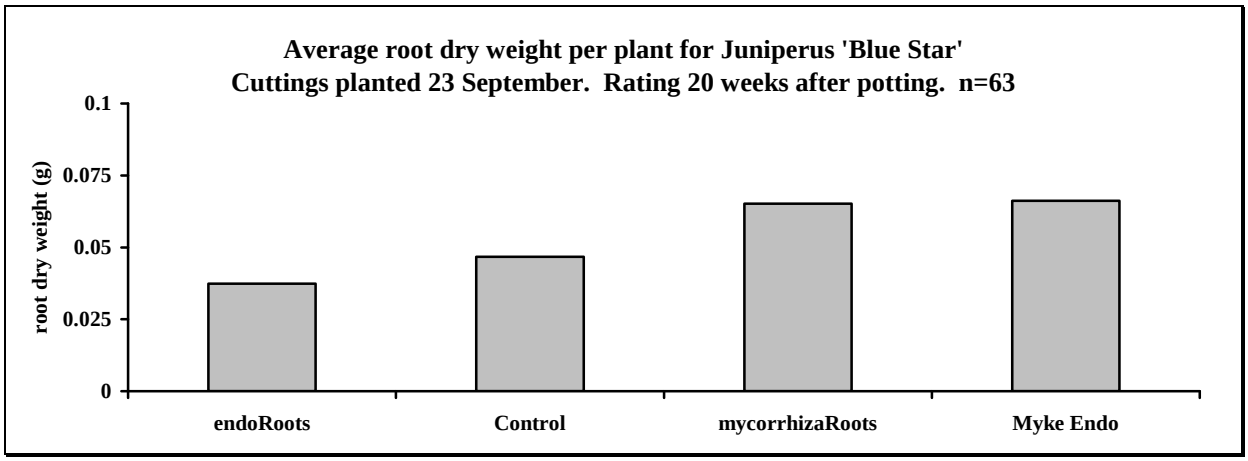
On July 4, 2001, we potted cuttings of perennial flowers in 6-inch pots with different potting mixes. One potting mix was augmented with "Myke Pro Endo" from Premier Tech. For cuttings of blue flax (*Linum p.*), the addition of mycorrhizae resulted in a significant increase in the number of branches breaking from the main stem when compared to control plants.



On 3-Sep and 3-Oct, results for "Byland's + Myke Pro" are statistically different than control at p=0.05, Tukey HSD Multiple Comparisons.

Impact on rooting of cuttings

On September 23, 2001, juniper cuttings were planted in 36-cell trays with a standard propagation media. Various mycorrhizae products were mixed into the media. At regular intervals, 36 plants were lifted in each treatment and a count made of number of roots emerging from the stem. Twenty weeks after potting, plants were removed and processed for dry weight. Fifteen weeks after planting, roots were present on 92% of cuttings treated with "mycorrhizaRoots" and 89% of cuttings treated with "Myke Endo", compared with 75% of untreated cuttings. Twenty weeks after planting, average root mass was also significantly higher.



Results for "mycorrhizaRoots" and "Myke Endo" are statistically different than control at p=0.05, Tukey HSD Multiple Comparisons.

Impact on post-planting survival

In April 2002, over 4,000 bare-root trees coming out of winter storage were potted in 10-gallon and 15-gallon containers with the regular potting mix. For some trees, a commercial mycorrhizae product was placed at label rate over the root system during potting.
In July, the trees were visually rated for quality of new growth. For tree cultivars with a high rate of post-planting survival, there was no benefit from the addition of mycorrhizae. For cultivars that are difficult to replant, survival rate was consistently higher when adding mycorrhizae.

Tree quality 3 months after potting with or without mycorrhizae incorporation

Tree type	Treatment	Number of trees	Active (new growth)	Wilting (dead, dying)
Malus 'Thunderchild	Regular mix	81	72 %	0 %
"	With mycorrhizae	25	88 %	0 %
Tilia 'Harvest Gold'	Regular mix	22	55 %	23 %
"	With mycorrhizae	116	72 %	3 %
Hackberry	Regular mix	40	60 %	23 %
"	With mycorrhizae	148	86 %	9 %
Sorbus 'Skinners'	Regular mix	64	61 %	34 %
"	With mycorrhizae	92	85 %	1 %

III. MYCORRHIZAE AND SOIL BIOLOGY

Mycorrhizal fungi are one of many different soil microbes. Nitrogen-fixing bacteria, flagellates and predatory nematodes are other beneficial microbes found in healthy soils. Much like the release of predatory mites and the welcomed presence of ladybeetles on aphid-infested shrubs, the use of soil microbes is part of the toolbox towards a more "natural" plant production system.

The components of soil chemistry are fairly well understood. Arborists and landscape managers know that nitrogen fertilizers will stimulate plant growth and high soil pH can be changed with sulphur. The components of soil biology are much less known. How many beneficial soil fungi are necessary for healthy growth of spruce trees? At this time, we do not know.

Arborists should expect radical changes in soil management in the coming years:

- Soil biology analysis will become a routine exercise, much like soil chemistry analysis.
- Fungi-enriched composts will be part of plant fertilization, much like N-P-K fertilizers.
- Commercial formulations of mycorrhizae products will be combined with other biocontrol agents to improve plant performance and to protect the root system against soil-borne diseases.

MYCORRHIZAE PRODUCTS AVAILABLE IN CANADA

1) "Myke Pro", Premier Tech Biotechnologies, 1-800-606-6926, www.premiertech.com.
The endomycorrhizal product contains *Glomus intraradices*. The ectomycorrhizal product contains *Pisolithus tinctorius, Rhizopongon* sp., *Laccaria* sp., and *Scleroderma* sp.

2) "endoROOTS granular", Roots Inc., 1-800-342-6173, www.rootsinc.com.
This product contains species of VAM mycorrhizae and a guaranteed analysis of 3-3-4. The water-soluble product "mycorrhizaROOTS" contains ecto and endo species, plus humic acids.

3) Mikro-Tek, Timmins, Ontario, phone (705) 268-3536.
The supplier of "Mikro-Cone" and "Mikro-VAM" designed towards forest seedling nurseries.

4) Philom Bios, Saskatoon, phone (306) 668-8220, www.philombios.ca
This company supplies "JumpStart", a formulation of *Penicillium* fungus for grain crops.

IV. FOR MORE INFORMATION

- Lanthier M. 2006. Mycorrhizal Fungi: Impact of Commercial Products in Nursery Propagation. International Plant Propagators Society. 47th Annual Meeting, Western Region. Coquitlam BC. Presentation on the web at http://www.ippswr.org/home/ippsna/2006/Presentations/Lanthier.pdf.
- B. Appleton et al. March 2003. *"Mycorrhizal Fungal Inoculation of Established Street Trees"*.
- D.H. Marx et al. November 1997. *"Root Response of Mature Live Oaks in Coastal South Carolina to Root Zone Inoculations with Ectomycorrhizal Fungal Inoculants"*.
- Maronek D.M., J.W. Hendrix and J. Kiernan. 1981. *"Mycorrhizal Fungi and Their Importance in Horticultural Crop Production"*. Horticultural Reviews, Volume 3. This journal article, still good despite its age, is probably available for free at any university library.
- http://mycorrhiza.ag.utk.edu/. An internet website with links to other sites.
- Podila G.K. and D.D. Douds. 2000. *"Current Advances in Mycorrhizae Research"*. APS Press. Available from American Phytopathological Society at http://www.shopapspress.org/

Above: Greenhouse plant propagation is the most effective use of mycorrhizal fungi products. The application is easy and inexpensive. In theory, the fungi will remain for the life of the plant. There are numerous studies showing excellent root colonisation of plants grown in containers.

Below: Urban use of mycorrhizal fungi has not reached widespread commercial use. Numerous studies conclude the applied fungus disappears rapidly after application to the roots. Exact reasons are still unknown but may have to do with inadequate diversity of soil microflora.