MICROBES-AT-WORK:
STIMULATING NATURAL SUPPRESSION OF PLANT DISEASES

Certified Organic Associations of British Columbia, Annual Conference
February 29, 2004, Naramata, B.C.

By Mario Lanthier
CropHealth Advising & Research, Kelowna, B.C.

In 1996, researchers at Ohio State University published a landmark study.

When cucumber seeds were grown in a composted bark medium, then injected with the disease anthracnose, the plants showed fewer symptoms of infection than similar plants grown in aged peat moss. Also, the cucumber plants growing in composted bark had a much higher level of peroxidase activity, a natural marker of systemic acquired resistance in plants.

This work by Dr. Harry Hoitink and his group was the first scientific report of a direct link between growth in compost and stimulation of systemic acquired resistance. Since, much progress has been made to understand the mechanisms at play. Growers now have access to a number of different procedures and products to take advantage of the natural phenomena.

This presentation will review some of the current technological knowledge.

I. ON-FARM COMPOSTING

Composting is the biological decomposition of organic waste under controlled conditions.

Usually, three phases occur during composting:
-An initial hot phase of 1 or 2 days, during which the smaller material is rapidly degraded.
-A period of many weeks when temperatures reach 45 to 65^{o}C and most microbes are killed.
-A final curing phase when temperature declines and the material is re-colonized by microbes.

The curing phase is important for natural disease suppression. After peak heating, different micro-organisms colonize the piles, including many parasites of root rot pathogens. Examples include species of *Bacillus, Flavobacterium, Streptomyces* and *Trichoderma.*

Two specific factors will help growers who wish to take advantage of this natural process.

Maintain moisture on the outside of the pile. A film of moisture must be present on the surface for microbes, especially bacteria, to successfully colonize the piles during curing. Compost that is stored dry (under 35% moisture) tends to be more conducive to *Pythium* diseases.

Produce the compost near a forest. Composts produced near a forest benefit from colonization by many beneficial microbes found in natural areas. These composts routinely test positive for presence of *Trichoderma*, a fungus associated with suppression of different root rot pathogens.

MECHANISMS OF DISEASE SUPPRESSION

Direct competition: beneficial soil microbes will out-compete root pathogens for food, especially *Pythium* and *Phytophthora.* Typically, when plant roots are growing, they release a number of amino acids and other molecules into the soil, which attract plant pathogens. Beneficial microbes remove the nutrients from the root zone, eliminating the "signal" sought by pathogens.

Systemic acquired resistance: many beneficial soil microbes promote the manufacturing of plant proteins that are involved in disease tolerance. In a way, the microbes stimulate a healthy plant. Researchers have demonstrated such an activity by myccorrhizal fungi.

Mycoparasitism: some beneficial soil microbes are known to actively attack plant pathogens, destroying their structures and feeding on their cell content, thus preventing root infection. This process works well for suppression of *Rhizoctonia* and *Fusarium* in greenhouse production.

Antibiosis: some microbes produce competitive products that kill or inhibit plant pathogens. For example, woody material that is partially composted and low on food will force *Trichoderma* fungi to start releasing substances that are toxic to other soil microbes.

Adapted from Hoitink H.A., A.G. Stone, D.Y. Han. 1997. *Suppression of Plant Diseases by Composts.* HortScience, 32(2): 184-187

II. PEAT MOSS PRODUCTS

Sphagnum peat moss, a material commonly used in greenhouse production and field plantings, is a primitive plant growing in a bog. The product appearance is an indication of microbial quality.

Light fibrous peat: this material is harvested from the top 1.2 meter of the bog and usually comes with higher beneficial microbial activity, competing for nutrients with the pathogen *Pythium.*

Dark fine peat: this material is harvested from deeper layers in the bog, is typically low in microbial activity, and often conducive to root disease caused by *Phytophthora* and *Pythium.*

As a routine procedure, our company is testing peat moss and compost materials for presence of root rot pathogens. *Pythium* and *Fusarium* are commonly found in very low level in most samples. However, in some products, the root rot pathogens are found in very high levels.

In the table below, the products #1, #2 and #3 are excellent quality for plant production. Product #4 is very poor quality and could trigger a serious disease outbreak if kept wet for too long.

Presence of root rot pathogens in commercial peat moss products

Peat moss product	*Phytophthora*	*Pythium*	*Fusarium*
Brand #1	0	Very low	Very low
Brand #2	0	Very low	0
Brand #3	0	Low	0
Brand #4	Low	Very high	Very low

Rating based on number of propagules per gram of soil. Testing at Ribeiro Plant Lab, Inc., Washington State. See the website http://www.ribeiroplantlab.com.

III. NEW MICROBIAL PRODUCTS

Over the past two years, new commercial products made from naturally occurring soil microbes were registered in Canada. They show excellent results against specific soil-borne diseases.

Mycostop (*Streptomyces griseoviridis* strain K61)

This product was registered in 2003 for the control of damping off and stem rot caused by *Fusarium* in greenhouse ornamentals and vegetables. The product is approved by OMRI (Organic Materials Review Institute), and thus can be used by organic farmers.

The active ingredient, *Streptomyces*, is an actinomycete bacteria widely distributed in most soil types. It is known to colonize the root area of plants, where it feeds on exudates and out-competes the pathogens. Research trials also indicate it can improve plant growth and yield.

Rootshield (*Trichoderma harziannum* strain KRL-AG2)

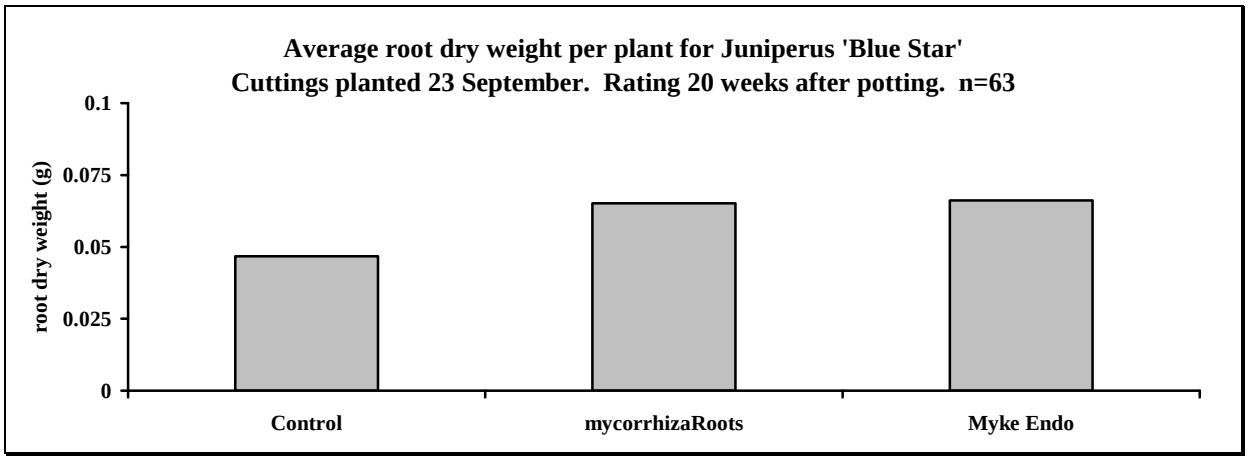
This product was registered in 2002 for the suppression of soil-borne diseases in greenhouse crops such as tomatoes, cucumbers and ornamentals. The active ingredient, *Trichoderma,* is a fungus commonly found in many soils, especially in the forest humus layer.

After growing towards the fungal pathogen, *Trichoderma* secretes enzymes that degrade cell walls, allowing it to invade its prey and feed on the cell content. For diseases caused by *Rhizoctonia, Pythium,* and *Fusarium,* researchers indicate a suppression effect rather than complete control. For best results, the product must be applied early in the crop production.

Mycorrhizal products

Mycorrhizal fungi are specialized organisms that live on plant roots in a mutually beneficial relationship. They are very common in nature, but less common in disturbed agricultural soils or in potting mixes. Plants colonized by mycorrhizae have a higher tolerance of environmental stresses caused by drought, cold, replant, low fertility, or presence of root rot pathogens.

Over the past 3 years, our company has tested commercial mycorrhizal products in different nursery and greenhouse settings. We have documented a number of benefits for the treated plants, including more rapid root development and higher survival after replanting.



Results for both products are statistically different than control at p=0.05, Tukey HSD Multiple Comparisons.

IV. COMPOST TEA

Compost tea is the water extraction of micro-organisms found in the parent compost material, and processed to increase the total microbial population. The tea is applied to the soil to stimulate microbial activity, or on the plant to stimulate plant defences against disease infection.

Recently, researchers have compared the merits of "fermented compost extract" (without aeration) and "aerated compost tea" (with active air supply). Research projects are underway and early results indicate enormous potential to induce disease resistance in plants.

A number of practices are currently recognized as critical to produce high quality compost tea.

Use a commercial machine. Different commercial brewers are now available. Manufacturers testify their equipment was tested and will deliver a consistent quality of finished product.

Use high-quality start-up material. A compost material of high quality will result in a compost tea with a rich diversity of microbes, offering the potential of many benefits after use.

Maintain a high oxygen level. Commercial brewers typically have a pump system to maintain the oxygen level above 6 ppm, seen as necessary to stimulate beneficial microbes, especially fungus.

Avoid animal manures. Fermentation of human pathogens such as *E. coli* is a serious concern in food production. Avoid stimulants such as animal manures, low oxygen level or sugar additives.

COMPOST TEA "RECIPES"

During compost tea brewing, food can be added to stimulate the growth of specific microbes. The type of food depends on the desired finished product and compliance with local standards.

The following start-up recipes are designed for 50 gallons of water mixed with 9 kg of compost.

Bacterial tea (for vegetable crops and grasses)
Add 500 ml of blackstrap molasses and 250 grams of soluble kelp.
Fungal tea (for shrubs, vines and trees)
Add 600 ml of humic acids and 250 grams of soluble kelp.

Adapted from Ingham E.R. 2002. *The Compost Tea Brewing Manual*. Soil Foodweb Incorporated, Corvallis, Oregon. Available at http://www.soilfoodweb.com/.

V. FOR MORE INFORMATION

-W. Zhang, W. Dick, H.A. Hoitink. 1996. *Compost-Induced Systemic Acquired Resistance in Cucumber to Pythium Root Rot and Anthracnose.* Phytopathology 86: 1066-1070
- The Canadian label of Mycostop can be found by searching at http://www.eddenet.pmra-arla.gc.ca/4.0/4.0.asp.
-Maronek D.M., J.W. Hendrix and J. Kiernan. 1981. *Mycorrhizal Fungi and Their Importance in Horticultural Crop Production.* Horticultural Reviews, Volume 3.
-http://mycorrhiza.ag.utk.edu/mycor.htm. An internet website devoted to mycorrhizae, with links to other sites.
-Scheurell S., W. Mahafee. 2002. *Compost Tea: Principles and Prospects For Plant Disease Control.* Compost Science & Ulilization 10(4): 313-338.
- More information on compost tea: the Compost Tea Industry Association, in Oregon, http://www.composttea.org/, and the International Compost Tea Council, based in Washington State, http://www.intlctc.org/events.htm.