

Biological Control of Rose Pathogens Part I: Biofungicides found in disease suppressive soils

At the dawn of the biotechnology age (not so long ago, circa 1972), biological researchers turned to the study of natural, disease suppressive soils: those soils where pathogens do not survive or fail to produce disease in host plants. They found that these biologically healthy soils contained large populations of microorganisms antagonistic to plant pathogens. This discovery launched a new research field, biological control of plant disease. In the past 20 years, the on-going research has increased the understanding of defensive strategies used by plants against microbial invaders; and has produced new environmentally-responsible, disease management products available commercially.

One of these tools is biological fungicides (biofungicides). These materials are composed of beneficial microorganisms that attack and control plant pathogens. These microorganisms are specialized fungi and bacteria that commonly inhabit the healthy soils of a well mulched and manured organic rose garden. They are being found to be so effective in disease control that the biotechnology industry is bottling them up for use in gardens, as well as the greenhouse, turf and agricultural industries.

A relevant example of a biological fungicide product is Serenade® Garden Disease Control (<http://www.agraquest.com>), made available in recent years for use in home gardens. It contains a unique, patented strain (QST 713) of *Bacillus subtilis* which provides protection against a broad spectrum of the most common fungal and bacterial garden diseases (mildews, molds, blights, leaf spots, rusts, see Table I). It is approved for use by certified organic growers through the National Organic Program and OMRI (Organic Materials Review Institute). According to the product literature, it is completely non-toxic to bees and beneficial insects; it is safe to use around people and pets; it doesn't do damage to plant foliage; fruits, vegetables, and flowers can

be harvested and eaten the same day. However, no matter how natural and seemingly benign, the material is a bacteria so it is important to read the label (<http://www.serenadegarden.com/labels/pdf/SGDC-RTU-Label.pdf>) and safety data sheet (<http://www.serenadegarden.com/labels/pdf/SGDC-RTU-MSDS-051506.pdf>) before spraying willy-nilly. This information cautions the applicator to avoid skin contact, inhalation or ingestion of the material.

There are many other biological fungicides containing other beneficial bacteria or fungi. An extensive list and description of commercial biocontrol products can be found at <http://www.oardc.ohio-state.edu/apsbcc/productlist2005USA.htm>.

How do these biological fungicides work? There are four mechanisms of control:

- Direct competition. A biofungicide covers a plant surface (e.g., root or leaf), forming a defensive barrier that effectively crowds out the harmful fungi.
- Antibiosis. The biofungicide produces a chemical compound such as an antibiotic that kills the invading organism.
- Predation or parasitism of the disease-causing fungus. The biofungicide directly attacks and feeds on the pathogen.
- Induced Resistance. The biofungicide triggers the plant to turn on its own defense mechanisms.

These capabilities make biofungicides impressive potential weapons to use against plant disease.

When and how should they be applied? A disease outbreak usually indicates that nature is out of balance. It might not be your fault: Southern California roller coaster weather, occasional water logging rains, and longer hot, dry spells can wreak havoc on microorganism populations. The first line of defense for preventing or controlling disease should be to build (or restore) a suppressive soil. Nurture your

native soil bacteria: mulch to improve their habitat, feed them with organic matter; and sustain them with the correct soil moisture. It's worth the effort.

A suppressive soil is unique to its environment. The complex microorganism network in this soil is capable of adjusting to the shenanigans of pathogens that continually evolve new strategies to overcome or sneak by the physical and chemical barriers of their hosts (your roses). Beneficial bacteria, like the pathogens, also rapidly evolve; their genetic diversity produces some strains that are clearly superior in disease control. The biofungicide, Serenade, contains a carefully selected strain of *B. subtilis* and has been awarded a patent for its effectiveness. If you have a suppressive soil, it naturally contains the right strains of beneficial bacteria at no cost.

There are times, however, when pure and simple measures don't manage disease outbreaks. It's happened to me. Although my roses, inter-planted with herbs and ground cover, (Figure I) are rarely affected by disease; areas of my commercial avocado grove, originally planted as a dense monoculture, are challenged by serious fungal diseases. A cutting rose garden, tightly planted with roses exclusively; and a California strawberry field, planted repeatedly with the same crop, are other examples of monocultures that fungal pathogens readily invade. We know what is applied to protect the bottom line in a strawberry operation: methyl bromide or a new, less controversial chemical fungicide. Biofungicides offer a viable alternative to chemical fungicides.

My goal is to transition my grove from a monoculture to an inter-cropped planting, opening up the space for cover crops to grow between trees. During this transition I am beginning to introduce some of the biofungicides, particularly those containing *B. subtilis* and *B. pumilus*. *B. pumilus* is being proven effective against *Phytophthora* diseases (in the same class as the dreaded downy mildew of roses). It is important to

consider that a teaspoon of healthy garden soil generally contains between 100 million and 1 billion bacteria; or one ton of microscopic bacteria may be active in each acre of soil. Commercial biofungicide products generally contain from 1 to 100 billion bacterial units (cfu's) per gram. So each gram of a biofungicide product like *Serenade Garden* (1 billion CFUs/gm) contains enough beneficial bacteria to match all the soil microorganisms (at 500 million total CFUs per gram) in around 50 gm (less than 2 ounces) of soil; a 32 oz bottle for \$20 covers all microorganisms in only 100 lbs. of soil, not much of an area.

An economically sensible approach to applying biofungicides to a garden is to think of seeding small population densities (diluting them in water) and nurturing these so that they can flourish and carry out their mission. The application is normally done through the irrigation water in which some favorite microbe food (e.g., liquid fish or yeast and molasses) is added to aid in establishing them in their new home. Another good time to use biofungicides is at planting when the roots of your rose plant can be directly drenched in the microbial soup. The beneficial bacteria ride in to the soil to chip away at targeted harmful organisms and keep pathogen populations below a level that impacts plant health.

Table I. List of plant diseases prevented and controlled by the biofungicide agent *Bacillus subtilis* in Serenade.

Plant Disease	Pathogen
Anthracnose	<i>Colletotrichum</i> spp.
Bacteria	<i>Erwinia</i> , <i>Pseudomonas</i> , <i>Xanthomonas</i> spp.
Bacterial Leaf Blight	<i>Xanthomonas campestris</i>
Bacterial Speck	<i>Pseudomonas syringae</i> pv. Tomato
Bacterial Spot	<i>Xanthomonas</i> spp. - suppression
Black Mold	<i>Alternaria alternata</i>
Black Root Rot / Black Crown Rot	<i>Alternaria</i> spp.
Black Spot of Rose	<i>Diplocarpon rosea</i>
Botrytis	<i>Botrytis</i> spp.
Downy Mildew	<i>Bremia lactucae</i> , <i>Personospora</i> spp., <i>Plasmopara viticola</i> - suppression
Early Blight	<i>Alternaria solani</i>
Fire Blight	<i>Erwinia amylovora</i> - suppression
Gray Mold	<i>Botrytis cinerea</i>
Late Blight	<i>Phytophthora infestans</i>
Leaf Spots and Rusts	<i>Alternaria</i> , <i>Cercospora</i> , <i>Entomosporium</i> , <i>Helminthosporium</i> , <i>Myrothecium</i> , <i>Septoria</i> , <i>Puccinia</i> , and <i>Phragmidium</i> spp.
Pin Rot	<i>Alternaria</i> / <i>Xanthomonas</i> complex) - suppression
Powdery Mildew	<i>Uncinula necator</i> , <i>Erysiphe</i> spp., <i>Sphaerotheca</i> spp., <i>Oidiopsis taurica</i> , <i>Leveillula taurica</i> , <i>Podosphaera leucotricha</i>
Scab	<i>Venturia</i> spp. - suppression
Walnut Blight	<i>Xanthomonas campestris</i>