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The Basics of Beneficial Soil Microorganisms

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Soils and potting media provide plants and other organisms with nutrients and habitats. Because bacterial and fungal microorganisms (a.k.a. microbes) in soils and potting media are constantly vying for food, water, and space, soils are regarded as dynamic living environments. Microbes in these substrates obtain nutrients by competing with each other for dead organic matter, feeding on other living organisms (including each other), and/or interacting cooperatively with other organisms.

How soil microorganisms directly or indirectly affect plant growth and health determines if they are considered beneficial, harmful, or insignificant to plants. Microbes that harm plants are plant pathogens since the harm that they cause is considered disease. On the other hand, beneficial microorganisms can either enhance plant growth, suppress plant diseases, or both. The purpose of this article is to help make better sense of the different types of beneficial effects and some of the beneficial microorganisms responsible for producing these effects.

Plant Growth Promotion

Plant growth is improved by beneficial microbes through at least two modes of action (MOAs). Increasing nutrient availability is one MOA. Numerous soil microorganisms help plants obtain otherwise unavailable nutrients by converting these nutrients into plant-available form in exchange for energy from their hosts. Another MOA is the stimulation of plant growth without actually increasing nutrient availability to plants. Certain beneficial bacteria and fungi stimulate plant growth through the production of metabolites or by their physical interactions with host plants. Several bacterial strains and fungal isolates that promote plant growth without improving nutrient uptake have been identified, though the specific mechanisms that cause these stimulatory effects are unclear.

Plant Disease Suppression

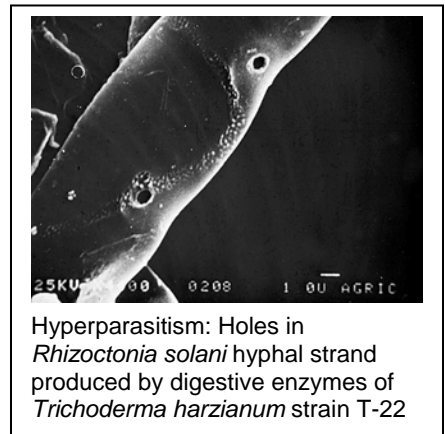
Beneficial microbes help to control plant diseases by the following mechanisms:

- **Predation and Hyperparasitism** = feeding on pathogens
- **Antagonism, competitive exclusion and microbiostasis** = competing for nutrients or space by producing metabolites that kill pathogens or inhibit their growth and movement;
- **Rhizosphere competency** = blocking pathogen access to plant roots;
- **Induced systemic resistance and systemic acquired resistance** = stimulating or priming the plant's own natural defense system.

As a general rule, disease-suppressive microorganisms work best at preventing rather than curing diseases.

Commercially Available Beneficial Microorganisms

Examples of commercially available beneficial microbes include bacterial strains belonging to the genera *Bacillus*, *Streptomyces*, and *Pseudomonas*, and fungal isolates belonging to the genera *Trichoderma* and *Glomus*. The list of commercially available beneficial microbes is dwarfed in comparison to the wide variety of native beneficial soil microbes found in healthy soils.



Hyperparasitism: Holes in *Rhizoctonia solani* hyphal strand produced by digestive enzymes of *Trichoderma harzianum* strain T-22

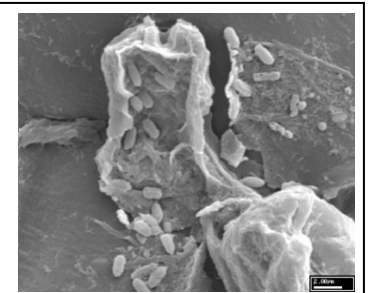
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Commercially available beneficial bacterial strains of *Bacillus* and *Streptomyces* grow near the roots, releasing secondary metabolites that inhibit pathogen growth by causing cell membranes to become “leaky.” Some of these commercial microbes and certain native bacterial strains also act as plant-growth promoting rhizobacteria or PGPRs by improving nutrient availability to the plant and through their interactions with host plants. Many PGPR strains of the bacteria described above have also been shown to induce systemic resistance in some plant species.

Certain beneficial fungi grow near, on and inside root tissue. The mycoparasite, *Trichoderma harzianum* isolate T-22 provides several beneficial effects. It preventively controls diseases through rhizosphere competence, hyperparasitism, and competitive inhibition and antagonism. T-22 also promotes plant growth as do other *Trichoderma* isolates.

Mycorrhizal fungi from the genus *Glomus* grow in and around roots of many mycorrhizal plant species to help supply host plants with insoluble phosphorus, especially in highly mineralized soils and container media. Several different mycorrhizal products are commercially available either as mycorrhizal spore preparations or formulated with fertilizers.



Bacillus subtilis strain QST 713 (small capsule-shaped object) feeding on killed fungal plant pathogen cell



Trichoderma harzianum strain T-22 (small filament in center) attacking *Rhizoctonia solani* hyphal strand

Keys to Effective Use of Beneficial Microorganisms

Understanding the strengths, requirements, limitations and general biology of a beneficial microorganism is crucial for obtaining the greatest benefits. Commercial microbes are added in large numbers to the soil by mixing in granules or by drenching *before* pathogen pressure is high. Knowing the environmental conditions under which the beneficial microbe performs best will help ensure the health and protection of the plant. Additionally, compatibility with the crop production system and grower inputs should be considered for the proper use of beneficial microorganisms. Soil pH, temperature, humidity, soil or container medium composition, and target plant tissue (root, tuber, etc.) all affect the establishment of beneficial microbes in the soil. Also important are how pesticide inputs, nutrient inputs, irrigation method and frequency, PGRs, etc., affect beneficial microbe performance or longevity. The supplier should be able to

provide information about environmental and production input compatibility and phytotoxicity information.

Longevity of a beneficial microbe or microbes in the soil or potting mix environment is a benefit for long-term crops. Bacteria tend to release their protective secondary metabolites for up to 4 weeks after application, even though they may persist in the soil environment longer. Fungi tend to survive longer with protection documented for up to 12 weeks. Ultimately all introduced beneficial microbes must be re-introduced to maintain protective levels in soils and potting media.