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Importance of soil micro-organisms in biocontrol of plant diseases

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Plant diseases need to be controlled to maintain the quality and abundance of food, feed and fibre produced by growers around the world. Different approaches may be used to prevent, mitigate or control plant diseases. Beyond good agronomic and horticultural practices, growers often rely heavily on chemical fertilizers and pesticides. However, the environmental pollution caused by excessive use and misuse of agrochemicals, as well as fear-mongering by some opponents of pesticides, has led to considerable changes in people's attitudes towards the use of pesticides in agriculture. Consequently, some pest management researchers have focused their efforts on developing alternative inputs to synthetic chemicals for controlling pests and diseases. Among these alternatives biological control is also one of the important method.

The terms "biological control" and its abbreviated synonym "biocontrol" have been used in different fields of biology, most notably entomology and plant pathology. In entomology, it has been used to describe the use of live predatory insects, entomopathogenic nematodes, microbial pathogens to suppress populations of different pest insects. In plant pathology, the term applies to the use of microbial antagonists to suppress diseases as well as the use of host specific pathogens to control weed populations. In both fields, the organism that suppresses the pest or pathogen is referred to as the biological control agent (BCA).

Requirements of successful biological control:

– Highly effective biocontrol strain must be obtained or produced

- Be able to compete and persist
- Be able to colonize and proliferate
- Be non-pathogenic to host plant and environment

– Inexpensive production and formulation of agent must be developed

- Production must result in biomass with excellent shelf live
- To be successful as agricultural agent must be
- Inexpensive
- Able to produce in large quantities
- Maintain viability

– Delivery and application must permit full expression of the agent:

- Must ensure agents will grow and achieve their purpose.

Mechanisms of biological control:

Competition: Competition within and between species competition between micro-organisms for carbon, nitrogen, O_2, iron, and other nutrients results in decreased growth, activity and/or fecundity of the interacting organisms. Biocontrol can occur when non-pathogens compete with pathogens for nutrients in and around the host plant. Direct interactions that benefit one population at the expense of another also affect our understanding of biological control.

Antibiosis: Antibiotics are microbial toxins that can, at low concentrations, poison or kill other micro-organisms. Most microbes produce and secrete one or more compounds with antibiotic activity. In some instances, antibiotics produced by micro-organisms have been shown to be particularly effective at suppressing plant pathogens and the diseases they cause.

Example: Zwittermicin production by *Bacillus cereus* against *Phytophthora* root rot in alfalfa.

Predation : It refers to the hunting and killing of one organism by another for consumption and sustenance. While the term predator typically refer to animals that feed at higher trophic levels in the macroscopic world, it has also been applied to the actions of microbes, e.g. protists and mesofauna, e.g. fungal feeding nematodes and microarthropods, that consume pathogen biomass for sustenance. Biological control can result in varying degrees from all of these types of interactions, depending on the environmental context within which they occur. Significant biological control, as defined above, most generally arises from manipulating mutualisms between microbes and their plant hosts or from manipulating antagonisms between microbes and pathogens.

Hyperparasitism: Hyperparasites attack hyphae and sporulating structures of plant pathogens in the field, reducing infection and pathogen inoculum. Availability of susceptible fungal tissue for a prolonged time seems a prerequisite for successful hyperparasitism. *Verticillium lecanii* is a parasite of both insects and rusts, including the coffee rust, Hemileia vastatrix . In temperate regions *V. lecanii* has been reported on carnation rust and on wheat stem rust. The hyperparasite was stimulated by prolonged moist weather, but frequently the degree of infection was moderate, even when mildew attack was very heavy. Hyperparasites on fungal pathogens of wild plants may provide an important inoculum source, which has often been lost under modern agricultural practices. There are several fungal parasites of plant pathogens including those that attack sclerotia (e.g. *Coniothyrium minitans*) while others attack living hyphae (e.g. *Pythium oligandrum*). And, a single fungal pathogen can be attacked by multiple hyperparasites. For example, *Acremonium alternatum*, *Acrodontium crateriforme*, *Ampelomyces quisqualis*, *Cladosporium oxysporum*, and *Gliocladium virens* are just a few of the fungi that have the capacity to parasitize powdery mildew pathogens. Other hyperparasites attack plant-pathogenic nematodes during different stages of their life cycles (e.g. *Paecilomyces lilacinus* and *Dactylella oviparasitica*).

Biological control of plant pathogens/diseases:

Crop: Trees, shrubs, transplants, ornamentals, cabbage, tomato, cucumber, bean, corn, cotton, potato, soybean, turf
Target pathogen/disease: *Pythium, Rhizoctonia, Fusarium, Sclerotinia homeocarpa*
Biocontrol fungus: *Trichoderma harzianum*
Trade name: Root shield, Bio-Trek T-22G, Planter Box

Crop: Cucumber, grape, nectarine, soybean, strawberry, sunflower, tomato
Target pathogen/disease: *Botrytis cinerea, Colletotrichum, Monilinia laxa, Plasmopara viticola, Rhizopus stolonifer, Sclerotinia sclerotiorum*
Biocontrol fungus: *Trichoderma harzianum*
Trade name: Trichodex

Crop: Greenhouse, nursery transplants, seedlings
Target pathogen/disease: *Pythium, Rhizoctonia, Fsarium*

Crop: Cucurbits, grapes, ornamentals, strawberries, tomatoes
Target pathogen/disease: Powdery mildew
Biocontrol fungus: *Ampelomyces quisqualis* M-10
Trade name: AQ10 Biofungicide

Crop: Citrus, pome fruit **Target pathogen/disease:** *Botrytis, Penicillium* **Biocontrol fungus:** *Candida oleophila* I-182
Trade name: Aspire

Crop: Basil, carnation, cyclamen, tomato
Target pathogen/disease: *Fusarium oxysporum*
Biocontrol fungus: *Fusarium oxysporum* (nonpathogenic)
Trade name: Biofox C

Crop: Fruit, flowers, ornamentals, turf, vegetables
Target pathogen/disease: Wilt and root rot pathogens, wood decay pathogens
Biocontrol fungus: *Trichoderma harzianum* and *T. polysporum*

Crop: Canola, sunflower, peanut, soybean, lettuce, bean, tomato
Target pathogen/disease: *Sclerotinia sclerotiorum* and *S. minor*
Biocontrol fungus: *Coniothyrium minitans*
Trade name: Contans

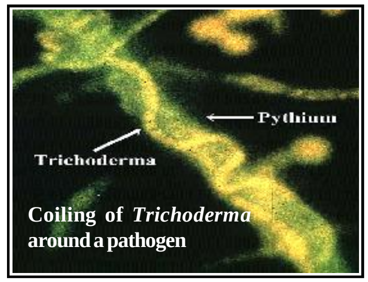
Crop: Sugar beet
Target pathogen/disease: *Pythium ultimum*
Biocontrol fungus: *Pythium oligandrum*
Trade name: Polygandron

Plant pathogen/disease control by *Trichoderma species:* *Trichoderma spp.* are present in nearly all agricultural soils. It can be used as both biocontrol agent and as a plant growth promoter. Most strains have innate resistance to some agricultural chemicals. It suppresses the plant pathogens by

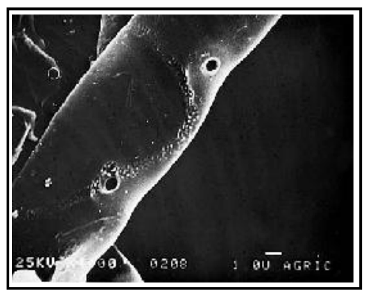
– Mycoparasitism
– Nutrient competition

Action against pathogenic fungi:

– Attachment to the host hyphae by coiling
  - Lectin-carbohydrate interaction
– Penetrate the host cell walls by secreting lytic enzymes
  - Chitinases
  - Proteases
  - Glucanases
– Some strains colonize the root with mycoparasitic properties
  - Penetrate the root tissue
  - Induce metabolic changes which induce resistance-accumulation of antimicrobial compounds



Coiling of *Trichoderma* around a pathogen



Application:

– Seed treatment (4-6 g/ kg of seeds), seedling dipping (10 g/ litr of water) or soil application by mixing with organic manures.

Conclusion: Successful biocontrol of plant disease requires an intricate array of interactions. Many factors have to be considered in deciding whether a biological system is feasible for the control of a particular pathogen. The environment under which the crop is grown will play a significant part in determining whether effective population levels of an antagonist can be established in competition with the existing microflora. The use of biological control agents results in the lessening of long term damage to the environment by the use of persistent chemicals, and an absence of chemical residues on edible parts of the crop.

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