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# *Trichoderma*: An Invisible Potent Agriculture Partner

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## Introduction

Since the early 1930s, when Weindling reported that *T. lignorum* produces and excretes a "lethal principle" in the surrounding, the scientists become involved in investigation of antifungal ability of various *Trichoderma* species, although *T. harzianum* arisen as the most prominent species of the genus. Today, their agricultural importance is good antagonistic abilities against soil born plant pathogenic fungi, thanks to different mechanisms of antagonism: the production of antifungal metabolites (antibiosis), competition for space and nutrients, induction of defense responses in plant and mycoparasitism. Along with revelation of diverse antifungal mechanisms of *Trichoderma*, the ability to promote plant growth and to increase plant height, leaf area and dry weight were perceived. First, this ability was treated as side effect of suppression of plant pathogenic fungi which leading to stronger root growth and nutrient uptake. Also, positive influence of *Trichoderma* to a faster germination and increase in percentage of emergency were perceived. Nowadays, *Trichoderma* species are considered as opportunistic plant symbionts because they colonize root surface and even penetrate into the epidermis of root tissue and a few cell layers below this level establishing pseudomycorrhizal relationship with plant host. This intimate relationship is what induces localized and systemic resistance plant responses to pathogen attack. For the *Trichoderma*, abundant healthy roots are environment where it grows and proliferates best owing to the main carbohydrates secreted by plant roots. Furthermore, roots are resort of plant pathogenic fungi and nematodes, the target for *Trichoderma* as mycoparasite and nematophagous. The plants also benefit from this relationship through increased root and shoot growth and increased macro- and micronutrient uptake. Therefore, *Trichoderma* may be benefit as growth promoting (biofertilizer) as well as pathogen control agent (mycofungicide), and their application may lower the production costs and environmental impact. Recently, it is recognized that *Trichoderma* positive effect on plant

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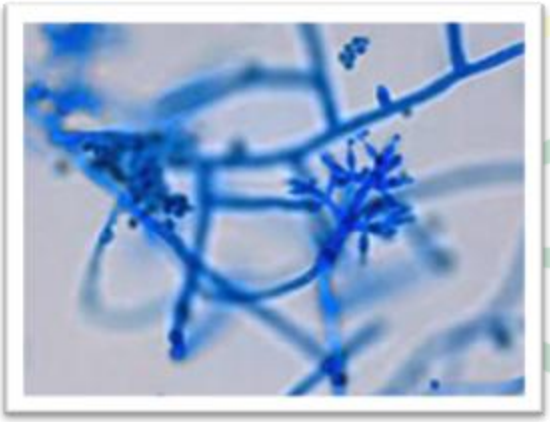
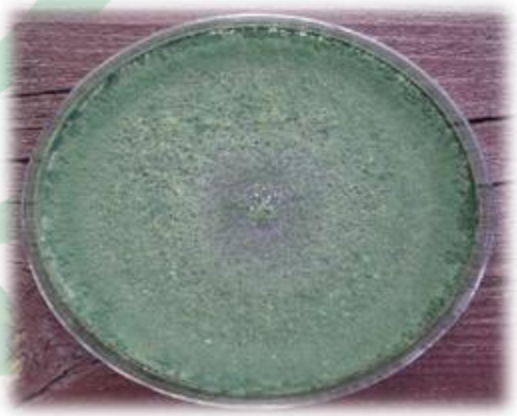
growth is independent ability and equally remarkable and significant as its antifungal ability because growth enhancement has been observed in the absence of any detectable disease and in sterile soil. Therefore, today is considered that the direct effects of these fungi on plant growth and development are crucially important for agricultural uses and for understanding the roles of *Trichoderma* in natural and managed ecosystems.

**Classification of *Trichoderma***

- **Kingdom:** Fungi kingdom composed of multicellular and unicellular organisms that obtain their nutrients from organic matter
- **Phylum:** Ascomycota - Fungi that are characterized by their ascus, a sac-like structure for reproduction
- **Class:** Euascomycetes - Fungi that tend to form lichen with other organisms
- **Order:** Hypocreales - fungi with brightly colored sphaeriaceous (structures that produce spores are brightly colored)
- **Family:** Hypocreaceae - contains species with perithecial ascomata that are brightly colored (red, yellow etc)
- **Genus:** *Trichoderma*





***Trichoderma*: Microscopic view *Trichoderma*: Plate View**

**Isolation and Maintenance of *Trichoderma***

To exploit *Trichoderma* benefits, it must be isolated from soil, studied, and encapsulated in formulation which will allow application into soil. But, reintroduction to soil, even the most strongly rhizosphere competent such as *Trichoderma* can be difficult.

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*Trichoderma* reintroduced into soil must compete with spectrum of rhizosphere microbes while trying to colonize available sites along the plant roots. Therefore, it needs to be applied in low cost but high density inocula engineered to maintain fungal propagule viable during the transport, storage, and application. To accomplished mentioned goals and effective dispersal of fungal inocula, it is necessity to choose the fungal inoculum carrier and the type of formulation. The *Trichoderma* potential as bioagent is utilized through the commercial production of *Trichoderma*-based biofungicides, which account for about 60% of the biofungicide market. The availability and dispersion of *Trichoderma* based biofertilizers are more widespread than commonly known with a tendency to expand due to the easier registrations because they are not registered as pesticides.

**_Trichoderma_ as a Biopesticides in Modern Agriculture**

*Trichoderma*-based biofungicides are booming in an agricultural market with more than 50 formulations registered products worldwide. Nowadays, there are more than 50 different *Trichoderma*-based agricultural products being produced in different countries and are sold to farmers to get better yields in different crops. Presently, *Trichoderma* spp.-based products are considered as relatively novel type of biocontrol agents (BCAs). The size of current biopesticide market is vague and only scattered information could be obtained based on registered as well as non-registered biofungicides.

*Trichoderma* spp. antagonize a wide range of soil borne plant pathogens combined with their ability to reduce the incidence of diseases caused by these pathogens in a wide range of crops. The mechanisms that *Trichoderma* uses to antagonize phytopathogenic fungi include competition, colonization, antibiosis and direct mycoparasitism. This antagonistic potential serves as the basis for effective biological control applications of different *Trichoderma* strains as an alternative method to chemicals for the control of a wide spectrum of plant pathogens.

**Mode of Action**

*Trichoderma* can work as biocontrol agents in several ways:

1. It may grow faster or use its food source more efficiently than the pathogen, thereby crowding out the pathogen and taking over, known as nutrient competition.

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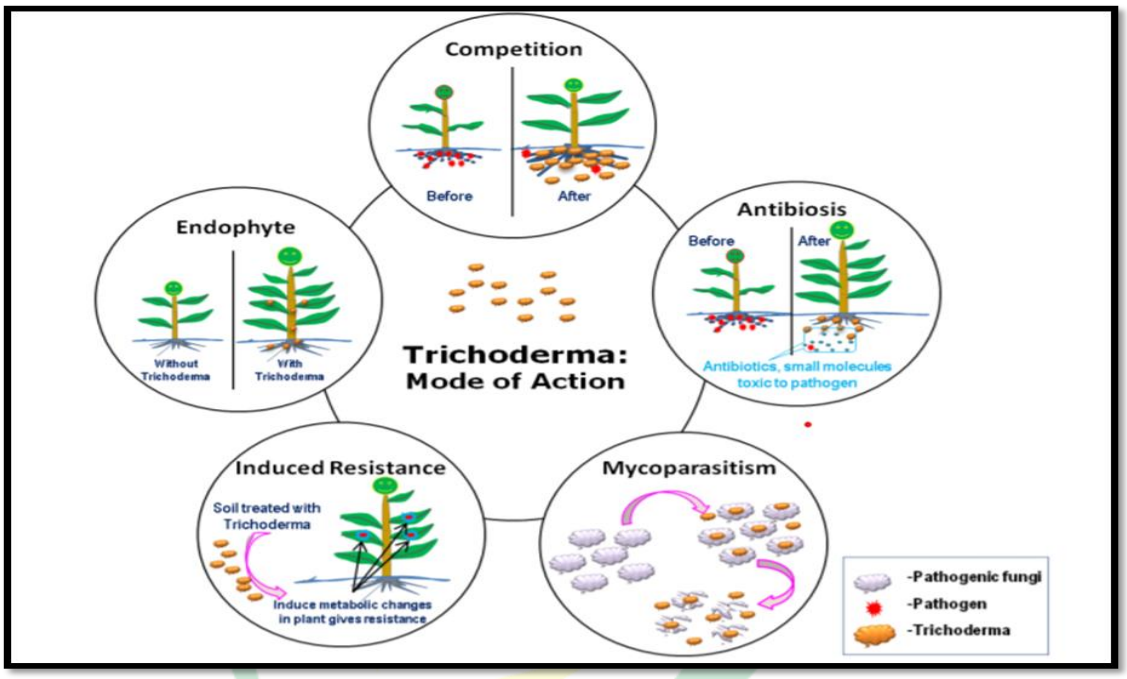
2. A biocontrol agent may excrete a compound that slows down or completely inhibit the growth of pathogens in the surrounding area of such a compound called antibiosis.
3. It may feed on or in a pathogenic species directly known as parasitism.
4. It may promote a plant to produce a chemical that protects it from the pathogen, which is induced resistance.
5. They can grow in an endophytic way in other species and supports plant growth.




Model depicting mode of action of *Trichoderma* spp. against pathogen and plant growth improvement.

**Commercial level production**

Bacterial based BCAs are being produced and marketed by many commercial firms and available in global market. In India, there are more than 250 BCA products available in the market. Formulization of commercial BCA for agricultural application should possess several desirable characters and need to have substantial proof in order to convince farmers. These include satisfactory market potential, easy preparation, unfussy application, high stability during transportation as well as storage, abundant viable propagules with good shelf life, sustained efficacy and accepted cost. Various carrier materials proved useful for the preparation of formulation of Trichoderma based BCAs because it works as a food base. Talc

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is the most common carrier material suggested for commercial production of Trichoderma worldwide


Different formulation of *Trichoderma* sold at commercial level

**Future Prospects**

In agriculture, the new and established innovations boost up the yield of agriculture produce. Unfortunately, several of these conventional practices give a destructive impact on the environment. The challenge faced by modern farming is to accomplish a great number of yields in an environment-friendly manner. Hence, quick action on finding eco-friendly solutions need to be done.

The success of *Trichoderma* strains as biocontrol agents against different pathogenic microorganisms is well known worldwide. Not only that, current findings revealed that these fungi also enhance plant resistance, plant growth and development, leading to an increase in yield production. Mechanisms that are usually involved are antibiotics, mycoparasitism, competition for nutrients and also stimulation of systemic resistance in plants. Recently, *Trichoderma* spp. are being used to control plant diseases in the sustainable disease management system.

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Besides playing its role in reducing diseases and improving plant growth, *Trichoderma* spp. can also be used in waste/organic materials decomposition and polluted area detoxification. The increase of nutrient value in compost degraded by *Trichoderma* strains is discovered in several research papers. Thus, the benefits of *Trichoderma* spp. when combined in a product are being able to control different crop diseases, stimulates plant growth and development, improves the composting process and promises a clean environment towards achieving sustainable agriculture.

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