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Trichoderma

(*Kavita Baror, Dr. Vinod Kumar Yadav, Dr. D.L. Yadav and Sandeep Kumar)

College of Agriculture, Agriculture University, Kota (Raj.)

*Corresponding Author's email: brorkavita@gmail.com

Abstract

Fungi of the genus Trichoderma are a very large group of microorganisms that play a significant role in the environment. They use a variety of mechanisms to colonise various ecological niches. Several Trichoderma spp. positively affect plants by stimulating plant growth, and protecting plants from fungal and bacterial pathogens. They are used in biological plant protection as bio fungicides as well as in bioremediation. Members of the genus Trichoderma are also utilised in various industry branches mainly in the production of enzymes, antibiotics, and other metabolites, but also of biofuel.

Keywords: Trichoderma, Biotic stress, Abiotic stress, Bioremediation, Seed biopriming, Formulation, Mass multiplication, Shelf life.

Introduction

Trichoderma is a fungus genus in the Hypocreaceae family that is found in all soils and is the most common culturable fungus. Many of the species in this genus are opportunistic avirulent plant symbionts. They breed via chlamydospores and ascospores and thrive at mesophilic temperatures (25-35°C) with a wide pH range. Several studies corroborated this, including one that found no apparent development of conidia at 15°C but retained growth at 25°C and achieved the greatest results at 30°C. Trichoderma colonises a variety of ecological niches where they play an important role; they have previously been identified as efficient biocontrol agents of plant-pathogenic fungus, makers of secondary metabolites of medicinal relevance, and bioremediation agents. Similarly, their capability to degrade lignocellulosic biomass and create second-generation biofuels and other value-added products is widely known.

Trichoderma species

- Asexually reproducing fungi.
- Soils contain 10^1-10^3 culturable propagules per gram.
- Sexual/Teleomorph *(*genus Hypocrea) often found on woody and herbaceous plant materials.
- Produce enzymes that degrade cellulose and chitin.
- Show 'rhizosphere competence'.

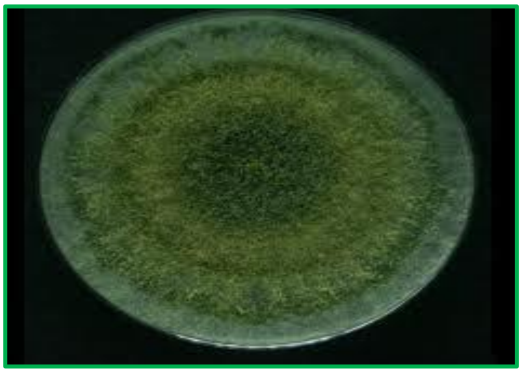
General characteristics:

- Cultures: fast growing at 25-30° C
- Conidiophores: highly branched
- Main branches produce lateral side branches and often phialides arising directly from the main axis near the tip.
- All primary and secondary branches arise at or near 90° with respect to the main axis.

- The typical *Trichoderma* conidiophore, with paired branches assumes a pyramidal aspect

Trichoderma viridae

- Please remember that the seeds to be treated with *Trichoderma viridae* should not have been pre-treated with fungicides.



Kingdom : Fungi
Phylum : Ascomycota
Class : Sordariomycetes
Subclass : Hypocreomycetidae
Order : Hypocreales
Family : Hypocreaceae
Genus : *Trichoderma*
Species : *viridae*
Binomial name: *Trichoderma viridae*

Trichoderma harzianum

- Conidiophores that are repeatedly branching and irregularly verticillate, bearing clusters of divergent, frequently irregularly bent, flask-shaped phialides.
- Conidia are slimy conidial heads (glioconidia) which grow at the ends of the phialides and are generally green, sometimes hyaline, with smooth or rough walls.

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Bionomial name: *Trichoderma harzianum*

Role of Trichoderma

1. Disease control:

Name of the crop	Name of the disease	Pathogen
Chilli, Tomato, Brinjal	Damping off	*Pythium spp.* *Phytophthora spp.* *Fusarium spp.*
Ginger, Turmeric, Onion	Rhizome rot	*Pythium spp.* *Phytophthora spp.*
Banana, Cotton, Tomato	Wilt	*Fusarium oxysporum*

2. Plant Growth Promoter: Solubilise phosphates and micronutrients. Increases the number of deep roots, thereby resist drought.

3. Biochemical Elicitors of Disease Resistance: Induces ethylene production, hypersensitive responses and other defence related reactions in plant cultivates (Sriram *et.al*, 2009).

4. Transgenic Plants: growth. Introduction of Endo chitinase gene from Trichoderma into plants such as tobacco and potato plants have increased their resistance to fungal

5. Bioremediation: Degrade a wide range of insecticides: organochlorines, organophosphates and carbonates.

Mode of Action: Trichoderma can act as a biocontrol agent in a variety of ways:

1. It may grow faster or use its food source more efficiently than the pathogen, crowding it out and eventually taking control, a process called as nutritional competition.
2. A biocontrol agent may emit a substance known as antibiosis, which slows or entirely inhibits the growth of infections in its vicinity.
3. It may directly feed on or in a pathogenic species, which is known as parasitism.
4. It may stimulate the production of a molecule that defends the plant against the disease, resulting in induced resistance.
5. They can grow endophytically in other species and help plant development.

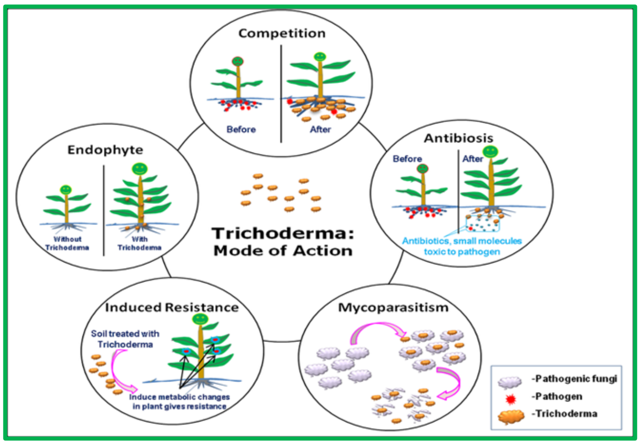

Figure: Model demonstrating *Trichoderma* sp. method of action against pathogens and plant growth enhancement.

Competition: The most prevalent cause of mortality for many microorganisms living near Trichoderma strains is malnutrition and a lack of limiting nutrients. This has the potential to be employed efficiently in the biological control of fungal phytopathogens. Carbon and iron are two important ingredients for the survival of most filamentous fungus. Competition for carbon is an efficient mechanism not just in Trichoderma but also in some other fungus, such as *F. oxysporum* strains (Sarrocco, *et al.*, 2009). Some Trichoderma isolates generate siderophores that are very effective iron chelators in competition with other root invaders (Viterbo *et al.*, 2005), and some of them aid to develop symbiotic relationships with host plants (Samolski *et al.*, 2012).

Biotic and abiotic tolerance: Trichoderma species contain a high concentration of natural proteins, which may aid the plant's survival under biotic and abiotic stress circumstances. The hsp70 gene from *T. harzianum* T34 was cloned and reported, and Arabidopsis with encoding protein expression showed better tolerance to heat and other abiotic stressors (Mantero-Barrientos et al., 2008). The protein product encoded by this gene enhances fungal resistance to heat and other stresses such as osmotic, salt, and oxidative tolerance.

Characteristics of Trichoderma for formulation development: Trichoderma should have the following characteristics in order to build a good Trichoderma formulation:

1. Extensive rhizosphere knowledge.
2. Outstanding saprophytic ability.
3. Improved plant growth
4. Easier mass multiplication
5. Wide range of action.
6. Reliable and excellent control.
7. Environmentally friendly.
8. Interoperable with various bioagents.
9. Must be resistant to desiccation, heat, oxidising chemicals, and UV radiation (Jeyarajan and Nakkeeran, 2000).

Formulation development: An optimal formulation's characteristics:

1. The shelf life should be extended.
2. Crop plants should not be harmed by it.

3. Should be able to withstand harsh environmental conditions.
4. Should be cost effective and provide dependable plant disease control.
5. It should dissolve easily in water.
6. Carriers must be inexpensive and easily accessible for formulation development.
7. Compatibility with other agrochemicals.

Shelf life of Trichoderma formulations: Trichoderma in coffee husk has a shelf life of more than 18 months. Trichoderma formulations based on talc, peat, lignite, and kaolin have a shelf life of 3 to 4 months. *T. viridae* formulation was stored in polypropylene bags of various colours, and the population of *T. viridae* was greatest in milky white bags with a thickness of 100 microns. Bhat et al. (2009) observed a shelf life of up to 180 days for talc-based formulations. The rate of desiccation was lower up to the first 75 days of storage than it was from 75 to 180 days of storage. For more than 150 days, the formulation preserved a high number of viable propagules (above 106 cfu/g).

Trichoderma Applications

Bioremediation: *T. harzianum* commonly degrades several harmful organic contaminants such as phenols, cyanides, and nitrates. Several studies have found *Trichoderma* spp. strains to be involved in the detoxification of polycyclic aromatic hydrocarbons (PAHs). Katayama and Matsumura confirmed Trichoderma spp. degradative activity against many synthetic dyes, including pentachlorophenol, endosulfan, and dichlorobiphenyl trichloroethane (DDT). The potential of immobilised *T. viridae* biomass in conjunction with cell-free Ca-alginate beads to bios orb Cr (VI) have previously been documented. Similarly, *T. inhamatum* shown an exceptional capacity to withstand and completely decrease Cr (VI) concentrations, playing an important role in the bioremediation of Cr (VI)-contaminated wastewaters. Similarly, *Trichoderma harzianum* exhibits a variety of adaptation mechanisms in the detoxification of Cd-contaminated soil.

Animal Feed: Lytic enzymes generated by Trichoderma spp., including as cellulases, hemicelluloses, and pectinases, can be used in feeds to partially hydrolyse plant cell walls. This technique improves the digestibility and nutritional value of the feed. As a result, there was an increase in animal body weight as well as a greater milk output. Trichoderma cellulases are also used to soften fabrics. Furthermore, Trichoderma enzymes are used to change fibre characteristics as well as to lower lignin content. Mutanase produced from *T. harzianum* can be added to toothpaste to prevent plaque formation. Additional metabolites derived from the various Trichoderma species are employed in the food business in addition to their enzymes. Nut scent generating chemicals, for example, derived first from *T. viridae* and then from *T. atroviridae*, exhibit beneficial antibacterial activities. Trichoderma spp. enzymes are also used in the brewing industry.

Second Generation Biofuels: Improved conservational awareness of whole populations, as well as increased interest in alternative energy sources, make it possible to employ fungus from the genus Trichoderma in the production of so-called second-generation biofuels. T. reesei-supplied cellulases and hemicelluloses, for example, are employed in the synthesis of bioethanol from agricultural waste. These enzymes do actually catalyse the biodegradation of substrates to simple sugars, which are then subjected to yeast-induced fermentation (*Saccharomyces cerevisiae*).

Wood Preservation: Chemical wood preservation is reasonably inexpensive and successfully extends the service life of wood. The toxicity of heavy metals and other compounds used as wood preservatives, on the other hand, is a severe health and environmental problem. The intensive research activities aimed at designing and testing less troublesome protection systems highlight the critical need for innovation in this sector.

Because the antagonistic qualities evolved in conflict with other wood killers, such as wood-rotting and sap-staining fungi or other moulds, it is reasonable to predict that Trichoderma isolated from wood can efficiently suppress wood-damaging fungi.

Method of application

1. **Seed treatment:** Mix 10g of Trichoderma formulation per liter of cow dung slurry for treatment of 1kg of seed before sowing, particularly for cereals, pulses and oilseeds.
2. **Nursery treatment:** Drench nursery beds with @ 5 Trichoderma formulation per liter of water before sowing.
3. **Cutting and seedling root dip:** Mix 10g of Trichoderma formulation per liter of water and dip the cuttings and seedlings for 10 minutes before planting.
4. **Soil treatment:** Mix 2 kg of Trichoderma formulation in 100 kg of farmyard manure and cover it for 15 days with polythene. Turn the mixture in every 3-4 days interval and then broadcast in the field before sowing.
5. **Seed biopriming:** Biopriming is the process of treating seeds with biocontrol chemicals and then incubating them in warm, moist conditions until the radical emerges. Such seeds are more tolerant of harsh soil conditions. Biopriming may also lower the quantity of biocontrol chemicals administered to the seed.

Trichoderma as a Biofertilizer

Trichoderma is frequently utilized as a bio-fertilizer, with or without additives, for practically all crops. Trichoderma has been widely employed in vegetable cultivation, with the best results in tomato. However, other crops such as groundnut, cotton, wheat, tobacco, Bengal gramme, brinjal, sugarcane, eggplant, red gramme, banana, tomato, sugar beet, chilies, potato, soybean, citrus, cauliflower, onion, peas, and sunflower showed a beneficial response. Trichoderma's capacity to breakdown complex organic compounds in the soil contributed significantly to its function in boosting crop production and performance. Complex organic chemicals were simplified and made available to plants for them to be absorbed. However, soil Trichoderma treatment is also useful, but not as much as seed infected Trichoderma. The use of Trichoderma can minimize the need for chemical fertilizer rates, and strong results have been observed when Trichoderma is combined with compost/FYM or organic manure rather than industrial fertilizers. Trichoderma spp. Antifungal activity replaces fungicide application in the soil while simultaneously maintaining soil health and sustainable farming.

Precautions in the use of Trichoderma

1. Buy Trichoderma product only from proper and certified organization or company.
2. The product should not be more than 6 months old.
3. Do the work of seed and plant treatment in a shady and safe place.
4. Do not use other fungicidal chemicals with Trichoderma.
5. Do not use chemical fungicide for 4-5 days after application of Trichoderma.
6. Do not use Trichoderma in dry soil, moisture is essential for its growth.
7. Choose a dry and cool place to store the Trichoderma product for a long time.

Trichoderma product Quality

1. Seed rate (CFU)should be at least 2×10 per gram.
2. The product should have a moisture content of 8 percent and a pH of 7.
3. Last method of use at least six months.

Advantages of Trichoderma spp.

- Harmless to human and livestock
- Act against wide range of pathogenic fungi.
- Uses various of action.

- Producing ample spores.
- Grow extremely rapidly and quickly colonies the soil.
- Promote nutrient uptake and enhance plant growth**.**

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