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Trichoderma – Bio Control Agent Gift from God

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Introduction

Agriculture is the backbone of the Indian economy. During the COVID-19 pandemic, agriculture contributed the highest GDP for the country's economic growth. The nation relies on agriculture to support millions of citizens through the production, marketing, and processing of agricultural products. However, crops in farmers' fields are constantly threatened by diseases and pests due to continuous changes in environmental conditions. The rapid population growth has led to an increase in the use of chemicals such as insecticides, fungicides, and weedicides to meet the population's needs. The unlawful use of toxic fungicides has a negative impact on human health, soil quality, and possibly the environment, leading to decreased beauty and polluted river water. The excessive use of chemicals has also resulted in the development of resistance, posing a major challenge for farmers. While novel technologies have improved production, some modern practices have adverse effects on our ecosystem. Therefore, finding economically viable, eco-friendly, and safe biological methods for plant disease management is the most cost-effective and sustainable approach for future agriculture.

Currently, several bio control agents, including fungal agents such as *Aspergillus*, *Gliocladium*, *Trichoderma*, and *Ampelomyces*, as well as bacterial agents like *Bacillus*, *Pseudomonas*, and *Agrobacterium*, have been recognized and are available (Naher et al., 2014). Among them, *Trichoderma*, a fungal biocontrol agent, is the most versatile, highly rhizosphere competent, cosmopolitan, and root colonizing agent used for managing plant pathogens.

Morphological characteristics

1. **Growth:** *Trichoderma* cultures are typically fast-growing at temperatures ranging from 25-30°C, although some species can grow at higher temperatures up to 45°C.

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2. **Spore Color:** *Trichoderma* produces spores of various colors, including light green, dark green, white green, dull green, as well as variations in colony color on the backside of the plate, such as amber, yellow, buff, and uncoloured.
3. **Growth Rate:** *Trichoderma* species are characterized based on their radial growth rate, which refers to the speed at which the colony expands outward from the point of inoculation.
4. **Chlamydospores:** During unfavourable conditions, most *Trichoderma* species produce chlamydospores, which serve as resting spores.
5. **Conidia:** *Trichoderma* conidia typically appear dry, although in some species, they may be suspended in drops of clear green-yellow liquid or clear green color.

Mechanisms of Trichoderma spp.

It included mycoparasitism, antibiosis, and competition for nutrients or space, among others. These mechanisms can independently or collectively suppress plant pathogens.

1. **Mycoparasitism: -** Mycoparasitism is a significant mechanism utilized by *Trichoderma* to exert its antagonistic activity against phytopathogenic fungi. Mycoparasitism involves the hyper parasitic activity of *Trichoderma*, which is characterized by the production of cell wall lytic enzymes. Mycoparasitism as a four-step process, including chemotropism and recognition, attachment and coiling, cell wall penetration, and digestion of the host cell. *Trichoderma* strains detect other fungi, grow towards them, and secrete cell wall degrading enzymes such as chitinases, β 1, 3 glucanase, and protease. *Trichoderma* attaches to the host, coils its hyphae around the host by forming appressoria on the host surface, penetrates the host cell, and ultimately collapses the host hyphae (Steyaert et al., 2003).
2. **Antibiosis: -** It involves an antagonistic interaction among the plant, pathogen, and *Trichoderma* fungus. This interaction leads to the secretion of low molecular-weight antibiotics or secondary metabolites, such as trichodermin, viridine, trichothecin, suzukacillin, and alamethicin, which are produced by *Trichoderma*. These compounds influence the morphological or physiological processes necessary for the successful penetration of *Trichoderma*.
3. **Competition: -** For nutrients and living space is a significant factor in ecological interactions among organisms. *Trichoderma* spp., a group of rapidly growing fungi,

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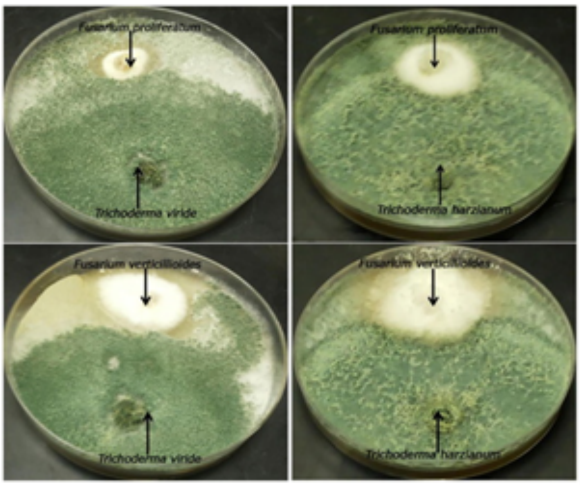
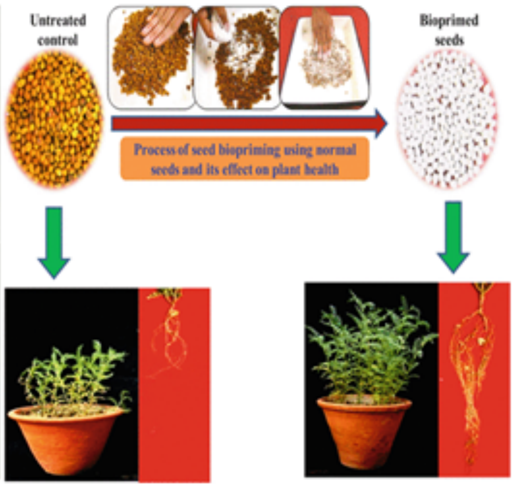
exhibit strong competitive abilities in this regard. They possess persistent conidia (asexual spores) and can utilize a wide range of substrates, allowing them to efficiently compete for nutrients and living space. Moreover, *Trichoderma* spp. have the ability to mobilize and acquire soil nutrients more effectively compared to pathogenic fungi and other microorganisms. This enhanced capacity to access and utilize available nutrients further enhances their competitiveness. *Trichoderma* spp. possess a suite of competitive traits that allow them to outcompete other organisms for nutrients and living space. Their efficient utilization of diverse substrates, resistance to toxic compounds, ability to mobilize soil nutrients, competition for carbon, and production of siderophores collectively contribute to their strong competitive advantage in various ecological contexts.



Antagonistic activity of *Trichoderma* against wilt pathogen *Fusarium*



Seed biopriming one of efficient *Trichoderma* application method

Mass production of Trichoderma: -

The development of a successful biological control agent depends on the mass culturing and delivery system of the bio-control agent. The most commonly used solid medium for *Trichoderma* culturing is a mixture of wheat bran, sawdust, sorghum, and other agro-based waste products. Various solid and liquid substrates such as banana, papaya, guava, spinach, sugarcane, potato peel, brinjal, used tea leaves, and pea husk have been reported as suitable substrates for the multiplication of *Trichoderma viride* and *Trichoderma harzianum*. The growth media used for the production of *Trichoderma* in liquid state fermentation include molasses, brewer's yeast, and jaggery-soy medium (Prasad et al., 2002).

Characteristics of an ideal formulation

- It should have an extended shelf life.
- It should be able to withstand adverse environmental conditions.
- It should be cost-effective.
- It should effectively control plant diseases.
- It should not be phytotoxic to crop plants.
- It should dissolve well in water.
- Carriers must be inexpensive and readily available.
- It should be compatible with other agrochemicals.

Plant Pathogen Management by using *Trichoderma*

Trichoderma species have emerged as effective biocontrol agents, showcasing their ability to suppress the growth of pathogenic microorganisms while concurrently stimulating plant and root growth. Diverse range of plant diseases that *Trichoderma* has shown efficacy against, including root rot, wilt, fruit rot, and damping off (Komy et al., 2022). Additionally, *Trichoderma* has been found to enhance soil fertility. Several studies have demonstrated the successful application of *Trichoderma* conidial suspension in preventing seed rot and root rot diseases caused by *Sclerotium rolfsii* in sunflower and mungbean, as well as damping off caused by *Pythium* spp., leading to improved plant growth (Yaqub & Shahzad, 2008). Furthermore, *Trichoderma* has exhibited effectiveness against other pathogens such as *Fusarium ciceris*, *Macrophomina phaseolina*, *Rhizoctonia solani*, plant parasitic nematodes, and *Fusarium oxysporum* (Mukhopadhyay and Pan, 2012; Li et al., 2018).

Application or delivery system:

Seed treatment, seed biopriming, seedling root dip, and soil treatment are effective methods for the application of *Trichoderma*, a biocontrol agent, in the management of soil-borne and seed borne diseases. Seed treatment involves coating the seeds with dry powder of *Trichoderma* before sowing, while seed biopriming treats the seeds with biocontrol agents and allows them to incubate under warm and moist conditions. Seedling root dip involves treating cuttings or seedlings with a spore suspension of *Trichoderma* before planting, and soil treatment delivers *Trichoderma* to the soil, increasing the population of fungal antagonists and suppressing the establishment of pathogenic organisms. They also promote seedling emergence, enhance seedling growth, and reduce the growth of plant pathogens. The

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recommended dosages and techniques vary depending on the specific crop and disease. Overall, the use of *Trichoderma* through these application methods offers promising prospects for disease management in agriculture.

Conclusion

Excessive use of chemical pesticides has led to negative impacts on human health, soil quality, and the environment, necessitating the adoption of sustainable and eco-friendly approaches for plant disease management. *Trichoderma*, a versatile and highly effective biocontrol agent, offers a promising solution. It employs mechanisms such as mycoparasitism, antibiosis, and competition to suppress plant pathogens. *Trichoderma* can be mass-produced using various substrates and delivered through seed treatment, seedling root dip, and soil treatment methods. These application techniques have shown efficacy in controlling a wide range of plant diseases while promoting plant growth and soil fertility. Implementing economically viable and environmentally sustainable biological methods, like *Trichoderma*-based disease management, is crucial for the long-term success of agriculture in India.

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