Trichoderma: Biocontrol of Fungal Phytopathogens in Sustainable Agriculture

Preety Verma[1*], Vinod Kumar Malik[1], Anil Kumar[3] and Mamta Khaiper[2]
[1]Department of Plant Pathology, College of Agriculture, CCSHAU, Hisar, Haryana, India.
[2]Department of Forestry, College of Agriculture, CCSHAU, Hisar, Haryana, India.
[3]Krishi Vigyan Kendra, Yamuna Nagar, CCSHAU, Hisar, Haryana, India.
*Corresponding Author: vermapreety5926@gmail.com

Various actions and strategies of sustainable food production systems, such as Integrated Pest Management (IPM) and organic farming, are taken to protect the environment from the negative effects of chemical fungicides. Biological Control Agents (BCAs), which are based on living microorganisms or their metabolites, and natural products that control the population of plant pathogens, are one of these strategies. The majority of effort has been expended over the last several decades to investigate the efficacy and practicality of non-pathogenic bacteria and fungi in the hope of commercializing them as BCAs. As a result of the research, a large number of bacterial and fungi, one of the important fungi is *Trichoderma* which have been used as BCAs. The efficiency with which Trichoderma can be used in agriculture is determined by their metabolic activity and the type of interaction they have with plants and other microorganisms.

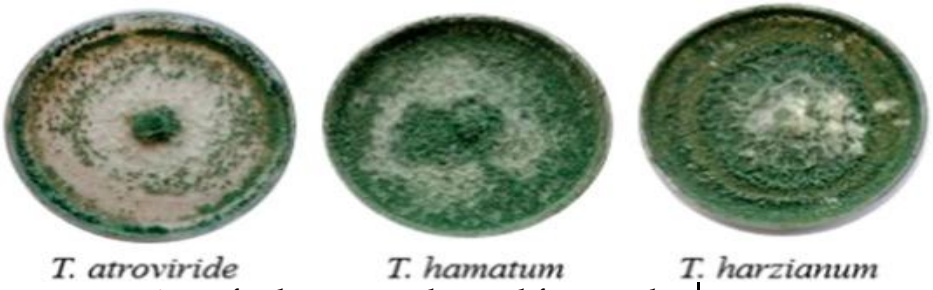
Bioremediation through Trichoderma

Trichoderma strains play an important role in the bioremediation of pesticide and herbicide-contaminated soil. They can degrade a wide range of insecticides, including organochlorines, organophosphates, and carbonates. It improves soil fertility, increase plant shoot and root growths, enhances flowering of the crops, increases phosphate uptake and increases resistance in plant against plant pathogens.

These fungi colonise the rhizoplane, rhizosphere, and plant roots effectively and produce a variety of metabolites with anti-microbial (cell wall degrading enzymes, antibiotics, volatile and non-volatile compounds) and bio stimulant (phytohormones, Phyto regulators) properties. Furthermore, Trichoderma is known for its intensive absorption of root schedules and interactions with not only pathogenic microorganisms, but also the entire soil microbiome.

Characteristics of Trichoderma

- The success of species belonging to the genus *Trichoderma* as biocontrol agents in the soil ecosystems results from their ability to rapid growth, the possibility of utilizing a variety of substrates, and resistance to many toxic chemicals, including fungicides (e.g., azoxystrobin, 3,4-dichloroaniline, and trifloxystrobin), herbicides, and other organic pollutants.
- *Trichoderma* was found to degrade some toxic contaminants through enzymes involved in cellulose/lignin degradation that have been shown to have xenobiotic-metabolizing enzyme potential.
- Trichoderma is a potent biocontrol agent and used extensively for soil borne diseases. It has been used successfully against pathogenic fungi belonging to various genera, viz. Fusarium, Phytopthara, Scelerotia etc.
- Trichoderma is not only abundant in the environment and easy to isolate, but it can also be easily multiplied under controlled conditions



on a variety of substrates and stored for months without losing viability or properties.

- Trichoderma reduces the occurrence of plant diseases through competition for nutrients and space, the synthesis of antifungal metabolites, mycoparasitism, the production of lytic enzymes that degrade fungal plant pathogen cell walls, and the induction of plant resistance.
- The most effective biocontrol properties are mainly attributed to the *T. virens*, *T. harzianum*, *T. koningii*, *T. longibrachiatum*, *T. asperellum*, *T. polysporum*, and *T. viride*, which have a significant impact on the development of plant diseases caused by *Rhizoctonia solani*, *Sclerotium rolfsii*, *Pythium aphanidermatium*, *Fusarium oxysporum*, and *Fusarium culmorum*, both under greenhouse and field conditions.
- The application of *Trichoderma* strains to the soil increased the productivity and quality of crops of monocotyledons and dicotyledons, such as cucumbers, tomatoes, carrots, beans, corn, cotton, tobacco, millet, and ornamental grasses.

How to apply

- Seed Treatment: Before sowing, mix 6 - 10 g of Trichoderma powder per Kg of seed.
- Nursery treatment: 10 - 25 g Trichoderma powder per 100 m2 nursery bed. The use of neem cake and FYM prior to treatment improves efficacy.
- Cutting and seedling root dip: In a litre of water, combine 10g of Trichoderma powder and 100g of well-rotten FYM, and dip the cuttings and seedlings for 10 minutes before planting.
- Soil treatment: After turning sun hemp or dhaincha into the soil for green manuring, apply 5 kg of Trichoderma powder per hectare. Alternatively, combine 1kg of Trichoderma formulation with 100 kg of farmyard manure and cover with polythene for 7 days. Sprinkle the heap with water intermittently. Turn the mixture in every 3-4 days interval and then broadcast in the field.
- Combination of soil application and leaf sprays with Trichoderma based bio preparate appears to be the most effective one, however, the increased quality and quantity of the yield in treated pepper plants may be due to the production of plant growth promoters or through indirect stimulation of nutrient uptake as well.

Conclusion

The Trichoderma and plant pathogen interaction is a complex and dynamic system. A thorough understanding of Trichoderma mechanisms toward plants and pathogens can significantly improve their effectiveness. Trichoderma employs a number of complex direct and indirect biocontrol mechanisms, both against biotic stresses (pathogenic microorganisms such as fungi, bacteria, insects, and nematodes) and abiotic stresses (unfavorable environmental conditions). Trichoderma has the ability to combine several benefits in one product, including the control of various plant diseases, the enhancement of plant growth, and the provision of a clean environment for the benefit of sustainable agriculture.

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