

## Trichoderma – A Biocontrol Agent

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**T***richoderma* spp. are free-living fungi often found in soil and root ecosystems. Known for their ability to control plant pathogens, these fungi suppress diseases through mycoparasitism, competition, and the production of secondary metabolites. Their eco-friendly nature and effectiveness have made them an important part of sustainable agriculture and integrated pest management (IPM) strategies.

### Introduction

Agriculture remains as a cornerstone of the Indian economy, yet plant diseases significantly impact crop productivity. While agrochemicals are widely used to combat these diseases, their excessive and non-judicious application poses serious threats to human health and the environment. As an eco-friendly alternative, biocontrol agents like *Trichoderma* have emerged as effective solutions in plant disease management. Naturally occurring in soil microflora, *Trichoderma* species suppress pathogens through

multiple antagonistic mechanisms, contributing to healthier crop ecosystems.

### Mode of Action

*Trichoderma* employs several strategies to control phytopathogens:

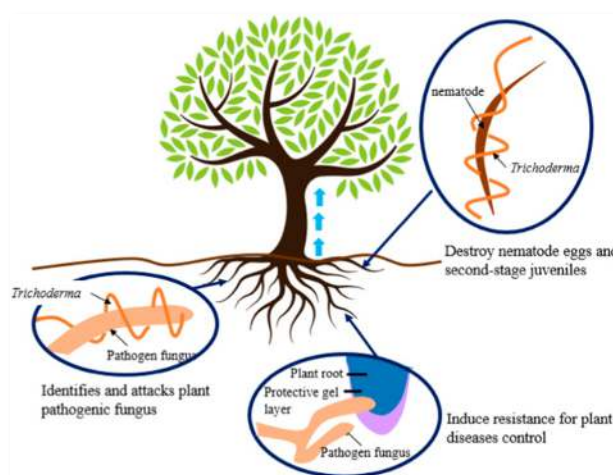
- **Competition:** It outcompetes pathogens for nutrients and space in the rhizosphere.

- **Enzymatic Degradation:** It secretes hydrolytic enzymes such as chitinases,  $\beta$ -1,6-glucanases, xylanases, proteases, and

mannosidases, which degrade the cell walls of fungal pathogens.

- **Mycoparasitism:** A direct mode of action where *Trichoderma* physically coils around and penetrates the hyphae of pathogenic fungi, leading to their destruction.

- **Induced Resistance:** It can trigger both local and systemic resistance in host plants, enhancing their defense mechanisms against a broad range of pathogens.



These multifaceted actions make *Trichoderma* a robust and reliable biocontrol agent.

### Advantages Over Chemical Pesticides

Unlike synthetic fungicides, *Trichoderma* is non-toxic, biodegradable, and safe for beneficial soil microflora. Its various modes of action lower the chances of resistance in pathogens. Moreover, *Trichoderma*-based products are approved for organic farming and leave no harmful residues in soil or crops, making them suitable for long-term agricultural sustainability.

### Secondary Metabolite Production

*Trichoderma* produces a wide array of secondary metabolites (SMs) that contribute to its antagonistic activity:

- **Peptaibols:** Antibiotic peptides that inhibit fungal and bacterial pathogens.
- **Trichodermin:** A trichothecene mycotoxin that impedes the growth of plant-pathogenic fungi.
- **Viridin:** An alkaloid from *T. viride* that suppresses multiple pathogens.
- **Hydrolytic Enzymes:** Including cellulases and chitinases, they break down the structural polymers of pathogen cell walls.

These SMs act as biochemical weapons, reinforcing *Trichoderma*'s biocontrol efficacy.

### Smart Formulations for Enhanced Efficacy

Recent advances have led to the development of *cell-free formulations*, also called smart formulations, derived from secondary metabolites produced by *Trichoderma* under controlled conditions. These formulations:

- Enable targeted field applications.

- Are free from live cells, enhancing their shelf life and safety.
- Offer potential applications beyond agriculture, including bioremediation.
- Allow cross-border movement without legislative concerns.

Such innovations significantly reduce dependence on chemical fungicides and broaden the scope of *Trichoderma* usage in integrated disease management.

### Applications in Agriculture

- **Seed Treatment:** Enhances germination, vigour, and resistance to seed-borne diseases.
- **Soil Amendment:** Promotes root development and balances soil microflora.
- **Foliar Spray:** Controls foliar pathogens effectively.
- **Compost Additive:** Accelerates composting and suppresses soil-borne diseases.

### Challenges and Limitations

Despite its benefits, *Trichoderma* application faces several limitations:

- Efficacy may vary under field conditions due to environmental factors.
- Short shelf life of some formulations.
- Need for crop-specific strain selection.
- Competition with native microbial populations may affect establishment.

### Conclusion

*Trichoderma* spp. are essential biocontrol tools in modern agriculture. Their unique ways of suppressing pathogens, combined with their ability to promote plant growth, make them a sustainable alternative to synthetic pesticides. With ongoing advancements in formulation techniques and strain development,

Trichoderma-based products are likely to become fundamental to sustainable crop protection strategies.

## References

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