Indian Farmer
Volume 8, Issue 01, 2021, Pp. 108-115.
Available online at: www.indianfarmer.net
ISSN: 2394-1227 (Online)

POPULAR ARTICLE OPEN ACCESS

Use of Trichoderma spp. as biocontrol for disease management

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Article Received on: *28 December 2020* ***Published on:*** *1 January 2021*

ABSTRACT

Trichoderma as biological control agents have been widely used against many plant pathogens. It suppressing the growth of plant pathogens, and it improves plant growth. It can produce different secondary compounds and readily activates others fungi, producing very significant enzymes, such as chitinase, proteases, and β-1,3-glucanase, inducing plant defense, systemic resistance, and strong and active competition against plant pathogens. It is party to an important detoxification process to reduce the toxicity secreted by plant pathogens. It is therefore necessary to clarify the significance of Trichoderma in the control of plant diseases that results in improvements in sustainable agriculture. Trichoderma strains have long been recognized as biological agents, for the control of plant disease and for their ability to increase root growth and development, crop productivity, resistance to abiotic stresses, and uptake and use of nutrients. It has been used successfully against various pathogenic fungi belonging to various genera, viz. Fusarium, Phytopthara and Scelerotia etc. Trichoderma strains solubilize phosphates and micronutrients. Biocontrol mechanisms of Trichoderma antagonist microorganisms, such as Trichoderma, reduce growth, survival or infections caused by pathogens by different mechanisms like competition, antibiosis, mycoparasitism, hyphal interactions, and enzyme secretion. Bio-agents help in not only managing the diseases but also increasing the crop yield.

Keywords: Trichoderma, competition, Antibiosis, Bio-control agent, Mycoparasitism.

INTRODUCTION

In agriculture, worldwide, pathogens are threat to crop production. The extensive use of fungicides in various parts of the world for years has increased the pollution level in soil and water, and adverse effect on food quality and human health. Apart from this, the chemicals tend to become less efficient due to the development of resistance among the pathogen a over time. Hence, it is necessary to look for alternative disease management practices, which include the use of eco-friendly biological control agents.

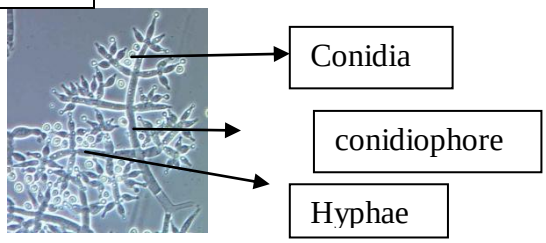
What are BIO-CONTROL AGENTS?

Control of plant pathogens and diseases caused by them through antagonistic microorganisms or botanicals is termed biological control agents. According to Baker and Cook's (1974) "Biological control is the reduction of inoculum or disease producing activity of a pathogen accomplished by or through one or more organisms other than man." Antagonistic microorganisms like species of Trichoderma, Penicillium, Bacillus, Pseudomonas etc.

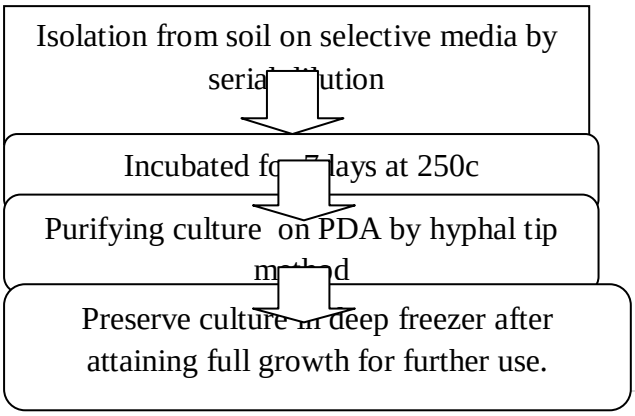
Taxanomy of Trichoderma		
Position	**Asexual Stage (Conidia)**	**SexualStage (Ascospore)**
Kingdom	Fungi	Fungi
Phylum	Ascomycota	Ascomycota
Sub-division	Deuteromycotina	Ascomycotina
Class	Hyphomycetes	Pyrenomycetes
Order	Monilliales	Sphariales
Family	Monilliaceae	Hypocreaceae
Genus	*Trichoderma*	*Hypocrea*

Trichoderma:

Trichoderma is a genus of fungi in the family Hypocreaceae, that is present in all soils, where they are the most prevalent culturable fungi. Many species in this genus can be characterized as opportunistic avirulent plant symbionts

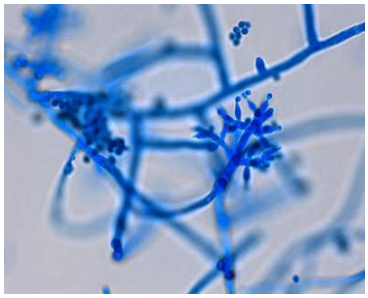


Isolation of Trichoderma:



Cultures are fast growing at 25-30 C. Conidia forming within week in compact or loose tufts in shades of green or yellow or less frequently white.Yellow pigment may be secreted into the agar, specially on PDA. A characteristic sweet or 'coconut' odour is produced by some species.

Common species are *Trichoderma viride, Trichoderma reesei, Trichoderma virens, Trichoderma atroviride, Trichoderma harzianum, Trichoderma asperellum, Trichoderma longibrachiatum, Trichoderma citrinoviride*



Microscopic view of Trichoderma

Trichoderma culture on PDA

Trichoderma on broth

BENEFITS OF TRICHODERMA

- ✓ **Disease Control**: Trichoderma is a potent biocontrol agent and used extensively for soil born diseases. It has been used successfully against pathogenic fungi belonging to various genera, viz. Fusarium, Phytopthara, Scelerotia etc.
- ✓ **Plant Growth Promoter:** Trichoderma strains solubilize phosphates and micronutrients. The application of Trichoderma strains with plants increases the number of deep roots, thereby increasing the plant's ability to resist drought.
- ✓ **Biochemical Elicitors of Disease**: Trichoderma strains are known to induce resistance in plants. Three classes of compounds that are produced by Trichoderma and induce resistance in plants are now known. These compounds induce ethylene production, hypersensitive responses and other defense related reactions in plant cultivars.
- ✓ **Transgenic Plants:** Introduction of endochitinase gene from Trichoderma into plants such as tobacco and potato plants has increased their resistance to fungal growth. Selected transgenic lines are highly tolerant to foliar pathogens such as *Alternaria alternata, A. solani,* and *Botrytis cirerea* as well as to the soil-borne pathogen, *Rhizoctonia* spp.
- ✓ **Bioremediation**: Trichoderma strains play an important role in the bioremediation of soil that are contaminated with pesticides and herbicides. They have the ability to degrade a wide range of insecticides: organochlorines, organophosphates and carbonates.

MECHANISM OF TRICHODERMA:

Trichoderma is a very effective biological mean for plant disease management especially the soil born. It is a free-living fungus which is common in soil and root ecosystems. It is highly interactive in root, soil and foliar environments. It reduces growth, survival or infections caused by pathogens by different mechanisms.

I. Trichoderma- pathogen interaction 1. Mycoparasitism 2. Antibiosis 3. Competition

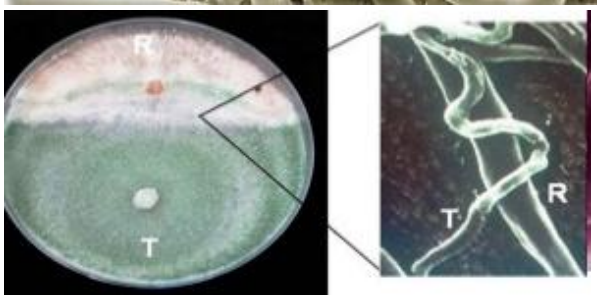
II. Trichoderma- Plant interaction 1. Plant root colonization 2. Plant growth promotion 3. Induced resistance 4. Symbiosis and Endophytism

1. Trichoderma- pathogen interaction:

`1.Mycoparasitism

The potential of *Trichoderma* spp. to parasitize, suppress, or even kill other plant pathogenic fungi has been recognized as an important mechanism for its success as a biological control. Mycoparasitism is a direct mechanism for biological control that works by parasitizing, detecting, growing, and colonizing pathogen.

Interaction – Coiling of hyphae around the pathogen, Vacuolization, Penetration by haustoria and lysis (Omero *et al*., 1999). Recognize and attach to the pathogenic fungus and excrete extra-cellular lytic enzymes like β-1,3-glucanase, chitinase, proteases and lipase (Schlick *et al.,* 1994).



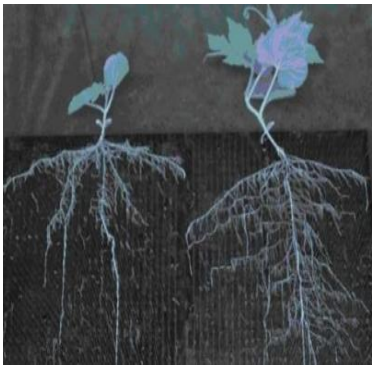
2. Antibiosis

Trichoderma spp. are rich and important sources of secondary metabolites (SMs) used for biological control of plant diseases. Antibiosis occurs during the interactions between a host plant, pathogens, and Trichoderma spp. that resulted in the production of antibiotics and low-molecular-weight compounds by Trichoderma to inhibit the growth of phytopathogenic fungi.

3. Competition

Competition among microorganisms occurs only when resources such as soil nutrients and space are limited. In this situation, antagonistic microbes produce secondary metabolites capable of inhibiting or slowing growth and other activities of pathogenic fungi, thus conferring ecological advantages over its competitors.

II) **Trichoderma- Plant interaction**



1. **Plant root colonization**: The hyphae penetrate the root cortex but the colonization by Trichoderma is stopped, probably by the deposition of callose barriers by the surrounding plant tissues. It appears that this interaction evolves into a symbiotic rather than a parasitic relationship between the fungus and the plant, whereby the fungus occupies a nutritional niche and the plant is protected from disease. Direct molecular cross-talk occurs between the fungus and the plant. Elicitors from Trichoderma activate the expression of genes involved in the plant defence response system, and promote the growth of the plant, root system and nutrient availability. This effect in turn augments the zone for colonization and the nutrients available for the biocontrol fungus, subsequently increasing the overall antagonism to plant pathogens.

2. Plant growth promotion: Trichoderma Secondary Metabolites: Koninginins, 6pentyl-a-pyrone, trichocaranes A – D, harzianopyridone, cyclonerodiol, harzianolide and harzianic acid are examples of isolated compounds that affect plant growth in a concentration dependent manner. (Vinale et al., 2014). Effect on seed germination : Seed biopriming and seed treatment with *Trichoderma* spp. trigger the release and/or production of enzymes and phytohormones which are involved in seed germination. *T.harzianum* produces a metabolite as gliotoxin that may mimic the plant growth hormone gibberellic acid which is involved seed germination process. Effect on plant morphology : Many lines of evidence strongly support a role for auxin in the regulation of root system architecture. *T. virens* is able to produce auxins as indole-3acetic acid (IAA), indole-3-acetaldehyde (IAAld), and indole-3-ethanol (IEt). (Contreras-Cornejo et al., 2009)

3. **Induced resistance in plants:** *Trichoderma* spp. were reported to induce the synthesis of regulatory proteins in plants especially under certain disease stress, where these regulatory proteins detect microbe effectors and activate the plant's defense systemss. In plant root colonization, *Trichoderma* spp. deals with a plant's defense system by synthesizing antimicrobial compounds such as phytoalexins. Its interactions with plants during the early stages of root colonization might stimulate the activation of cell detoxification and plant protection mechanisms. Interaction of Trichoderma with the plant, different classes of metabolites may act as elicitors or resistance inducers. These molecules include: (i) proteins with enzymatic activity, such as xylanase (ii) avirulence-like gene products able to induce defence reactions in plants (iii) low-molecular-weight compounds released from fungal or plant cell walls by the activity of Trichoderma enzymes.

4. **Symbiosis and Endophytism**: a fungus, or a bacterium living within plant tissues for a part of its life without causing apparent damage/injury. The saprophytic fitness of *Trichoderma* species has enabled their establishment in soil and rhizosphere and often within roots where hyphae grow between cortical cells Although well known for their ability to colonize the rhizosphere with limited root penetration, some *Trichoderma* species are known

to reside in plants as typical endophytes, entering through trichomes by producing appressoria-like structures. *T. Asperellum, T. virens, T. koningiopsis, T. stilbohypoxyli* and *T. stromaticum*. Trichoderma secretes siderophores and is able to grow in conditions that are poor in iron by using residual immobilized Fe. Siderophore production can be beneficial to the plant and microbes for two reasons: (1) siderophore production by antagonist fungi cansuppress the growth of plant pathogens by depriving it of an iron source and (2) siderophores can help in solubilizing iron that was unavailable to the plant.

Method of application:

- **Seed treatment:** Mix 6 - 10 g of Trichoderma powder per Kg of seed before sowing.
- **Nursery treatment**: Apply 10 - 25 g of Trichoderma powder per 100 m2 of nursery bed. Application of neem cake and FYM before treatment increases the efficacy.
- **Cutting and seedling root dip**: Mix 10g of Trichoderma powder along with 100g of well rotten FYM per liter of water and dip the cuttings and seedlings for 10 minutes before planting.
- **Soil treatment**: Apply 5 Kg of Trichoderma powder per hector after turning of sun hemp or dhainch into the soil for green manuring. Or Mix 1kg of Trichoderma formulation in 100 kg of farmyard manure and cover it for 7 days with polythene. Sprinkle the heap with water intermittently. Turn the mixture in every 3-4 days interval and then broadcast in the field.
- **Plant Treatment**: Drench the soil near stem region with 10g Trichoderma powder mixed in a liter of water.

Trichoderma formulations:

Important commercial formulations are available in the name of Sanjibani, Guard, Niprot and Bioderma. These formulations contain 3x106 cfu per 1 g of carrier material. Talc is used as carrier for making powder formulation.

Table3) Trichoderma sp. use as a Biocontrol agent

Bio-agents	**Mycelial growth inhibition (%) a zone of inhibiti**	**Host**	***Rhizoctonia* (Pathogen)**	**Source**
Trichoderma harzianum TG1	74.8	Fir (*Abies pindrow*)	*Rhizoctonia* sp	Dar *et al.,* 2017
Trichoderma harzianum-1	62.53	Tomato	*Rhizoctonia solani*	Rajendraprasad *et* 2017
Trichoderma viride	72.2	Sheath blight of Rice	*Rhizoctonia solani*	Datta and Kalha., 201
Trichoderma viride	65.08	Stem rot in carnation	Rhizoctonia solani Kuhn	Chandel Sharma,2014

T. viride	70.0	tobacco seedlings.	*R. solani*	Seema and Devaki, 20
T. harzianun	71.11	Mungbean (*Vigna radiate* L.)	Rhizoctonia solani *(*Kuhn*)*	Meena *et al*., 2018

Uses:

- Reduce the use of chemical fungicides.
- Decrease disease intensity.
- •Reduce undesirable effects from chemical pesticide.
- Play a key role in integrated management of diseases
- •Safe for the users and the farming community.
- Provide natural long term immunity to crops and soil.

Recommended For:

Trichoderma is most useful for all types of Plants and Vegetables such as cauliflower, cotton, tobacco, soybean, sugarcane, sugarbeet, eggplant, red gram, Bengal gram, banana, tomato, chillies, potato, citrus, onion, groundnut, peas, sunflower, brinjal, coffee, tea, ginger, turmeric, pepper, betel vine, cardamom etc.

CONCLUSIONS

Biological control an attractive alternative to chemicals. *Trichoderma* species are effective in biological control of fungus-induced plant disease. Plant diseases cause major loss of food and money. Biological control occurs via several mechanisms Competition Antagonism Mycoparasitism. A biocontrol program is only established when the bicontrol agent can successfully manage the interaction between the host plant and pathogen. The ability of Trichoderma to successfully manage this interaction has been well established. The fungi have also been demonstrated to enhance the defence responses in plants. Thus, as an effective biocontrol agent the use of Trichoderma will certainly ensure sustainable disease management.

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