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Trichoderma- A Potential Bio-Control Agent for Sustainable Agriculture

Devendra Singh
Scientist, ICAR-Central Arid Zone Research Institute, Jodhpur, Rajasthan

SUMMARY

Trichoderma spp. are filamentous, asexually reproducing fungi found in soil and roots. They create or release chemicals that trigger plant resistance. It's easy to isolate and grow, multiplies rapidly on numerous substrates, acts as a mycoparasite, strong opportunistic invader, and avirulent plant symbiont, competes for food and location with diseases, and produces prolific spores, antibiotics, antifungal chemicals, secondary metabolites, and enzymes. These features make them ecologically successful and widespread. This form of fungi is widespread in most soil types and is the most established of the culturable types. These fast-growing fungi thrive in temperatures between 25-30°C, but not above 35°C. These colonies are opaque and smell like coconut or something pleasant. One of the most common fungal species in soil, they have helpful qualities, colonise easily, and affect the plant's root zone. Trichoderma is a very prolific fungus in the root zone, and stimulating its growth can improve crops. Trichoderma helps seeds germinate and promotes germination and seedling sustainability.

INTRODUCTION

Trichoderma boosts plant growth by solubilizing phosphates and micronutrients. It also creates biochemical elicitors that promote ethylene synthesis, hypersensitive responses, and other disease-resistant plant responses. Trichoderma's endochitinase gene boosts plant resistance to phytopathogenic fungi. Trichoderma strains bioremediate pesticide-contaminated soil and breakdown organochlorines, organophosphates, and carbonates. Trichoderma plays a key role in biocontrol management of cereals, pulse, oilseed, fruit, vegetable, and spice crop diseases by creating antagonistic compounds that inhibit pathogen development and infection through competition, antibiosis, mycoparasitism, hyphal interactions, and enzyme release. Internationally, 104 Trichoderma species have been documented, including 13 from India. These species are molecularly characterised. T. hamatum, T. harzianum, T. koningii, T. pseudokoningii, T. virens, T. viride, T. aureoviride, T. longibrachiatum are some species (Monaco et al. 1991).

Modes of action

Through mechanisms such as competition, antibiosis, mycoparasitism, hyphal contacts, and enzyme release, the antagonistic fungus Trichoderma can inhibit the development, survival, or infection of pathogens.

Competition:

It's the situation when the disease and the introduced biocontrol agent (antagonist) both want to survive, but there's only so much space and food to go around. It is possible that the antagonist's presence throughout this phase will slow the proliferation of pathogens in the rhizosphere, so preventing the disease from spreading (Nirmalkar et al. 2017). For instance, collar rot in elephant foot yam can be reduced by 80-85% with the help of Trichoderma harzianum.

Antibiosis:

Some species of Trichoderma produce antibiotics or other compounds that are toxic to the pathogen and stunt its development. Trichoderma virens, which is known to produce gliotoxins, is a known opponent of several soil-borne plant diseases, including Rhaizoctonia solini, Sclerotium rolfsii, S. sclerotiorum, and Pythium ultimum (Ragab et al. 2015). Non-volatile antibiotics like those made by Trichoderma spp. provide more benefits than their volatile equivalents. If antibiotics were volatile enough to penetrate through the air through the soil's pores, direct contact between the pathogen and antagonist might not be necessary for inhibition. Antibiotics and toxins can be produced by certain Trichoderma strains. Trichodermin, trichodermol, harzianum A, gliovirin, heptelidic acid, viridin, and gliotoxin are all examples of such compounds.

Mycoparasitism:

This term refers to the phenomena in which pathogenic fungus feed off of other types of fungi. The mechanism encompasses numerous steps of the interaction process (Chen et al. 2016). The first stage is when the

chemical stimulation produced by the pathogenic fungi attracts the antagonist fungi and causes the antagonist to respond in a chemotropic manner. The second stage is the recognition of the antagonists by both the pathogen and the lectins that are present. Interactions between the hyphae of the pathogen and the antagonist come in the third stage, which follows the second stage. The antagonist (Trichoderma) hyphae either grow along the host hyphae or coil around it and secrete various complexes of lytic enzymes such as chitinase, glucanase, and pectinase which are key factors in pathogen cell wall lysis, leading to the process of mycoparasitism (Haran et al. 1996).

Competitive saprophytic ability-

Due of Trichoderma's high level of competitive saprophytic activity, it can degrade substrates in a relatively short period of time. As a consequence, plant pathogens were unable to compete with this BCA, which led to a reduction in the incidence of disease (Singh et al. 2016). The findings of this study might be useful to farmers in the management of microbial diseases.

Induced resistance-

It is believed that certain strains of the fungus Trichoderma colonise and penetrate plant tissues, inducing a series of morphological and biochemical changes in the plant. These changes are regarded as the plant's defense response, and they ultimately lead to an induced systemic response in the plant (Brotman et al.2012).

Inactivation of the pathogen's enzymes:

Through this additional biocontrol mechanism of Trichoderma, numerous enzymes of pathogens, such as pectinases, glucanases, and cutinases, are inhibited on plant surfaces by the action of Trichoderma's secreted protease.

Method of application

a) Treatment of Seeds Before Planting: For cereals, pulses, and oilseeds in particular, mix 10g of the Trichoderma formulation into one liter of cow dung slurry to treat one Kg of seeds before planting them.

b) Treatment for nurseries: Before sowing, drench nursery beds in water containing five milliliters of a Trichoderma formulation per liter of water.

c) Cutting and seedling root dip: Combine 10g of Trichoderma formulation with one liter of water, then soak the cuttings and seedlings in the mixture for ten minutes prior to planting.

d) For the treatment of the soil: combine one Kg of the Trichoderma formulation with one hundred Kg of farmyard manure and then cover the mixture with polythene for a period of seven days. After an interval of three to four days, give the mixture a stir, and then spread it out across the field.

e) Formulations containing Trichoderma: Sanjibani, Guard, Niprot, and Bioderma are the names of some of the most important commercial formulations containing Trichoderma. These formulations have a total of three times 10^6 CFU per one gram of carrier material.

Benefits of Trichoderma

i. The Prevention and Treatment of Disease: Trichoderma is a powerful biocontrol agent that is widely utilized for the prevention and treatment of post-harvest diseases. It has been shown to be effective against a wide variety of pathogenic fungi belonging to a variety of genera, including Fusarium, Phytopthara, and Scelerotia.

ii. Phosphate and micronutrient solubilization by the use of Trichoderma strains as a plant growth promoter

iii. Biochemical Elicitors of Disease Resistance: It's been shown that certain strains of Trichoderma can make plants resistant to disease. It has now been determined that Trichoderma produces three different types of chemicals, each of which induces resistance in plants. These chemicals cause plant cultivates to produce ethylene as well as hypersensitive responses and other defense-related behaviors.

iv. Genetically Modified Plants: The introduction of the endochitinase gene from Trichoderma into plants such as tobacco and potato plants has resulted in an increase in the plants' resistance to the growth of fungi. Certain transgenic lines have developed an extremely high level of resistance to foliar infections such Alternaria alternata, A. solani, and Botrytis cirerea, as well as to the soil-borne pathogen Rhizoctonia spp.

v. Bioremediation: Trichoderma strains are extremely useful in the process of bioremediating soil that has been contaminated with herbicides and pesticides. They are capable of breaking down a wide variety of pesticides, including organochlorines, organophosphates, and carbonates.

Plant disease control by different Trichoderma spp.:

Crop	Name of disease	Pathogens	Trichoderma spp.
Tomato, chili, peanut, Potato, black pepper	Wilt	Fusarium spp	T. hamatum, T. harzianum, T. virde, T. Virens
Citrus, Tobacco, Pineapple, black pepper	Root rot	Phytophthora spp.	T. harzianum, T. virde
Chilli, peanut, Potato,Tomato, soybean, maize, Cabbage,	Damping off	Pythium spp., R. solani	T. hamatum, T. harzianum, T. virde, T. Virens
Tomato, chilli, peanut, Potato, soybean	Southern stem rot	Sclerotium rolfsii	T. hamatum, T. harzianum, T. virde, T. Virens
Rice, maize	Sheath blight	R. solani	T. harzianum, T. virde
Rice, maize, wheat , soybean, chickpea, beans, tomato, brinjal, chilli	Sheath blight, late blight, early blight, leaf spot, root rots, downy mildew	Soil-borne pathogens and few foliar pathogens	T. harzianum strainTh3

Commercial products of Trichoderma spp. available in India:
Trichoderma viride : Ecofit, Funginil, Trichogourd, Defense SF, Tricho-X, Biogourd, Biocon
Trichoderma harzianum: Pant biocontrol, Pusa Th3

Disadvantages of Trichoderma

Despite the fact that it has an enormous number of applications for the sustainable agriculture, it also has a number of drawbacks, which include the following:

1. The shelf life of formulations containing Trichoderma is very short. Because of this, we are unable to store it or utilize it for an extended period of time.
2. The host range of Trichoderma spp. is limited since the majority of the fungal infections it controls are soil-borne, and it only controls a small number of foliar pathogens.
3. The horticultural industry faces potential danger from certain species of the fungus Trichoderma. For instance, an infection with Trichoderma has been shown to reduce mushroom yield by as much as fifty percent, and as a result, Trichoderma is regarded as a parasite that is detrimental to mushroom growth. Additionally, it has an effect on the organ (the liver) that has been transplanted in a human.

CONCLUSION

Trichoderma are useful antimicrobial agents in the realm of agriculture, where they are effective against pathogenic bacteria, fungus, and yeast. Through processes like as decomposition and biodegradation, organisms these kind of also play an important part in enhancing the vegetative growth of plants and the nutrient content of soil. Plants benefit from Trichoderma species because they encourage growth and suppress disease development. As effective biofungicides, Trichoderma species are capable of enzymatically destroying other fungi, creating anti-microbial chemicals that kill pathogenic fungus, and outcompeting harmful fungi for space and nutrients.

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