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Trichoderma's Contribution in Environmentally Friendly Plant Disease Management

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Abstract

Agriculture is an essential element of every country's economy since it feeds hundreds of thousands of people, yet plant pathogens seem to be the most important variables reducing crop productivity, causing serious losses to agricultural goods every year. The most recent challenge for modern farming is to increase yields while being environment friendly. As a result, there is an urgent need to discover environmentally responsible alternatives. Among the numerous species employed as biological control agents, Trichoderma are frequently utilized as a biological control agent against various plant diseases. According to study published, this fungus not just works as a BCA, but also increases plant resilience, and development, leading to increased agricultural production. The antagonistic action includes mycoparasitism, antibiotics, and the induction of systemic resistance in plants. This article reviews the existing data on *Trichoderma* Species' use as a biocontrol agent, its biocontrol activity and application to crop disease prevention strategies.

Introduction

Agriculture is essential in providing food security, relieving poverty, and protecting a valuable environmental resource on which the world's current and future generations will be completely dependent for existence and well-being. The global population scenario has altered dramatically during the last 20 years. The current challenge for the farming sector, farmers, and researchers around the world is to produce crops while maintaining crop quality and vitality through the use of eco-friendly methods. Various pathogens attack various plants in fields and natural environments, and these pathogens damage the entire crops and contribute to a reduced agricultural yield. Plant pathogens, which cause plant infections, reduce farmers' or growers' capacity to produce high-quality, plentiful harvests. Pathogens can infect nearly any species of plants. Using of Pesticides, insecticides, fungicides, and herbicides, rodenticides, and other chemical formulations are among the old and conventional means of controlling plant diseases. These chemicals suppress plant infections to a large extent, but their negative consequences can often be seen and recognized in the food chain. For years, the widespread use of fungicides in many regions of the world has created soil and water contamination, with negative consequences for quality of food and public health. To address these issues, researchers are looking for other solutions including the use of biocontrol agents (BCA) as disease management, either alone or in conjunction with other chemicals, for eco-friendly and sustainable disease management approaches. The concept "biocontrol" or "biological control" involves the reduction of plant pest populations *via* the use of naturally occurring organisms in integrated disease management.

Several biocontrol agents have been identified and are now accessible, including bacterial agents such as *Pseudomonas, Bacillus*, and *Agrobacterinum,* as well as fungal agents including *Aspergillus, Trichoderma, Ampelomyces*, and *Candida etc*. Among these biocontrol agents, *Trichoderma* spp. are the most adaptable, having long been employed to manage plant pathogenic fungus.

Trichoderma spp. are ubiquitous anaerobic, facultative, and cosmopolitan fungus found in agricultural soils and other substrates such as rotting wood. The purpose of *Trichoderma* spp. is not only to prevent development of harmful microorganisms, but there are numerous additional applications for Trichoderma such as, (i) promote colonizing of rhizosphores, (ii) energizes plant growth, growth parameters, and (iii) increase plant defensive responses.

Trichoderma spp. have been shown in several studies to be efficient biological control agents for plant protection, and commercially Trichoderma products are now available as biopesticides, soil supplements, and plant growth enhancers.

Trichoderma as Biocontrol Agent

Trichoderma was initially identified as a biocontrol agent in the early 1930's, and members of the genus Trichoderma are free-living, ubiquitous fungus that degrades organic and vegetable materials in soils. *Trichoderma* species are efficient antagonists with biocontrol abilities against relevant crop parasite, soil-borne diseases, as well as they may be found in almost every soil type.

Infectious agents and pathogenic microbes were managed with the use of biocontrol antagonists. Trichoderma inhibits the growth of other plant pathogenic fungus and stimulates the growth of plants and roots.

Antibiosis, mycoparasitism, induced host cell resistance, and nutrition and space competition are among the strategies used to control plant pathogenic diseases by *Trichoderma* spp. It is often regarded as an aggressive opponent that colonizes pathogens quickly, particularly soil-borne pathogens such as *Fusarium* species, *Phytophthora* species as well as *Rhizoctonia* species (Ghazanfar *et al*., 2018).

Trichoderma Bioecology

Mycoflora from the genus Trichoderma is typically ubiquitous, possessing a high amount of genetic diversity and living in a wide range of environments. Trichoderma species are imperfect fungi that may be acquired by direct extraction from natural soil, decomposing plant organic waste, and wood. They are categorized as Ascomycota's Hypocreales order. In diverse nutritional sources such as Malt Agar (MA) and Potato Dextrose Agar (PDA) as well as Czapek Dox Agar (CDA), Trichoderma grows and develops rapidly, generating greenish-coloured conidia/ spores in a variety of shades.

Trichoderma species thrive quickly at temperatures ranging from 25 to 30 °C. This genus is notable for its capacity to parasitize other harmful fungal mycoflora, particularly those linked to root rot and wilt infections. Endophytic fungi have been discovered as Trichoderma species. Despite the fact that it may be found in a variety of soils, including agricultural soil, as well as forest soil *etc*, and are typically regarded as successful plant pathogen competitors (Ghazanfar *et al*., 2018).

Climatic circumstances influence the distribution of Trichoderma species. The genus Trichoderma has over 80 species that can be utilized to manage phytopathogenic fungus. For instance, a warm environment is generally preferred by *Trichoderma harzianum*, but *Trichoderma viride* as well as *Trichoderma polysporum* prefer a chilly climate. *Trichoderma hamatum*, *Trichoderma pseudokoningii*, as well as *Trichoderma koningii, Trichoderma lignorum, Trichoderma reesei*, and *Trichoderma longibrachiatum* are thought to be the most promising biocontrol agents (Singh *et al*., 2021).

Advantages of Trichoderma

a) Disease Control

Phytopathogenic microbes have a substantial influence on agricultural yields and can impair plant productivity and crop quality dramatically. Trichoderma is a strong biological control agent that is frequently used to treat diseases that are spread through the soil. It has been shown to be effective against pathogenic fungi of various genera, including *Fusarium*, as well as *Phytopthara*, and *Scelerotia*, which cause diseases such as seedling blight, collar rot, loose smut, karnal bunt, black scurf, foot rots, capsule rot, and damping off, silver leaf of plum, peach, fungal and bacterial wilt, and others.

b) Plant Growth Promoter

Trichoderma was also shown to be capable of solubilizing phosphates as well as other micronutrients. Trichoderma, whether used alone or in conjunction with other plant growth boosting microorganisms, improves the plant's ability to withstand drought by increasing the number of deep roots, increases shoot length and plant height, enhances yield, and improves plants quality of the product.

c) Diseases Biochemical Elicitors

Plants are known to develop resistance with Trichoderma strains. Trichoderma aids in the activation of Systematic acquired induced resistance (SAR), induced systemic resistance (ISR), and hormonal level change in plant tissues. In plant cultivars, these chemicals cause ethylene synthesis, hypersensitive reactions, as well as other defensive reactions.

d) Bioremediation

Trichoderma strains are essential for the bioremediation of pesticide or herbicide polluted soil. They can destroy a wide spectrum of pesticides, including: carbonates, organochlorines, and organophosphates.

Trichoderma Mechanisms

Trichoderma has excellent antagonistic powers against a variety of phytopathogens thanks to a variety of methods, including direct competition for nutrients and space with the target organisms, antibiosis, mycoparasitism, and inducing plant resistance.

Mycoparasitism

Mycoparasitism, also known as hyper parasitism, is a mechanism that involves hyphae twining around the target organism, penetration, the development of haustoria, and hyphae lysis *via* secretion of inter-cellular lytic enzymes like glucanase, cellulase, and chitinase, as well as protease, and lipase, which disintegrate the pathogen's cell wall.

Antibiosis

Trichoderma species produce antimicrobial chemicals that induce phytopathogenic fungi to decay without even any physical contact among microorganisms. Antibiosis occurs when Antibiotics or low molecular diffusible chemicals that limit pathogen development are used by Trichoderma strains to interact with infectious pathogens. The metabolic chemicals produced by *Trichoderma* species are both volatile and non-volatile, that are toxic to the target pathogen, such as *gliovirin*, *harzianic acid*, as well as *glisoprenins*, and *alamethicins* (Ghazanfar *et al*., 2018).

Competition

Competition was a postulated process, but it was not demonstrated to be the primary activity. Trichoderma species and pathogens competed for resources and space, resulting in low pathogenic capabilities because Trichoderma develops quickly and colonizes substrates quickly, excluding pathogens.

In comparison to other microorganisms, Trichoderma has a higher potential for soil nutrient mobilisation and absorption. Of all the processes that inhibit pathogen infection, nutrient competition is the most significant.

Because of its aggressiveness and competitiveness, soil treatments with Trichoderma reduced infestations of many soil-borne plants pathogenic illnesses.

Induced Resistance in Plants

Trichoderma spp. has been found to enhance the production of regulatory proteins in plants, particularly when subjected to specific disease stress, where regulatory proteins recognise effectors and trigger the plant's defence mechanisms. During plant root colonisation, *Trichoderma* spp. interacts with the defence system of plants by producing antimicrobial chemicals such as phytoalexins (Thakur, 2021).

Applications of Trichoderma Species

a) Seed Treatment

It is a method of protecting planted seeds against wilting as well as rotting caused by fungi that live in the soil, such as *Rhizoctonia* species, *Macrophomina* species, and *Sclerotinia* species, *etc*. For bigger seeds, combine 8-10 g *Trichoderma* spp. (powder formulation 2×10^6 cfu/g) with 50 ml water, and 6-8 g for smaller seeds, for a total treatment of one kilogram of seed before planting. Prior to planting, add 10 g Trichoderma combination per 1 kg of seed to each litre of cow dung slurry, especially for pulses and cereal crops (Ghazanfar *et al*., 2018).

b) Treatment in the Nursery

Disease is more vulnerable in young seedlings; this causes the sick plant to develop. During the germination stage, moist soil increases the danger of root rot and wilt fungal infection. Drench nursery beds treated with @ 5 kg Trichoderma solution per litre of water or rather apply 10-25 g Trichoderma powder per 100 m^2 of nursery bed before sowing the crop (Ghazanfar *et al*., 2018).

c) Root Cutting or Seedling Dip

Dip plant cuttings and seedling roots in Trichoderma solution to safeguard seedlings and cuttings against pathogen infection is another technique include in Trichoderma therapy. Soak root cuttings or seedlings in a solution of 10 g Trichoderma mixture per litre of water for 10 minutes prior to actually planting.

d) Soil Treatment

After turning sun hemp on the field for green manuring, use 5 kg Trichoderma powder per hectare. Alternatively, 1 kg of Trichoderma powder should be mixed with 100 kg of green manure and covered with polythene for 7 days, frequently saturate the piles with water. The mixture should be turned in each and every 3-4 days and then spread on the field.

Recommendation

Trichoderma can be used to improve the production of a variety of plants and vegetables, including tomato, potato, and sugar beet, sugarcane, as well as brinjal, turmeric, banana, and others (Ghazanfar *et al*., 2018).

Precautions

When using Trichoderma inoculums in the field, there are a few precautions to keep in mind. The following are some of them.

- Do not leave treated Farm Yard Manure (FYM) to settle for an extended period of time.
- Keep Trichoderma-treated seeds out of direct sunlight.
- Wait 5-6 days after applying Trichoderma before using

chemical insecticides or fungicides.

• Because moisture is required for Trichoderma development and reproduction, it should not be grown in dry soil.

Conclusion

For disease suppression and control, biocontrol appears to be a viable alternative to chemical-based pesticides. For the suppression of single or complex plant diseases, *Trichoderma* spp. can be used alone or in combination with other biological control agents and organic amendments. As a biocontrol agent, Trichoderma is an essential component of integrated plant disease management, because it may combat soil-borne phytopathogens. However, its biocontrol potential has so far been limited to laboratory investigations, with little emphasis paid to commercial formulation. Furthermore, farmers lack knowledge on how to use it. As a result, the idea of Trichoderma commercialization must be enhanced, and cost-effective manufacturing formulations must become more widely known.

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