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Trichoderma: A potential biocontrol agent for plant disease management

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Abstract
Trichoderma species are one of the most common soil fungi, isolated from various habitats, Most of the Trichoderma strains are mesophilic and grow well in a wide range of temperature from 15-35°C. Low temperatures in winter may cause a problem during biological control by influencing the activity of the Trichoderma. Trichoderma species are best friends of higher plants. They not only protect them by killing or antagonizing their enemies but also improve their overall health including toning up of their ability to tolerate diseases and pests. They act as symbiont and may colonize epidermal and cortical cells.

Keywords: *Trichoderma*, Biocontrol, Plant, Disease, Management

1. Introduction

Trichoderma is known for secreting secondary metabolites in the environment which affects on wide spectrum of various fungal groups, especially pathogenic fungi. More than two hundred years ago, when it was first described by Persoon in 1794, mycologists mistook Trichoderma Pers.: Fr. for a gasteromycetes. The true nature of this fungus was realized only half a century later. Although, *Trichoderma* has not yet given us any “wonder drugs” like penicillin, but the ability of some species to produce enzymes and/or attack or inhibit other fungi causing diseases in plants has attracted major research efforts in several areas specially biological control of plant diseases. About 35 species of *Trichoderma* are currently recognized on the basis of morphological and molecular data. However, *T. harzianum, T. virens* and *T. viride* are the three most cited species of *Trichoderma* for biological control of plant diseases.

Weindling in 1932 [13], for the first time implicated the role of *Trichoderma lignorum* in the biological control of citrus seedling disease caused by *Rhizoctonia solani*. Since this pioneering work, several reports on successful biocontrol by *Trichoderma* spp. have accumulated. *T. harzianum*, *T. viride* and *T. virens* are the most widely used for biological control. They are reported effective in controlling root rots /wilt complexes and foliar diseases in several crops and are reported to inhibit a number of soil borne fungi like *Rhizoctonia*, *Pythium, Sclerotinia, Sclerotium, Fusarium* spp., *Macrophomina* etc. and recently root knot nematode, *Meloidogyne* spp.

Trichoderma cannot tolerate dry conditions; however, we may need these agents against plant pathogenic fungi which are able to grow and cause disease even in dry soils. The pH characteristics of the soil are also considered to the most important parameters affecting the activities of mycoparasitic *Trichoderma* strains. *Trichoderma* strains were able to grow in a wide range of pH from 2.0 – 6.0 with an optimum at 4.0. Mycoparasitic *Trichoderma* strains were found to be able to display various enzyme activities under a wider range of pH values 3.0- 6.0.*Trichoderma* are more effective in acidic soil, however Pseudomonas fluorescence are more effective in slightly alkaline soil (above pH 6.5).

One of the most interesting aspects of studies on *Trichoderma* is the varied mechanisms employed by *Trichoderma* species to affect disease control. In addition to being parasite of other fungi recent studies shows that they are opportunistic plant symbionts. They produce or release a variety of compounds that induce localized or systemic resistance responses. Biocontrol activity of *Trichoderma* is due to combination of its ability to serve as antagonist, plant growth promoter, plant defense inducer, rhizosphere colonizer and neutralizer of pathogen’s activity favouring infection.

Mycoparasitism is a complex process involving tropic growth of the biocontrol agent towards the target organism, coiling and finally dissolution of the target organism’s cell wall/cell membrane by the activity of enzymes. (Rather than coiling, hyphae of *Trichoderma* may grow attached with hyphae of *R. solani,* form haustoria, which may penetrate host fungal cell to draw nutrients. Same isolate of *Trichoderma harzianum,* against *R. solani,* may show both coiling and haustoria formation, however, one or other mechanism may dominate depending upon isolate of the antagonist.

Studies on the molecular and cellular aspects of the process of mycoparasitism indicate that it is an extremely complex process involving several steps and numerous separate genes and gene products.

Most of the pathogenic fungi contain chitin and β-glucans in their cell walls. Dissolution or damage of these structural polymers has adverse effects on the growth of these fungi. Recent research work has implicated a major role of enzymes in biological control by *Trichoderma* species and the secretion of enzymes is reported to be an integral step of the mycoparasitic process of *Trichoderma*. *Trichoderma* species secrete a number of hydrolytic enzymes, which includes chitinases, proteases, cellulases, glucanases and xylanases. Lorito (1998) [10] listed 10 separate chitinolytic enzymes alone. Similar levels of diversity are reported to exist for β-1,3 glucanases (Benftez, 1998) [2].

Weindling in 1934 [14] reported that a strain of *T. lignorum* produced a “lethal principle” that was excreted into the surrounding medium. He characterized it and demonstrated that it was toxic to both *R. solani* and *Sclerotinia americana* and named it “gliotoxin”. Later in 1983, Howell and Stipanovic isolated and described a new antibiotic “gliovirin”, from *Gliocladium virens* that was strongly inhibitory to *Pythium ultimum* and *Phytophthora* but was ineffective against *R. solani*, *Theilaviopsis basicola*, *Rhizopus arrhizus*, *Bacillus thuringensis* and *Pseudomonas fluorescens* (Howell *et al*., 1993) [9]. At present *Trichoderma* species are reported to produce a number of antibiotics. These include gliotoxin and glioviridin from *T. virens*, viridin, alkyl pyrones, isonitriles, polyketides, peptaibols, diketopiperazines, sesquiterpenes and some steroids from other *Trichoderma* species (Howell, 1998) [7].

Competition is considered as a ‘classical’ mechanism of biological control. It involves competition between antagonist and plant pathogen for space and nutrients (Chet, 1987) [3]. The idea of the involvement of this mechanism in biocontrol by *Trichoderma* has gained popularity in recent years. It is assumed that the mechanism of competition is involved in biocontrol, if no evidence for mycoparasitism or antibiosis is found in a particular *Trichoderma*-host fungus interaction (Alexander, 1982; Cook & Baker, 1983) [1, 4]. The omnipresence of *Trichoderma* in agricultural and natural soils throughout the world proves that it must be an excellent competitor. In studies conducted by Elad and Kapat (1999) [6] presented information regarding biocontrol of *B. cineria* by *T. harzianum* strain T-39. *B. cineria* conidia require external nutrients for germination and infection. When conidia of T-39 were applied to leaves, germination of conidia of the pathogen was slowed, an effect attributed in part to competition (Elad, 2000) [5]. The competitive ability of *Trichoderma* and therefore its biocontrol potential is affected by soil properties.

The ability of *Trichoderma* to sense and respond to different environmental conditions, including the presence of a potential host, is essential for successful colonization of soil, organic material, and developing plant roots. Sensing of such environmental conditions may occur through a variety of transduction pathways, which determine the adequate cellular response. Mitogen-activated protein kinase (MAPK) cascades and G-protein αsubunits transduce a large variety of signals, including those associated with pathogenesis (Mukherjee *et al.* (2003) [11].

2. Conclusion

This colonization results in improved root growth, which in turn improves overall plant health. *Trichoderma* species also make micro- and macro-nutrients available to the plants by enhancing their availability in soil. They decompose soil organic matter which helps in plant growth. *Trichoderma* spp are highly efficient producer of many extra cellular enzymes like cellulases, chitinases, glucanases, proteases etc. They are being exploited in variety of ways like source of cellulases (used in foods and textiles and also in poultry feed) and chitinases (generating disease resistant transgenic), in plant disease control (through their anti-fungal and anti-nematode and plant defense inducing activities), improvement of plant growth and organic matter/compost decomposition.

3. References

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