Vol. 3 Issue-4, December 2022 (e-ISSN: 2582-8223)

Trichoderma– A Useful Fungal Antagonist

Ganesh Pawar

ARTICLE ID: 53

Introduction

Trichoderma is a fungal genus that was described in 1794, including anamorphic fungi isolated primarilyfrom soil and decomposing organic matter (Persoon 1794). They are free-living fungi that are common in soil and root ecosystems. They are highly interactive in root, soil and foliar environments. They produce or release a variety of compounds that induce localized or systemic resistance responses in plants. *Trichoderma* strains have long been recognized as biological agents that controls plant diseases and alsogiveswide spectrum of evolutionary solutions that range from very effective soil colonizers with high biodegradation potential, to non-strict plant symbionts that colonize the rhizosphere.Some groups of biotypes within this conglomerate are able to antagonize phytopathogenicfungi by using substrate colonization, antibiosis and/or mycoparasitism as the main mechanisms.

Biodiversity of *Trichoderma*

Most of the *Trichoderma* species are morphologically very similar and were considered for many years as a single species: *T. viride*(Bisby 1939). Since new species were discovered, a consolidated taxonomical scheme was needed and then Rifai (1969) proposed and defined nine morphological species aggregates. DNA methods brought additional valuable criteria to the taxonomy of *Trichoderma*which are being used today for studies that include identification (Hermosa *et al.* 2001;Lübeck *et al.* 2000) and phylogenetic classification (Kullnig-Gradinger*et al.* 2002; LieckfeldtandSeifert 2000). Most isolates of the genus *Trichoderma* that werefound to act as mycoparasitictomany economically important aerial and soil-borne plant pathogens, have been classified as *T.harzianum*Rifai (Gams and Meyer, 1998). Due to the fact that the species *"harzianum"* is generallyconsidered as a group made of mycoparasitic and biocontrol strains, and there is large morphologicalplasticity that results in character overlaps with other species, the identification of thespecies may be difficult. Several authors have reported a large genetic variability among *T.harzianum*isolates (Bowen *et al.* 1996; Gomez *et al.* 1997; Grondona*et al.* 1997;Muthumeenakshi*et al*, 1994). In fact, it has been demonstrated that at least four distinct speciesare present within the biocontrol *T. harzianum*aggregate: *T. harzianums.str., T. atroviride, T. longibrachiatum*and *T. asperellum*(Hermosa *et al*. 2000). This is strongly advantageous in that they are less likelyto act against non-target organisms, but it does mean that a new selection process must takeplace for each crop/pathogencombination (Grondona*et al*., 1997).

Benefits of Trichoderma

Disease Control: *Trichoderma*is a potent biocontrol agent and used extensively for post-harvest disease control. It has been used successfully against various pathogenic fungi belonging to various genera, viz. *Fusarium, Phytopthara, Sclerotium.*

Mode of action of *Trichoderma* for Disease management

Trichoderma as a biocontrol agent controls the plant disease through different mechanisms. The mode of action to control foliar pathogens may differ from that of the root and soil patho-gens. Sometimes involvement of more than one mechanism in the interaction is also observed. The various mode of action employed by *Trichoderma* are described below:

Mycoparasitism:

Trichoderma species have special ability to parasitize other fungi and involves direct attackof one fungal species (say *Trichoderma*) on another one and the process is called as mycoparasitism. This process involved different complex sequential events from recognition of the fungal strain by *Trichoderma*, effective penetration into the host fungi, attack on cellular machinery to finally killing of the host (Benítez *et al.*, 2005; Waghunde*et al.*, 2016). According to Verma *et al.* (2007), production of various enzymes by species of *Trichoderma* helps in penetration of cell by hydrolysing polysaccharides, β-glucans, cellulose and chitin present in the cell walls of the plant patho-genic fungi. Development of biocontrol strategies were enhanced by the discovery of mycoparasitic ability of *Trichoder-ma* over other important economic fungi (Harman *et al.*, 2004).

Competition: *Trichoderma* can act as biocontrol agent by growing faster or by using its food source more efficiently than the pathogen which causes comparatively higher crowding of the biocontrol agent and finally taking over the pathogen. This process is referred as nutrient competition. Rhizosphere com-petence for food and space is also common among *Trichoderma* species. According to Harman (2000), *Trichoderma* species grow readily along with the developing root system of the treated plant when added to the soil or applied as seed treatments. A review Waghunde*et al.* (2016) ascribed regarding the deaths of microorganisms growing near the *Trichoderma* strains and suggested starvation and scarcity of limiting nutrients as the most common cause of death.

Antibiosis: Antibiosisis mode of action is a biological interaction mainly observed in between microorganisms in which one is adversely affected. Kucuk and Kivank (2003) stated that *Tricho-derma* species have potential to produce number of antibiotics such as trichodernin, trichodermol, harzianun and harzianolide which helps in controlling the plant pathogens. According to Benitez *et al.* (2004), in case of *Trichoderma* the mechanism of antibiosis involves the production of small sized diffusible com-pounds by *Trichoderma* species called antibiotics that inhibits the growth of other microorganisms. Bhattacharjee and Dey (2014) reported the control of *Pythium* spp. with the use of virdin antibiotic produced by *T. Viride*colonizing Pea seeds.

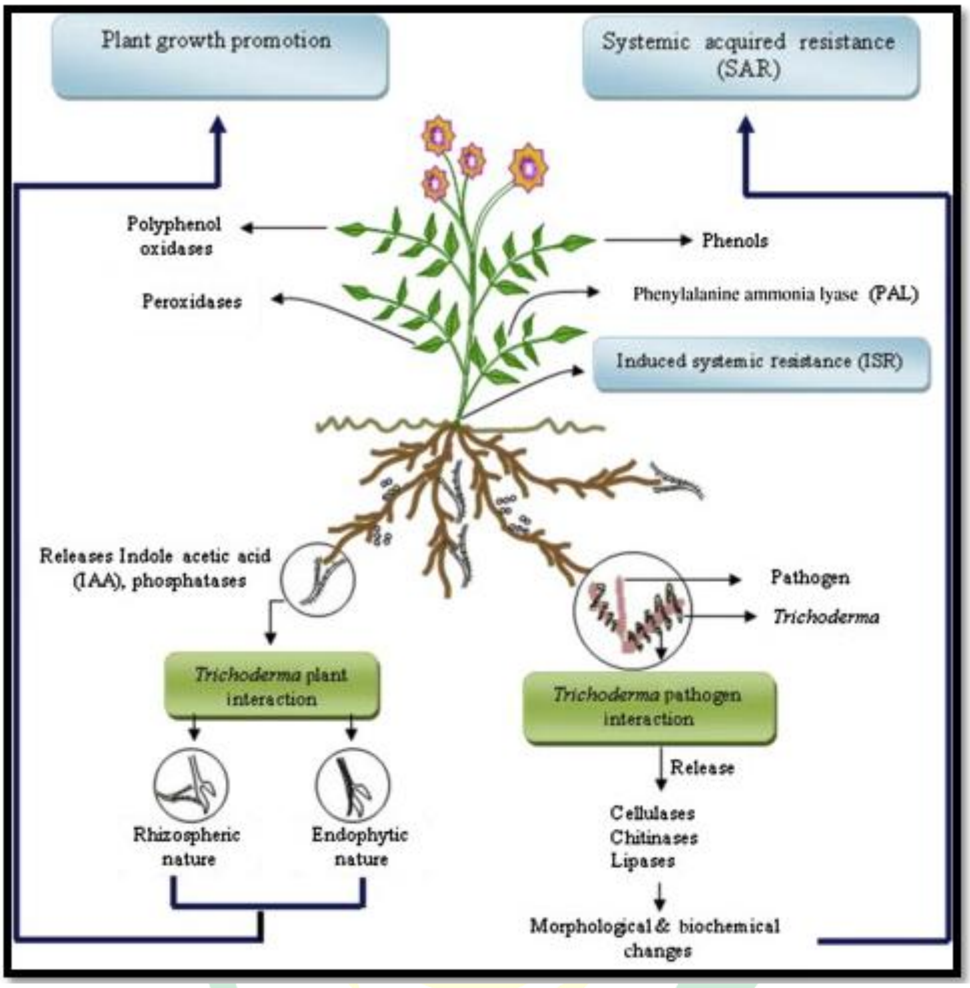
Induced resistance: The mode of action of *Trichoderma* species involves another mechanism of inducing resistance in the plant when treated with the biocontrol agent. The soil treated with biocontrol agent induced the resistance in leaves against fungal pathogens such as *B. cinerea* and *C. lindemuthianum*though biocontrol agent (T-39) was applied only on the roots. Later, an isolate of *T. harzianum*- T39 when applied into soil was found to be inducing systemic resistance in plants which resulted in reduction of foliar diseases including powdery mildew and also the application of biocontrol agent in the dead cells of roots induced foliar resistance against pathogens (Elad*et al.*, 2000). Other studies like Saksirirat*et al.* (2009) reported the induction of resistance in tomato plant (cv. Sida cultivar) by an isolate of *T. harzianum*(T9) against bacterial spot (*Xanthomonas campestris* pv. vesicatoria) reducing disease incidence upto 69.32% after 14 days of post inoculation. Hoitink*et al.* (2006) suggested the effectiveness of induced systemic resistance in compost amend-ed medium as it helped in the multiplication of *Trichoderma spp.*

Table. Biocontrol action of *Trichoderma* against differentcrop diseases.

S.N.	Plant	Disease	Pathogen	*Trichoderma* species	Experiment condition	Result	Reference
1	Sugarcane (*Saccharum officinarum*)	Pineapple disease	*Creatocystispa radoxa*	*T. harzianum* IMI- 392432	In *vitro*	63.80% inhibition of radial growth when culture plug was at the margin and 80.82% radial growth inhibition when culture plug was away from margin	Rahman *et al.* (2009)
2	Bean (*Phaseolus vulgaris)*	Root rot	*Rhizoctonia solani*	*T. asperellum*	In *vitro* and greenhouse	In vitro: lowered disease incidence (19.3%) In green house: only 30.5% of incidence	Asad*et al.* (2014)
3	Cacao (*Theobroma cacao*)	Black-pod	*Phytophthora palmivora*	*T. martiale*ALF247	In *vivo*	Progressive decrease in disease severity with increase in inoculum concentration	Handa*et al.* (2009)
4	Grapes (*Vitis venifera*)	Esca	*Phaemoniella chlamydospora*	*T. harzianum*	In *vivo*	Treated plant did not show necrosis or black goo	Marco *et al.* (2004)
5	Broad leaves and conifer-ous trees	Brown root rot	*Phellinus noxius*	*T. asperellum* TA	In *vitro*	The size of *Phellinus noxius*colonies was reduced from 7.3% to 15.8% than that of control	Chou *et al.* (2019)
6	Maize (*Zea mays*)	Stalk rot	*Fusarium graminearum*	*T. asperellum*ZJSX5 003	In *vitro* and in *vivo* (greenhouse)	Disease reduction of 71%	Li *et al.* (2016)
7	Coconut (*Cocos*	Black rot	*Ceratocystis paradoxa*	*T. sp*	In *vitro*	More than 60% growth inhibition of pathogen on the 7th day of incubation in	Kannangara*et al.* (2016)

JUST AGRICULTURE
multidisciplinary e-Newsletter

	nucifera)					dual culture	
8	Cocoyam (*Colocasia esculenta*)	Root rot	*Pythium myriotylum*	*T. asperellum*	In *vitro* and in *vivo*	Above 60% growth inhibition in vitro. 50% reduction of infection in vivo.	Mbarga (2012)
9	Sugar beet (*Beta vulgaris*)	Leaf spot	*Cercosporab eticola*	*T. hermatum*(Ba8/86 , Ba9/86, Ba12/86)	In *vitro* and in *vivo*	Maximum (63.5%) inhibition of mycelial growth by Ba9/86. 100% inhibition of conidia germination by Ba8/86. Ba9/86 and Ba8/86 were effective in controlling patho-gen under field condition.	Galletti*et al.* (2008)
10	Beans (*Phaseolus vulgaris*)	Damping off	*Pythium aphaniderma tum*	T105 strain	In *vitro* and in *vivo* (greenhouse)	In vitro: maximum inhibition (only 4.16% disease severity) In green house condition: 82.86% reduction of disease incidence.	Kamala and Indira (2011)
11	Rice (*Oryzae sativa*)	Brown leaf spot	*Bipolarisoryz ae*	*T. harzianum*	In *vitro* and In *vivo* (field)	In vitro: 48% inhibition if pathogens after 6 days. In field condition: *Trichoderma harzianum*has lowest (2.5%) disease severity and lowest disease incidence (46.9%) on 21st day of incubation.	Abdel-fattah*et al.* (2007)



1. ***Trichoderma* as biofertilizer:**

Some of the*Trichoderma* makes nutrients available to the plants through different biological processes. In contrast to synthetic fertilizers, they improves soil properties and microbial activities. They can maintain soil fertility for longer period as compared to chemical fertilizers. They can be applied alone or along with other chemical and biofertilizer in the field. Haque *et al.* (2012) reported that the application of 50% Nitrogen fertilizer and 50% *Trichoderma* enriched biofertilizer has increased the yield of mustard and tomato upto 108.36% and 125.45% over controlled condition respectively. Similarly, Doni*et al.* (2017) observed increased plant height, photosynthetic rate, chlorophyll content, stomatal conductance, and tiller and panicle numbers of rice with the application of *Trichoderma* enriched biofertilizer in SRI system. Moreover, *Trichoderma* has the potential to increase the availability of micronutrients to the plants.

2. **Plant Growth Promoter:**

*Trichoderma*strains solubilize phosphates and micronutrients. The application of *Trichoderma*strains with plants such as grasses, increases the number of deep roots, thereby increasing the plant's ability to resist drought.*Trichoderma* is often associated with the root ecosystems of the host plants. Therefore, *Trichoderma* is usually defined as the genus of symbiotic, opportunisticand avirulent microorganisms that colonize the roots and stimulate plant growth through mechanisms similar to those used by mycorrhizal fungi. The beneficial effects of *Trichoderma* species on plants include the promotion of their growth, improvement to root structure and condition, enhancement in seed germination and viability, as well as increased photosynthesis efficiency, flowering, and yield quality.

3. **Biochemical Elicitors of Disease Resistance:**

*Trichoderma*strains are known to induce resistance in plants. Three classes ofcompounds that are produced by *Trichoderma*induce resistance in plants are now known.These compounds induce ethylene production,hypersensitive responses and other defencerelated reactions in plant cultivates.

4. **Transgenic Plants:**

Introduction of endochitinase gene from *Trichoderma*into plants such as tobacco and potato plants have 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.

5. **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. *Trichoderma*species can be identified based on the morphology and colour of the colonies obtained on the potato dextrose agar medium. Further identification can be confirmed on the basis of the morphology of the conidia and conidiophores of different *Trichoderma*species when viewed under a microscope. Bioremediation refers to the degradation of pollutants present in the environment by using potential bioagents. The accumulation of chemical residue is increasing day by day in the environment causing a

JUST AGRICULTURE
multidisciplinary e-Newsletter

great loss of biodiversity and has also brought serious health hazards to human beings. Application of *Trichoderma* can be the sustainable and viable solution in this regard.

6. *Trichoderma* spp. as natural decomposition agent:

Decomposition is defined as the biological process to degrade and break down organic materials into smaller particles that can be used by other organisms. Decomposers/natural decomposition agents such as fungi play a vital role during this process. Nutrient cycling can be achieved by the role played by decomposer in returning nutrients from dead organic matter back into the soil. Eventually, these nutrients will be used by plants to undergo photosynthesis