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Trichoderma harzianum: An Overview

Saishubham Pani, Adesh Kumar* and Adarsh Sharma
School of Agriculture, Lovely Professional University, Phagwara-144 411, India
E-mail: adesh.19078@lpu.co.in, phytopath06@gmail.com

ABSTRACT
Since the decade of the "Green revolution"[1960-1970] to meet the demand of an over-growing population, the consumption of chemical fertilizers and chemical pesticides has been gradually increasing and finally in the 20th century it became a need which is very much hazardous to the environment. To minimize the negative impact of these chemical fertilizers, the emergence of bio-agents and bio-fertilizers can't be avoided. Trichoderma harzianum is the most used bio-agent as most of the biological fungicides being utilized by farmers is being prepared from Trichoderma formulations. Novel properties like mycoparasitism, antibiosis and competition with fungal pathogens make T. harzianum a bio-agent . It is beneficial to plants by various means like as a growth promoter, as an antagonist to pathogens, as a source of nutrients etc. It is also found to be associated with increase in efficiency of photosynthetic and respiratory activities which indirectly helps the plant to grow and develop. It helps in mobilisation of immobile minerals and maintains hormonal balance for optimum growth and development. Still in our country commercialization of Trichoderma is yet to be developed and awareness of bio-agents and bio-fertilizers to be focused more to improve the quality of environment.
Keywords:Trichoderma harzianum, mycoparasitism, antibiosis, competition, growth Promoter, bio-fertilizer, mobilization

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INTRODUCTION

Plant diseases are the major problems in crop production resulting in large scale loss of production and productivity worldwide, therefore diseases need to be controlled timely to maintain the consistency in supply of foods to meet the huge demand of the growing population [85].During disease management, the excess chemical consumption is adversely affecting environmental quality and resulted in development of tolerant organisms [11]. *Trichoderma harzianum* is a biocontrol agent tremendously utilized in the management of fungal diseases as they have mycoparasitic properties [69].*Trichoderma harzianum*a well-known bio-agent is ubiquitous and endophyticsymbiont in nature [31]. *Trichoderma harzianum* is considered beneficial in the field of agriculture because of their high level of antagonism against diverse phytopathogenic microorganisms [3, 26,58,83].*Trichoderma harzianum* increases the level of Co2 and O2 utilization efficiency by controlling expression of genes in plants [71]. In soil *T. harzianum* helps to mix the insoluble minerals and makes them available for normal growth and development of plants [2]. In adverse conditions for crop growth and development*T. harzianum* is found to be associated with normal growth of sweet corn [26].*Trichoderma harzianum* rifai has the ability to increase the solubilization of P and many essential nutrients in an artificial growth medium [2]. Some strains encourage the growth of saprobic bacteria and mycorrhizal fungi, as well as growing plant size, foliar surface area, and weight [25]. It is especially useful for its ability to promote growth and induce plant resistance, in addition to its direct impact on fungal plant pathogens [23] .The procedure by which *T. harzianum* becomes able to increase the availability of minerals and enhances the absorption by plants is to be confirmed.

Trichoderma harzianum ASA FUNGUS

*Trichoderma*genus of phylum Ascomycota is spread worldwide and produces greenish spores[85]. Even under adverse environmental conditions, *Trichoderma* can continue to exist, that indicates its probability of growth promotion to improved stress resistance [87]. After being settled down in the host they utilize their degradative potential for degradation of diverse substrates [69]. It can develop rapidly or make enough use of food supply, effectively clearing the pathogen and invasion, which is known as competition for nutrients [75]. *Trichoderma* an asexually dividing fungus found to be associated predominantly in the rhizosphere of almost all soils [32].*Trichoderma harzianum* is aggressive, rapidly proliferating, profusely spore producing fungus strongly competing for light [27], minerals [66] and space [50]. *Trichoderma harzianum* secretes secondary metabolites [13, 14], that have been shown to suppress the microbial activity [38] while also inducing growth of plants [39]. *Trichoderma harzianum* releases lytic enzymes to its substrate or prey [49] and binds to and wraps all over the organism's mycelia, often penetrating them by mycoparasitism [21]. Furthermore, the plant-*Trichoderma* spp. relationship effectively regulates root architecture [9], extends the length of lateral and primary roots [55], and improves the plant's nutrient uptake performance [85]. *Trichoderma* prepares the plant's systemic defense mechanisms to respond more quickly and efficiently to possible pathogen invasion threats [39].

Trichoderma harzianum AS A GROWTH PROMOTER

Trichoderma harzianum can eliminate plant pathogens [16] even while enhancing plant growth [52,75]. *Trichoderma* spp. are well-known fungi that promote plant growth [47], that help plants absorb nutrients [86], produce growth hormones [13, 14]and protect them from attack of pathogens. [87]. When compared to amendments of organic fertilizers or *Trichoderma* strains separately, combining organic fertilizers[compost] and *Trichoderma* strains as bio fertilizers may be an effective way to encourage greater plant biomass [87]. *Bacillus* and *Trichoderma*bio fertilizers boosted growth of bananas [21, 69] and increased microbial population in soil [84]. Microbes infect in the roots and serve a useful function in bio-control activities by preventing its crop against soil-borne diseases and promoting crop growth [34]. *Trichoderma* reduces pollutants [78] by operating on chemicals and metal waste through the action of different enzymes [6], as well as improving soil's physicochemical characteristics [19]. Evidence has emerged for the importance of Auxin found in microorganisms while *T. harzianum* is more important to stimulate growth by affecting the combination of factors such as Auxin [46], gibberellin [27], and ethylene. *Trichoderma harzianum* found to enhance the seed viability by producing Reactive species of oxygen [76].*Trichoderma harzianum* enhances the sprouting of seed, crop stature and dry mass when applied in soil [34]. *Trichoderma harzianum* enhances resistance of plants to stress conditions and uptake of nutrients. *Trichoderma harzianum* acts as plant growth promoter by increasing flower count and fruit dimension [18]. *Trichoderma harzianum* promoted growth and development in *Viciafaba* when inoculated in absence of *Orobanche* species [19].*Trichoderma harzianum* generates growth promoting hormones, antibiotic substances and proteolytic enzymes that works against pathogenic fungi and plant growth is stimulated [55]. The use of *Trichoderma* spp. in the soil has improved nutrient uptake and fruit standard while also providing resistance to various fungal infections [26, 33, 48]. Water quality has been shown to have a significant impact on *Trichoderma* functions, including association with several other species [7] germination of spores, growth of germ tube [44], and development of enzyme [23], development of mycelium [33].

Trichoderma harzianum AS A BIO CONTROL AGENT

Trichoderma spp. have been known to invade other fungi for more than six decades. They're also well-known among scientists as powerful biological control agents [44,53,67]. *Trichoderma harzianum*, a filamentous soil-borne mycoparasitic fungus with several modes of action, has been shown to be effective against a variety of soil-borne plant pathogens [74]. The first step in realizing maximum potential of *T.harzianum* for specific applications is to characterize them for their antagonistic potential [68]. *Trichoderma harzianum*, a good biocontrol agent can suppress the pathogenic activity by opposition, synthesizing antibiotic compounds and direct attack [55]. The development of many phytopathogens can be restricted by several phenolic compounds released by *Trichoderma* species [43]. *Trichoderma harzianum* roughly equivalent to other fungi known to have related biocontrol abilities, has been associated with significantly higher output of chitinase chemicals [49]. Only by generating active substances, several *Trichoderma* species limited the growth of *Fusarium*species [81]. Glucanases, chitinases and proteases are the enzymes that degrade the cell walls of phytopathogenic fungi [37,52].Spatial and nutritional competition, development of volatile and non-volatile antibiotics and inactivation of pathogenic enzymes are all examples of direct effects and indirect effects include modification in host plants and induction of resistance in hosts [64]. *Trichoderma*'s effectiveness can be explained by its capacity to generate toxic water - soluble metabolites or lytic enzymes [76,78]. This lytic enzyme includes chitinase and glucanase which are released by *T.harzianum* in very negligible amounts [28,33]. As a result, it can react on fungal pathogens before interacting with the two mycelia, enhancing *Trichoderma*'s antagonistic ability [74,79]. *Trichoderma harzianum* and *P. fluorescens* worked together to reduce nematode populations by creating a special structure that produced toxins and alkaloids that destroyed larvae [13,84]. When *T. harzianum* and *P. fluorescens* were combined, the two biocontrol agents' potency and efficiency improved, resulting in a complementary reaction against rice blast disease [47,73]

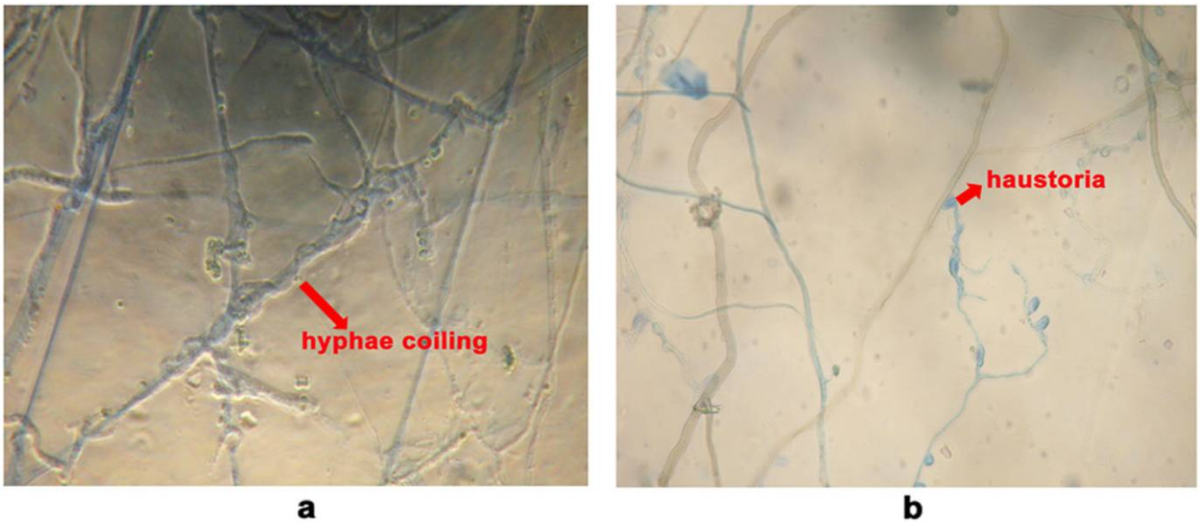

Fig 1

a) *Trichoderma harzianum* wrapping across *Rhizoctoniasolani* hyphae,
b) *Macrophomina* sp. development is inhibited by the production of haustoria of *T.harzianum*

Trichoderma harzianum AS A BIO FERTILIZER

Trichoderma harzianum is being commonly utilized in almost all plants as a source of nutrients even with and without modifications [57]. *Trichoderma harzianum* function for enhancing crop production and efficiency has been accomplished mainly via the potential to break down organic molecules present in the soil [68]. Mostly in simplified type, organic molecules were given access for crops such that they'll be consumed effectively [49,64]. The use of *Trichoderma* fungi guarantees a suitable climate for the growth of adequate roots and carbohydrate obtained by plants at the same time, which is an urgent priority supported by *Trichoderma* spp. [22]. It reduces the need for conventional NPK fertilizers and aids in the solubilization of phosphate in soil and makes it accessible to plants, as well as improving the absorption of micronutrients such as Na, Zn, Cu, Fe and others [31]. Furthermore, the ability of *Trichoderma* spp. to detoxify toxic compounds and accelerate the degradation of organic material has been demonstrated [52,69,82]. By colonizing roots, growing leaf area and minor roots, and improving root system, *Trichoderma* spp. may promote plant growth and development [73,88]. In both well-watered and dry conditions, the use of *Trichoderma* based products resulted in an increase in root mass [55]. Root growth and water productivity are aided by hydrogel and *Trichoderma*, which are effective in increasing soil moisture availability and thus plant establishment [38].

PLANT-_Trichoderma harzianum_ INTERACTION

The stimulation of cell disinfection and defense mechanisms in the fungi is necessary for the effective development of Plant-*Trichoderma* relationship during early stages [72] of root colonization[29]. As a component of the benefits reported with in Plant-*Trichoderma* relationship that*T. harzianum* not only stimulates the concentrations of the hormonal levels produced by plants, but it can also make a contribution of its own hormones or supplies intermediates for the production of some plant hormones [33]. As the chemicals released by plants roots, *T. harzianum* becomes very much attracted towards it [45]. *Trichoderma harzianum* is benefited by sucrose from plants and in exchange contributes many beneficial effects to plants [89]. It is associated with penetration of roots into deep extent, stimulates production of siderophores and maintains soil pH, so directly and indirectly *T.harzianum* is involved in better absorption of mineral nutrients for the plant [58]. In controlled environmental conditions seeds being treated with spores of *T.harzianum* enhances crop yield [53]. Dimension of several flowers found to be increased when they are being applied with *T.harzianum* cultures [79]. *Trichoderma harzianum* cell wall degrading enzymes not only induce antagonistic activity by inducing expression of mycoparasitic genes [22], but they also serve as elicitors when introduced into plant cells or implanted underneath the leaf and root surface [33]. *Trichoderma harzianum* releases elicitor molecules that promote plant growth, roots, and nutrient availability by stimulating the expression of genes involved in the plant defense system [74]. Most enzymes associated with mycoparasitism are produced in response to the glucanous and chitinous fibrils incorporated in a protein network found in the cell walls of most phytopathogenic fungi [63].

MODE OF APPLICATIONS OF *T. harzianum*

Trichoderma harzianum is applied as

Seed treatment: One packet of 200gm *T. harzianum* is sufficient to treat 10-12kg of Cereals and oilseed seeds. A formulation of 1;2 ratio of *T. harzianum* and water is recommended and it should be sprinkled on the seed followed by shade drying [46].

Seedling treatment and root dip treatment:*Trichoderma harzianum* and water in the ratio of 1:10 is recommended. Small bundles of seedlings are allowed to dip in this formulation for 15-30 minutes before transplanting.A suspension of 200gm *T. harzianum* in 2 litres of water is made which is enough to treat 200-300 plants [29,58].

Set treatment: *Trichoderma harzianum* and water is mixed in 1:50 ratio and sets are allowed to dip in this suspension for 30 minutes followed by shade drying and then subjected to transplantation in the field and just after the transplanting of sets field must be irrigated within 24 hours [75].

Soil treatment: On the basis of duration it varies from crop to crop. A mixture of 2-3kg *T. harzianum* and 40-60kg of manure or 40-60kg of soil per acre is recommended for short duration crops. And for long duration crops 4-6kg *T. harzianum* mixed with 80-120kg manure or soil and subject to broadcasting on soil [70].**Table 1.**

Table.1 Mode of treatment by *Trichoderma harzianum*

Species	Plant	Mode of treatment	Pathogen/ stress	Effect	Reference
T. harzianum	Common Bean	Seed treatment and Soil treatment	*P. syringae*pv.*phaseolicola*	Secrets Peroxidase and Polyphenol oxidase as defensive enzyme	[70]
T. harzianum	Wheat	Seed bio priming	Drought	Increases Osmotic potential	[46]
T. harzianum + *T. asperellum*	Tomato	Soil Treatment	*X. campestris*pv*vesicatoria*	Secrets Chitinase and glucanase for defense against pathogen	[70]

CONCLUSION

Trichoderma harzianum converts the immobile form of iron into mobile form by releasing siderophores, so that all the mobile form of iron is absorbed by plants. Huge diversification in potential physiological characteristics is responsible for the emergence of *T. harzianum* as a versatile bio-agent which can be used for both industrial purpose and natural phenomenon. *Trichoderma harzianum* can increase the potential of plants to withstand various biotic and abiotic factors associated with yield loss. So *T.harzianum* is directly and indirectly associated with normal growth and development of plants and also found effective in elimination of harmful plant pathogens. So the farmers should be aware about *Trichoderma* which will help them eco-friendly management of plant diseases for the benefits of the environment. It would be possible when the production of *Trichoderma* based formulations will be boosted by fungicide manufacturing organisations. Distinct pathways of signalling have been investigated in order to learn more about *Trichoderma*'s bio - control system. Last but not the least ecological impact of *T. harzianum* must be evaluated to establish the basement of ideas about different beneficial fungi which will drive farmers towards large scale use of bio-agents and bio-fertilizers.

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