TRICHODERMA SP. AS A BIOCONTROL MEASUREFOR PLANT DISEASES MANAGEMENT

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ABSTRACT

Harmful chemical fungicides as well as fertilizers which are being applied today for increasing crop production, creates very serious hazardous health problems to human beings and ecosystem as a whole.To overcome all these disadvantages caused by excessive use of chemical fungicides for controlling disease, a new approach evolved that uses micro-organisms for the control of phytopathogens i.e., biocontrol of disease.The antagonistic potential of Trichoderma species which has been long known to control various soil-borne fungal pathogens in biological way have been utilized. The faster growth rates with which it competes with fungal pathogen mainly brings upon their antagonistic characteristics. According to literature, it is revealed that Trichoderma spp are good for future practice as a biocontrol agent for controlling various plant pathogens.

Keywords: Plant disease, Chemical fungicides, Biocontrol agents and *Trichoderma spp.*

Introduction

Disease in plants, in a simple way defined as the series of invisible and visible responses of plant cells and tissues to a pathogenic organism or environmental factor that result in adverse changes in the form, function, or integrity of the plant and may lead to partial impairment or death of plant parts or of the entire plant (Agrios, 2005). Similarly, Plant diseases, by their presence prevent the cultivation of growth of food plants in some areas; or food plants may be cultivated and grown but plant diseases may attack them, destroy parts or all of the plants, and reduce much of their produce i.e., food, before they can be harvested or consumed(Agrios, 2005).

The losses produced due to plant diseases are usually lower in the developed countries and higher in the developing countries i.e., countries that need food the most. It is been estimated that of the 36.5% average of total losses, 14.1% are caused by diseases. Considering that 14.1% of the crops are lost to plant diseases the total annual worldwide crop loss from plant diseases is about \$220 billion(Agrios, 2005).

The agents that cause disease in plants are the same or very similar to those causing disease in humans and animals. They include pathogenic microorganisms, such as viruses, bacteria, fungi, protozoa, and nematodes, and unfavourable environmental conditions, such as lack or excess of nutrients, moisture, and light, and the presence of toxic chemicals in air or soil(Agrios, 2005).Because it is not known whether plants feel pain or discomfort and because, in any case, plants do not speak or otherwise communicate with us, it is difficult to pinpoint exactly when a plant is diseased.

Traditional Plant Disease Management

Methods of plant disease management vary considerably from one disease to another, depending on the kind of pathogen, the host, the interaction of the two, and many other variables. In controlling diseases, plants are generally treated as populations rather than as individuals, although certain hosts (especially trees, ornamentals, and, sometimes, other virus-infected plants) may be treated individually. Control measures are generally aimed at saving the populations rather than a few individual plants (Agrios, 2005).

Traditionally the plant disease management can be classified as regulatory, cultural, biological, physical, and chemical, depending on the nature of the agents employed. Regulatory control procedures aim at excluding a pathogen from a host or from a certain geographic area. Most cultural control methods aim at helping plants to avoid contact with a pathogen, creating environmental conditions unfavourable to the pathogen or avoiding favourable ones, and eradicating or reducing the amount of a pathogen in a plant, a field, or an area. Finally, physical, and chemical methods aim at protecting the plants from the pathogen inoculum that has arrived, or is likely to arrive, or curing an infection that is already in progress (Agrios, 2005).

In general, excluding or reducing the initial inoculum is most effective for the management of monocyclic pathogens. Controls such as crop rotation, removal of alternate hosts, and soil fumigation reduce the initial inoculum. With polycyclic pathogens, the initial inoculum can be multiplied many times during the growing season. Therefore, a reduction in the initial inoculum must usually be accompanied by another type of control measure (such as chemical protection or horizontal resistance) that also reduces the infection rate. Many controls, e.g., excluding a pathogen from an area, are useful for both monocyclic and polycyclic pathogens (Agrios, 2005).

The physical agents used most in controlling plant diseases are temperature (high or low), dry air, unfavourable light wavelengths, and various types of radiation. Chemical agents are generally used to protect plant surfaces from infection or to eradicate a pathogen that has already infected a plant. A few chemical treatments, however, are aimed at eradicating or greatly reducing the inoculum before it encounters the plant. They include soil treatments (such as fumigation), disinfestation of warehouses, sanitation of handling equipment, and control of insect vectors of pathogens (Agrios, 2005, Mahmood *et al.*, 2016).

The traditional agricultural practice employed to control the plant disease have severe disadvantage that it is not effective to check the pathogen and is not eco-friendly. However, excessive use of chemical fungicides in agriculture has led to deteriorating human health, environmental pollution, and development of resistance in pathogen to fungicide (Dalvi and Rakh 2017, Bolognesi and Merlo, 2019).

Trichoderma spp. as Emerging Biocontrol Practice

Trichoderma species can antagonize and control a wide range of economicallyimportant plant-pathogenic fungi and have been known as biocontrol agentsagainst soil-borne, foliar and postharvest phytopathogenic fungal pathogens andcanalso control viruses and bacteria (Sivan and Chet 1992; Herrera-Estrella andChet 1998; Yedidia et al. 2003; Harman 2006).

Table1: *Trichoderma spp* showingbiocontrol action against some plant pathogenic diseases

Trichoderma spp	Host	Disease	Reference
T. harzianum& T hamatum	Cucumber plant		Abd-El-Moity *et.al.* (2003)
T viridеae	Groundnut	Stem rot	Karthikeyan *et al* (2006)
T virideae	Ground nut	Stem rot	Manjula *et al* (2004)
T longibrachiatum			Deng *et al* (2007)
T harzianum	Ground nut	Stem rot	Ganesan *et al* (2007)
T spp	Sunflower	Root rot	Yaqub & Shahzad(2008)
T harzianum	Sugarbeet	Root rot	Rawat & Tiwari(2010)
T hamanatum	Groundnut	Collar rot	Bagwan(2011)
T virideae	Ground nut	Macrophomina phaseolina (collar rot)	Doley & Jite(2012)

Mechanism of *Trichoderma* Bio Control Action: -

Trichoderma spp. possess different mechanisms to tackle the plant pathogens in lab as well as in the farm which are listed as follows:

Competition

One of the mechanismsthat is shown by *Trichoderma spp.* as biocontrol agent is competition through rhizosphere competence. Rhizosphere competence is important because a biocontrol agent cannot compete for space and nutrients if it is unable to grow in the rhizosphere. *Trichoderma* species, either added to the soil or applied as seed treatments, grow readily along with the developing root system of the treated plant. This can be shown by simply plating surface sterilized root segments from treated plants on an agar medium. After incubation period, the fungus grows from all parts of the root. The difficulty in viewing competition through rhizosphere competence as a major mechanism in biological control is that strains of *T. koningii* that are excellent root colonizers exhibit little or no biocontrol activity against *R. solani* on cotton seedlings (Howell, 2003).

Mycoparasitism or Hyperparasitism

Oneof the salient featuresofmembers of the genus *Trichoderma* is their ability to parasitize other fungi. It is therefore not surprising that Weindling (1932) described biocontrol by *T. lignorum* of citrus seedling disease, incited by *Rhizoctonia solani*, to mycoparasitism. Weindling described the mycoparasitism of *R. solani* hyphae by the hyphae of the biocontrol agent, including coiling around pathogen hyphae, penetration, and subsequent dissolution of the host cytoplasm. This phenomenon occurred regardless of the supply of external nutrients to the host or mycoparasite. Although he considered the possibility that under certain circumstances *T. lignorum* might act as a competitor for nutrients with *R. solani*, he much favoured mycoparasitism as the principal mechanism for biocontrol (Howell,2003).

Enzymes

More recent research into the possible mechanisms involved in biological control by *Trichoderma species* has led to several alternative explanations for successful biocontrol. One idea that has been advanced is that enzymes such as chitinases and/or glucanases produced by the biocontrol agent are responsible for suppression of the plant pathogen. These enzymes function by breaking down the polysaccharides, chitin, and β-glucans that are responsible for the rigidity of fungal cell walls, thereby destroying cell wall integrity(Howell, 2003).

Similarly, Metcalf and Wilson (2001) described the colonization of onion roots, infected with *Sclerotium cepivorum*, by *T. koningii*. Hyphae of the biocontrol agent penetrated into infected epidermal and cortical tissue of the root to destroy the hyphae of the pathogen, with little or no damage to uninfected plant tissue. The authors ascribed this biocontrol phenomenon to production of endo- and exo-chitinases by *T. koningii*(Howell, 2003).

Antibiotic mediated suppression

Many instances of successful biocontrol by *Trichoderma* species have been credited to the mechanisms of mycoparasitism and/or antibiosis. In 1983, Howell and Stipanovic isolated and described a new antibiotic, gliovirin, from *Gliocladium (Trichoderma) virens* (GV-P) that was strongly inhibitory to *Pythium ultimum* and a *Phytophthora* species, but not to *R. solani*, *Thielaviopsis basicola*, *Phymatotrichum omnivorum*, *Rhizopus arrhizus*, or *Verticillium dahlia*. Gliovirin also was not inhibitory to the bacteria *Bacillus thuringensis* and *Pseudomonas fluorescens*. They demonstrated that mutants unable to synthesize the antibiotic lost the capacity to control Pythium damping-off of cotton. a mutant (GV-1) with enhanced gliovirin production was no more effective than the wild type in controlling the disease (Howell, 2003).

Induction of systemic resistance

Another mechanism proposed to explain biocontrol activity by *Trichoderma* species is that of induction of resistance in the host plant by treatment with the biocontrol agent. This concept is supported by the work of Yedidia *et al.*, (1999) who demonstrated that inoculating roots of 7-day-old cucumber seedlings in an aseptic hydroponic system with *T. harzianum* spores to a final concentration of 10^5 per ml-initiated plant defence responses in both the roots and leaves of treated plants. They also demonstrated that hyphae of the biocontrol fungus penetrated the epidermis and upper cortex of the cucumber root. The plant response was marked by an increase in peroxidase activity (often associated with the production of fungitoxic compounds), an increase in chitinase activity, and the deposition of callose-enriched wall appositions on the inner surface of cell walls. Increased enzyme activities were observed in both roots and leaves. Interestingly, the plant defence became muted with time and began to resemble a symbiotic mycorrhizal association (Howell, 2003).

Conclusion

These literatures support that *Trichoderma spp* are good for future practice as the bio control agent for the management of various plant pathogens which cause loss in crop production.

Acknowledgement

The authors are grateful for encouragement and support given by Hn. Principal, Shri. Guru Buddhiswami Mahavidyalaya, Purna(jn) and Hn. Principal, Mrs. KSK College, Beed to carry out this work.

References

1. Adams, P. B. (1990). The potential of mycoparasites for biological control of plant diseases. Annual review of phytopathology, 28(1), 59-72.
2. Ahanger, R., Bhatand, H. A., & Dar, N. A. (2014). Biocontrol agents and their mechanism in plant disease management. Sci Acta Xaveriana, 5(1), 47-58.
3. Aluko, M. O., and Hering, T. F. 1970. The mechanism associated with the antagonistic relationship between Corticium solani and Gliocladium virens. Trans. Br. Mycol. Soc. 55:173-179.
4. Bliss, D. E. 1951. The destruction of Armillaria mellea in citrus soils. Phytopathology 41:665-683.
5. Chaparro, A. P., Carvajal, L. H., & Orduz, S. (2011). Fungicide tolerance of Trichoderma asperelloides and T. harzianum strains. Agricultural sciences, 2(03), 301.
6. Chet, I. 1987. Trichoderma-Application, mode of action, and potential as a biocontrol agent of soilborne pathogenic fungi. Pages 137-160 in: Innovative Approaches to Plant Disease Control. I. Chet, ed. John Wiley & Sons, New York.
7. Gopal, K., M. C., & Lassaad, B. (2009). Indigenous pest and disease management practices in traditional farming systems in north east India. A review. Journal of plant breeding and crop science, 1(3), 028-038.
8. Harman, G. E. 2000. Myths and dogmas of biocontrol: Changes in perceptions derived from research on Trichoderma harzianum T22. Plant Dis. 84:377-393.
9. Howell, C. R. (2003). Mechanisms employed by Trichoderma species in the biological control of plant diseases: the history and evolution of current concepts. Plant disease, 87(1), 4-10.
10. Howell, C. R. 1982. Effect of Gliocladium virens on Pythium ultimum, Rhizoctonia solani, and damping-off of cotton seedlings. Phytopathology 72:496-498.
11. Howell, C. R., and Stipanovic, R. D. 1983. Gliovirin, a new antibiotic from Gliocladium virens, and its role in the biological control of Pythium ultimum. Can. J. Microbiol. 29:321- 324.
12. Howell, C. R., Hanson, L. E., Stipanovic, R. D., and Puckhaber, L. S. 2000. Induction of terpenoid synthesis in cotton roots and control of Rhizoctonia solani by seed treatment with Trichoderma virens. Phytopathology 90:248- 252.
13. Howell, C. R., Stipanovic, R. D., and Lumsden, R. D. 1993. Antibiotic production by strains of Gliocladium virens and its relation to the biocontrol of cotton

seedling diseases. Biocontrol Sci. Technol. 3:435-441.

14. Kannahi, M., Dhivya, S., & Senthilkumar, R. (2016). Biological control on rice false smut disease using Trichoderma species. Int J Pure App Biosci, 4(2), 311-316.
15. Khoury, W. E., & Makkouk, K. (2010). Integrated plant disease management in developing countries. Journal of Plant Pathology, S35-S42.
16. Lewis, J. A., & Papavizas, G. C. (1991). Biocontrol of plant diseases: the approach for tomorrow. Crop protection, 10(2), 95-105.
17. Lo, C.-T., Nelson, E. B., Hayes, C. K., and Harman, G. E. 1998. Ecological studies of transformed Trichoderma harzianum strain 1295-22 in the rhizosphere and on the phylloplane of creeping bent grass. Phytopathology 88:129-136.
18. Ly, L. K., Underwood, G. E., McCully, L. M., Bitzer, A. S., Godino, A., Bucci, V., ... & Silby, M. W. (2015). Draft genome sequences of Pseudomonas fluorescens strains SF39a and SF4c, potential plant growth promotion and biocontrol agents. Genome Announcements, 3(2), e00219-15.
19. Metcalf, D. D., and Wilson, C. R. 2001. The process of antagonism of Sclerotium cepivorum in white rot affected onion roots by Trichoderma koningii. Plant Pathol. 50:249- 257.
20. Sharon, E., Chet, I., & Spiegel, Y. (2011). Trichoderma as a biological control agent. In Biological Control of Plant-Parasitic Nematodes: (pp. 183-201). Springer, Dordrecht.
21. Weindling, R. 1932. Trichoderma lignorum as a parasite of other soil fungi. Phytopathology 22:837-845.
22. Wells, H. D., Bell, D. K., and Jaworski, C. A. 1972. Efficacy of Trichoderma harzianum as a biocontrol for Sclerotium rolfsii. Phytopathology 62:442-447.
23. Xu, X. M., Jeffries, P., Pautasso, M., & Jeger, M. J. (2011). Combined use of biocontrol agents to manage plant diseases in theory and practice. Phytopathology, 101(9), 1024-1031.
24. Yedidia, I., Benhamou, N., and Chet, I. 1999. Induction of defence responses in cucumber plants (Cucumis sativus L.) by the biocontrol agent Trichoderma harzianum. Appl. Environ. Microbiol. 65:1061-1070.
25. Zhang, J., Howell, C. R., and Starr, J. L. 1996. Suppression of Fusarium colonization of cotton roots and Fusarium wilt by seed treatments with Gliocladium virens and Bacillus subtilis. Biocontrol Sci. Technol. 6:175-187.

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