Biological Forum – An International Journal **14(3): 724-727(2022)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Compatibility of *Trichoderma* species with Plant Growth Promoting Rhizobacteria (PGPR)

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(Received 06 June 2022, Accepted 25 July, 2022)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: *Trichoderma* are the biocontrol agents, plays an important role in integrated disease management as a key constituent. These fungi have been widely studied for their biocontrol activities *viz*., micoparasitism, antibiosis, competition for nutrient and space, niche exclusion, stress tolerance, induced resistance in plants as well as inactivation of the pathogens enzymes by producing various antimicrobial compounds. Along with *Trichoderma* other important beneficial microorganisms like plant growth promoting rhizobacteria's also present in the soil ecosystem. *Trichoderma* spp. and PGPR's are often predominant components of the mycoflora in soil, litter, organic matter and rhizospheric ecosystem of all climatic zones. Which are helps in plant growth and development. In order to know the interaction (positive or negative) between PGPR's and *Trichoderma* spp. present investigation was carried out using four species of PGPR's *viz., Bacillus megaterium, Bacillus mucilagenosus, Azotobacter* and *Pseudomonas fluorescens* and three species of *Trichoderma viz., T. asperillum, T. virens,* and *T. aureoviridae* using dual plate technique method. Among all the PGPR's *B. mucilagenosus, B. megaterium*, showed 100% compatibility, whereas *Azotobacter* was moderately compatible and *Pseudomonas fluorescens* showed least compatibility. This shows both the biocontrol agents (except *Pseudomonas fluorescens*) can be applied to plants in combination will helps in enhancing the plant growth and development, protects plants from pest and disease also produces many antimicrobial enzymes which helps in plant defense mechanism.

Keywords: *Trichoderma,* Plant Growth Promoting Rhizobacteria (PGPR), biocontrol activities, Compatibility, .

INTRODUCTION

Now a days due to biotic and abiotic stresses leads to severe yield reduction. Biotic constraints includes like fungi, bacteria, virus, nematodes, weeds and insects which causes yield loss up to 31 to 42 per cent (Agrios, 2005). To manage these, farmers also using exhaustive amount of pesticide increases year by year. These results in environment pollution as well as negative effect on non target organisms. Continuous and tremendous uses of chemical pesticides create high selection pressure on pathogens and force them to undergo mutation and develop pesticide resistance races.

One of the important biocontrol agent is *Trichoderma,* possessing reasonable biological control attributes belonging to species *T. harzianum, T. ressey, T. asperellum, T. viridae, T. virens, T. aureoviridae, T. konigii etc.* These fungi have been widely studied for their biocontrol activities *viz*., micoparasitism, antibiosis, competition for nutrient and space, niche exclusion, stress tolerance, induced resistance in plants as well as inactivation of the pathogen's enzymes by producing various antimicrobial compounds. The most commonly used microbial biopesticides are living organisms, which are parasites for the pest of interest. These include biofungicides, bioherbicides, and bioinsecticides (Gupta and Dikshit 2010).

Bio-control agents, manage pathogens either by producing many toxic metabolites specific to the pest, preventing establishment of other microorganisms through their modes of action. Application of certain compatible plant growth-promoting rhizobacteria (PGPR) with *Trichoderma* also increases phenlyalanine ammonia lyase (PAL) and peroxidase (PO) activities upto 50 and 25 per cent respectively (Sarma *et al*., 2015; Singh *et al*., 2015). PGPR's are considered as one of the best strategies; a better alternative for sustainable agriculture, and a viable solution to meet the challenges of plant disease management, global food security and environmental stability. Use of PGPR's due to its sustainable and environmentally friendly mechanisms of plant growth promotion, is becoming more widespread in the agricultural industry. PGPR's helps in nutrient fixation, phosphorous solubalizaton,

potassium solubaliztion, siderophore production, zinc solubilization and production of phytohormones. PGPR's such as *Bacillus, Pseudomonas, Arthrobacter,* and *Azospirillum* are major genuses and have many species (Shah *et al*., 2021).

In this study PGPR's (Plant Growth Promoting Rhizobacteria) like *Pseudomonas fluorescens, Bacillus megaterium, Azotobacter and Bacillus mucilagenosus* were used. Besides the classic mycorrhizal fungi and PGPR's, other plant-growth-promoting fungi such as *Trichoderma* spp. (Teleomorph: Hypocrea) can protected from numerous pathogens by responses that are similar to systemic acquired resistance (SAR) and rhizobacteria induced systemic resistance (Wees *et al.,* 2015). So both PGPR's and *Trichoderma* spp. frequently enhances root growth and development, crop productivity, uptake and use of nutrients and resistance to biotic and abiotic stress. Keeping in this view, investigation was undertaken to study the "Compatibility of *Trichoderma* spp. with plant growth promoting rhizobacteria".

MATERIALS AND METHODS

***Trichoderma* spp. and PGPR's.** In this study, to check the compatibility between *Trichoderma* spp. and PGPR's different *Trichoderma* spp. were used. Those are, *Trichoderma asperillum, Trichoderma virens* and *Trichoderma aureoviridae* and PGPR's (Plant Growth Promoting Rhizobacteria) like *Pseudomonas fluorescens, Bacillus megaterium, Azotobacter and Bacillus mucilagenosus.* Compatibility test was carried out with the help of dual culture technique.

Dual culture technique. Twenty ml of sterilized and cooled potato dextrose agar was poured into sterile Petri plates under aseptic condition and allowed to solidify. For evaluation of compatibility of *Trichoderma* with PGPR (Morton and Strouble 1955), the suspension of PGPR will be streaked one day earlier at one end of the of the Petri plate and the *Trichoderma* spp. of mycelial discs (5 mm) was placed at another end of the petriplate by leaving 2mm periphery of petriplate. In control only *Trichoderma* disc was placed. The plates were incubated at 27±1°C and zone of inhibition was recorded by measuring the clear zone between the margins of the organisms. The colony diameter in control plate was also recorded.

The per cent inhibition of growth of the *Trichoderma* spp. with the PGPR's was calculated by using the formula as suggested by Vincent (1947).

$$I = \frac{C - T}{C} \times 100$$

Where,
I = Per cent inhibition
C = Growth in control plate
T = Growth in treatment plate

RESULT AND DISCUSSION

The study was aimed to identify the compatibility of *Trichoderma* spp. with different PGPR's. *In vitro* study revealed that, among different PGPRs *Bacillus mucilagenosus* was found to be the best organism which showed compatibility with all the three *Trichoderma* species, *Trichoderma asperillum, Trichoderma virens and Trichoderma aureoviridae i.e.,* with 100 per cent compatibility followed by *Bacillus megaterium* which exhibited the 100 per cent compatible with *T. asperillum* and *T. aureoviridae* whereas 98.45 per cent compatible with *T. virens* Whereas *Azotobacter* was 96.30 per cent compatibility with *T. aureoviridae,* followed by, *Trichoderma asperillum* and *Trichoderma virens* at 95.56 and 91.49 per cent, respectively. Also *Pseudomonas fluorescens* was found to be compatible with *T. aureoviridae, T. asperillum* and *T. virens* about 95.60, 75.93 and 80.38 per cent, respectively.

All the three isolates of *Trichoderma* are showed about 80 to 100 percent compatability with *Bacillus mucilagenosus* followed by *Bacillus megaterium*, *Pseudomonas fluorescens* and *Azotobacter*. Due to different mode of action to inhibit the plant pathogens of *Trichoderma* and PGPRs. They are mutual in nature hence they are compatible with each other. Little bit inhibition due to siderophores and enzymes produced by PGPRs will hinder the growth of *Trichoderma* spp. They are equally antagonistic with each other individually (Table 1 and Fig. 1). The result was contradict with the results of (Lorito *et al*., 1993; Sridhar *et al.,* 1993; Jayarajan and Ramabadran, 1999; Montealegre *et al*., 2003; Rudresh *et al.,* 2005; Niranjan *et al.*, 2009; Sandheep *et al.*, 2013; Akthar and Tanweer 2014; Tanushree *et al*., 2017; Majumder *et al*., 2019) showed that PGPR's and *Trichoderma* mixture were statistically at on par to manage plant diseases also increase in growth and development of the plants.

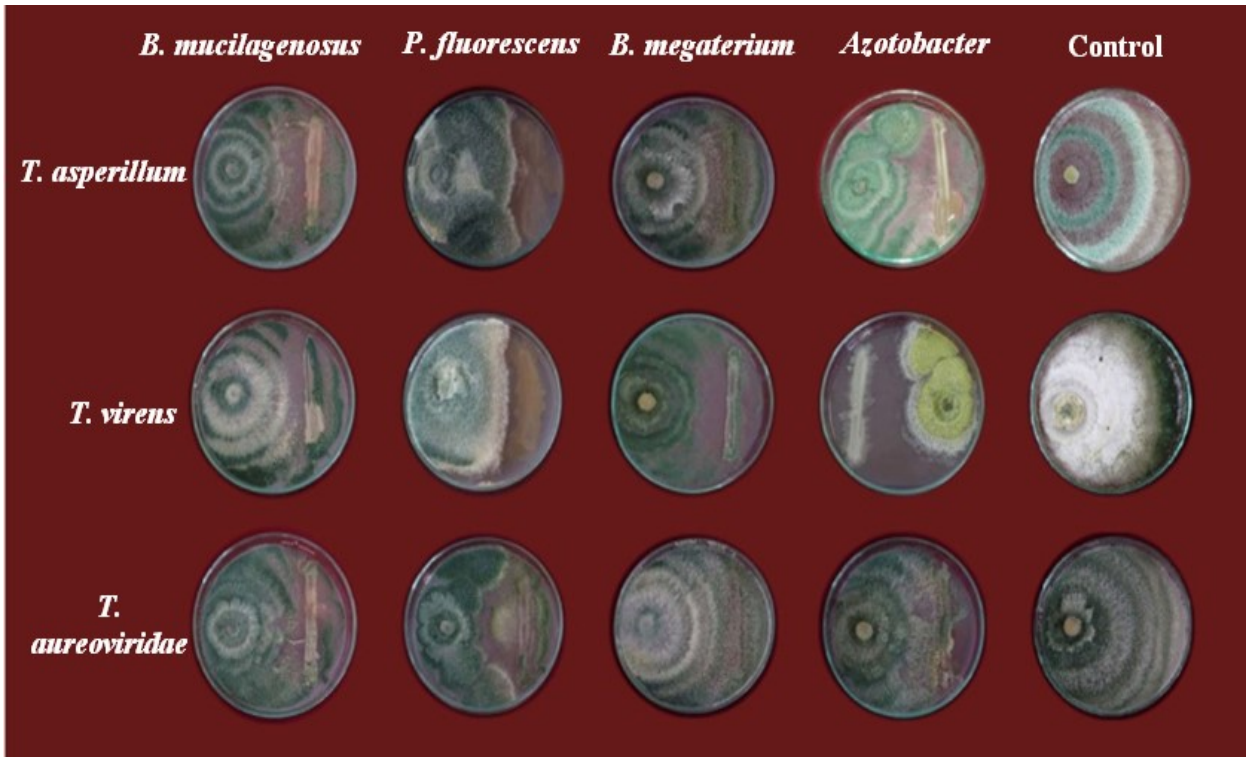

Plate 1. Compatibility of *Trichoderma* spp. with Plant Growth Promoting Rhizobacteria's in dual plate technique.

Table 1: Compatibility of *Trichoderma* isolates with PGPRs in dual plate technique.

Treatments	Inhibition (%)			Compatibility (%)		
	T. asperillum	*T. virens*	*T. aureoviridae*	*T. asperillum*	*T. virens*	*T. aureoviridae*
P. fluorescens	24.07 (29.36)*	19.62 (19.62)	4.44 (12.15)	75.93	80.38	95.56
Azotobacter	8.51 (16.95)	4.44 (4.45)	3.70 (11.08)	95.56	91.49	96.30
B. megaterium	0.00 (0.00)	1.55 (3.40)	0.00 (0.00	100	98.45	100
B. mucilogenus	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	100	100	100
S. Em±	0.44	0.05	0.25			
CD (1 %)	2.30	0.29	1.33			

*Figures in parenthesis are arc sine transformed values.

CONCLUSION

The species of *Trichoderma* tested were found to be compatible with the all four isolates of plant growth promoting rhizobacteria. However among the PGPR highest level of compatibility (100 %) was recorded with *Bacillus megaterium*, whereas *Bacillus mucilagenosus* and *Azotobacter* are moderately compatible and *Pseudomonas fluorescence* showed least compatible with all the species of *Trichoderma*. The results obtained could be utilized to develop a microbial formulation (microbial consortia) for the benefit of the forming community.

Acknowledgement. The corresponding author thankful to Dr. B. Gangadhara Naik, Head of the department, Department of Plant Pathology, University of Agricultural and Horticultural Sciences, Shivamogga, for providing facilities in course to conduct this research work.

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How to cite this article: Pavitra, Gangadhara Naik B., Meghana S.P., Ranjana Joshi and Nandish M.S. (2022). Compatibility of *Trichoderma* species with Plant Growth Promoting Rhizobacteria (PGPR). *Biological Forum – An International Journal*, *14*(3): 724-727.