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Compatibility of Trichoderma viride with commonly used fungicides in management of early blight pathogen of tomato

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Abstract
Tomato (*Solanum lycopersicum*) is an important vegetable crop after potato and predominantly grown in almost all tracts of world. Early blight of tomato caused by Alternaria solani emerged as one of the major foliar diseases of tomato. As Trichoderma viride established as one of the potential biocontrol agents for the control of fungal diseases, there is a need for testing the efficacy of Trichoderma viride with fungicides which are used against early blight. The invitro compatibility of Trichoderma viride with fungicides *viz*., Copper oxy chloride, azoxystrobin, Chlorothalonil, Antracol, Azoxystrobin+Difenconazole and Hexaconazole conducted to minimise the excessive use of chemical fungicides as part of an integrated disease management. The compatibility was tested at every 24 hrs after inoculation upto 7 days. The fungicides such as COC (0.1%, 0.2%) azoxystrobin and antracol found to be highly compatible with Trichoderma viride. Hexaconazole even at lower concentration 0.05% found to be highly incompatible and showed 100% percent inhibition on the growth of the antagonist at all tested concentrations from 24 hrs. to 168 hrs. of inoculation. Whereas azoxystrobin+Difenconazole and chlorothalonil @0.05 and 1% concentration and have showed minor inhibitory effect on Trichoderma viride.

Keywords: Compatibility, Trichoderma viride, pathogen, tomato

Introduction
Tomato (*Solanum lycopersicum*) is an important vegetable crop after potato and predominantly grown in almost all tracts of world. Early blight of tomato caused by *Alternaria solani* emerged as one of the major foliar diseases of tomato. Early blight can be effectively managed by commonly used synthetic fungicides but the pathogen can develop resistance against the existing chemical fungicides. Hence the use of bio control agents, such as antagonists and beneficial microorganisms is essential in biological plant protection strategies. Bioagents help to avoid fungicide resistance in pathogens by reducing the overuse and misuse of synthetic fungicides. Fungicides and bioagents together can be a key component in disease management systems that are both effective and safe. The compatibility of potential bioagents with chemical fungicides is crucial for developing an effective disease management. In an IDM strategy, a combination of compatible chemicals and bioagents are used to protects seeds and seedlings from soil or seed-borne inoculums (Dubey *et al*. 2001) [1]. By the use of a compatible bioagent in combination with chemical fungicide many of the soil borne diseases can be managed effectively (Papa*viz*as *et al*., 1981) [4]. The integration of biological control agents in combination with fungicides would result in similar disease reduction to that attained with increased fungicide usage (Monte and colleagues, 2001) [3].

As *Trichoderma viride* is one of the potential biocontrol agents for the control of fungal diseases, there is a need for testing the efficacy of *Trichoderma viride* with fungicides which are used against early blight. The invitro compatibility of *T. viride* with fungicides viz., Copper oxy chloride, azoxystrobin, Chlorothalonil, Antracol, Azoxystrobin+Difenconazole and Hexaconazole conducted to minimise the excessive use of chemical fungicides as part of an integrated disease management. The compatibility was tested at every 24 hrs after inoculation upto 7 and 10 days after inoculation.

Materials and Methods

The *in vitro* experiment was conducted at laboratory of department of plant pathology, JNKVV. The compatibility of Trichoderma viride tested with fungicides used against early blight of tomato, the experiment was conducted through poison food technique. The quantity of fungicides needed to get the desired concentration was added to 100 ml sterilized, molten PDA medium, mixed well and poured in sterilized Petri dishes at the rate of 20 ml per plate. To avoid contamination, all the eight fungicides were exposed to UV light for a period of 30 min before adding it into the medium. After solidification of the medium, mycelial discs of 9 mm diameter from actively growing fungal antagonists and Trichoderma viride were cut and placed at the center of each petri dish. Control consisted of PDA medium alone inoculated with the antagonist. Three replications were maintained for each concentration. The inoculated plates were incubated at room temperature and observations on the mycelial growth of the fungal antagonists were taken when control plates showed full growth. The per cent inhibition of growth of the antagonists were calculated by using the formula.

PI= C-T/CX100

Results and Discussion

The fungicides such as COC (0.1%, 0.2%) azoxystrobin and antracol found to be highly compatible with Trichoderma viride at all the tested concentrations. Hexaconazole even at lower concentration 0.05% found to be highly incompatible and showed 100% percent inhibition on the growth of the antagonist at all tested concentrations from 24 hrs. to 168 hrs. of inoculation. Whereas azoxystrobin+Difenconazole and chlorothalonil @0.05 and 1% concentration and have showed minor inhibitory effect on Trichoderma viride (plate 1). The fungicides azoxystrobin, antracol, Copper oxychloride found to be highly compatible with T. viride at all the tested concentrations. Where as azoxy strobin+Difenconazole, Chlorothalonil were moderately compatible upto 168 hours after inoculation. Hexaconazole at lower conventration allowed slight growth of T. vride at 10 days after inoculation.

Table 1: Compatibility of Trichoderma with chemical fungicides at 7 days after inoculation

S. No	Chemical fungicide	concentrations	Radial growth (mm)*	PI (%)
T1	Hexaconazole	0.05	0.000	100
		0.1	0.000	100
		0.15	0.000	100
T2	Chlorothalonil	0.1	65.06	27.71
		0.2	60.17	33.14
		0.25	26.05	71.05
T3	Azoxystrobin	0.05	90.00	0.00
		0.1	90.00	0.00
		0.15	90.00	0.00
T4	Azoxystrobin+ difenconazole	0.05	35.00	61.11
		0.1	20.08	77.68
		0.15	14.03	84.41
T5	Antracol	0.05	90.00	0.00
		0.1	90.00	0.00
		0.25	90.00	0.00
T6	Copper oxy chloride	0.1	90.00	0.00
		0.2	88.04	2.17
		0.25	80.00	11.10
T7	Propiconzole	0.025	0.00	100
		0.05	0.00	100
		0.1	0.00	100
T8	Tebuconazole+ Trifloxy strobin	0.05	0.00	100
		0.1	0.00	100
		0.25	0.00	100
T9	Control		90.00	0.00
	C.D.		0.870	
	SE(m)		0.306	
	C.V.		1.110	

*Mean radial growth of *T. viride*
PI= percent inhibition

It was evident from the data (Table 1) that the fungicide Hexaconazole (0.15%), propiconazole and Trifloxystrobin +tebuconazole were highly inhibitory against Trichoderma by showing cent percent inhibition on mycelial growth of *Trichoderma.* Similar observation was made by Bheemaraya *et al*. (2012) [8] whose studies found that propiconazole having 100% inhibitory effect on radial mycelial growth of Trichoderma even at lower concentrations. The results are in agreement with findings of Priti sonavane and Venkataravanappa (2017) [7].

The similar results obtained by Vijayaraghavan and Abraham (2004) [6] who tested invitro efficacy of different fungicides against Trichoderma viride and found that T. viride is incompatible with Bordeaux mixture, Copper oxy chloride, Captan and chlorothalonil, while it found to be compatible with Ridomil MZ, Antracol and Akomin. Studies made by Madhusudhan *et al*. (2010) [5] also reported that Hexaconazole and propiconazole showed cent percent inhibition on growth of Trichoderma at 50 to 100 ppm. Similarly, Deepthi (2013) [2] also observed the compatibility of Trichoderma with Copper oxychloride @ 0.1%, Thiophanate methyl @ 0.1%, Propiconazole @ 0.1% and Hexaconazole @ 0.1%.

Table 2: Compatibility of fungal biocontrol agent Trichoderma with chemical fungicides at 10 days after inoculation

Treatments	Radial growth (mm)			Mean radial growth of T(Treatments)	PI (%)
	C1	C2	C3		
T1- Hexaconazole	29.667	0.000	0.000	9.889	89.11
T2-Chlorothalonil	70.000	68.110	38.000	58.703	34.77
T3-Azoxystrobin	90.000	90.000	90.000	90.00	0.00
T4-Azoxystrobin+Difenconazole	34.000	30.000	23.000	29.00	67.77
T5-Antracol	90.000	90.000	90.000	90.00	0.00
T6- Copper oxy chloride	90.000	90.000	90.000	90.00	0.00
T7-Propiconazole	0.000	0.000	0.000	0.000	100
T8- Trifloxystrobin+Tebuconazole	0.000	0.000	0.000	0.00	100
T9- control	90.000	90.000	90.000	90.00	0.00
Mean of C (concentrations)	54.852	50.901	46.778		

Factors	C.D.	S.E(d)	SE(m)
Factor (Treatments)	0.937	0.466	0.329
Factor (Concentrations)	0.541	0.269	0.190
Factor (Treatments X Concentrations)	1.622	0.807	0.571

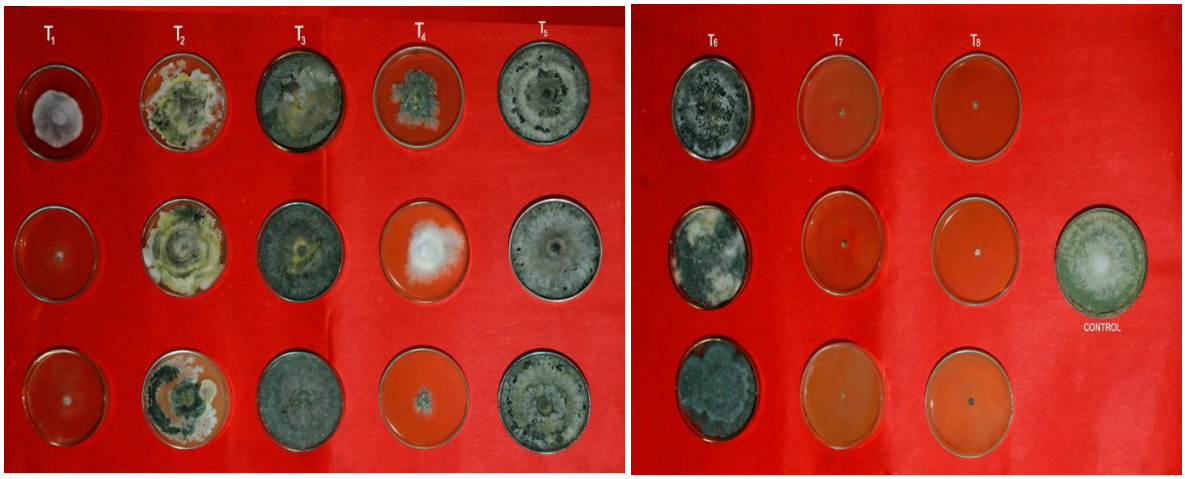

Plate 1: Compatibility of fungal biocontrol agent Trichoderma with chemical fungicides at 10 days after inoculation ; T1- Hexaconazole, T2-Chlorothalonil, T3- Azoxystrobin, T4- Antracol, T5- Azoxystrobin+Difenconazole, T6- Copper oxy chloride, T7-Propiconazole, T8-trifloxystrobin+Tebuconazole

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