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Integrated effect of *Trichoderma* spp., chemical fungicides and soil amendments on seed treatments of Fusarium wilt of tomato against *Fusarium oxysporum* f.sp. *lycopersici*

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Abstract
Tomato wilt caused by *Fusarium oxysporum* f.sp. *lycopersici* is most important and destructive disease of tomato in Uttar Pradesh, which causes considerable losses in yield of tomato. Therefore, present studies were undertaken to test the efficacy of two fungicides, three bioagents and organic amendmants *in vitro* Azad T-6 varieties of tomato in green house against Fusarium wilt of tomato among the both fungicides carbendazim@0.2% and Tebuconozole @0.3% were more effective against *Fusarium oxysporium* f.sp. *lycopersici* as compared to bioagents. Among *Trichoderma* isolates, T-02 @ 5g/kg seed was found most effective in Average No. of dead plant per pot, Average No. of wilted plant per pot, Disease incidence, Plant height (cm) and Average Yield (kg/pot) over other treatments, respectively.

Keywords: *Trichoderma* spp., chemical fungicides, soil amendments, *Fusarium oxysporum f.sp. lycopersici*

Introduction
The word of tomato (*Lycopersicon esculentum* Mill.) krust is derived from Latin words Aztec xitomate or xitomate and its origin is Tropical America (Thompson and Kelly, 1957) [5]**.** It was introduced into Europe by Spanish explorer in early sixteen century. Subsequently, it was perhaps introduced in India by Portuese though there is no definite record of when and how it came to India. Tomato wilt caused by *Fusarium oxysporum* f.sp. *lycopersici* is most important and destructive fungal disease causing substantial quantitative and qualitative losses. Considering the seriousness of the disease, the present studies were undertaken *in vitro* to test the efficacy of two different fungicides, three bioagents and organic amendmant (fungal and bacterial) against *Fusarium oxysporum* f.sp. *lycopersici* of tomato against Fusarium wilt of tomato in green house.

Materials and Methods
To evaluate the effect of seedling treatment with *Trichoderma* sp. isolates against *Fusarium oxysporum* f. sp. *lycopersici* trial conducted as below said treatment detail.

Treatment details
T_1: Vermicompost recommended dose (1.2 kg/M^2)
T_2: Farm Yard Manure recommended dose (2 kg/M^2)
T_3: Poultry Manure recommended dose (200 gm/M^2)
T_4: Neem cake recommended dose (200 gm/M^2)
T_5: *Trichoderma harzianum* (100gm/litter, seedling treatment)
T_6: *Trichoderma viride* (100 gm/litter, seedling treatment)
T_7: *Trichoderma koningiopsis* (100 gm/litter, seedling treatment)
T_8: Carbendazim recommended dose (2 gm/litter, seedling treatment)
T_9: Tebuconozole recommended dose (3 gm/litter, seedling treatment)
T_{10} : Without seedling treatment (control).

The whole experiment was carried out under glass house conditions maintained at 28 ± 2 ºC with 80% RH under twelve hours alternate light and dark conditions. Three sets of the treatments were maintained as done while estimating the growth promotion activity of the plants. For *Fusarium oxysporum* f. sp. *lycopersici* inoculation, the prepared conidial suspension was sprayed on soil until it was completely drenched. The pots were then covered with sterile poly bags for 48 h to maintain humidity. Three seedlings were placed in each pot. After 120 days recorded growth promoting data like Number of dead plant on after 15 days of transplanting, Number of wilted plant per pot, Disease severity, Plant height after 30, 60 and 90 days and yield per pot were recorded.

Statistical analysis

The data were analyzed statistically to draw the conclusion. Statistically analyses of laboratory and pot experiments were done by the method of Completely Randomized Block Design (CRBD) prescribed by (Goon *et al.*, 1931) [1]. The significance of treatments differences was tested by variance ratio test of 5 per cent level of probability.

Results

The findings of the present study as well as relevant discussion have been presented under the following heads:

Average No. of dead plants per pot

At 15 DAT

The clearly indicated that all treatments reduced the dead plants per pot as compare to control. Maximum average dead plants was observed with Seedling treated with Poultry Manure and neem cake (1.00%), Vermicompost, FYM, T-05 and T-02 (0.66%), T-10 and Tebuconozole @0.3% (0.33%). Minimum average dead plants was found in control (1.33%) followed by Carbendazim@0.2% (0.00%). Treatments, showed the similar average dead plants per pot. Mostly plants were dead 15 DAT.

At 30 DAT

The clearly indicated that all treatments reduced the dead plants per pot as compare to control. Maximum average dead plants was observed with Seedling treated with Poultry Manure and neem cake (1.33%), Vermicompost, FYM, T-05 and T-02 (1.00%), T-10 and Tebuconozole @0.3% (0.66%). Minimum average dead plants was found in control (1.67%) followed by Carbendazim@0.2% (0.33%). Treatments, showed the similar average dead plants per pot. Mostly plants were dead 30 DAT.

Average No. of wilted plants per pot

The clearly indicated that all treatments reduced the wilted plants per pot as compare to control. Maximum average wilted plants was observed with Seedling treated with Neem cake (2.33%), Poultry Manure (2.00%), Vermicompost, FYM, T-05 and T-02 (1.66%), T-10 (1.33%). Minimum average wilted plants was found in control (2.66%) followed by Tebuconozole @0.3% and Carbendazim@0.2% (1.00%). Treatments, showed the similar average wilted plants per pot. Mostly plants were wilted 2017-18.

Disease incidence

The lowest disease incidence was observed in treatment, Carbendazim@0.2% about 12.41 per cent, which is statistically similar to Tebuconozole @0.3% (14.00 per cent), T-10 (16.88 per cent) and T-02 (17.06 per cent) but significantly differ from control (40.60 per cent). Other treatment viz. T-05 (21.33 per cent), FYM (26.12 per cent), Vermicompost (28.88 per cent) and Poultry manure (31.19 per cent) was also effective against wilt disease. Lowest efficacy of treatment, Neem cake was observed with maximum disease incidence 31.25% just after control.

Plant Height

The maximum plant height and development was recorded in treatment, carbendazim @0.2% as 50.66 cm in (2017-18). The maximum plant height recorded in treatment, carbendazim @0.2% followed by Tebuconozole @0.3% (47.48 cm), T-10 (44.77 cm), T-02 (44.45 cm), T-05 (42.88 cm), FYM (42.22 cm), vermacompost (41.77 cm), poultry manure (39.77 cm) and neem cake (39.00 cm), while least plant height was observed in control (36.44 cm).

Average yield

The maximum average yield per plot and development was recorded in treatment, carbendazim @0.2% as 686.66 gm in (2017-18) data. The maximum yield per pot are recorded in treatment, carbendazim @0.2% followed by Tebuconozole @0.3% (676.67 gm), T-10 (640.00 gm), T-02 (616.44 gm), T-05 (610.00 gm), FYM (590.00 gm), vermacompost (573.33 gm), poultry manure (553.33 gm) and neem cake (476.66 gm), while least yield per pot was observed in control (380.00 gm).

Discussion

The impact of seedling treatment with *Trichoderma* isolates, fungicides, organic amendments against *Fusarium oxysporium* f.sp. *lycopersici* were evaluated in 2017-18 year pot experiment. Both fungicides carbendazim@0.2% were more effective against *Fusarium oxysporium* f.sp. *lycopersici* as compared to bioagents. Among *Trichoderma* isolates, T-02 @ 5g/kg seed was found most effective in Average No. of dead plant per pot, Average No. of wilted plant per pot, Disease incidence, Plant height (cm) and Average Yield (kg/pot) over other treatments. Narnawar and Kalekar (1997) [3] reported that carbendazim was effective against tomato wilt caused by *Fusarium oxysporum* f.sp. *lycopersici.* Poddar *et al.* (2004) [4] reported that the use of systemic fungicides *viz.*, Carbendazim, Propiconazole, Thiophanate methyl and Tubeconazole was effective against *Fusarium oxysporum* in chickpea. Musmade *et al.* (2009) [2] reported that *in vitro* Carbendazim (0.1%) completely inhibited the growth of pathogen.

Conclusion

Since single strategy like amendment, biocontrol agent or chemical fungicides can't success to manage the disease completely when large scale infection is already established in the field. Chemical based strategies among the various strategies available for disease management have been so far dominating and effective than other single strategies. But for several problems like environmental pollution, residual effect in grain and killing of non-target organism (s) chemical strategy is responsible. Development of new resistant strains of plant pathogens are serious problem of disease management, increase due to the application of only chemical strategies for disease management. Due to the disadvantages of chemicals, integrated disease management programs in which judicious use of chemical and their integration with biocontrol agents, amendments is favored. The most significant information that generated in this experiment,

Trichoderma, amendments can be applied to crops along with agrochemicals for tomato wilt *Fusarium oxysporium* f. sp. *lycopersici* management.

Table 1: Effect of seedlings treatment with *Trichoderma* sp. and chemical fungicides along with different soil amendments on the incidence of wilt disease in tomato in pot condition

S. No.	Treatment	Average No. of dead plant per Pot		Average No. of wilted plant per pot	Disease Incidence (%)	Plant height (cm)				Yield per pot (gm)
		15 DAT	30 DAT			30 DAT	60 DAT	90 DAT	Average plant height	
1	Vermicompost	0.66	1.00	1.66	28.883	23.66	43.00	58.67	41.77	573.33
2	FYM	0.66	1.00	1.66	26.120	24.00	43.66	59.00	42.22	590.00
3	Poultry Manure	1.00	1.33	2.00	30.197	22.33	40.66	56.33	39.77	553.33
4	Neem cake	1.00	1.33	2.33	31.250	21.00	41.00	55.00	39.00	476.66
5	*T. harzianum* (T-2)	0.66	1.00	1.66	17.067	24.66	46.66	62.00	44.45	616.66
6	*T. viride* (T-5)	0.66	1.00	1.66	21.333	24.33	45.00	59.33	42.88	610.00
7	*T. koningiopsis* (T-10)	0.33	0.66	1.33	16.883	26.00	47.33	61.00	44.77	640.00
8	Carbendazim	0.00	0.33	1.00	12.417	29.33	54.33	68.33	50.66	686.66
9	Tebuconozole	0.33	0.66	1.00	14.000	28.33	50.00	64.00	47.48	676.67
10	Control	1.33	1.67	2.66	40.607	19.00	40.00	50.33	36.44	380.00
CD @ 5 %		N.S.	N.S.	0.822	3.276	1.703	2.564	1.585		39.587
S.Em		0.258	0.258	0.278	1.150	0.577	0.869	0.537		13.416

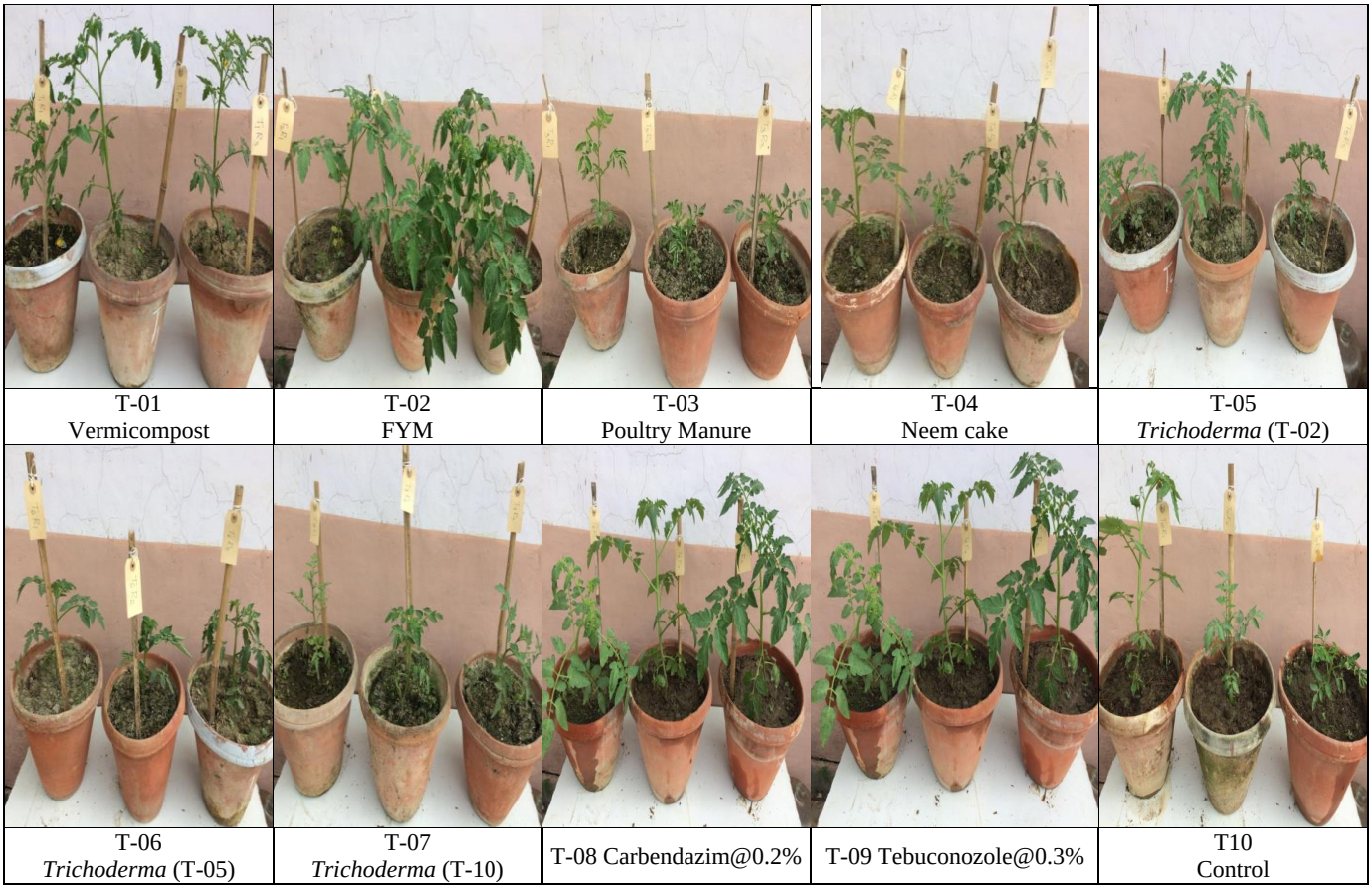

Fig 1: Effect of seedlings treatment with *Trichoderma* sp. and chemical fungicides along with different soil amendments on the incidence of wilt disease in tomato in pot condition

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