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IPM APPROACH FOR THE MANAGEMENT OF WILT DISEASE CAUSED BY *Fusarium oxysporum f. sp. lycopersici* ON TOMATO (*Lycopersicon esculentum*)

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KEYWORDS

Fulorescent *Pseudomonas*

Carbendazim

Spent mushroom compost

Solarized soil

Fusarium oxysporum

Wilt diseases

ABSTRACT

This study was conducted to find out the effect of combined application of fluorescent *Pseudomonas*, spent mushroom compost and the fungicide (Carbendazim 50 % W.P) on *Fusarium* wilt disease infected tomato plants grown in solarized and non-solarized soil. Results of study revealed that inoculation of fluorescent *Pseudomonas* and spent mushroom compost have significant effect on the number and weight of tomato fruits per replicate with cost benefit ratio as compared to the control treatment having *Fusarium oxysporum* f.sp. *lycopersici* infection. No significance differences was reported among the various treatments imposed, and highest tomato fruit per plant (8.75 fruits/plant) was reported from the treatment containing only sterilized soil after 150 days of plantation this was followed by treatment containing *P. fluorescens* (7.35 fruits/plant), spent mushroom compost (7.00 fruits/plant), Carbendazim (7.00 fruits/plant) and spent mushroom compost with *Pseudomonas fluorescens* (6.90 tomato fruit/plant). Similar trends was reported in case of fruit weight and net return and treatment containing only sterilized soil show highest fruit weight (158.60g), maximum net return (113329 Rs/ha) and incremental cost benefit ratio (1:4.50). While minimum net return (0 Rs/ha) was observed in the treatment containing non sterilized soil and *F. oxysporum* infection.

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1 Introduction

Tomato (*Lycopersicon esculentum* Mill) is an important vegetable crop which widely grown by both small and large scale farmers; even it is common in kitchen and home gardens too. It's good source of Vitamins A, B and C and also ripens fruits is have antibiotic properties which is helpful in healing wounds (Baloch, 1994). Wilts disease of tomato is caused by *Fusarium oxysporum* f.sp. *lycopersici.* It is one of the highly destructive tomato disease which caused infection even in plant grown in greenhouse (Larkin & Fravel, 1998; Borrero et al., 2004). The pathogen enters through the plant roots and proliferates in the vascular tissues leading to breakdown of the water supply of the infected plants (Agrios, 2005). Typical symptoms of the disease are yellowing and wilting of leaves and it progressing upward from the base of the stem. Initially, only one side of a plant is affected but after some time these symptoms spread to the rest of the plant and finally kill the plant. Due to prolonged survival in soil as a saprophyte and as resistant structures, *F. oxysporum* is difficult to control (Khan & Khan, 2002; Borrero et al., 2004). Tomato yield loss due to *F. oxysporum* infection varies between 10 to 90% and it depends on the stage of the plant growth and the environmental conditions (Kumar & Sood, 2002; Singh, 2005).

Wilt disease of tomato can be easily control by the application of chemical fertilizers, but excess use of chemical fertilizers not only affect the quality of tomato fruit but also cause environmental pollution. Further, chemical fertilizers also caused severe damage to not target organisms. Now in these days, most of the researchers worked on the searching of alternative approach for the management of this disease. Various bio-control organisms help in reducing this pathogen infection. Among these *Pseudomonads fluorescens* is a non-pathogenic rhizobacteria which suppress the soil-borne pathogens through rhizosphere colonization, antibiosis and iron chelation by siderophore production (Elad & Chet, 1987; Lemanceau et al., 1992; Pierson & Thomashow, 1992). Further, these bacteria have ability to promote plant growth, either by directly stimulating the plant or by suppressing pathogens (Ross et al., 2000; Haas & Defago, 2005; Carlier et al., 2008; Rovera et al., 2008; Rosas et al., 2009; Srinivasan et al., 2009). Various researchers have been tested the antagonistic properties of *F.oxysporum* (Madi et al., 1997; Tsahouridou & Thanassoulopoulos, 2002; Errakhi et al., 2007). Further researchers also established the fact that *F. pseudomonads* can be used as a biological control agent against *F. oxysporum* (Elad, 1995; Singh et al., 2003).
Soil solarization is also a common practice for managing soil born diseases; it’s affect soil health, plant growth, crop yield, and quality of crop plants (Katan, 1987).

Like other management practices, soil solarization also used to control tomato wilt disease, (Ioannou et al., 2000; Tamietti & Valentino, 2006). Barakat & AL-Masri (2012) carried out soil solarization for the management of *F. oxysporum* f. sp. *lycopersici*, for seven weeks from July to August 2008 and 2009 and reported significant reduction in the population of the pathogen. Further, Raj & Kapoor, (1997) reported that mushroom compost also enhancing microbial activity in the amended soil and higher dosage (2%, w/w) of composts are most effective in managing the pathogen *F. oxysporum* f. sp. *Iycopersici*, therefore it can be use for better plant health and disease control. It was well reported that mushroom compost (spent mushroom substrate, SMS, mushroom soil) exhibits suppressive characteristics against various fungi, as well as against plant diseases caused by fungi. In addition, mushroom compost has physical and chemical characteristics that make it ideal for blending with landscape mulch to enhance growth of horticultural plants (Davis et al., 2005). Incorporation of composted Spent Mushroom Substrate (SMS) not only improves the nutrient status but also neutralizes the acidity of soils (Pannier, 1993; Ahlawat et al., 2005) and facilitates cultivation even in problematic soils (Ahlawat et al., 2011). In addition, SMS also possesses good bio-control activity against certain foliar and soil borne diseases (Yohalem et al., 1996; Ahlawat et al., 2007).

Ajay & Shashi (2012) reported that effective control by 10 minute dipping of tomato seedlings roots in 0.3% solution of Carbendazim 50 WP before transplanting inhibited wilt disease caused by *F. oxysporum* f. sp. *lycopersici.* Amini (2009) evaluated carbendazim against *F. oxysporum* f. sp. *lycopersici in vivo,* the result of glasshouse tests revealed efficacy of fungicide in reducing disease infestation. The aim of this study was to evaluate the number of tomato fruits and cost benefit ratio of yield by using IPM approach with fluorescent *Pseudomonas*, soil solarization, spent mushroom compost and fungicide (Carbendazim).

2 Materials and Methods

This pot study was conducted during 2014 under net house condition at Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad, India. Experimental pots were laid out in Complete Randomized Block Design (CRBD) with six treatments and five replicates. Pot used in this study was of 10 cm in diameter and with capacity of 10 kg soil. Pots soil was artificially contaminant by adding pure culture of *F. oxysporum* f. sp. *lycopersici* @ 2 g/kg soil, this pure culture was multiplied on sorghum grains.

2.1 Process of soil solarization

Soil solarization was conducted for 2 months from 15th April to 15th June 2013 at research field of SHIATS, Allahabad. Soil was solarized with the help of 40 µm thick polythene sheet, soil was properly irrigated before laying the polythene sheet.

2.2 Source of Tomato seeds, fluorescent *Pseudomonas*, Spent mushroom compost and pathogen

Seeds of local tomato variety (CO-3) were collected from Indian Institute of Vegetable Research), Varanasi, Uttar

Pradesh, India. Healthy seeds were selected manually and used for study. Fluorescent *Pseudomonas* was acquired from Yash Trichoguard, DBT Referral Lab, SHIATS, Allahabad, Uttar Pradesh, India while the culture of spent mushroom compost and *F. oxysporum* was acquired from Department of Plant Pathology, Sam Higginbottom Institute of Agriculture, Technology & Sciences, Naini, Allahabad. Pure culture of *F. oxysporum* was maintained on czapek's dox agar and mass culture of *F. oxysporum* was maintained on sorghum grains.

2.3 Application of fluorescent *Pseudomonas*, carbendazim and Spent mushroom compost

The solarized and unsolarized soil was mixed with FYM @ 100 g/pot and filled in the experimental pots. Tomato seeds were treated with bioagent *P. fluorescens* and chemical fertilizer Carbendazim @ 4g /1kg seeds and shown in the pot @ 10 seeds per ponds. Simultaneously pot soil was inoculated with *P. fluorescens* and Carbendazim @ 2 g / pot. Ten pots were supplemented with spent mushroom compost @ 20 g / kg.

3 Results and Discussion

3.1 Effect of various treatments on fruit production

All studied combinations have statistically significant difference than the control (Non sterilized soil along with *F. oxysporum* inoculation). Among various tested treatments, treatment containing only sterilized soil without *F. oxysporum* shows superiority over the rest of the treatments and gave average 8.75tomato fruit/plant after 150 days of plantation. This fruit number was followed by treatment containing solarized soil containing *P. fluorescens* (7.35 tomato fruit/plant), solarized soil along with spent mushroom compost (7.00 tomato fruit/plant), solarized soil and Carbendazim (7.00 tomato fruit/plant) and spent mushroom compost with *P. fluorescens* (6.90 tomato fruit/plant). These three treatments are not statistically different among themselves. Similar, type of findings was reported by Haruna et al. (2011) when they tried carbendazim for wilt disease management in tomato plant.

These researchers reported 12% improvement in fruit production rate on the application of carbendazim and compost. Average weight of five tomato fruits per replicate (g) was also significantly different and varies with the treatments. Like fruit numbers, treatment containing only solarized soil show superiority (158.60g) over all the other studied treatments. This fruit weight was followed by the combination of solarized soil and Carbendazim (132.50g), solarized soil along with spent mushroom compost (131.60g), solarized soil along with *P. fluorescens* (116.20g) and spent mushroom compost with *P. fluorescens* (97.20g).These treatments are significantly different that the control (Non Solarized soil + *F. oxysporum*) but are not significantly different when compare with each other except compost with *P. fluorescens*. These results are in agreement in the findings of Seleim et al. (2011) those have reported highest increases in tomato yield by the application of *P. fluorescens*.

3.2 Cost benefit ratio

Data with respect to agronomical practices were same for all treatments (Table 2) while the economic values of all treatments were significantly different between treatments (Table 3). Like fruit characteristics, maximum net return (113329 Rs/ha) was recorded from the treatment containing solarized soil, this cost benefit ration was followed by treatment containing solarized soil with *P. fluorenscens* (72871 Rs/ha), Carbendazim (67819 Rs/ha), Spent mashroom compost, (58329 Rs/ha) and Spent mashroom compost with *P. fluorenscens* (40617 Rs/ha). The minimum net return (0 Rs/ha) was observed from the treatment containing Non solarized soil along with *F. oxysporum*.

Table 1 Effect of spent mushroom compost, *P. fluorescens* and carbendazim using solarized and unsolarized soil on the number of fruits and fruits weight.

Treatments	Average number of fruits / plant			Average weight of five fruits / replicate (g)
	Days			
	90	120	150	125
Non SS along with *Fo*	0.00	1.00	3.00	25.00
SS along with Smc and *Fo*	1.70	5.85	7.00	131.60
SS along with *P f* and *Fo*	0.80	6.15	7.35	116.20
SS in combination with Smc + *Pf* + *Fo*	0.25	5.80	6.90	97.20
SS along with C +*Fo*	3.25	5.75	7.00	132.50
SS along with tomato plant	1.20	4.75	8.75	158.60
C. D. (P = 0.05)	1.765	1.974	1.809	29.038

Here SS - Solarized soil; Fo – F. oxysporum; Smc - Spent mashroom compost; C- Carbendazim and Pf- P. fluorenscens

Table 2 Estimated Cost of production based on the amount spend on agronomical practices for cultivation/ha (Pot data is converted in to field data).

Sr. No.	Particular	Requirement	Rate/unit Rs.	Cost (Rs)
(A)	Land preparation			
I.	Ploughing	3 hours	500 Rs/hours	1500
II.	Harrow	3 hours	500 Rs/hours	1500
III.	Layout of field	10 labours	150 Rs/labour	1500
(B)	Manures and fertilizer			
I.	FYM	20 tons	100 Rs /qu.	20000
II.	Urea	193 Kg	7 Rs/Kg	1351
III.	DAP	174 Kg	15 Rs/Kg	2610
IV.	Labour	6 labours	150	900
(C)	Seed sowing			
I.	Seed material	0.5 kg	1500 Rs/Kg	750
II.	transplanting and leveling	12 labours	150	1800
(D)	Weed Management	15 labour X3 time	150 Rs/labour	6750
(E)	Harvesting	30 labours	150 Rs/labour	4500
(F)	Total cost of cultivation			25161

Table 3 Estimated cost of various treatments formulation.

Treatments	Cost of Smc + Pf + carbendazim (Rs)	Labor cost (Rs)	Total Cost (Rs)
Non SS along with *Fo*	0	0	0
SS along with *Smc* and *Fo*	20000	900	20900
SS along with *Pf* and *Fo*	200	900	1100
SS in combination with *Smc* + *Pf* + *Fo*	20200	900	21100
SS along with C +*Fo*	280	900	1180
SS along with tomato plant	0	0	0

Here SS - Solarized soil; Fo – F. oxysporum; Smc - Spent mashroom compost; C- Carbendazim and Pf- P. fluorenscens

Similarly, maximum cost benefit ratio and incremental cost benefit ratio were obtained with treatment containing solarized soil (1:4.50), this was followed by the treatment containing solarized soil along along with *P. fluorenscens* (1:2.77), Carbendazim (1:2.57), Spent mashroom compost (1:1.26), and Spent mashroom compost with *P. fluorenscens* (1:0.87). The minimum cost (0) benefit ratio and incremental cost benefit ratio was reported from Non solarized soil with *F. oxysporum* (Table 4).

Conflict of interest

Authors would hereby like to declare that there is no conflict of interests that could possibly arise.

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Table 4 Impact of various treatments on the Cost benefit ratio of tomato.

Treatments	M	N	A	D	E	F	G	B	H	O	C	
	Treatment cost RS /ha. (M)	Agronomical Practices cost Rs/ha (N)	Total cost Rs /ha. (A) = M+N	Yield Ton /ha.(D) = no of plants /ha (37000) × yield / plant	Increase in yield over control (ton/ha)(E) = (D) of treatments-(D) of control	Price of yield Rs/ton (F)	Total value of yield Rs/ha (G)=D × F	Value of increased yield RS / ha (B) = E × F	Net return Rs/ha (H) = G - A	Cost benefit Net return/total cost (O)=H/A	Incremental benefit Rs/ha (C) = B-A	Incremental cost benefit ratio (ICBR) = C/A
Non SS along with *Fo*	0	25161	25161	0	0	22000	0	0	0	0	0	0
SS along with *Smc* and *Fo*	20900	25161	46061	4.745	4.745	22000	104390	104390	58329	1:1.26	58329	1:1.26
SS along with *Pf* and *Fo*	1100	25161	26261	4.506	4.506	22000	99132	99132	72871	1:2.77	72871	1:2.77
SS in combination with Smc + Pf + Fo	21100	25161	46261	3.949	3.949	22000	86878	86878	40617	1:0.87	40617	1:0.87
SS along with C +*Fo*	1180	25161	26341	4.280	4.280	22000	94160	94160	67819	1:2.57	67819	1:2.57
SS along with tomato plant	0	25161	25161	6.295	6.295	22000	138490	138490	113329	1:4.50	113329	1:4.50

Here SS - Solarized soil; Fo – F. oxysporum; Smc - Spent mashroom compost; C- Carbendazim and Pf- P. fluorenscens.

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