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INTEGRATED STRATEGIES IN THE MANAGEMENT OF TOMATO WILT DISEASE CAUSED BY *FUSARIUM OXYSPORUM* F. SP. *LYCOPERSICI*

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ABSTRACT

Wilt of tomato (*Lycopersicon esculentum*) caused by *Fusarium oxysporum* f. sp. *lycopersici* (Sacc.) Snyder and Hansen is considered as one of the most devastating disease of tomato both in field as well as green house conditions. In present investigation bio-agents, organic amendment and fungicides were evaluated on different combinations and mode of treatments. In the experiment under field conditions, the treatments are: seedling treatment (ST) of *T. harzianum* at 100 gl^{-1} of water, soil application (SA) of FYM at 1000 $kgha^{-1}$ having *T. harzianum* at 1 kgq^{-1} of FYM, ST of *P. fluorescens* at 100 gl^{-1} of water, SA of FYM at 1000 $kgha^{-1}$ having *P. fluorescens* at 1 kgq^{-1} of FYM; SA of FYM at 1000 $kgha^{-1}$; SA of neem oil cake 250 $kgha^{-1}$ plus FYM 1000 $kgha^{-1}$; SA of Neem oil cake 250 $kgha^{-1}$; ST of carbendazim at 1 gl^{-1} of water and ST of thiram 2 gl^{-1} of water. Minimum wilt incidence was recorded by soil application of FYM at 1000 kg/ha having *T. harzianum* at 1 kgq^{-1} of FYM (4.16 per cent) and maximum disease inhibition percent (94.11 per cent). This treatment also recorded the highest number of branches per plant (16.0), plant height (69.60 cm), highest fruit yield (300.75 q/ha) and increase in fruit yield over the control of 52.87 percent with per rupee return of 4.99.

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill) belongs to the family solanaceae and is one of the most remunerable and widely grown vegetables in the world. Among the vegetables tomato ranks next to potato in world acreage and ranks first among the processing crops. It is grown for its edible fruits, which can be consumed either fresh or in processed form and is a very good source of vitamins A, B, C and minerals. Indian contribution to the world's production was 11.97 million tones. Tomato crop was grown in area of 0.59 million hectare with a productivity of 19.97 tonnes per hectare (Anon., 2010). In Uttar Pradesh, it occupied an area of 7600 hectare with an annual production of 92500 tones (Anon., 2009).

Fusarium wilt of tomato caused by *Fusarium oxysporum* f. sp. *lycopersici* (Sacc.) Snyder and Hansen is recognized as one of the most devastating disease in major tomato growing regions worldwide (Walker, 1971; Beckman, 1987; Abdel-Monaim, 2012). The vegetable growers suffer more than 25.14 – 47.94 % crop losses due to Fusarium wilt of tomato in Uttar Pradesh (Enespa and Dwivedi, 2014). Being a soil-borne disease it is very difficult and uneconomical to control with chemical alone. Biological control of soil-borne pathogens through antagonists offer environmentally safe, sustainable and cost alternative to chemicals.

In eastern Uttar Pradesh wilt disease causes serious loss because of climate. Several bio-control strategies have been proposed for controlling root pathogens (Hibar *et al.*, 2007), but practical application are still limited. Seed treatment with synthetic fungicides considerably reduce wilt incidence in tomato (Asha *et al.*, 2011), however the fact that pesticide applications on greenhouse crops have become strongly regulated. The main challenge to production of tomatoes therefore is finding affordable and effective method of controlling Fusarium wilt. Integration of biocontrol agents with botanicals and organic amendment may improve the efficacy of the biocontrol organism and health of host plant. Therefore present experiment was conducted to see the integral effect of bioagents, organic amendment and fungicides against soil borne pathogen.

MATERIALS AND METHODS

The experiments were conducted during cropping season of 2012-13 and 2013-14 at central research field SHIATS, Allahabad. The experiment was laid out in RBD with three replications. The plot size was kept 2×2 m^2 in the irrigated conditions. All pots were made sick by adding mass multiplied culture of *F. oxysporum* f. sp. *lycopersici* on sorghum before 15 day of planting. Planting of susceptible local tomato variety 'Pusa Ruvi' was done in the second week of November. Disease intensity, plant height and number of branches were measured at 30 days of intervals after transplanting.

Isolation of *Fusarium oxysporum* f. sp. *lycopersici* from tomato plants

Tomato plants showing vascular wilt symptoms were collected from the farmers' fields. The roots of infected plants were washed separately with tap water to separate adhering soil particles. The infected root of tomato plants was split opened longitudinally (Fig. 2) with the help of sterilized scalpel. The plant parts showing brown discoloration of vascular tissues were cut into small bits and washed well in running tap water. These bits were surface sterilized with 0.1 % sodium hypochlorite (NaClO) solution for fifteen seconds. These pieces were washed thoroughly in sterile distilled water and aseptically transferred on to each Petri plate containing sterile potato dextrose agar (PDA) at equal distance. These plates were incubated at 25±2°C for 5 days. The resultant fungus was isolated (Fig. 3) and purified using hyphal tip method (Hawker, 1990), then culture was maintained on PDA for further studies. The pathogen was identified as *Fusarium oxysporum* f. sp. *lycopersici* based on its morphological characters Jens *et al.* (1991); Barnett and Hunter (2003) and the *forma specialis* of the pathogen was identified using pathogenicity tests. The pathogenicity test was performed using a susceptible tomato cultivar according to the post-culture inoculation method of Nene and Haware (1980).

Isolation of *Trichoderma* spp.

Trichoderma spp. was isolated from soil sample collected from rhizosphere of tomato plant from farmers' field of Allahabad by dilution plate technique and using Potato dextrose agar. The probable colonies of *Trichoderma* were picked up, purified and kept in PDA slant at 4°C for further studies. The *Trichoderma* spp. was identified on the basis of morphological, taxonomic keys and colonial c haracteristics (Rifai, 1969).

Assessment of disease severity

In this experiment under field conditions nine treatments were used, first treatment (T^1) was seedling treatment (ST) of *T. harzianum* at 100 gl^{-1} of water, second treatment (T^2) soil application (SA) of FYM at 1000 $kgha^{-1}$ having *T. harzianum* at 1 kgq^{-1} of FYM, third (T^3) ST of *P. fluorescens* at 100 gl^{-1} of water, fourth (T^4) SA of FYM at 1000 $kgha^{-1}$ having *P. fluorescens* at 1 kgq^{-1} of FYM, fifth (T^5) SA of FYM at 1000 $kgha^{-1}$; sixth (T^6) SA of neem oil cake 250 $kgha^{-1}$ plus FYM 1000 $kgha^{-1}$; seventh (T^7) SA of Neem oil cake 250 $kgha^{-1}$; eighth (T^8) ST of carbendazim at 1 gl^{-1} of water; ninth (T^9) ST of thiram 2 gl^{-1} of water and one (T^0) without treatment as control.

Statistical Analysis

In the experiment Randomized Block Design (RBD) was adopted. The analysis of variance (ANOVA) technique was applied for drawing conclusion from data. The calculated values were compared the tabulated values at 5% level of probability (Fisher and Yates, 1959) for the appropriate degree of freedom.

RESULTS AND DISCUSSION

The present investigation under field conditions revealed that, wilt incidence was significantly reduced due to seedling dip treatment and soil treatment with soil *T. harzianum* (1 kg q^{-1}) + FYM (1000 kg ha^{-1}) was found to be significantly superior treatment and recorded maximum per cent disease control (94.11 %) followed by carbendazim (1 gL^{-1} water) seedling treatment (88.23 %), thiram (2 gL^{-1} water) seedling treatment (85.29 %), *T. harzianum* (100 gL^{-1} water) seedling treatment (82.35 %), *P. fluorescens* (1kg q^{-1}) + FYM (1000 kg/ha) soil treatment (82.35 %), Neem oil cake (250kg/ha) soil treatment (82.35 %), *P. fluorescens* (100 g/l water) seedling treatment (79.41 %), neem oil cake (25 kg q^{-1}) + FYM (1000 kg ha^{-1}) soil treatment (76.47 %) and FYM (1000 kg ha^{-1}) soil treatment (52.94 %) as over the control. Sundaramoorthy and Balabaskar (2013) have also shown that isolates of *T. harzianum* from tomato rhizosphere were strong and virulent antagonists, which can be effectively used in the management of tomato wilt. Christopher *et al.* (2010) revealed that seed plus soil application *T. harzianum* along with organic amendments reduced wilt incidence and increased the fruit yield of tomato. Sen and Kapoor (1975) reported that disease incidence was reduced with the application of carbendazim (1%).

All treatments significantly increased the plant height and number of branches of tomato plant as compared to the control either as soil or seedling treatment. Maximum plant height (75.46 cm) and number of branches (17.56) observed when soil were treated *T. harzianum* (1 kg q^{-1}) + FYM (1000 kg ha^{-1}) followed by *T. harzianum* (100 gL^{-1} water), carbendazim (1 gL^{-1} water) seedling treatment as seedling treatments and rest of treatment. From the perusal of data it is inferred that *T. harzianum* seems to be more effective with FYM in increasing plant height and number of branches. The present result is supported by the observation of Barnwal *et al.* that seed and soil application of *Trichoderma viride* recorded highest

Table 1: Evaluation of different integrated management strategies against wilt disease of tomato

Treatments	Disease incidence (%)		Plant height (cm)		Number of branches	
	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
Control	70.83	77.08	40.27	33.16	9.97	8.55
Trichoderma harzianum (100 gl^{-1} water)**	12.50(82.35)*	14.58(81.08)*	69.60	66.78	16.53	16.76
Trichoderma harzianum (1kgq^{-1}) + FYM (1000 $kgha^{-1}$)***	4.16(94.11)*	6.25(91.89)*	76.96	75.46	19.46	17.56
Pseudomonas fluorescens (100 gl^{-1} water)**	14.58(79.41)*	16.67(78.33)*	72.00	69.74	16.20	15.74
Pseudomonas fluorescens (1kgq^{-1}) +FYM (1000 $kgha^{-1}$)***	12.50(82.35)*	18.75(75.67)*	71.30	69.06	14.13	14.30
FYM (1000 $kgha^{-1}$)***	33.34(52.94)*	37.50(51.35)*	69.86	66.38	13.25	15.02
FYM (1000 $kgha^{-1}$) + Neem oil cake (25 kgq^{-1})***	16.67(76.47)*	18.75(75.67)*	66.60	65.36	16.40	14.53
Neem oil cake (250 $kgha^{-1}$)***	12.50(82.35)*	16.67(78.33)*	67.60	65.67	14.80	13.93
Carbendazim (1 gl^{-1} water)**	10.41(88.23)*	8.34(89.18)*	71.90	71.96	16.06	17.13
Thiram (2 gl^{-1} water)**	8.34(88.22)*	10.41(86.49)*	72.50	68.03	16.80	16.06
S. Ed (±)	5.56	5.07	2.10	2.27	1.46	0.80
CD (5%)	11.69	10.67	4.41	573	3.07	1.68

*Disease inhibition percent over the control, **Seedling treatment, ***Soil treatment

Table 2: Cost benefit ratio of tomato as affected by different treatments

Treatments	Average Yield (q/ha)	Gross return(Rs/ha) average	Production cost fix (Rs/ha)	Treatment cost	Total cost + 10 % interest	Cost benefit ratio (C:B)
Control	141.87	170244	63960	-	70356	1:2.41
Trichoderma harzianum (100 gl^{-1} water)**	268.58	322296	63960	1200	71676	1:4.40
Trichoderma harzianum (1kgq^{-1}) + FYM (1000 kgha^{-1})***	300.75	360900	63960	1700	72226	1:4.99
Pseudomonas fluorescens (100 gl^{-1} water)**	252.50	303000	63960	1400	71896	1:4.21
Pseudomonas fluorescens (1kgq^{-1}) +FYM (1000 kgha^{-1})***	240.25	288300	63960	1900	72446	1:3.97
FYM (1000 kgha^{-1})***	207.50	249000	63960	1100	71566	1:3.47
FYM (1000 kgha^{-1}) + Neem oil cake (25 kgq^{-1})***	213.65	256380	63960	1350	71841	1:3.56
Neem oil cake (250 kgha^{-1})***	232.50	279000	63960	3100	73766	1:3.78
Carbendazim (1 gl^{-1} water)**	273.22	327864	63960	1280	71764	1:4.56
Thiram (2 gl^{-1} water)**	266.75	320100	63960	1300	71786	1:4.45

**Seedling treatment, ***Soil Treatment

Figure 1: Completely wilted plant with partial wilted and healthy plant

Figure 2: Infected plant root showing blakish pith with healthy right hand side

Figure 3: *Fusarium oxysporum* f. sp. *lycopersici*

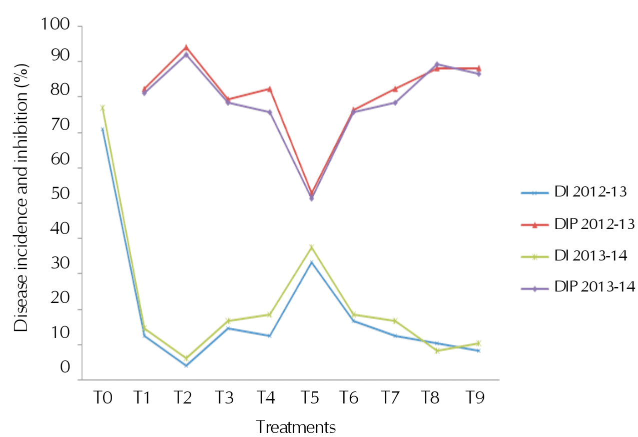

Figure 4: Evaluation of different integrated management strategies against wilt disease of tomato

number of branches per plant and plant height (cm). Data of field experiment showed that all the treatments significantly improved the plant height and number of branches over control. This may be due to the easy and quick multiplication in rhizosphere.

The data presented in Table 2 revealed that maximum yield of 300.75q/ha with cost benefit ratio 1:4.99 was obtained with *T. harzianum* (1kg q^{-1}) + FYM (1000 kg ha^{-1}) as soil application. Next effective treatment was carbendazim (1 gL^{-1} water) seedling treatment with maximum CB (1:4.56), followed by thiram (2 gL^{-1} water), seedling treatment with CB (1:4.45), *T. harzianum* (100 gL^{-1} water) seedling treatment with CB (1:4.40), *Pseudomonas fluorescens* (100 gL^{-1} water) seedling treatment with CB (1:4.4.21), *P. fluorescens* (1 kg q^{-1}) + FYM (1000 kg

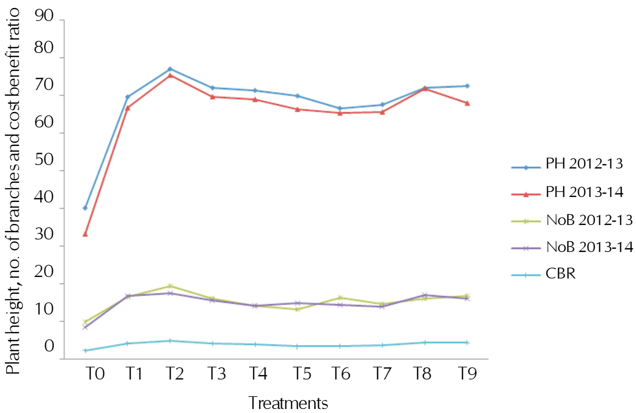

Figure 5: Effect of different integrated management strategies on plant height, number of branch and feasibility of wilt disease tomato

ha^{-1}) soil treatment with CB (1:3.97), Neem oil cake (250 kg ha^{-1}) soil treatment than with CB (1:3.78), Neem oil cake (25 kg q^{-1}) + FYM (1000 kg ha^{-1}) soil treatment CB (1:3.56) and least affective treatment FYM (1000 kg ha^{-1}) soil treatment over the control.

The present investigation indicates that application of *T. harzianum*, *P. fluorescens* with (soil) or without (seedling) FYM can be used as an effective treatment of wilt disease and to develop ecofriendly strategy for the management of Fusarium wilt of tomato.

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REFERENCES

Abdel-Monaim, M. F. 2012. Induced systemic resistance in tomato plants against Fusarium wilt disease. *Int. Res. J. Microbiol.* **3:** 14-23.

Asha, B. B., Chandra, N. S., Udaya, A. C., Srinivas, C. and Niranjana, S. R. 2011. Biological control of *Fusarium. oxysporum* f. sp. *lycopersici* causing wilt of tomato by *Pseudomonas fluorescens, Int. J. Microbiol. Res.* **3(2):** 79-84.

Anonymous. 2009. All India area, production and yield of Tomato. In: Area, production and yield of crops (I). Agricultural statistical data Ministry of Agriculture, Govt. of India, New Delhi.

Anonymous. 2010. Science Reporter. Food and Agriculture Organization .

Balanchard, D. 1992. A colour atlas of tomato diseases. *Wolfe Publication, Ltd., Brook House, London*, p. 298.

Beckman, C. H. 1987. The nature of wilt diseases of plants. *The American Phytopathological Society*, St. Paul, Minnesotta.

Barnwal, M. K., Maiti, D. and Pandey, A. C. 2011. Management of tomato wilt caused by *Fusarium oxysporum* f. sp. *lycopersici* by using bio-agents and organic amendments. *Ind. Phytopathol.* **64(2):** 194-196.

Chopada, G. B., Singh, P. and Korat, C. 2014. Pathogenic variation among *Fusarium oxysporum* f. sp. *lycopersici* isolates and varietal screening of tomato against wilt under south gujarat, india. *The Bioscan*. **9(1):** 351-354.

Christopher, D. J., Raj, T. S., Shanmugapackiam, S., Udhayakumar, R. and Usharani, S. 2010. Ecofriendly management of Fusarium Wilt disease in tomato. *Ann. Pl. Protect. Sci.* **18(2):** 447-450.

Enespa and Dwivedi, S. K. 2014. Effectiveness of some Antagonistic fungi and botanicals against *Fusarium solani* and *Fusarium oxysporum* f. sp. *lycopersici* infecting brinjal and tomato plants. *Asian J. Plant Path.* **8(1):** 18-25.

Hibar, K. Daami-Remadi, M. and El Mahjoub, M. 2007. Induction of resistance in tomato plants against *Fusarium oxysporum* f. sp. *radic is-lycopersici* by *Trichoderma* spp. *J. Pl. Protec.* **2:** 47-58.

Nene, Y. L. and Haware, M. P. 1980. Screening chickpea for resistance to wilt. *Pl. Dis.* **66:** 379-380.

Rifai, M. A. 1969. A revision of the genus *Trichoderma*, Mycological paper, No. 116. *Commonwealth Mycological Institute, Association of Applied Biologists, Kew, Surrey, England.*

Sen, B. and Kapoor, I. J. 1975. Systematic fungicides for the control of wilt of peas. *J. Veg. Sci.* **2:** 76-78.

Singh, S. P. Singh, H. B. and Singh, D. K. 2013. *Trichoderma harzianum* and *Pseudomonas* sp. mediated management of *Sclerotium rolfsii* rot in tomato (*Lycopersicon esculentum* Mill.) *The Bioscan*. **8(3):** 801-804.

Sundaramoorthy, S. and Balabaskar, P. 2013. Biocontrol efficacy of *Trichoderma* spp. against wilt of tomato caused by *Fusarium oxysporum* f. sp. *lycopersici*. *J. App. Biol. Biotech*. **1(03):** 036-040.

Vibha and nidhi 2014. Management of Fusarium wilt of tomato by weeds and mycoflora processed weeds compost. *The Bioscan*. **9(1):** 197-202.

Walker, J. C. 1971. Fusarium wilt of tomato. Monograph 6. *American Phytopathological Society*; St. Paul, Minnesotta.