Effect of Soil Application with *Trichoderma harzianum* and Some Selected Soil Amendments on Fusarium Wilt of Tomato

M. T. Islam*, A. N. Faruq, M. M. Uddin and N. Akhtar
Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka (1207), Bangladesh

Article History

Manuscript No. 31
Received 23rd May, 2010
Received in revised form 19th August, 2010
Accepted in final form 23rd August, 2010

Correspondence to
**E-mail*: tohid_sau@yahoo.com

Keywords
Tomato, Fusarium wilt, soil amendments, *Trichoderma harzianum*

Abstract

Field experiments were carried out to test the efficacy of *Trichoderma harzianum* and some selected soil amendments such as poultry waste, coco-dust, vermicompost, ash, saw-dust, khudepana, cow dung, solarized sand, etc. against wilt disease of tomato during the winter season of 2008-2009. The treatments were applied in the soil at 15 days before transplanting. It was found that all the treatments appreciably reduced wilt incidence at different days after transplanting. In general, the wilt incidence was higher on control plot where no treatments were used. The most effective treatment was *Trichoderma harzianum* followed by poultry waste in terms of suppressing wilt incidence, increasing plant growth and fruit yield. Vermicompost also showed better performance in suppressing the wilt incidence at different days after transplanting over control and enhancing the plant growth and fruit yield.

1. Introduction

Tomato is cultivated nearly in all homestead gardens besides fields, especially in the winter season in Bangladesh. The demand of tomato is increasing day by day in the agro-food industries of Bangladesh. In Bangladesh, the total area of tomato cultivation is 18.8 thousand ha with annual production of 131.3 thousand mt, and the average yield was 6.98 t ha^{-1} in the year 2005-06 (BBS, 2007). Fusarium wilt disease caused by the pathogenic formae speciales of the soil inhabiting fungus *Fusarium oxysporum* can cause severe loss in a wide variety of crop plants. On tomato, two symptomologically distinct forms of the pathogen can cause either a vascular wilt (*F. oxysporum* f. sp. *lycopersici* W. C. Snyder & H. N. Hans.) or a crown and root rot (*F. oxysporum* f. sp. *radicis-lycopersici* W. R. Jarvis & Shoemaker). Both of these pathogens occur throughout most of the tomato growing areas and either can devastate a crop. Although the use of Fusarium-resistant tomato cultivars can provide some degree of control of these disease, the occurrence and development of new pathogenic race is a continuing problem, and currently there are no commercially acceptable cultivars with adequate resistance to *F. oxysporum* f. sp. *radicis-lycopersici* or race 3 of *F. oxysporum* f. sp. *lycopersici* (Jarvis, 1988; Jones et al., 1991). Root-knot nematode infection makes Fusarium wilt resistant variety more susceptible to the fungus because of physiological changes in the root. These diseases are generally controlled in tomato (and several other crops) by pre-plant soil fumigation with methyl bromide (MBr). However, fumigation with MBr is expensive and not always effective. In addition to other potential health, safety, and environmental risks, MBr is classified as an ozone-depleting compound and, as required by the Clean Air Act (CAA), is scheduled to be removed from the market in the world by 2001. The amount of MBr produced and imported in the U.S. was reduced incrementally until it was phased out in January 1, 2005 pursuant to the obligations under the Montreal Protocol on Substances that Deplete the Ozone Layer (Protocol) and the CAA. Therefore, alternative control measures are necessary and need to be made available as soon as possible. Biological control has potential for the management of these diseases. A variety of soil micro-organisms have demonstrated their role in the control of various soil borne plant pathogens, including Fusarium wilt pathogens. Fusarium wilt suppressive soils are known to occur in many regions of the world, and suppression has generally been shown to be biological in origin. Antagonists recovered from the Fusarium wilt suppressive soils, especially non-pathogenic *F. oxysporum,* have been used to reduce Fusarium wilt diseases of several different crops (Paulitz et al., 1987; Postma and Rattink, 1992; Alabouvette, et al., 1993; Minuto et al., 1995; Larkin et al., 1996). Other bio-control fungi, such as *Trichoderma* and *Gliocladium* spp., have been used to control a variety of fungal pathogens, including *Rhizoctonia*, *Pythium*, *Sclerotinia*, *Sclerotium* and *Fusarium* spp. (Lumsden and Locke, 1989; Harman, 1991; Taylor et al., 1994; Lewis et al., 1996), and may also be effective against Fusarium wilt diseases (Marois et al., 1981; Sivan and Chet, 1993; Datnoff et. al., 1995; Zhang et. al., 1996). Although many different bio-control strains have shown potential for some degree of control of Fusarium diseases, strains which can provide the best control of Fusarium wilt of tomato and have potential for effective implementation in commercial agriculture have not yet been identified. It has been suggested that antagonistic micro-organisms isolated from the root or rhizosphere of a specific crop may be better adapted to that crop and may provide better control of diseases than organisms originally isolated from other plant species. Management of wilt diseases of tomato with indigenous plant products and other organic substances as amendment to the soil are relatively a recent innovation. Considering the above facts the present investigation was undertaken to evaluate *Trichoderma harzianum* and some selected soil amendment against Fusarium wilt of tomato.

2. Materials and Methods

The experiment was conducted in a Complete Randomized Block Design (CRBD) with three replications at the field of SAU (Sher-e-Bangla Agricultural University, Dhaka) farm during 2008-2009 cropping season. Unit plot size was 3x1m^2, maintaining a distance of 75 cm from plant to plant and 1 m from row to row. Tomato variety BARI Tomato-2 (Ratan) was used for the experiment. Ten different treatments, viz. T_1=Soil application with *Trichoderma harzianum*; T_2=Soil application with poultry waste; T_3=Soil application with coco-dust; T_4=Soil application with vermin-compost; T_5=Soil application with ash; T_6=Soil application with saw-dust; T_7=Soil application with *khudepana*; T_8=Soil application with cow dung; T_9=Soil application with solarized sand; and T_{10}=Control (untreated) were assessed in the experiment. An effective isolate of *Trichoderma harzianum* was used in this experiment. The antagonistic *Trichoderma* were mass multiplied in PDA media incubated at 25^{0}C for 7-10 days. The fungal mat suspension was made by scraping the 10-15 days old culture substrate with the help of blender, and adjusted the concentration 10^7 colony forming unit ml^{-1} (cfu ml^{-1}). Then, soil of the specific plot was drenched with the fungal suspension @ 3 l plot^{-1} with the help of compressed air hand sprayer after pulverized the soil to mix up fungal inoculum throughout the soil. Seed treatment with bio-agent was done by dipping the seeds in the fungal suspension for 1 h. After treatment, the seeds were allowed to air dry for 6 h. Soil amendments were applied on the seed-bed soil and left for 15-30 days for proper decomposition, growing antagonistic micro-organisms and developing suppressiveness. Data on incidence of wilts were recorded at 55, 65, 75 and 85 days after transplanting (DAT). The percentage of disease incidence was calculated using the following formula:

$$\text{Disease incidence (\%)} = \frac{\text{Number of infected plants}}{\text{Number of total plants}} \times 100$$

The growth and yield parameters were also taken under investigation. The data were analyzed statistically using the computer package program MSTAT. Treatments' means were compared by DMRT (Duncan's Multiple Range Test).

3. Results and Discussion

At 55 DAT (days after transplanting), the lowest wilt incidence was recorded from T_1, which was statistically similar to T_3 where no wilt incidence was found. The wilt incidence in T_5, T_6 and T_9 was statistically similar and significantly lower as compared to other treatments. At 65 DAT, the wilt incidence in T_3 was significantly lower as compared to all other treatments. The treatment T_2, T_3, T_4, T_5, T_6, T_7 and T_9 was showed no statistically significant differences. At 75 DAT, the highest result, i.e. lowest wilt incidence was found in T_1 which was closely followed by T_2 and T_3. The highest wilt incidence was recorded in T_{10}. The wilt incidence in T_4, T_5 and T_8 showed statistically similar result. At 85 DAT, the lowest wilt incidence was found in T_1 which was closely followed by T_2. The wilt incidence in T_4 and T_5 showed statistically similar result (Table 1).

Table 1: Effect of different treatments on the wilt incidence of tomato at 55, 65, 75 and 85 DAT (days after transplanting)

Treatments	Wilt incidence (%)			
	55 DAT	65 DAT	75 DAT	85 DAT
T_1	0.00e	3.33c	10.00d	23.33f
T_2	3.33de	10.00bc	16.67cd	30.00ef
T_3	0.00e	13.33bc	16.67cd	33.33def
T_4	6.67cde	13.33bc	26.67bcd	43.33cde
T_5	10.00cd	16.67bc	33.33bcd	43.33cde
T_6	10.00cd	20.00bc	43.33b	60.00b
T_7	13.33bc	20.00bc	43.33b	53.33bc
T_8	20.00b	26.67b	33.33bcd	46.67bcd
T_9	10.00cd	16.67bc	36.67bc	56.67bc
T_{10}	33.33a	53.33a	83.33a	96.67a

The effect of different treatments showed considerable variations in terms of yield and yield contributing characters of tomato. Plant height of tomato under different treatments varied from 70.33 to 91.33 cm. The tallest plants were found in T_1 and the shortest plants were found in T_{10}. The other treatments were also showed significant result in comparison to control. Similar result was also found in case of shoot and root length of tomato. The fresh shoot weight of tomato varied from 214.7 to 321.7 g, where the highest and lowest values were recorded from T_1 and T_{10}, respectively. Similar result was also recorded in case of fresh shoot and fresh root weight of tomato (Table

Table 2: Effect of different treatments on the growth parameters of tomato at 85 DAT (days after transplanting)

Treatments	Plant height (cm)	Shoot length (cm)	Root length (cm)	Fresh plant weight (g)	Fresh shoot weight (g)	Fresh root weight (g)
T_1	97.50 a	70.67a	26.83a	350.0a	335.3a	14.67a
T_2	91.33b	70.67a	20.67b	321.7b	311.5b	10.22b
T_3	84.00c	65.10bc	18.90c	315.0c	305.6b	9.40c
T_4	90.33b	69.00ab	21.50b	317.3bc	306.7b	10.65b
T_5	80.00de	62.67cd	17.17d	267.3d	258.9c	8.40d
T_6	82.67cd	65.83bc	16.83d	252.3f	243.8e	8.50d
T_7	77.67e	60.33d	17.17d	259.7e	250.2d	9.47c
T_8	77.33e	58.00d	19.33c	270.7d	262.8c	7.87e
T_9	83.00cd	65.33bc	17.50d	249.7f	242.4e	7.20f
T_{10}	70.33f	60.00d	13.67e	214.7g	208.7f	6.00g

2). Dry plant weight of tomato varied from 26.33 to 45.60 g. The highest dry plant weight was found in T_1, which was followed by T_2 and T_4. The lowest dry plant weight was recorded in T_{10}. Similar result was also recorded in case of dry shoot and dry root weight. Significantly, the highest yield of 3.90 kg plant^{-1}, 19.50 kg plot^{-1} and 32.50 t ha^{-1} was recorded from T_1.The second highest yield was obtained from T_2, which was statistically similar to T_4. The grain yield obtained from T_5 and T_6 was statistically similar but significantly higher as compared to control. The lowest yield was obtained from T_{10} (Table 3). Correlation and regression analysis revealed that significant and positive correlations exist between different DAT and wilt incidence (Figure 1). Wilt incidence was increased with the increase of DAT.

Table 3: Effect of different treatments on the growth parameters and yield of tomato at 85 DAT (days after transplanting)

Treatments	Dry plant weight (g)	Dry shoot weight (g)	Dry root weight (g)	Yield plant^{-1} (kg)	Yield plot^{-1} (kg)	Yield (t ha^{-1})
T_1	45.60a	41.68a	3.92a	3.90a	19.50a	32.50a
T_2	40.58b	37.45b	3.13c	2.95c	16.00b	26.67b
T_3	35.60c	32.76c	2.84d	2.53d	13.00c	21.67c
T_4	40.87b	37.54b	3.33b	3.17b	17.00b	28.33b
T_5	35.42cd	32.72c	2.70e	2.32e	9.20de	15.33de
T_6	32.37e	29.87d	2.49fg	2.10f	9.00de	15.00de
T_7	34.30d	31.91c	2.39g	2.27e	10.57d	17.61d
T_8	30.32f	28.06e	2.25h	2.50d	13.37c	22.28c
T_9	32.20e	29.63d	2.57f	2.03f	8.80e	14.67e
T_{10}	26.23g	24.22f	2.02i	0.30g	1.10f	1.83f

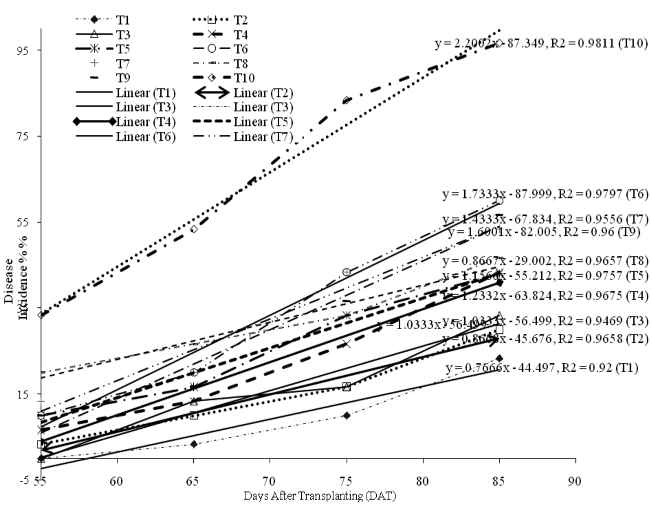

Figure 1: Relationship between DAT and wilt incidence

Findings of the present investigation are in agreement with the findings of Faruq et al., 2006 who found that soil application of saw-dust, *Trichoderma harzianum* T_{22}, Furadan 5G suppressed the wilt incidence of egg-plant and increased fruit yield by 622.08, 605.54, 526.25 and 501.67, respectively over control. The effect of bio-agent and different soil amendments on wilt of tomato as observed in the present study was similar to that obtained by Hossain et al., 2006. They observed that application of saw-dust, Furadan 5G, grafting and *T. harzianum* T_{22} showed the highest effect against the wilt pathogens where no wilt and gall incidence were observed even at 85 DAT and also enhanced fruit yield over control. Contribution of the highest yield by *T. harzianum*, poultry waste and vermin-compost treatment might be due to the increase in the suppressive nature as well as organic matter in the soil. The findings in the present study are also in agreement with the findings of several other workers (Bari, 2001; Prasad et al., 2002; Pandey et al., 2005). Bari (2001) stated that *T. harzianum* showed antagonistic effect to *Fusarium* and *Meloidogyne* spp. of egg-plant and tomato. *T. harzianum* is a non-pathogenic fungus that captures the root zone for its profuse growth and competes with the pathogenic micro-organisms for space and nutrition. Sometimes *T. harzianum* secretes some toxins and enzymes injurious to pathogenic organisms. Moreover, it can directly parasitize other soil borne pathogens. This myco-parasitism might be the reason of controlling wilt pathogens by *T. harzianum*. Prasad et al. (2002) conducted an experiment to control wilt disease of pigeon-pea by bio-agent and found that *T. harzianum* resulted in 22 to 35.3% disease reduction for soil treatments even at the highest pathogen density (log 5.34). In seed treatment plots, disease control ranged between 4.36 and 13.7%. In general, soil application of *T. harzianum* was found to be more effective than seed treatment for disease suppression. Pandey et al. (2005) conducted a pot experiment in greenhouse condition to study the management of root-knot nematode and Fusarium wilt infesting chick-pea and found that soil application with *Trichoderma viride* and neem oil cake showed better performance in controlling the wilt of chick-pea, and increased yield and yield contributing characters.

4. Conclusion

From the findings of the present investigation it can be concluded that *Trichoderma harzianum*, poultry waste and vermicompost showed better performance against wilt disease among the treatments tested in the investigation.

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