Efficacy of soil application with *Trichoderma harzianum* T22 and some selected soil amendments on Fusarium wilt of eggplant (*Solanum melongena* L.)


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**Abstract**

Field experiments were carried out at the field of Sher-e-Bangla Agricultural University farm during 2011-2012 cropping season to test the efficacy of *Trichoderma harzianum* T22 and some selected soil amendments viz. poultry waste, coco-dust, vermi-compost, ash, saw-dust, khudepana (*Azolla pinnata*), cowdung and solarized sand against Fusarium wilt disease of eggplant. The treatments were applied in the soil at 15-30 days before transplanting. Wilt incidence was recorded from 55 DAT to 95 DAT. 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. Poultry waste and vermi-compost also showed promising performance against the disease. The applied treatments enhanced plant growth and increased fruit yield over untreated control. Poultry waste treated plot showed best growth performance and gave highest yield followed by vermi-compost, *Trichoderma harzianum* and coco-dust treated plot. A significant and positive correlation was existed between days after transplanting and wilt incidence.

**Key words:** Eggplant, *Fusarium* wilt, soil amendments, *Trichoderma harzianum*

**Introduction**

Eggplant or Brinjal (*Solanum melongena* L.) belongs to the family Solanaceae, is native to the Indian subcontinent and now it is present all over the world (Yiu, 2006; Doijode, 2001). Worldwide production area of eggplant is approximately 1.6 million ha and production is nearly 4.2 million tons (FAO, 2012). More than 1,600,000 ha are devoted to the cultivation of eggplant in the world. In Bangladesh, 8 million farmers grow eggplant in around 50,000 hectares land with an annual production of 350,000 tonnes (BBS, 2012-2013). Fusarium oxysporum f. sp. melongena, is a soil inhabiting fungus responsible for Fusarium wilt of eggplant is very common in the eggplant growing areas and can cause severe yield loss. Eggplant is susceptible to several diseases particularly Fusarium wilt; Verticillium wilt and Bacterial wilt (Kalloo and Berg 1993; Sihachak et al. 1994; Chakraborty, 2005).

Although the use of Fusarium-resistant eggplant cultivars can provide some degree of control of this 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. melongena. Root-knot nematode infection makes Fusarium wilt resistant variety more susceptible to the fungus because of physiological changes in the root. The wilt diseases are generally controlled in eggplant 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 recommended management methods against the wilts are the rotation of crops, use of resistant varieties, solarization, soil sterility and use of fungicides (Yucel et al., 2007) and application of sawdust, *Trichoderma harzianum* T22 and grafting of eggplant with wild Solanum (*Solanum sisymbriifolium*) could be used as eco-friendly approach and may be advised to the farmers for management of wilt diseases and profitable production of eggplant (Ahmmed, 2012). Chemical control of wilt disease is very difficult and not environmentally sound. Therefore, alternative control measures are necessary and need to be made available as soon as possible.

Biological control has potential for the management of wilt diseases by developing suppressiveness of soil. A variety of soil microorganisms have demonstrated their role in the control of various soil borne plant pathogens. Antagonists recovered from the Fusarium wilt suppressive soils, especially non-pathogenic F. oxysporum, have been used to reduce Fusarium wilt diseases of 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). Trichoderma spp. are considered as potential bio-control and plant growth promoting agents for many crop plants (Verma et al., 2007; Bai et al., 2008; Savazzini et al., 2009; Abdel-Monaim, 2014). Trichoderma harzianum and T. viride specifically were found to have reduced the incidence of wilt disease effectively up to 86% and 83%, respectively (Chakraborty et al., 2009).

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 eggplant and have potential for effective implementation in commercial agriculture have not yet been identified. Management of wilt diseases of eggplant 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 eggplant.

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 2011-2012 cropping season. Unit plot size was 3x1m², maintaining a distance of 75 cm from plant to plant and 1 m from row to row. Eggplant variety BARI Begun 5 (Nayan Tara) was used for the experiment. Ten different treatments, viz. T₁ = Soil application with Trichoderma harzianum; T₂ = Soil application with poultry waste; T₃ = Soil application with coco-dust; T₄ = Soil application with vermi-compost; T₅ = Soil application with ash; T₆ = Soil application with saw-dust; T₇ = Soil application with khudepana (Azolla pinnata); T₈ = Soil application with cow dung; T₉ = Soil application with solarized sand; and T₁₀ = Control (untreated) were assessed in the experiment. An effective isolate of Trichoderma harzianum T₂₂ was used in this experiment.

The antagonistic Trichoderma harzianum T₂₂ were mass multiplied in PDA media incubated at 25°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 10⁶ colony forming unit ml⁻¹ (cfu/ml). 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 inoculums throughout the soil. Seed treatment with bio-agent was done by dipping the seeds in the fungal suspension for one hour. After treatment, the seeds were allowed to air dry for six hours. Soil amendments were applied on the seed bed followed by main field and left for 15-30 days for each case for proper decomposition, growing antagonistic microorganisms and developing suppressiveness.

Fusarium oxysporum f. sp. melongenae was grown on PDA (Potato Dextrose Agar) medium at 25°C temperature. After sporulation (in about 15-20 days), 5 ml sterile water was added in each plate and the spore masses was scraped away with sterile needle / scalpel. The conidial suspension thus made with additional water was then blended in a Moulinex blender for 2 minutes in medium speed and filtered through sterile cheesecloth, adjusted the concentration 1.2 X 1⁰ conidia / ml solution. Then, inoculation done at the root zone of plant by drenching of spike suspension @ 250ml / plant with the help of compressed air hand sprayer following pulverized the soil to mix up the Fusarium oxysporum spores thoroughly to the soil. Inoculation was done at 30 days after transplanting (DAT) (Faruq et al., 2006).

Data on incidence of wilt were recorded at 55, 65, 75, 85 and 95 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).

Results and Discussion

Effect of different treatments on Fusarium wilt incidence of eggplant

The effect of different treatments on Fusarium wilt of eggplant is shown in Figure 1. At 55 DAT (days after transplanting), no wilt incidence was recorded from Trichoderma harzianum T₂₂ applied plot (T₁) whereas the highest wilt incidence (30%) was recorded from control plot (T₁₀). The wilt incidence in T₂, T₃, T₄ and T₅ was statistically similar and significantly lower as compared to other treatments. At 65 DAT, the lowest wilt incidence (10%) was in T₁ followed by T₂ and T₃ (20%). The highest disease incidence was in control plot (43.33%). The treatment T₄, T₅ and T₆ gave same wilt incidence (30%) which was statistically similar with T₇ and T₈. At 75 DAT, the highest effect, i.e. lowest wilt incidence was found in T₄ (20%) which was statistically similar with T₂ (26.67%) and followed by T₃ (30%) and T₅ (30.33%). The highest wilt incidence was recorded in T₁₀ (60%). The wilt incidence in the treatments was same in T₆, T₇ and T₈. At 85 DAT, the lowest wilt incidence was found in T₁ (33.33%) which was statistically identical with T₂ (36.67%) whereas the highest 80% wilt incidence was found in control plot T₁₀. Finally at 95 DAT, the lowest wilt incidence (40%) was also
found in *Trichoderma harzianum* T22 applied plot T1, which was statistically identical with T2 (46.67%). The highest 100% wilt incidence was observed in control plot T10. The wilt incidence in T3 and T5 showed statistically similar result. Poultry waste, coco-dust, vermi-compost and solarized sand showed moderate effect against the wilt diseases.

**Effect of different treatments on growth characters of Eggplant**

The effect of different treatments showed considerable variations in terms of growth and yield contributing characters of eggplant (Table 1). Plant height of eggplant under different treatments varied from 103.7 to 125.3 cm. The tallest plants were found in T2 followed by T1 and T3 (120.7 cm) and the shortest plants were found in T10. The other treatments also showed significant result in comparison to control. Similar results were also found in case of shoot and root length of eggplant. Shoot length was varied from 77.33 to 93.83 cm and root length was varied from 24.33 to 31.50 cm. In both cases highest length was found in poultry waste applied field. The fresh shoot weight of eggplant varied from 111.7 to 241.7 g, where the highest and lowest values were recorded from T2 and T10, respectively. Similar result was also recorded in case of fresh root weight of eggplant. Dry shoot weight of eggplant varied from 27.33 to 44.67 g. The highest weight was found in T2, which was followed by T4 and T1 where the lowest weight was recorded in T10. Similar result was also recorded in case dry root weight.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Plant Height (cm)</th>
<th>Shoot length (cm)</th>
<th>Root length (cm)</th>
<th>Fresh shoot weight (g)</th>
<th>Fresh root weight (g)</th>
<th>Dry shoot weight (g)</th>
<th>Dry root weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>120.7b</td>
<td>91.83a</td>
<td>28.83b</td>
<td>209.0 c</td>
<td>71.00c</td>
<td>37.67 c</td>
<td>17.67 c</td>
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<tr>
<td>T2</td>
<td>125.3 a</td>
<td>93.83a</td>
<td>31.50a</td>
<td>241.7 a</td>
<td>80.00a</td>
<td>44.67 a</td>
<td>24.33a</td>
</tr>
<tr>
<td>T3</td>
<td>120.7b</td>
<td>92.33a</td>
<td>28.33b</td>
<td>184.0 d</td>
<td>62.67d</td>
<td>36.67 c</td>
<td>14.67d</td>
</tr>
<tr>
<td>T4</td>
<td>116.3 c</td>
<td>85.83b</td>
<td>30.33a</td>
<td>229.0b</td>
<td>76.33b</td>
<td>41.67 b</td>
<td>21.00b</td>
</tr>
<tr>
<td>T5</td>
<td>113.7d</td>
<td>86.17b</td>
<td>26.33c</td>
<td>156.7f</td>
<td>57.67 e</td>
<td>34.67 d</td>
<td>13.33de</td>
</tr>
<tr>
<td>T6</td>
<td>113.7d</td>
<td>86.7b</td>
<td>27.50bc</td>
<td>178.0e</td>
<td>59.33e</td>
<td>33.33d</td>
<td>13.00e</td>
</tr>
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<td>113.7d</td>
<td>85.83b</td>
<td>28.00 b</td>
<td>140.0h</td>
<td>51.67f</td>
<td>30.67 e</td>
<td>13.67d</td>
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<td>82.00c</td>
<td>26.67 c</td>
<td>152.3g</td>
<td>48.33g</td>
<td>29.67 e</td>
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<tr>
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<td>105.7 f</td>
<td>77.33e</td>
<td>28.33 b</td>
<td>122.3i</td>
<td>60.00e</td>
<td>30.00 e</td>
<td>13.67de</td>
</tr>
<tr>
<td>T10</td>
<td>103.7g</td>
<td>79.33d</td>
<td>24.33 d</td>
<td>111.7j</td>
<td>42.33h</td>
<td>27.33 f</td>
<td>11.67f</td>
</tr>
</tbody>
</table>

*T1 =* *Trichoderma harzianum*; *T2 =* Poultry waste; *T3 =* Coco-dust; *T4 =* Vermi-compost; *T5 =* Ash; *T6 =* Saw-dust; *T7 =* Khudepana; *T8 =* Cow dung; *T9 =* Solarized sand; and *T10 =* Control (untreated)
Effect of different treatments on yield of Eggplant

The effect of different treatments showed considerable variations in terms of yield (Figure 2). The highest yield of 17 kg plot$^{-1}$ and 17 t ha$^{-1}$ was recorded from poultry waste treated plot (T$_2$). The second highest yield (14.5 t/ha) was obtained from vermi-compost treated plot (T$_4$), which was closely followed by T$_1$ (12.33 t/ha) and T$_3$ (10.33 t/ha). The lowest yield was obtained from control plot T$_{10}$ followed by T$_9$, T$_6$, T$_5$ and T$_7$.

Correlation and regression study

Correlation and regression analysis revealed, there is a significant and positive correlations exist between different days after transplanting (DAT) and wilt incidence. Wilt incidence was increased with the increase of days after transplanting (Figure 3).

The experimental findings revealed that, bio agent *Trichoderma harzianum* T$_{22}$ showed tremendous performance in controlling wilt incidence of eggplant. The growth performance like plant height, shoot and root length, fresh shoot and root weight, dry shoot and root weight were positively influenced by the soil application of this bio agent. Soil amendments viz. poultry waste, coco-dust and vermi-compost had remarkable effect on growth performance and yield.
They also showed better effect against wilt pathogen in reducing wilt incidence. All the growth parameters of the plant prominently increased in comparisons to control that contribute a good harvest. These soil amendments not only suppressed the wilt pathogen but also acted as organic matter in the soil. The performance of the application of cow dung, ash, saw dust and khudepana are not so remarkable but far better then control. The reason for the control of wilt incidence by bio agent and soil amendments might be due to the influence of antagonists of the soil that acts against the wilt pathogens.

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 T22, Furadan 5G suppressed the wilt incidence of eggplant 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 eggplant as observed in the present study was similar to that obtained by Islam et al., 2010. They observed that application of T. harzianum, poultry waste and vermi-compost showed the highest effect against the wilt pathogens of tomato where the lowest wilt incidence were observed even at 95 DAT and also enhanced fruit yield over control. Contribution of the highest yield by T. harzianum, poultry waste and vermi-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 eggplant and tomato. T. harzianum is a non pathogenic fungus that captures the root zone for its profuse growth and competes with the pathogenic microorganisms 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 from 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.

**Conclusions**

From the findings of the present investigation it can be concluded that *Trichoderma harzianum*, poultry waste and vermi-compost showed promising performance against wilt disease among the treatments tested in this investigation. These bio-fungicide and soil amendments could be used as an eco-friendly approach and may be advised to the farmer for profitable organic farming.

**References**


