EFFECT OF COMPOSTED ORGANIC AMENDMENTS ON THE INCIDENCE OF BACTERIAL WILT OF TOMATO

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Abstract. Suppression of bacterial wilt of tomato (Lycopersicon esculentum Mill) by various composted organic amendments was evaluated in greenhouse experiments. Soil infested with Pseudomonas solanacearum Smith was collected from the base of infected tomato plants from 2 commercial farms in Gadsden County, Fla. 'Bonny Best' tomato seedlings were transplanted into pots containing infested soil and composted amendments. Incidence of bacterial wilt in one soil was reduced from 70% to 45% upon addition of mushroom compost. With the second soil, incidence was reduced from 30% to 15% upon addition of yard waste co-composted with 10% poultry broiler litter or mushroom compost, and from 30% to 10% with composted yard waste alone. Addition of yard waste co-composted with 25% cow manure or composted sewage sludge with wood chips added as a bulking agent did not reduce the incidence of bacterial wilt in either infested soil. The relationship between bacterial wilt, organic carbon content, and soil pH was examined using stepwise regression analysis. Soil pH accounted for a significant portion of the explainable variation in disease with one soil, while organic carbon content accounted for a significant portion of the variation in disease with the second soil. The results suggest that the effect of composted organic amendments on bacterial wilt of tomato were mediated by several factors and are site specific.

Bacterial wilt of tomato is caused by the plant pathogenic bacterium Pseudomonas solanacearum Smith. Pseudomonas solanacearum is indigenous to the soils of the southeastern USA, and major epidemics of bacterial wilt of tomato have occurred on crops planted for the first time on virgin soils (Jaworski and Morton, 1964; Dukes et al., 1965). Bacterial wilt of tomato was first reported in Florida in 1897 (Rolfs, 1898). Although the disease is considered to be of minor importance to the overall production of tomatoes in Florida (Sonoda et al., 1979), severe epidemics have been reported in western and southeastern Florida (Cox, 1959; Walter, 1967). In the north Florida tomato production area, centered around Quincy, crop losses due to bacterial wilt have been so severe that entire fields have been abandoned (senior authors observation).

Disease management techniques have concentrated on the development of resistant cultivars (Sonoda et al., 1979). Tomato cultivars with both high resistance to P. solanacearum and good horticultural characteristics are not yet available for Florida. Soil fumigation does not provide acceptable levels of season-long disease control (Enfinger et al., 1979). The existence of soils that suppress epidemics of bacterial wilt of tomato has been documented (Bereau and Messiaen, 1975; Nesmith and Jenkins, 1983; Ho et al., 1988; Hopkins and McCarter, 1988). Incorporation of various organic and inorganic materials into soil infested with P. solanacearum has been shown to suppress bacterial wilt of tomato in China (Sun and Huang, 1985) Taiwan (Hartman and Yang, 1990) and Guadeloupe (Prior and Beramis, 1990). The purpose of this study was to evaluate the effect of various composted organic soil amendments on bacterial wilt of tomato using naturally infested field soil from north Florida.

Materials and Methods

Infested soil was obtained from 2 tomato farms, designated farm H and farm W, located in different sections of Gadsden County, Florida. Both farms had been planted to tomato in July of 1991, and by Oct. 1991, the incidence of bacterial wilt was greater than 50% on both farms. In Nov. 1991, soil was collected from the base of infected plants on each farm, passed through a 1-cm screen to remove plant debris, and stored in plastic containers. Soil from farm H was a Carnegie loamy fine sand (Thomas, 1961) and is characterized as a Plinthic Paleudult, clayey kaolinitic thermic. Soil from farm W was a Ruston loamy sand and is characterized as Typic Kandiudult, fine-loamy siliceous thermic.

The inoculum density of soil samples was determined using a soil dilution plating technique that included modification of a medium selective for P. solanacearum (McLaughlin and Sequeira, 1988). The modified medium, designated SM-3T, consists of antimicrobial compounds added to Kelman's tetrazolium chloride agar medium (Kelman, 1954) as follows: tyrothricin (0.02 g/liter), chloramphenicol (0.005 g/liter), cycloheximide (0.05 g/liter), crystal violet (0.0125 g/liter), and polymyxin B sulfate (0.1 g/liter).

Infested soil from each farm was mixed in a 1:1 ratio (v/v) with either composted yard waste, yard waste co-composted with 10% poultry broiler litter, yard waste co-composted with 25% cow manure or pasteurized Tifton loamy fine sand. Infested soil was also mixed in a 5:3:2 ratio with pasteurized Tifton loamy fine sand and either mushroom compost or composted sewage sludge with wood chips added as a bulking agent.

Three-week-old 'Bonny Best' tomato seedlings were transplanted into 10-cm pots containing the different compost treatments. Pots were placed in the greenhouse, and the incidence of bacterial wilt was monitored over a 30 to
42 day period. Ten pots were used for each compost treatment and the experiment was performed twice. In the first experiment, plants were fertilized weekly with a soluble 20N-8.6P-16.6K fertilizer at a rate of 1.4 g per liter of water. In the second experiment, the plants were not fertilized.

The organic carbon content in each compost treatment was determined using the Walkley-Black procedure (Nelson and Sommers, 1982). Soil pH was determined for each compost treatment using a 2:1 suspension of deionized water and soil.

Analysis of variance was performed on disease incidence data. Stepwise multiple regression analysis was used to regress disease incidence on soil pH and percent organic matter (SAS Institute, 1988). Alphas for independent variables to enter and exit the analyses were both 0.15.

**Results and Discussion**

The pH of infested soil from farm H ranged from 4.8 with the composted sewage sludge treatment to 6.4 with the mushroom compost treatment (Table 1). Organic carbon content ranged from 4.0% in unamended soil to 10.9% in the composted yard waste treatment. Disease incidence ranged from 45% with the mushroom compost treatment to 85% with the composted yard waste + poultry litter treatment.

The pH of infested soil from farm W ranged from 4.8 with the composted sewage sludge treatment to 6.7 with the mushroom compost treatment (Table 1). Organic carbon content ranged from 1.2% with unamended soil to 7.3% with the composted yard waste + 25% cow manure treatment. Disease incidence ranged from 10% with the composted yard waste treatment to 50% with the composted sewage sludge.

Inoculum densities were $7.6 \times 10^4$ and $1.2 \times 10^4$ in the infested soils from farm H and W, respectively. Disease incidences with all treatments were substantially higher with infested soil from farm H than from farm W (Figure 1). Higher disease levels were probably due to an almost 10-fold higher inoculum density at farm H than farm W.

The composted organic amendments affected disease incidence differently on the 2 soils. Disease incidence in infested soil from farm H was suppressed only by the use of mushroom compost (Figure 1). However, the suppression was not significant at $P = 0.05$ (Table 1). Disease incidences with all other compost treatments and with the unamended soil were very high. With soil from farm W, three treatments suppressed the incidence of disease when compared with the unamended control (Table 1). Disease incidence with the composted sewage sludge treatment was twice as high as with unamended soil and was significantly greater than with mushroom, yard waste and yard waste with 10% poultry broiler litter.

![Figure 1. Incidence of bacterial wilt of tomato in naturally infested soils amended with various organic compost treatments. Treatments include composted yard waste, yard waste co-composted with 10% poultry broiler litter (PBL), yard waste co-composted with 25% cow manure (CM), mushroom compost, or composted sewage sludge with wood chips added as a bulking agent. A-soil collected from farm H, B-soil collected from farm W.](image-url)

<table>
<thead>
<tr>
<th>Compost treatment</th>
<th>pH</th>
<th>Organic carbon (%)</th>
<th>Disease incidence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm H</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yard waste + 10% poultry litter</td>
<td>6.3</td>
<td>9.0</td>
<td>85 a</td>
</tr>
<tr>
<td>Yard waste</td>
<td>5.9</td>
<td>10.9</td>
<td>75 a</td>
</tr>
<tr>
<td>Yard waste + 25% cow manure</td>
<td>6.3</td>
<td>8.8</td>
<td>75 a</td>
</tr>
<tr>
<td>Sewage sludge</td>
<td>4.8</td>
<td>5.2</td>
<td>70 a</td>
</tr>
<tr>
<td>Control</td>
<td>5.3</td>
<td>4.0</td>
<td>70 a</td>
</tr>
<tr>
<td>Mushroom</td>
<td>6.4</td>
<td>4.4</td>
<td>45 a</td>
</tr>
<tr>
<td>Farm W</td>
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<td></td>
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</tr>
<tr>
<td>Sewage sludge</td>
<td>4.8</td>
<td>4.8</td>
<td>50 a</td>
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<tr>
<td>Yard waste + 25% cow manure</td>
<td>6.4</td>
<td>7.3</td>
<td>30 a</td>
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<tr>
<td>Control</td>
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<td>1.2</td>
<td>25 ab</td>
</tr>
<tr>
<td>Yard waste + 10% poultry litter</td>
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<td>6.9</td>
<td>15 b</td>
</tr>
<tr>
<td>Mushroom</td>
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<tr>
<td>Yard waste</td>
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<td>7.1</td>
<td>10 b</td>
</tr>
</tbody>
</table>

*Means followed by the same letter are not significantly different at $P = 0.05$ according to Duncan's multiple range test.

*Disease ratings were made 30 to 42 days after transplanting 'Bonny Best' into pots containing infested soil and compost treatments.*

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Stepwise regression analysis indicated that on soil collected from farm H, organic carbon content explained 48% of the variation in disease incidence (Table 2) but soil pH had no significant effect on the $R^2$ value. However, the soil pH of soil from farm W accounted for 57% of the variation in disease incidence but organic carbon content did not significantly increase the models $R^2$ value.

The effect of composted organic amendments upon bacterial wilt of tomato appeared to be site specific. Biological diversity of *P. solanacearum* strains from the two sites may account for some of the variability between sites. While Velupillai and Stall (1984) found that variation among Florida strains is not as great as the variation of strains in a world collection, McLaughlin and Sequeira (1989) examined 85 strains collected from a 0.3-ha field near Hastings and concluded that major variation among antibiotic production and sensitivity, pathogenic aggressiveness and carbohydrate utilization occurred even within a localized geographic area. Strains collected from commercial farms in Gadsden County exhibited different fatty acid profiles and varied in their pathogenicity to tomato genotypes representing several sources of resistance (Chellemi et al., 1992).

Reports on the effect of soil physical factors on disease development have been inconsistent. Ho et al. (1988) found that disease increased with increasing soil pH, while Locascio et al. (1988) found that disease decreased with increasing soil pH. Kelman (1950) found that disease decreased with increasing Ca levels in the soil while Jaworski and Morton (1964) could find no relationship between Ca levels and disease. In this study, soil pH had a significant effect on disease with one soil type while organic carbon content had a significant effect with a second soil type. The contradictory effects of soil physical factors on disease may be attributed to their direct influence on the pathogen or host or indirect influence via changes in the composition of antagonistic soil microflora.

It is concluded that composted organic amendments can reduce the incidence of bacterial wilt of tomato but the levels of reduction will be variable and may depend upon site specific soil properties.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Partial $R^2$</th>
<th>Prob &gt; F</th>
<th>Model $R^2$</th>
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</thead>
<tbody>
<tr>
<td>Farm H</td>
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<tr>
<td>Organic carbon</td>
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<tr>
<td>Soil pH</td>
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<tr>
<td>Organic carbon</td>
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<td>0.56*</td>
<td>0.62</td>
</tr>
</tbody>
</table>

*Did not meet the 0.15 significance level for entry into the model.

Literature Cited


