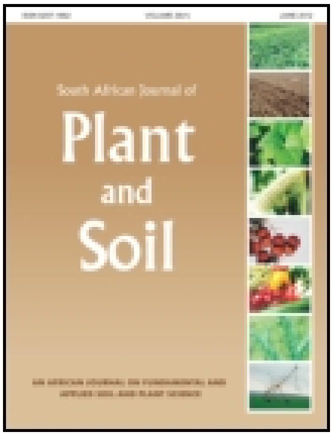

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Impact of soil amendments and weather factors on bacterial wilt and yield of two tomato cultivars in Abeokuta, Nigeria

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Tomato bacterial wilt, caused by *Ralstonia solanacearum*, leads to tomato yield losses of up to 80% in south-western Nigeria. Soil amendments and weather conditions are important in the management of the disease. Field experiments were conducted at the Research Farm of the Federal University of Agriculture, Abeokuta, Nigeria in the late and early rainy seasons of 2006 and 2007, respectively, to evaluate the effects of soil amended with three bactericidal plant materials and prevailing weather conditions on severity of tomato bacterial wilt and yield of two tomato cultivars. The experiment was designed in a split-plot with cultivars as main plot and composts as subplots. Soil amendment with bactericidal plant material reduced mean soil population of *Ralstonia solanacearum* by 4.78 × 10^7 cfu g^{-1} soil, mean wilt incidence by 31.35%, percent severity index by 22.90, and increased tomato yield by 50%. Relationships between disease severity index (*Y*) and cumulative number of rainy days (*X*) in 2006 and 2007 were described, respectively, by linear models $Y = 4.093X - 78.2$ and $Y = 2.593X - 10.81$. Growing tomato on soil amended with bactericidal plant materials under fewer rainy days reduced bacterial wilt and increased yield of tomato.

Keywords: bacterial wilt, fruit yield, soil amendment, tomato, weather factors

Introduction

One of the major constraints of tomato (*Solanum lycopersicum* L.) production in Nigeria, and other parts of sub-Saharan Africa, is attack by pests and diseases, especially fungal and bacterial pathogens (Popoola et al. 2011). Taiwo et al. (2007) reported a total loss of tomato crop from combined infestation of bacterial and fungal pathogens on farmers' fields in Nigeria. Prevalence of bacterial wilt of tomato leading to a loss of about 80% in south-western Nigeria was reported by Adebayo et al. (2009).

Ralstonia solanacearum (Smith) Yabuuchi et al. (syn. *Pseudomonas solanacearum*) race 1 is the soil-borne causal agent of bacterial wilt of more than 50 families of host plants, especially of the solanaceous crops potato and tomato (Thwaites et al. 2000). It is considered a tropical pathogen (EFSA 2008). Prevalence and control of pathogens is linked to variations in weather conditions, most especially temperature, rainfall and relative humidity (Mew and Ho 1977).

Another major consideration in plant disease management is the increasing public interest in protecting the environment and human health. This interest has prompted research in agronomic strategies with reduced requirements for fungicides, bactericides, fertilisers and herbicides (Moulas et al. 2013). Consequently, development of alternative control methods with high efficacy, low cost and limited environmental effects are a high priority for contemporary agriculture (Martin 2003). Organic farming is such an alternative control method.

Organic farmers often use composts as soil amendments, particularly in intensive vegetable production systems, to improve soil fertility and quality and sustain productivity (Maynard 1994). Composts incorporated into soil or planting mixes can provide effective biological control of diseases caused by soil-borne plant pathogens (Coventry et al. 2005), reduce the severity of disease caused by foliar plant pathogens (Tränkner 1992), and improve the systemic ability of plants to resist diseases caused by root and foliar pathogens (Pharand et al. 2002).

Plant materials, usually added in compost amendments, represent a reservoir of effective chemotherapeutants and can provide valuable sources of natural pesticides (Termorshuizen et al. 2007). Reports are also available on the use of several plant by-products, which possess antimicrobial properties on several pathogenic bacteria and fungi (Helsey and Gorham 1992). Satish et al. (1999) reported antimicrobial properties of leaves of such plants as *Lawsonia inermis*, *Aloe vera*, neem (*Azardirachta indica*) and *Mimosa pudica*. Ganiyu et al. (2008) and Popoola et al. (2011) reported bactericidal properties of neem, mango (*Mangifera indica*) and siam (*Chromolaena odorata*) trees.

The objective of this study was to apply compost amended with bactericidal foliage parts of neem, mango and siam trees with a view to controlling bacterial wilt caused by *Ralstonia solanacearum* and improving fruit yield of two tomato cultivars. The study also examined the relationship between weather variables (rainfall, relative humidity, and air and soil temperature), incidence and severity of bacterial wilt, and yield of tomato.

Materials and methods

Experimental site

The experimental site was the Research Farm of Organic Agriculture Project in Tertiary Institutions in Nigeria (OAPTIN), Federal University of Agriculture, Abeokuta, Nigeria (7°15′ N, 3°25′ E; altitude 108 m above sea level). The average annual rainfall in the area is 1 153.4 mm. The rainy season is further subdivided into an early rainy season (May–July) and a late rainy season (September–November). The annual average maximum temperature is 31.1 °C and the average minimum temperature is 23.7 °C. The soil texture of the field plot is a loamy type with 80.6% sand, 6.8% silt and 12.6% clay, pH (H_2O) = 5.6. The bacterial wilt pathogen, *Ralstonia solanacearum*, is endemic to the site, with a previously reported average concentration of 6.22×10^7 colony forming units (cfu) g^{-1} soil sample (Popoola et al. 2011). Soil samples, from a depth of 10–15 cm at the experimental site, were analysed for total nitrogen (N), available phosphorus (P) and exchangeable potassium (K).

Weather data

Weather data for the late rainy season (September–November) of 2006 and the early rainy season (May–July) of 2007 were collected from the Department of Agrometereology and Water Resources Management, Federal University of Agriculture, Abeokuta. Weekly means of rainfall, maximum temperature, minimum temperature, relative humidity, soil temperature and hours of sunshine were calculated from the daily readings obtained. Weekly cumulative number of rainy days and cumulative rainfall were also calculated. The data were statistically analysed by applying the stepwise sequential multiple regression technique (Payne 2008) contained in the GenStat Discovery Edition 3 software (VSN International, Hemel Hempstead, UK). The response variable was the mean percent severity index (PSI) of bacterial wilt assessed at weekly intervals for 11 weeks in both late and early rainy seasons of 2006 and 2007, respectively.

Compost formulation and application

Unamended compost contained cured poultry manure (24%), bush marigold (*Aspilia africana*) (24%), *Leuceana leucocephala* (24%), maize residue (24%) and ashes (4%). Amended compost contained cured poultry manure (24%), bush marigold (24%), *Leuceana leucocephala* (24%), bactericidal plant leaves (24%) (consisting of neem 8%, mango 8% and siam 8%) and ashes (4%).

Materials were left in a $2 \times 2 \times 1$ m pit for eight weeks for full composting, following the technique of Akanbi et al. (2000). Compost was evacuated from the pit and air-dried for two weeks. It was then worked into the soil with a hoe to a depth of 5–8 cm at a rate of 10 t ha^{-1} dry weight. This was done two weeks before transplanting tomato plants into the field. Three samples each of soil and compost were analysed and mean values obtained for pH, N, P and K.

Treatments and experimental design

There were 18 plots, each of $3 \text{ m} \times 3$ m, giving a total area of 162 m^2. The trial was arranged as a thrice-replicated split-plot design, with two tomato cultivars ('UC82B' and 'Beske') in the main plot and types of compost in the subplots, all randomised within the whole plots. 'Beske' is a landrace that is susceptible to bacterial wilt (Nwanguma et al. 2001). 'UC82B' and 'Beske' are commonly cultivated by farmers in northern and south-western Nigeria, respectively.

Tomato seedlings, raised in seed trays in sterilised sandy loam soil, were transplanted to the field at the end of the fourth week, with 50 cm intra-row and 60 cm inter-row spacing between plants. The transplant was done in late August 2006 and late April 2007 to coincide with the late rainy season of 2006 and the early rainy season of 2007, respectively.

There were 25 plants per replicate, giving a total of 75 plants per treatment. Sliced bamboo served as stakes. Weeding was performed regularly. All other cultural practices for growing tomato under field conditions, as practiced by farmers in Nigeria, were followed (Nwanguma et al. 2001).

Identification and quantification of **Ralstonia solanacearum** *in the soil*

Ralstonia solanacearum was identified using a combination of response to triphenyl tetrazolium chloride (TTC), the 3% potassium hydroxide solution (KOH) solubility test, and utilisation of sugar and sugar alcohol in Hayward's medium (Hayward 1964).

A soil sample (10 g), from pooled samples of sandy loam soil collected from the root region (10–15 cm soil depth) of infected tomato planted along the row, was suspended in 90 ml sterile water and shaken on a platform shaker for 20 min. The supernatant collected from the settled suspension was subjected to serial dilution. Aliquots (0.1 ml each) of supernatants from the dilution series were spread on replicated plates of TTC agar medium and incubated at 28 °C for 48 h in accordance with the method of Pradhanang et al. (2000). *Ralstonia solanacearum* colonies were distinctively bold, fluidal and creamy-white on the medium, turning characteristic reddish in the centre and whitish at the periphery of the TTC agar after 48 h incubation.

The KOH solubility test was performed by placing two to three drops of 3% KOH on a glass slide, following the procedure of Fahy and Hayward (1983). Colonies of *R. solanacearum* were selected with a clean wire loop and smeared into the KOH solution on the glass slide for 5–10 s. A viscous sticky solution on the loop indicated that the organism was Gram-negative.

Utilisation of sugar and sugar alcohol was observed in Hayward's basal medium (1 g $(NH_4)_2H_2PO_4$, 0.2 g KCl, 0.2 g $MgSO_4.7H_2O$, 0.3 g bromothymol blue [1%, w/v], 1.5 g agar, 11 g distilled water) as described by Hayward (1964). The pH was adjusted to 7.1 with 40% (w/v) NaOH solution before addition of the agar. A 5 ml quantity of each filter-sterilised solutions of hexose alcohol (mannitol, sorbitol and dulcitol) and dissacharides (cellobiose, lactose and maltose) was added to 45 ml of molten cooled sterilised Hayward's basal medium, and 10 ml of the resulting amended medium was dispensed into sterile test tubes (Hayward 1964) with five replicates. Hayward's medium without a sugar or sugar alcohol carbon source served as the control. The test tubes containing Hayward's medium were inoculated with a single colony of *R. solanacearum,* incubated at 30 °C and checked for acid production (colour change from green to yellow) at various intervals for up to five weeks (He et al. 1983).

Quantification of *R. solanacearum* was through colony counts recorded 48 h after inoculation and repeated two and six weeks after compost application (WACA). The two weeks after compost application corresponded to the time of transplanting. Average colony counts were multiplied by the dilution factor and the results expressed as cfu per gram soil sample.

Disease assessment

Bacterial wilt incidence was assessed as percentage of wilted plants within each treatment. It was calculated in accordance with the formula provided by Getachew et al. (2011), namely $I = \text{NPSWS}/\text{NPPT} \times 100$, where I = wilt incidence, NPSWS = number of plants showing wilt symptoms, and NPPT = number of plants per treatment.

Symptom development was evaluated at weekly intervals up to 11 weeks after transplanting. Severity of wilting was ranked following a modified scale of He et al. (1983): 0, no symptoms; 1, one leaf wilted; 2, two or three leaves wilted; 3, four or more leaves wilted; 4, whole plant wilted; and 5, death (collapse) of the whole plant.

The PSI was calculated using the method described by Cooke (2006): PSI = $\sum$(scores $\times$ 100)/(number of plants rated $\times$ maximum scale of the scores) for each scoring date.

Assessment of fruit yield

Tomato fruit were periodically harvested and weighed. Yield (kg plot^{-1}) was converted to tons per hectare.

Statistical analysis

Effects of compost types on percentage incidence (I) of bacteria wilt, PSI and yield (tons ha^{-1}) of the two cultivars of tomato during the early rainy season of 2006 and late rainy season of 2007 were analysed by analysis of variance with GenStat 7th Edition version 7.2.2.222 (VSN International, Hemel Hempstead, UK, 2008). Means showing significant differences were separated using the least significant difference (LSD) test at 5%.

Results

Chemical characteristics of soil and compost

The pH, total N, available P and exchangeable K in the soil and compost (amended and unamended) are shown in Table 1. The pH of the soil was acidic (5.6), whereas the pH of the amended and unamended compost was alkaline (8.2 and 8.1, respectively). Total N, available P and exchangeable K were all significantly lower ($p \leq 0.05$) in the soil than in the two composts.

Identification of **Ralstonia solanacearum**

Ralstonia solanacearum cultured on TTC agar medium was observed to produce fluidal colonies with a reddish centre and whitish periphery after incubation at 25 °C for 48 h. The colonies were Gram-negative in the KOH test. The bacterium changed the colour of Hayward's medium containing mannitol, sorbitol, dulcitol, cellobiose, lactose and maltose from green to yellow, confirming not only the identity of the pathogen but also classifying the pathogen as biovar 3.

Effect of compost application on soil population of **Ralstonia solanacearum**

The population of *R. solanacearum* was significantly reduced ($p \leq 0.05$) by an average of 4.68×10^7 cfu g^{-1} soil in amended compost at 6 WACA over the two seasons under study. At 2 WACA, a lesser reduction in the pathogen population (1.51×10^7 cfu g^{-1} soil) was observed (Table 2) over the same period of two seasons. There was no significant difference ($p \leq 0.05$) in the soil population of *R. solanacearum* at 2 WACA in the three treatments.

Percentage incidence (I) and PSI were significantly lower ($p \leq 0.05$) in soil containing amended compost (Table 3). This reduction in incidence and severity of wilt was observed in both cultivars. From the mean values, application of compost containing bactericidal plant materials led to an average reduction of 32.3% in disease incidence and 23.3% in severity index for 'Beske' when compared with plants treated with soil containing no compost. For 'UC82B', reductions of 30.5% in disease incidence and 22.5% in severity index were observed. There was no significant difference in incidence and severity of bacterial wilt in tomato plants grown in soil containing no compost and in soil containing unamended compost. There was no significant difference ($p < 0.05$) in both cultivars with respect to disease incidence and severity.

Relationship between weather variables and percent severity indices of bacterial wilt

There were more rainy days in 2006 (highest cumulative rainy days, $X_8 = 25.13$) than in 2007 (highest cumulative rainy days, $X_8 = 14.38$), and the difference was significant at $p \leq 0.05$ (Table 4). Also significant were the differences in sunshine of 1.15 h d^{-1} in 2006 and 3.43 h d^{-1} in 2007; the PSI was significantly higher in 2007 (26.46%) than that in 2006 (24.58%) (Table 4).

Stepwise multiple regression analysis of the combined effect of all weather parameters (Table 5) showed that cumulative number of rainy days (X_8) contributed positively and significantly to the development of bacterial wilt.

Table 1: Chemical properties of the soil and compost

Soil/compost	pH	Total nitrogen (%)	Available phosphorous (%)	Exchangeable potassium (%)
Soil	5.6	0.03	0.02	2.57
Unamended compost	8.1	0.49	11.67	14.04
Amended compost	8.2	0.46	12.60	15.21
$LSD_{0.05}$	0.2	0.22	1.30	1.43

Fixing the most significant explanatory variable (X_8) into a model with the response variable (PSI, represented by Y) produced two models (Figures 1 and 2), one each for the late rainy season of 2006 and the early rainy season of 2007.

In the late rainy season of 2006, four weather parameters were positively and significantly correlated with the PSI of bacterial wilt, namely cumulative number of rainy days (X_8), maximum temperature (X_2), cumulative rainfall (X_9) and soil temperature at 20 cm (X_6). In the early rainy season of 2007, three weather parameters were positively and significantly correlated with the PSI, namely relative humidity (X_5), cumulative rainfall (X_9) and cumulative number of rainy days (X_8). The model for the late rainy season of 2006 was $Y = 4.093X_8 - 78.2$ ($R^2 = 0.888$, $p \leq 0.001$), and the model for the early rainy season of 2007 was $Y = 2.593X_8 - 10.81$ ($R^2 = 0.958$, $p \leq 0.001$), where Y = percent severity index of bacterial wilt and X_8 = cumulative number of rainy days (Figures 1 and 2).

Effect of cultivar, compost and weather on fruit yield

The early rainy season of 2007 recorded a higher yield in both cultivars (Table 6). The highest yield of 22.74 t ha^{-1} was recorded for 'Beske' grown in soil amended with compost containing bactericidal plant material in the early rainy season of 2007. The lowest yield recorded (0.74 t ha^{-1}) was recorded for 'UC82B' grown in soil with no added compost in the late rainy season of 2006. Soil

Table 2: Reduction in soil *Ralstonia solanacearum* (*Rs*) population at two and six weeks after application of amended compost. WACA = weeks after compost application

Treatments	Soil *Rs* population (×10^7 cfu g^{-1} soil)					
	Late rainy season 2006		Early rainy season 2007		Mean	
	2 WACA	6 WACA	2 WACA	6 WACA	2 WACA	6 WACA
Soil alone	3.39	4.27	3.63	6.03	3.55	5.13
Soil + Unamended compost	4.68	6.76	4.17	4.47	4.47	5.50
Soil + Amended compost	2.45	1.26	1.70	0.16	2.04	0.45
$LSD_{0.05}$	ns	2.57	ns	2.04	NS	2.29
Reduction in *Rs* population[1]	0.94	3.01	1.93	5.87	1.51	4.68

ns = not significant

[1] Reduction in *Rs* population = *Rs* population in Soil alone – *Rs* population in Soil + Amended compost

Table 3: Effect of compost application on the incidence and severity of bacterial wilt in two varieties of tomato. Values in parentheses = *I* (%) of No Compost – *I* (%) of Amended compost

Cultivar	Compost application	Late rainy season 2006[1]		Early rainy season 2007		Mean	
		I (%)	PSI (%)	*I* (%)	PSI (%)	*I* (%)	PSI (%)
'Beske'	No compost	84.90	67.62	44.10	25.42	64.40	46.46
	Unamended compost	81.10	64.59	48.45	27.92	64.78	46.26
	Amended compost	41.80	33.29	22.50	12.97	32.15	23.13
		(43.10)	(34.33)	(21.60)	(12.45)	(32.25)	(23.33)
'UC82B'	No compost	79.80	63.55	42.90	24.73	61.35	44.14
	Unamended compost	88.70	70.64	42.55	24.52	65.63	47.58
	Amended compost	35.00	2.88	26.80	15.45	30.90	21.67
		(44.80)	(60.67)	(16.10)	(9.28)	(30.45)	(22.47)
$LSD_{0.05}$	Cultivars (V)	ns	ns	ns	ns	ns	ns
	Composts (C)	12.24	7.43	5.42	3.12	8.83	5.28
	V × C	ns	ns	ns	ns	ns	ns

ns = not significant

[1] *I* (%) = percentage incidence of bacterial wilt; PSI = percent severity index (Cooke 2006)

Table 4: Mean values of weather parameters in the two seasons, *t*-probability values and statistical inferences. PSI = Percent severity index

Year of planting	Weather parameter[1]									(*Y*) PSI
	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	
2006 Late rainy season	3.28	30.88	23.17	82.75	73.67	28.71	1.15	25.13	307.73	24.58
2007 Early rainy season	6.93	30.65	22.62	83.78	75.04	28.88	3.43	14.38	301.96	26.46
t-probability for H_o	0.15	0.77	0.13	0.65	0.73	0.85	0.01	0.00	0.85	0.05
Significance (5% level)	ns	ns	ns	ns	ns	ns	*	*	ns	*

* $p < 0.05$, ns = not significant

[1] X_1 = rainfall (mm), X_2 = maximum temperature (°C), X_3 = minimum temperature (°C), X_4 = relative humidity at 09:00 GMT (10:00 local time), X_5 = relative humidity at 15:00 GMT (16:00 local time), X_6 = soil temperature at 20 cm (°C), X_7 = sunshine (h d^{-1}), X_8 = cumulative number of rainy days, X_9 = cumulative rainfall (mm)

amended with compost containing bactericidal plant material supported the highest mean yield of 13.98 t ha^{-1} for 'Beske' and 12.23 t ha^{-1} for 'UC82B' in the pooled data for the two years. These values were significantly ($p \leq 0.05$) higher than the yield values recorded for plants grown in soil with no added compost (5.71 t ha^{-1} and 4.30 t ha^{-1} for 'Beske' and 'UC82B', respectively) and for plants grown in soil with compost containing no bactericidal plant material (10.28 t ha^{-1} and 8.86 t ha^{-1} for 'Beske' and 'UC82B', respectively). However, the yield of plants grown in soil with unamended compost and those grown in soil with no added compost were not significantly different at $p \leq 0.05$.

Discussion

The findings of Tränkner (1992), Adebayo and Kuku (1998) and Abbasi et al. (2002) showed that composts incorporated into soil reduced the severity of some soil-borne diseases of plants. In the present study compost application increased soil pH and the concentrations of available P, exchangeable K and total N. However, these variables were correlated weakly with suppression of bacterial wilt in tomato, indicating that they were less informative predictors of suppressiveness in plant disease control. Bonanomi et al. (2010) attributed suppression of pathogens by organic composts to the low C:N ratio elicited in the soil. In the present study, the amended compost contained leaves and branches from mango, siam and neem, which show bactericidal properties (Popoola et al. 2011). The amended compost had a low C:N ratio and supported tomato plants with a low incidence of bacterial wilt.

Hoitink and Fahy (1986) and Hoitink and Boehm (1999) postulated the mechanisms of suppression of soil-borne plant pathogens in response to compost application. Beneficial micro-organisms successfully compete for nutrients, parasitise pathogens and activate disease-resistance genes in plants. Other mechanisms of control are the production of toxic or stimulatory volatile compounds from composts, changes to the physical properties of the growing medium or soil, and changes to soil conductivity and pH (Smolinska 2000; Coventry et al. 2002). In the present work, the combination of a lower C:N ratio and higher amounts of N suggested the presence of easily decomposable organic matter in the soil with amended compost. Islam and Toyota (2004) demonstrated that bacterial wilt of

Table 5: Degree of freedom and mean sum of squares from stepwise multiple regression analysis of weather parameters in the late and early rainy seasons of 2006 and 2007, respectively

Serial no.		Weather parameter	df	Contributory mean sum of squares	
				Late rainy season 2006	Early rainy season 2007
1	X_1	Rainfall (mm)	1	239.4	232.66
2	X_2	Maximum temperature (°C)	1	1 744.1	1 194.71
3	X_3	Minimum temperature (°C)	1	22.8	18.10
4	X_4	Relative humidity at 09:00 GMT	1	739.2	54.58
5	X_5	Relative humidity at 15:00 GMT	1	1 403.6	1 146.57
6	X_6	Soil temperature at 20 cm (°C)	1	1 476.7	573.18
7	X_7	Sunshine (h d^{-1})	1	379.2	223.52
8	X_8	Cumulative number of rainy days	1	1 857.2	1 908.89
9	X_9	Cumulative rainfall (mm)	1	1 712.2	1 891.20
		Residual	7	293.5	282.90

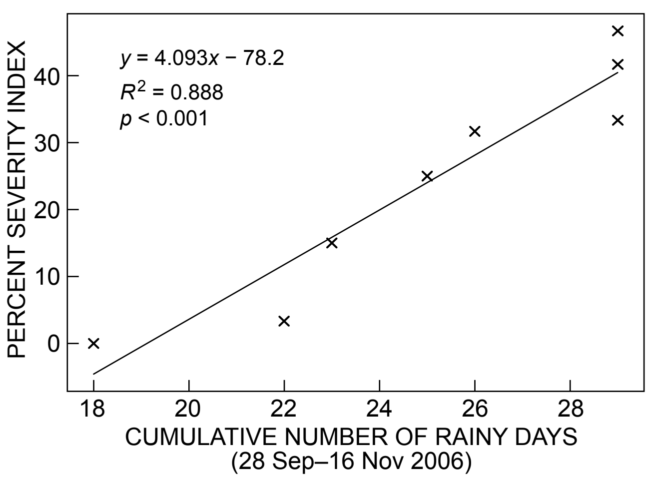

Figure 1: Relationship between bacterial wilt percent severity index and cumulative number of rainy days during the late rainy season of 2006

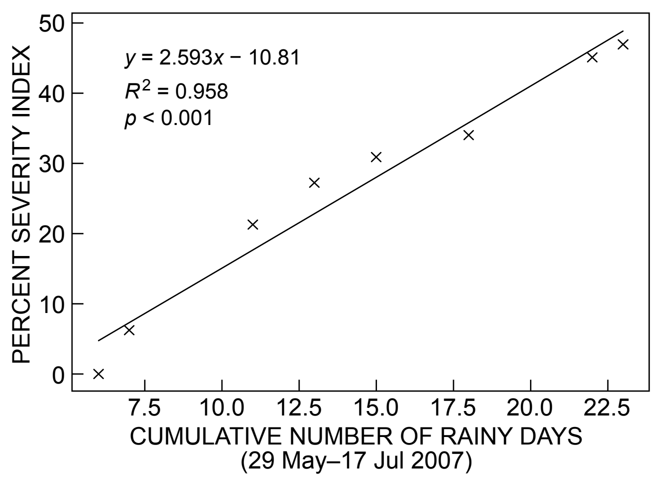

Figure 2: Relationship between bacterial wilt percent severity index and cumulative number of rainy days during the early rainy season of 2007

Table 6: Effect of compost application on the yield of two tomato cultivars

Cultivar	Compost application	Yield (t ha^{-1}) during late rainy season 2006	Yield (t ha^{-1}) during early rainy season 2007	Mean yield (t ha^{-1})
'Beske'	No compost	1.97	9.44	5.71
	Unamended compost	3.93	16.64	10.28
	Amended compost	5.22	22.74	13.98
'UC82B'	No compost	0.74	7.87	4.30
	Unamended compost	3.79	13.92	8.86
	Amended compost	4.07	20.39	12.23
$LSD_{0.05}$	Cultivars (V)	ns	ns	ns
	Composts (C)	ns	5.28	3.25
	V × C	ns	ns	ns

tomato was suppressed in the farmyard manure-amended soil because of higher microbial activity resulting from high contents of easily decomposable materials.

According to Bonilla et al. (2012), the effect of organic amendments on soil suppressiveness was often related to a general suppression mechanism. The input of organic matter may lead to an increase in total microbial biomass and activity in soil, causing the inhibition of the pathogen by competition for resources or through other direct forms of antagonism. No specific microorganism is responsible for general suppression, but all microbiota cooperate in the generation of an environment hostile for disease development (Bonilla et al. 2012).

In both seasons covered by the present study, cumulative number of rainy days was the weather parameter most significantly, positively correlated with bacterial wilt incidence. It corroborates the reports of Yogendra et al. (1995) and Nguyen and Ranamukhaarachchi (2010) who reported the occurrence of maximum disease intensity in years with above-average rainfall. In several other crop plants, weather factors also have been reported to play major roles in the development of various diseases, and therefore the prediction equations have been derived to estimate the disease severity in these crops by considering the weather factors (Hennessy et al. 1990; Shaw et al. 1990; Awasthi and Kolte 1994). Srikantaswamy et al. (2006) inferred that among the various weather factors studied, the number of rainy days and cumulative rainfall coupled with advanced crop age were the most important factors for development of rust disease in mulberry.

Similar information as provided by Srikantaswamy et al. (2006) was obtained in this study with respect to tomato. Hitherto, farmers believed that high rainfall increased tomato susceptibility to bacterial wilt and hindered the growth and yield performances of the crop. The hindrance was not so much due to quantity of rainfall, but the cumulative number of rainy days. A much higher correlation coefficient between PSI and cumulative number of rainy days testified to this inference.

Conclusions

Cultivation of a local tomato cultivar ('Beske') on soil amended with bactericidal plant material in the early rainy season of 2007 produced the highest tomato fruit yield of 22.74 t ha^{-1} in this study. This yield was supported by cumulative rainy days of 23, cumulative rainfall of 491.20 mm, and mean relative humidity of 75.04%.

The work has shown a suppression of plant pathogens following compost application in a field experiment. It provided linear models connecting the PSI of bacterial wilt with the prevailing number of rainy days with a high coefficient of multiple determination of 88.8–95.8%. The models could serve as prediction tools for severity of bacterial wilt of tomato in places where a forecast for total number of expected rainy days was available.

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