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# Field evaluation of compost extracts for suppression of *Fusarium* wilt of tomato caused by *Fusarium oxysporum* F. sp. *lycopersici*

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## Abstract

Field experiment was conducted at Research and Training Farm of Federal College of Horticulture Dadin Kowa, in the 2008 to 2009 cropping seasons, to evaluate the effect of compost extracts in suppressing *Fusarium* wilt on three tomato varieties. The treatments consisted of three compost extracts: poultry manure-based compost extract (PMCE), neem leaf-based compost extract (NLCE), cow dung-based compost extract (CDCE), a synthetic fungicide (TEAM®) and sterile distilled water serving as the control; and three tomato varieties (Roma VF, Duck Sekarat and UC 82B). The results showed that all tomato varieties were infected by the pathogen, but Roma VF was the least infected. Disease incidence and severity was significantly ($P \leq 0.05$) lower on tomato plants treated with the respective compost extract than on untreated plants. TEAM® was only effective at the early stages of infection compared to the various extracts which were effective starting from 6 – 7 weeks after transplanting till harvesting. However, poultry and cow dung based- compost extracts were the most effective in reducing incidence and severity of the disease. Higher yields were obtained with the application of PMCE (3.2 t ha$^{-1}$) and CDCE (3.0 t ha$^{-1}$) in comparism with other treatments. It is therefore recommended that farmers should use Roma VF and soil drenching with PMCE and/or CDCE in an integrated pest management package in the control of *Fusarium* wilt of tomato.

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## Introduction

*Fusarium* wilts of tomato caused by *Fusarium oxysporum* f.sp. *lycopersici* (Sacc.) W. C. Snyder & Hansen is one of the most economically important and widespread diseases of the cultivated tomato (*Solanum lycopersicum* L.). It is one of the most important diseases which are highly destructive to tomatoes grown in greenhouse and in the field in many warm regions of the world, where it causes 10-50 % yield loss (Larkin and Fravel, 1998; Borrero *et al*., 2004). The disease is endemic in vegetable growing areas especially, in the savannah areas of Nigeria (Erinle, 1981). The management of Fusarium wilt pathogen is particularly complex because it lives in or near the dynamic environment of rhizosphere and can frequently survive long periods in soil through the formation of certain resistant structures of the pathogen (Blum and Rodriquez-Kabana, 2004).

Currently, pre-plant soil fumigation and fungicide applications are employed as control measures (Larkin and Fravel, 1998). The use of pesticides in the control of Fusarium wilt of tomato has remained limiting. Fumigation with Methyl Bromide is expensive and not always effective (Kimaru *et al*., 2004). Besides, the continuous use of this chemical has become un-advisable because it has been defined by Montreal Protocol of 1999 as a chemical that contributes to the depletion of the ozone layer and has since been phased out in 2005 (Horinouchi *et al*., 2008). In addition to other potential health, safety and environmental risks, Methyl Bromide fumigation and other soil sterilization procedures usually destroyed beneficial micro-organisms such as mycorrhizae, biocontrol agents and plant growth promoting micro-organisms (De Causter and Hointink, 1999).

The prohibitive costs of available pesticides and environmental implications arising from its usage have necessitated the need for other eco-friendly options. The increasing public outcry against pesticide has generated an interest in the use of compost and compost extracts to prevent and control plant diseases. The use of compost extracts to control diseases in plants is an effective alternative that enables the use of pesticides to be reduced (Segarra *et al*., 2009). The use of compost extracts in controlling soil-borne diseases has been reported by several researchers (Scheurell and Mahaffee, 2004; Litterick *et al*., 2004; Segarra *et al*., 2009). This work was therefore, conducted to investigate the efficacy of compost extracts in suppressing Fusarium wilt on tomato.

## Materials and methods

*Isolation of the pathogen*

*Fusarium oxysporum* f. sp. *lycopersici* was isolated from the stem and roots of naturally infected tomato plant in Dadin Kowa, Gombe State. They were surface-sterilized by soaking in 0.5 % bleach solution (sodium hypochlorite) for five minutes, washed in three changes of sterile distilled water. The pieces were placed on acidified (with lactic acid) potato dextrose agar (APDA) sterilized and contained in Petri dishes which had been sterilized in an autoclave at 121°C for 15minutes. The inoculated plates were arranged on the bench at room temperature (27±2 °C) under fluorescent light in the laboratory for seven days as described by Wong (2003). Using a No 3 cork-borer, agar plugs were taken from the actively growing region of the mycelial growth for sub-culturing in other sterilized Petri dishes containing APDA and left for 14 days under fluorescent light at the room temperature. Sub-culturing was done and repeated until the pure culture of the pathogen was obtained and kept as stock culture for subsequent use.

*Preparation of compost /compost extracts*

Three different composts were prepared using cow dung, poultry manure, and neem leaves as poultry manure- based compost (PMBC), cow dung- based compost (CDBC) and neem-leaf based compost (NLBC). The compost extracts were prepared according to the procedures described by Weltzien (1991). The composts were separately prepared to aqueous solution at 1:5 as poultry manure based-compost extract (PMCE), cow dung based-compost extract (CDCE) and neem leaf based-compost extract (NLCE). They were stirred for 5-10 minutes every day using stirring rod and allowed to ferment for seven days to enhance disease suppression (Hmouni *et al*., 2006). The different composts extracts were then filtered separately and were applied as soil-drench.

*Experimental site, design and agronomic procedure*

The experiment was conducted at Research and Training farm of Federal College of Horticulture Dadin kowa, Gombe State in 2008 and 2009 rainy seasons. The area is located in Sudan savannah ecological zone of Nigeria, on latitude 10° 18′ 10″ N, longitude 11° 31′ 09″ E, and altitude of 218 metres above sea level. It is also characterized with single peak of rainy season (800mm), mean daily temperature ranges from 32 to 35 °C and relative humidity of 17% to 90%. Three tomato varieties (Roma VF, Duck Sekarat and UC 82B) were raised in a nursery for 30 days. The seedlings were then transplanted early in the morning at 6 to 9 O' clock. The experiment was laid out in split-plot design with the of three compost extracts (PMCE, NLCE and CDCE), TEAM® (Carbendazim 12% + Mancozeb 63% W.P.), and ordinary distilled water which was used as the control (CNTL), in the sub-plots while the three tomato varieties were assigned the main plot. The 15 treatments were replicated three times. The fungicide was applied once at transplanting as a soil drench at the rate of 100 grams/100litres of water per hectare. Different compost extracts were weekly drenched at the rate of 0.4 L/plant. Inorganic fertilizer in form of N P K fertilizer (15:15:15) was applied at the rate of 120 kg in two splits at transplanting and at flowering.

*Disease scoring and data recording*

*Fusarium* wilts incidence and severity were taken at weekly intervals, starting from 4 weeks after transplanting (WAT) to 9 WAT. Disease incidence was recorded by counting the number of infected plants and dividing it with the total number of plant assessed in each treatment. The result obtained was converted to percentage using the formula:

Disease incidence = (Number of diseased plants /number of plants assessed) x 100.

The severity of the disease on tomato plants was scored using 1-5 scale developed by De-Cal and co-workers (1995) as shown below: 1 - All leaves green, 2 - Lower leaves yellow, 3 -Lower leaves dead, 4- Lower leaves dead and upper leaves wilted, 5 – Dead plant. Data on disease incidence was arcsine transformed before analysis. The data on plant height, number of branches, leaves, flower truss, flowers, fresh fruit weight, fresh shoot weight, and yield were also taken along side with incidence and severity of the pathogen.

*Data analysis*

Statistical analysis of the data was conducted using GenStat Release 7.2 DE (PC/Windows XP) Copyright 2007, Lawes Agricultural Trust (Rothamsted Experimental Station) and treatment means were separated using LSD at 5% level of significance.

## RESULTS

*Effect of compost extracts and fungicide on the incidence and severity of Fusarium wilt of tomatoes*

Figure 1 showed the mean incidence and severity of *Fusarium* wilt of tomato and their effect on year (A), variety (B) and compost extracts (C). The results show that the highest mean incidence and severity were recorded in 2008; varieties Duck Sekarat and on those tomatoes in the control treatment and those that were treated with fungicide (TEAM). Lowest *Fusarium* wilt incidence and severity were found in 2009, resistant cultivar Roma VF and on those tomatoes on which PMCE and CDCE were applied.

Tomato plants whose roots were drenched with compost extracts and fungicide differed significantly ($p \leq 0.05$) with those tomatoes in the control at the early stages of the infection (C). However, at the later stage tomato seedlings whose roots were drenched with PMCE and CDCE exhibited same effect and were significantly different with those treated with NLCE and TEAM respectively.

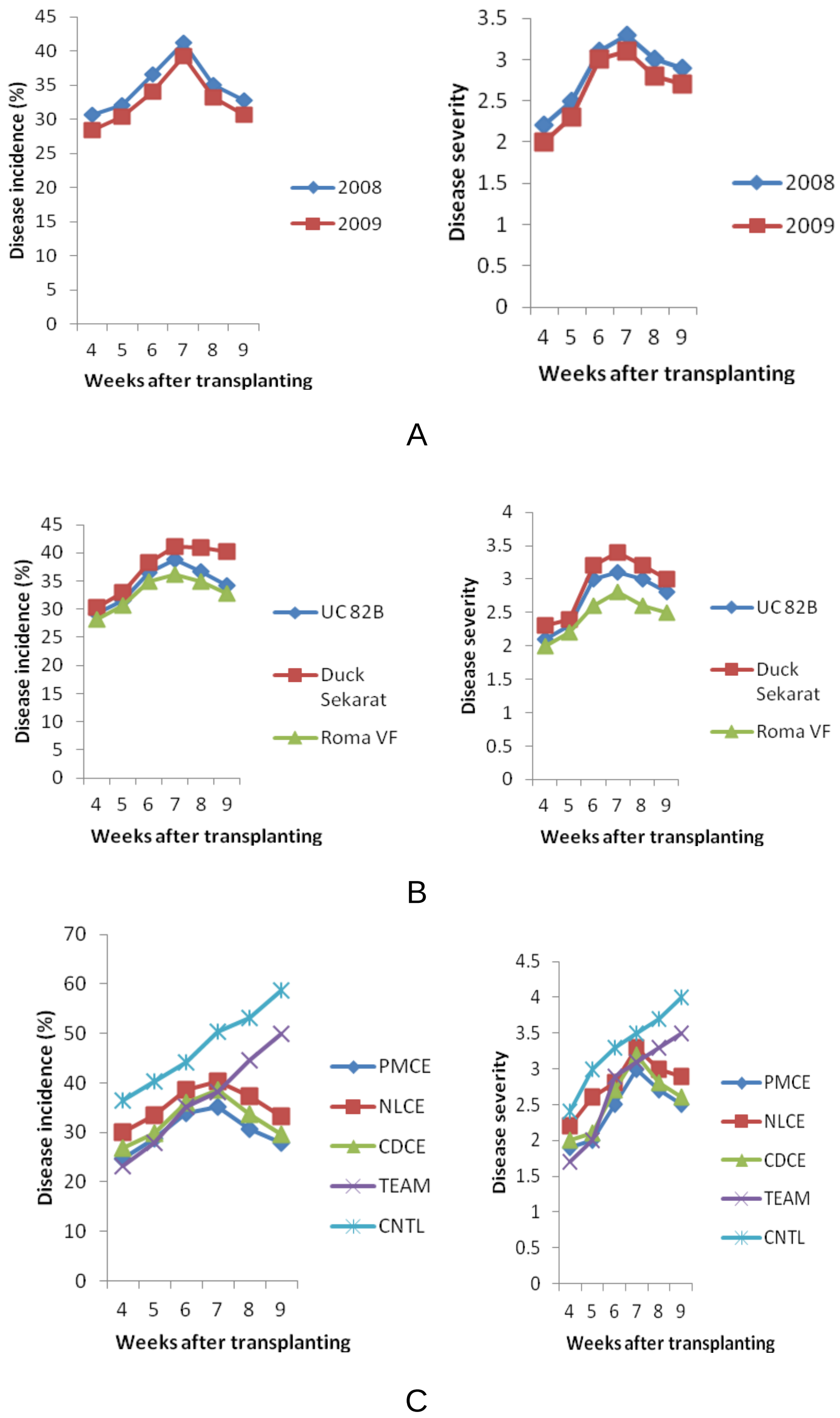


**Fig. 1.** Disease progress curve of *Fusarium* wilt of tomato for year (A), variety (B) and compost extracts (C).

Table 1 shows interaction effect of compost extracts and tomato varieties in 2008 and 2009. Higher *Fusarium* incidence was recorded in the year 2008 than in 2009. Poultry manure compost extracts applied as soil drench on Roma VF and UC 82B significantly induced lower disease severity than on Duck Sekarat. Soil drenching with CDCE and NLCE exhibited comparable *Fusarium* wilt incidence on all the three varieties. However, the use of Fungicide on Roma VF significantly reduced disease incidence than when it was applied on Duck Sekarat and UC 82B.

**Table 1.** Effect of interaction between year, variety and compost extracts on severity of *Fusarium* wilt of tomato.

| Compost extracts | 2008 | | | 2009 | | |
|---|---|---|---|---|---|---|
| | UC 82B | Duck Sekarat | Roma VF | UC 82B | Duck Sekarat | Roma VF |
| PMCE* | 24.6 | 28.8 | 24.6 | 23.4 | 27.5 | 22.8 |
| NLCE | 33.2 | 34.4 | 30.2 | 30.1 | 32.6 | 22.8 |
| CDCE | 33.2 | 33.5 | 31.7 | 33.0 | 33.1 | 30.0 |
| TEAM® | 50.2 | 50.8 | 45.9 | 50.0 | 50.3 | 45.7 |
| CNTL | 56.8 | 59.3 | 58.9 | 57.8 | 59.1 | 56.8 |
| LSD ($P \leq 0.05$) | | | 3.05 | | | |

* PMCE: Poultry manure-based compost extract, CDCE: Cow dung based-compost, extract NLCE: Neem-leaf based compost extract. CNTL: Control

**Table 2.**Effect of interaction between variety and compost extracts on severity of *Fusarium* wilt of tomato at 9 WAT.

| Compost extracts | Varieties | | |
|---|---|---|---|
| | UC 82B | Duck Sekarat | Roma VF |
| PMCE* | 2.1 | 2.7 | 2.0 |
| NLCE | 2.8 | 2.9 | 2.6 |
| CDCE | 2.2 | 2.7 | 2.0 |
| TEAM® | 3.6 | 3.5 | 3.4 |
| CNTL | 4.0 | 4.0 | 3.9 |
| LSD ($P \leq 0.05$) | | 0.17 | |

* PMCE: Poultry manure-based compost extract, CDCE: Cow dung based-compost, extract NLCE: Neem-leaf based compost extract. CNTL: Control

**Table 3.**Effect of interaction between year, variety and compost extracts on severity of *Fusarium* wilt of tomato

| Compost extracts | 2008 | | | 2009 | | |
|---|---|---|---|---|---|---|
| | UC 82B | Duck Sekarat | Roma VF | UC 82B | Duck Sekarat | Roma VF |
| PMCE* | 2.1 | 2.8 | 2.0 | 2.0 | 2.6 | 1.7 |
| NLCE | 2.8 | 3.0 | 2.2 | 2.7 | 2.9 | 2.0 |
| CDCE | 2.2 | 2.8 | 2.0 | 2.1 | 2.6 | 1.8 |
| TEAM® | 3.5 | 3.7 | 3.3 | 3.3 | 3.5 | 3.1 |
| CNTL | 3.9 | 4.0 | 3.9 | 4.1 | 4.1 | 3.9 |
| LSD ($P \leq 0.05$) | | | | 0.17 | | |

* PMCE: Poultry manure-based compost extract, CDCE: Cow dung based-compost, extract NLCE: Neem-leaf based compost extract. CNTL: Control

**Table 4.** Effect of year, variety and compost extracts on plant height (cm) of tomato *Fusarium* wilt.

| Treatments | Weeks after transplanting | | | | |
|---|---|---|---|---|---|
| | 5 | 6 | 7 | 8 | 9 |
| Year | | | | | |
| 2008 | 15.5 | 23.2 | 30.0 | 42.5 | 61.8 |
| 2009 | 20.8 | 27.4 | 53.1 | 70.1 | 79.1 |
| LSD ($P=0.05$) | 0.39 | 0.54 | 1.34 | 1.27 | 1.77 |
| Variety | | | | | |
| UC 82B | 18.5 | 25.6 | 41.0 | 56.8 | 70.2 |
| Duck Sekarat | 17.4 | 24.6 | 38.3 | 53.0 | 68.0 |
| Roma VF | 18.6 | 25.7 | 41.9 | 57.2 | 70.9 |
| LSD ($P=0.05$) | 0.47 | 0.66 | 1.64 | 1.55 | 2.17 |
| Compost extracts | | | | | |
| PMCE* | 19.7 | 26.6 | 45.0 | 61.2 | 75.6 |
| NLCE | 18.0 | 25.0 | 40.3 | 56.1 | 70.3 |
| CDCE | 19.0 | 26.1 | 43.6 | 59.6 | 74.1 |
| TEAM® | 17.5 | 24.6 | 39.0 | 52.7 | 67.2 |
| CNTL | 16.6 | 23.3 | 36.8 | 50.0 | 64.2 |
| LSD ($P=0.05$) | 0.61 | 0.85 | 2.12 | 2.00 | 2.80 |

* PMCE: Poultry manure-based compost extract, CDCE: Cow dung based-compost, extract NLCE: Neem-leaf based compost extract. CNTL: Control

Table 2 shows the interaction effect of tomato varieties and compost extracts on severity of Fusarium wilt in the field. Application of compost extracts differed significantly with fungicide and control in all tomato varieties. Low disease severity was recorded on Roma VF and UC 82B whose roots were treated with PMCE and CDCE. These were followed by soil-drenching with PMCE, NLCE and CDCE on Duck Sekarat and NLCE on UC 82B and Roma VF respectively. It was also observed that the use of the fungicide (TEAM) had similar effect on the severity of the disease. High severity values were obtained in the control treatments on Roma VF, Duck Sekarat and UC 82B respectively. Generally, severity of *Fusarium* wilt of tomato was observed to be lower with the application of compost extracts than the use of fungicide.

*Fusarium* wilt severity index recorded in 2008 was significantly higher than those obtained in 2009 (Table 3). Soil drenching with PMCE and CDCE on Roma VF had same effect in reducing the disease severity than application of NLCE on Duck Sekarat and UC 82B.

*Effect of compost extracts and fungicide on plant height (cm) of tomatoes infected with Fusarium oxysporum* f. sp *lycopersici*

Table 4 shows the effect of compost extracts and fungicide on plant height of tomato infected with Fusarium wilt. Tomatoes planted in 2009 differed significantly ($p \leq 0.005$) with those cultivated in 2008 in terms of plant height. Tomato variety 'Roma VF' and UC 82B significantly produced higher plant height than Duck Sekarat.

**Table 5.**Effect of year, variety and compost extracts on number of flowers of tomato *Fusarium* wilt.

| | Weeks after transplanting | | | |
|---|---|---|---|---|
| Treatments | 5 | 6 | 7 | 8 |
| Year | | | | |
| 2008 | 14.2 | 17.8 | 18.1 | 13.7 |
| 2009 | 20.8 | 23.7 | 20.5 | 15.6 |
| LSD ($P=0.05$) | 0.82 | 0.96 | 1.37 | 0.75 |
| Variety | | | | |
| UC 82B | 17.6 | 20.1 | 19.3 | 15.0 |
| Duck Sekarat | 16.3 | 18.9 | 18.6 | 14.5 |
| Roma VF | 18.7 | 23.1 | 23.1 | 17.5 |
| LSD ($P=0.05$) | 1.00 | 1.18 | 1.68 | 0.92 |
| Compost extracts | | | | |
| PMCE* | 20.7 | 24.2 | 23.6 | 18.0 |
| NLCE | 17.7 | 21.0 | 19.7 | 15.3 |
| CDCE | 19.8 | 23.1 | 21.7 | 16.2 |
| TEAM® | 15.0 | 18.2 | 16.4 | 12.1 |
| CNTL | 14.4 | 18.1 | 16.2 | 11.7 |
| LSD ($P=0.05$) | 1.29 | 1.52 | 2.17 | 1.19 |

* PMCE: Poultry manure-based compost extract, CDCE: Cow dung based-compost, extract NLCE: Neem-leaf based compost extract. CNTL: Control

Application of compost extracts induced better plant height compared to those that were treated with fungicide and those in the control treatments. At 5 WAT, tomatoes whose roots were drenched with PMCE, CDCE, NLCE and TEAM significantly produced higher plant height than those untreated. However, at 6 WAT, soil drenching with PMCE and CDCE significantly induced higher plant height than on those tomatoes treated with NLCE and TEAM which were statistically similar. At 7, 8 and 9 WAT, Application of PMCE and CDCE had same effect on plant height and were better than NLCE, and TEAM respectively, in producing tall plant.

*Effect of compost extracts and fungicide on number of flowers of tomatoes infected with Fusarium oxysporum* f. sp *lycopersici*

As obtained in Table 5, Tomatoes planted in 2009 significantly ($p \leq 0.005$) produced higher number of flowers than those cultivated in 2008. Similarly, tomato variety 'Roma VF' and UC 82B showed same effect significantly produced higher flowers than Duck Sekarat.

At 5 to 7 WAT, tomato plants whose roots were drenched with PMCE and CDCE significantly induced higher flower production compared to flower produced by those that received application of NLCE. Plants treated with TEAM exhibited similar effect on those tomatoes in the control treatments in terms of flower production. However, at 8 WAT, High flower production was induced with the application of PMCE. These were followed by the use of CDCE and NLCE which were statistically similar.

**Table 6.**Effect of year, variety and compost extracts on yield (t ha-1), fresh shoot and root weight (g) of tomato infected with *Fusarium* wilt.

| Treatments | Yield (t $ha^{-1}$) | Fresh shoot weight (g) | Fresh shoot weight (g) |
|---|---|---|---|
| Year | | | |
| 2008 | 2.6 | 42.9 | 341.3 |
| 2009 | 3.1 | 68.1 | 383.0 |
| LSD ($_{P=0.05}$) | 0.17 | 1.35 | 6.17 |
| Variety | | | |
| UC 82B | 2.9 | 55.6 | 360.0 |
| Duck Sekarat | 2.8 | 54.97 | 357.1 |
| Roma VF | 3.1 | 68.9 | 369.5 |
| LSD ($_{P=0.05}$) | 0.21 | 1.66 | 7.55 |
| Compost extracts | | | |
| PMCE* | 3.2 | 59.9 | 389.4 |
| NLCE | 2.9 | 57.4 | 381.7 |
| CDCE | 3.0 | 59.8 | 388.8 |
| TEAM® | 2.6 | 51.3 | 328.3 |
| CNTL | 2.1 | 49.8 | 322.8 |
| LSD ($_{P=0.05}$) | 0.27 | 2.14 | 9.75 |

* PMCE: Poultry manure-based compost extract, CDCE: Cow dung based-compost, extract NLCE: Neem-leaf based compost extract. CNTL: Control

*Effect of compost extracts and fungicide on fresh shoot and root weight and yield of tomatoes infected with Fusarium oxysporum* f. sp *lycopersici*

The effect of compost extracts and fungicide on fresh shoot and root weight and yield of tomatoes infected with *Fusarium oxysporum* f. sp *lycopersici* is presented in Table 6. The results showed significantly heavier root and shoot weight and higher yield in 2009 than what was obtained in 2008. Roma VF significantly showed heavier fresh root and shoot weight and higher yield than Duck Sekarat and UC 82B which were at par. Tomato plants whose roots were drenched with PMCE and CDCE significantly produced higher yield, better fresh root and shoot weight in comparison with those that were drenched with NLCE. Application of fungicide on tomatoes did differ with the control treatments and were less in terms of yield, fresh shoot and root weight.

**Discussion**

A striking observation in this experiment is the infection of Roma VF by the pathogen, since the variety is previously known to be resistant to Fusarium. The reasons for this may perhaps be due to the presence of root knot nematode in the field which might have predisposed the crop roots to attack from the fungus, or the variety might have probably lost its resistance to the pathogen. Another reason why Roma VF became infected may probably due to the development of new pathogenic races of the pathogen to which Roma VF became susceptible, though this assertion was not confirmed in the present study. However, earlier findings from a different studies corroborate this phenomenon (Rini and Sulochana, 2004; Amini, 2009). Agbenin *et al.* (1999) reported that most tomato varieties are resistant to race 1 and are susceptible to race 2 of the pathogen. Despite the susceptibility exhibited by Roma VF variety of tomato, it still showed some level of resistance since it has the lowest severity index than the other varieties. Continuous application of compost extracts on the three varieties indicated reduction of disease incidence due to induced natural defense mechanisms as reported by Al- Dahmani *et al.* (2003) and Gangaih (2004).

The effect of compost extracts on *Fusarium* wilt severity shows that all the compost extracts suppressed the growth of *Fusarium* wilt of tomato. The greatest suppression was recorded where PMCE was used and this was followed by CDCE and NLCE in that other. Application of fungicide was only effective in the early stages of infection. The ineffectiveness of the fungicide following application might be due to the active compounds being adsorbed to the soil particles, or to the difficulty of the chemical to reach pathogen in the soil. The effectiveness of PMCE and CDCE is due to the presence of several micro-organisms with antagonistic potency against several plant pathogens (Weltzien, 1992; Elad and Shtienberge, 1994; Yohalem *et al.*, 1996; Al-Dahmani *et al.*, 2003). Compost extracts contain several antagonistic bacteria, fungi and other micro-organisms that suppress plant pathogens (Daami-Remadi *et al.*, 2006). Application of NLCE was also found to be effective in suppressing Fusarium wilt. This is in compormity to the earlier findings of Singh and Singh, (1970) who reported effective control of *Fusarium udum* using neem cake organic amendments. Lakashmi and Jeyarajan, (1987) also reported significant reduction of *Fusarium solani* with neem amendment. The suppression effect exhibited by NLCE was mainly due to the presence of antifungal compounds such as Limonoids contained in the extract (Sivakumar, 2009). The suppressive ability of neem organic amendments in inhibiting growth of soil-borne pathogens has been demonstrated to be through competition, antibiosis or due to the increase of saprophytic soil microbial populations (Zakaria and Lackword, 1980). Neem plant possesses biologically active compounds mainly alkaloids such as isoprenoids that control various pest and diseases.

Application of compost extracts significantly enhanced tomato growth and yield The attainment of all these is attributable to the use of the compost extracts which could have complimented the inorganic fertilizer used in getting good growth and yield of tomato. On the other hand, because of the presence of anti-biotic micro-organisms they possess besides the biologically active compounds which together could have exerted suppression of *Fusarium oxysporum* f. sp. *lycopersici* which causes wilting on the plants. The reduction in the activity of this pathogen led to enhanced growth and yield of the treated tomatoes. This is in agreement with earlier works of other researchers who reported that that compost extracts promoted plant growth by inducing plant resistance or by directly affecting the pathogen through several modes of action (Kerkeni *et al.* 2008; Ben-Jenana *et al.* 2009). Soil application of PMCE and CDCE at the rate of 100 L/ha is recommended for an effective control of *Fusarium* wilt of tomato. However, further research to identify the biocontrol agents in the compost extracts is recommended.

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