Antagonistic Effect of Compost Extracts on Growth of Tomato Root Rot Pathogens

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ABSTRACT

Isolation trials from tomato roots and basal stem rot symptoms resulted in securing several pathogens. Pathogenicity tests of the most frequently isolated fungi, i.e., *F. oxysporum, P. ultimum* and *R. solani* on Peto 86, Castle Rock and Super Strain B tomato cvs., indicated that, *R. solani* isolate number II was the most destructive among the other tested damping-off pathogens. Peto 86 cv. proved to be relatively more susceptible compared with the other tested cultivars. All the tested compost extracts proved to be suppressive on the mycelial growth of the tested root rot pathogens. However, spent mushroom compost extract and sheep manure compost extract with or without additives were more effective in hyphal growth inhibition than other extracts. *F. oxysporum* and *R. solani* were the most sensitive to compost extract among the other tested pathogens. The concentration of 15% was the most effective, while the least one was 5%. Isolation trails from the tested composts showed the presence of many microorganisms including bacteria, fungi, actinomycetes and Sacharomyces. The most predominant microorganisms were those related to *Bacillus* spp., *Pseudomonas* spp., *Trichoderma* spp. and *Fusarium* spp. On the other hand, the compost fermented with additives had higher microbial content. Chemical analysis of compost types showed high content of macro-, and micronutrients, especially compost fermented with additives. On the other hand, the level of heavy metals in composts was lower than the toxic level found in plants.

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.), ranked as the number one vegetable cash crop in Egypt and other countries (Anon., 2005). Unfortunately, tomato is subjected to infection by several air-, and soil-borne diseases which caused considerable losses in yield and quality of the crop. Root rot and wilt diseases caused by soil borne fungi are the most serious diseases of tomato plants. In a survey study 62% of tomato plants were infected by *Fusarium oxysporum* f. sp. *lycopersici* (Jarvis *et al.*, 1983). *F. oxysporum*, *F. solani* and *R. solani* were also isolated from rotten roots of tomato in several countries (Wokosha *et al.*, 1986). *F. oxysporum f.* sp. Lycopersici and *R. solani* were the most dominant among other soil-borne fungi infecting tomato plants (Kapoor, 1988 and Moustafa & Khafagi, 1992).

The control of damping-off disease of seedlings, commonly caused by *Pythium* spp. is of particular interest to greenhouse grower (Stephens

and Powell, 1981; Stephens *et al.*, 1983). The widespread use of chemicals has become a subject of public concern and scrutiny, mainly due to their harmful effect on environment, human and animal health (Zaki *et al.* 1998). Compost tea used increasingly as an alternative plant disease control measure in commercial horticulture (Anon, 2004). Moreover, the use of compost tea as a soil drench for seed or rot root suppression has received very little attention.

It has been proposed that, increasing the population of total and active bacteria of compost extract will generally increase the level of plant disease suppression (Ingham, 2000). Compost extract can be also used to protect cucumber wilt caused by *F. oxysporum* f.sp. *cucumerinum.* The possible mechanisms of compost extract against plant disease pathogens involved the inhibition of conidial germination (Liping *et al.*, 1999 and Stirnimann, 2000). Significant suppresion of *Pythium debaryanum*, *F. oxysporum f.* sp. *Lycopersici* and *Sclerotinia bataticola* was obtained *in vitro* using leafy fruitm garden and crop composts at concentrations 5-15% (El-Marsy *et al.*, 2002). He concluded that all treatments significantly reduced dry weight of the above mentioned pathogens, however, leafy fruit compost was the least effective. El-Farnawany and Amer (2006) found the tested tea composts significantly reduced the growth and development of *R. solani in vitro*,however, hosre manuure tea compost was the most effective, followed by sheep manure compost tea.

Thus, the present investigation was conducted to study the following points:

1. Isolation, purification and identification of the causal pathogens responsible of tomato root rot diseases.
2. Pathogenicity of the most frequent pathogens on different tomato cultivars under greenhouse conditions.
3. Effect of compost extracts on the growth rates of tomato root rot pathogens *in vitro.*
4. Isolation of microorganisms from the most effective compost types.
5. Chemical analysis of compost types.

MATERIALS AND METHODS

Isolation, purification and identification of pathogens

A survey of tomato root rot diseases was carried out during the growing season of 2004 at different farms in three Governorates namely, El-Beheira, Alexandria and El-Fayoum. The diseased roots were carefully washed in tap water and cut into small pieces. Infected samples were

surface sterilized by immersing in 1% sodium hypochlorite for two minutes, then rinsed in sterilized distilled water and dried between two folds of sterilized filter papers. The treated plants were cut into small pieces (2 cm) and transferred to Petri dishes containing potato dextrose agar (PDA) medium (4 pieces/dish). The dishes were incubated at 25 ± 1 ^{0}C for 3 to 7 days. After emerged fungi were counted, purified using the single spore technique or hyphae tip method, inoculum of each purified culture was transferred into (PDA) slant agar and incubated at 25 ± 1 ^{0}C for further studies. The isolated fungi were identified microscopically either to its genera or species level according to the description of Gilman (1957), Satour (1960), Booth (1971), Barrent and Hunter (1986) and Ramirez (1982). Isolates were confirmed by Assiut University Mycological Center (AUMC), Egypt. Stock cultures were maintained on PDA slants and kept in refrigerator at 5°C for subsequent studies.

Pathogenicity testes

Pathogenicity tests were carried out under greenhouse conditions at the Faculty of Agriculture (Saba-Basha), Alexandria University, Egypt, during 2005 and 2006 seasons. Pure fungal isolates were tested for these pathogenic capabilities. The ability of three pathogens namely, *Fusarium oxysporum* (3 isolates), *Pythium ultimum* (3 isolates) and *Rhizoctonia solani* (3 isolates) to infect tomato plants was examined. The susceptibility of three tomato cultivars, namely Peto 86, Castle Rock and Super Strain B to infection with the isolated fungi were tested. Pots 15 cm diameter were sterilized by immersing them in 5% formalin solution for 15 minutes and covered over night with plastic sheets. Soil was autoclaved at pressure of 1.5 kg/cm^2 for 90 minutes. Inocula of the tested fungi were prepared by growing each fungus on potato dextrose broth (PD) 50 ml/125ml. in conical flasks. The cultures were incubated at 25 ^{0}C ± 1 for 10 days. Later on, the fungal mat was collected and blended with 100 ml sterilized distilled water in blender. The prepared inocula were added to potted soil (kg soil/15 cm pot) and covered with a thin layer of soil. The pots were watered every 2 days for a week before planting. Pots used for control were filled with the same soil. Tomato transplant roots were surface sterilized with 1% sodium hypochlorite for one minute, then washed several time in sterilized water and left to dry. Eight transplants were planted in each pot. Three replicates were used for each treatment. After planting, pots were kept in the greenhouse.

Compost tea preparation

The composts used in this experiment were spent mushroom compost, sheep manure compost, chicken manure compost, trufgrass compost, wheat straw compost, alfalfa hay compost, and mushroom compost. The quantities of compost needed for particular applications were mixed with water (1:2 W/V, compost/water) in plastic containers and incubated without agitation in the laboratory or a storage shed (15 to 25°C) for 7-8 days. After incubation, the containers contents were stirred and the compost extracts were obtained by filtration through a single layer of cheesecloth. (El-Farnawany and Amer, 2006).

In vitro experiments

Evaluation of the effect of compost tea on growth of pathogenic fungi

Twelve compost extracts namely, mushroom compost, spent mushroom compost, sheep manure compost plus additives, sheep manure compost, chicken manure compost plus additives, chicken manure compost, trufgrass compost plus additives, trufgrass compost, wheat straw compost plus additives, wheat straw, alfalfa hay plus additives and alfalfa hay tea were tested *in vitro* to evaluate there effect on the mycelial growth of the isolated root rot pathogens *Fusarium oxysporum, Fusarium solani, Alternaria solani, Rhizoctonia solani, Pythium debaryanum, Pythium ultimum, Macrophomina phaseolina.* Compost extracts were prepared as mentioned before and centrifuged at 4000-5000 rpm for 15 min, then sterilized by Seitiz filter (El-Farnawany and Amer 2006). The effect of compost tea on the growth rate was measured by two ways as follow:

Fungal growth diameter method

Filtrate composts were added to melted PDA medium by (5, 10 and 15 ml /100ml medium) in Petri plates (9 cm diameter). Four replicated plates were applied for each treatment. Medium without compost tea was served as control. After the medium had solidified a 8 mm disk from the edge of a 5 days old culture of each fungus was placed in the middle of each plate. All plates were incubated at 25 ± 1° C until linear growth of the pathogen in the control treatment completely covered the medium surface and then the diameter growth of tested fungi was measured. The percentage efficacy ratio (ER) was calculated according to the following formula (Amer, 1995):

$$ER\,(\%) = \frac{RNT - RT}{RNT} X100$$

Where:
RNT= Radius for none treated media.
RT = Radius for treated media.

Fungal inhibition diameter method

The multipoint-inoculation technique with different types of needles such as right or curved sharp pointed, or right and flat headed (Poppe, 1991) was used to inoculate petri dishes with the tested fungi. Paper disks (8 mm diameter) soaked in one of three concentrations (5, 10 and 15%) of compost tea then, placed on inoculated plate. Four disks were placed on each plate. Paper disks soaked in sterilized water, were used as a control. The fungal inhibition diameter (FID) was measured after 4-7 days.

Compost microflora

Microbiological studies

Mushroom compost, spent mushroom compost, sheep manure compost, sheep manure plus additives compost, chicken manure compost, chicken manure plus additives compost were selected as the most effective compost types These types of compost were obtained for the isolation and identification of the contents of microorganisms. One gram of experimental material was suspended in 99 ml of sterile distilled water and shaked with shaker for 60 mins.

Isolation and identification of fungi

Inoculation of 0.1 ml portions of the suspension was made onto 3 replicate plates; 30 ml potato dextrose agar (PDA) medium was poured onto each plate and thoroughly mixed with inoculum and 0.5 ml of streptomycin. Identification procedures of Barnett (1986) and Gilman (1957) were followed.

Isolation and identification of actinomycetes and bacteria

From the suspension described above, 0.1 ml portion was inoculated onto each of 3 replicate plates; 30 ml of medium were then poured onto each plate and thoroughly mixed with the inoculum. Pure cultures were obtained for microscopic identification. Unknown bacterial isolates were identified according to the flow chart of Schaad (1988). All strains were tested for Gram reaction. Cell morphology was determined from cultures grown on nutrient agar. Culture and colony comparisons were made on nutrient agar.

Determination of nutrient composition of compost

The above selected types of composts were tested for their nutrient composition. Compost material was dried at 70°C for 48 hours. Powder of dried material (0.5 g) was digested by sulfuric acid and hydrogen peroxide (Lowther, 1980) for the following determination, at laboratory of soil and

plants analysis, Department of Soil Science, Faculty of Agriculture Saba-Basha.

1. The percentage of total nitrogen content was determined in digested material colorimetrically by Nessler's method using spectrophotometer according to Chapman and Pratt (1978).
2. Total potassium was determined in the digested solution using the flame photometer according to Jackson (1973).
3. Total phosphorus was determined colorimetrically by spectrophotometer according to Evenhuis (1976).
4. Total Zn, Mn and Fe and total heavy metals Ni, Cd and Pb were determined in digested solution by Atomic Absorption Spectrophotometer.
5. Electrical conductivity (EC) of compost, water extract, 1:2 (w/v) was measured using electrical conductivity meter according to Jackson (1967).
6. Acidity of compost was determined in 1:1 (W/V) using pH meter.
7. Compost carbon content was obtained and then C/N ratio was calculated for each tested compost.

Statistical analysis

The present investigations were carried out in a split-split plot design. Data of these experiments were statistically analyzed, and comparison between means were carried out using least significant differences (L.S.D) at 0.05 probability level according to Steel and Torrie (1984).

RESULTS

Isolation and identification

Isolation trails were carried out from naturally infected tomato plants showing damping–off and root rot from three Governorate Alexandria, EL-Behera and EL-Fayoum. Fungi isolated from diseased samples and their incidence in tomato plants were tabulated in Table (1). The obtained data indicated that *Fusarium oxysporum* was the most prevalent fungus at the frequency (16.81%) followed by *Pythium ultimum* and *Rhizoctonia solani* kuhn at the frequencies of (15.10% and 14.25 %, respectively). *Alternaria* sp., *Fusarium solani* (Mart.) Sacc., *Fusarium moniliforme* and *Pythium debaryanum* were recovered at 9.69, 8.83, 8.55 and 8.26%, respectively. The frequencies of *Sclerotioum rolfsii*, *Rhizopus stolonifer*, *Aspergillus niger* and *Macrophomina phaseolina* ranged from (2.56 to 4.27 %). On the other hand, *Mucor* sp., *Trichoderma* sp., *Penicillium* sp., *Helminthosporium* sp. and *Aspergillus flavus* were recovered at low frequencies ranged from 0.85 to 1.71 %.

Pathogenicity tests

Data presented in Table (2) showed that, all the tested pathogens were found to be pathogenic in varied degrees to the tested tomato cultivars. *Rhizoctonia solani* was the most virulent pathogen to tomato seedling especially isolate number II. Infection percentage on the cultivars Peto 86, Super Strain B and Castle Rock were 83.33, 75.0 and 62.5%, respectively. *Fusarium oxysporum* isolate number I followed by *R. solani* isolate number II (79.17, 62.5 and 70.83%, respectively). On the other hand, *P. ultimum* had the least infection percentage on tomato cultivars. All the tested tomato cultivars showed disease symptoms due to inoculation. However, the tested cultivars showed different degrees of susceptibility. Peto 86 cv. proved to be the most susceptible cultivar followed by Super Strain B cv. The least percentages of infection were obtained with Castle Rock cv. The difference between Castle Rock and Peto 86 cv. was significant while it was insignificant with Super Strain B.

In vitro experiments

Effect of compost extracts on fungal growth

The three mentioned isolates namely, *R. solani* (II), *F. oxysporum* (I) and *P. ultimum* were used in the subsequent compost trials *in vitro.* The twelve kinds of compost which fermented with or without additives (super phosphate and urea), i.e. sheep manure, chicken manure, wheat straw, alfalfa hay, turfgrass, mushroom and spent mushroom compost were tested against seven tomato root rot pathogens namely, *Fusarium oxysporum, Fusarium solani, Alternaria alternata, Rhizoctonia solani, Pythium debaryanum, Pythium ultimum, Macrophomina phaseolina in vitro.* The growth reduction were calculated for each treatment.

Fungal growth diameter

Effect of compost extract

According to the results in Table (3) all the applied compost extracts reduced the fungal growth, however the highest reduction were obtained by sheep manure compost either with or without additives and spent mushroom compost extracts (62.69, 62.42 and 65.67%, respectively).

On the other hand, wheat straw compost extract with or without additives reduced the least ER values (6.27 and 5.44%, respectively). Generally, it was clear that, all applied compost extracts were significantly affected fungal growth.

Effect of the pathogens

Results in Table (3) revealed that, the growth of the tested pathogens was significantly reduced due to the compost treatments. However, *F. oxysporum* was the most sensitive pathogen, followed by both *R. solani* and *P. debaryanum* (reduction rates were 50.93, 42.73 and 26.44%, respectively).

Effect of compost extract concentrations

From Table (4) it is clear that, all the tested concentrations of compost extracts were effective in reducing growth of fungi on PDA medium. Moreover, the antagonistic effect increased by increasing extract concentration. Concentration of 15% was the most effective followed by 10% (48.82 and 38.36%, respectively), while 5% extract concentration presented the lowest significant effect in reducing fungal growth (27.41%).

Effect of interactions

From results presented in Tables (3 & 4), It is evident that percentage of reduction in fungal linear growth were significantly influenced by the interaction between type and concentration of the tested compost extract. Regarding to the interaction between compost extract types and their concentrations, spent mushroom compost extract at concentration of 15% was the most effective in reducing linear growth of pathogens (77.70 %). Both of chicken manure compost plus additives extract and sheep manure compost plus additives extract showed significant reduction at the highest concentration (73.69 and 72.54 %, respectively). The lower reduction effect was observed from wheat straw compost extract with or without additives at concentration of 5 % and 10%. Moreover, there were a positive relationship between the tea compost concentrations and % growth reduction of the tested pathogens (Table 4).

Data in Table (3) clearly showed that sheep manure compost plus additives extract was the most effective on reducing growth of *F. oxysporum* (88.33 %), followed by sheep manure compost extract with the same fungus (87.13 %), while wheat straw compost with or without additives did not reduce the growth of both *Pythium* spp. (*P. debaryanum* and *P. ultimum*) as well as alfalfa hay compost extract with *P. ultimum*. Interaction between concentrations and pathogens presented in Table (4) showed that the highest antagonistic effect was exerted on *F. oxysporum* and *R. solani* by compost extract at concentration of 15% (67.52 and 51.69 %, respectively). The lowest reduction % was *obtained in P. debaryanum* at

concentration of 5 % (18.65 %), followed by *F. solani* at the same concentration (18.70%).

Data of the interaction between three factors (compost extract types, compost concentrations and tested pathogens) were presented in Table (4). Data clearly showed that, the highest efficiency was obtained with sheep manure compost with or without additives at the concentration of 15% with *F. oxysporum*, *R. solani* and *M. phaseolina* (91.1 %). It is also clear that both of mushroom compost tea at 15 % concentration with *F. oxysporum* and trufgrass compost at 15 % concentration with *M. phaseolina* had the highest efficiency ratio%. On the other hand, the least antagonistic effect was observed from wheat straw compost tea with or without additives at all tested concentrations with both of *P. debaryanum* and *P. ultimum*, whereas the fungal growth did not reduced completely (0.0%). Also, all concentrations of alfalfa hay compost tea without additives completely did not reduce the linear growth of *P. ultimum.*

Fungal inhibition Effect of compost extract types

Results in Table (5) showed that all treatments with compost extracts significantly increased inhibition zone (mm), compared with control. However, sheep manure compost extracts with or without additives had the highest inhibition zones (25.35 and 24.64 mm, respectively) compared with other tested extracts, followed by spent mushroom compost and mushroom compost extract (22.20 and 21.32 mm, respectively). While wheat straw compost extract showed the least inhibiting effect (6.90 mm).

Effect of pathogens

The obtained data in Table (5) showed significant differences in sensitivity of pathogens to compost extract treatments. *R. solani* had the highest value of inhibiting (20.96 mm), followed by *F. oxysporum* (17.58 mm), then *A. alternata*, *M. phaseolina* and *P. ultimum* (13.93, 13.83 and 13.64 mm, respectively). On the other hand, the least inhibition value was observed with *P. debaryanum* (9.12 mm).

Effect of compost concentrations

Inhibition zones of fungal growth increased with increasing the concentration of compost extracts (Table 6). Data also showed that concentration of 15% presented the highest effect (19.36 mm), followed by concentration of 10% (14.64 mm), while 5% concentration of compost extract had the least inhibiting effect (9.48 mm), compared with other tested concentrations.

Effect of interactions

With regard to the effect of interaction between compost extracts and concentrations on fungal growth (Table 6), it was evident that the application of highest concentration (15%) of sheep manure compost plus additives extract was the most effective in inhibiting fungal growth (31.32 mm) compared with other treatments. The least effect observed with the extract of alfalfa hay compost plus additives was 5% concentration. On the other hand, the effect of interaction between compost extracts and tested pathogens showed significant reduction. The highest inhibiting effect were obtained by applying sheep manure compost plus additives extract on *F. oxysporum* (38.17 mm), followed by *R. solani* (37.92 mm). The least effect of interaction was obtained from extract of wheat straw compost plus additives and wheat straw compost combined with *P. ultimum*.

Interaction between concentrations of compost extract and the tested pathogen (Table 6) significantly affected inhibition zones. The highest effect was obtained with concentration of (15%) combined with *R. solani* (26.79 mm), followed by 15% concentration with *F. oxysporum* (21.46 mm). The least effect was obtained from concentration of 5% combined with *P. ultimum* (4.19 mm).

Interaction among the three tested factors i.e., compost extracts, compost extract concentrations and tested pathogens are presented in Table (6). Data indicated that. The highest value was obtained from applied sheep manure compost plus additives extract at concentration of (15%) with *F. oxysporum* and *R. solani* (45.0 and 44.0 mm, respectively).

Compost microflora

Isolation of microorganisms was carried out from the most antagonistic compost types. Identification of the obtained microorganisms revealed the presence of many bacteria related to the genera *Bacillus*, *Pseudomonas*, *Corynebacterium* & *Micrococcus* and actinomyces. In addition, many fungal species were also obtained i.e., *Aspergillus* sp., *Fusarium* spp., *Penicillium* sp., *Rhizopus* sp. and *Trichoderma* spp. (Table 7). *Bacillus* spp. was found in all tested types of compost. *Pseudomonas* spp. was also isolated from all types except mushroom and spent mushroom compost.

Nutrient composition of compost

Table (8) showed that organic material content was differed according to the tested type of compost, i.e. carbon % were ranged from

31.2 in sheep compost without additives to 40.4 in spent mushroom compost. The data also indicated that C/N ratios ranged from 12.8 in chicken manure compost plus additives to 24.05 in spent mushroom compost. All types of compost proved to contain high concentrations of macro-, and microelements. In general, this study proved that the compost which was fermented with additives had more concentrations of nutrients, especially nitrogen and phosphorus, than the compost which fermented without additives. On the other hand, the concentration of heavy metals Cd, Pb and Ni were detected through the tested compost types.

Table (8) also showed also that the lowest level of Cd (0.0 mg/L) was found in chicken manure with additives, whereas the highest level of Cd (0.031 mg/L) was obtained from sheep manure compost without additives. Pb in chicken manure compost with additives had the lowest concentration (0.249 mg/L), while the highest concentration (0.328 mg/L) was found in sheep manure without additives and spent mushroom compost. On the other hand, the concentration of Ni showed lower level in mushroom compost (0.264 mg/L), whereas, the highest Ni concentration was obtained from chicken manure without additives (0.426 mg/L).

DISCUSSION

According to isolation experiments carried out throughout this study, three pathogenic isolates related to *F. oxysporum*, *R. solani* and *P. ultimum* were found to be the causal agents of tomato root rot and damping-off diseases. *R. solani* isolate proved to be the most destructive followed by *F. oxysporum*. Moreover, tomato cv. Peto 86 was the most susceptible among the other tested cultivars. This was generally inagreement with the findings of Khalifa (1991), Ramsey *et al.* (1992), Moustafa and Khafagi (1992), Lahoza *et al.* (1996). According Seth and Ownley (2001), virulent isolates of *R. solani* caused 69.25% seed mortality in tomato plants.

In vitro studies revealed that all the tested types of compost extracts were antagonistic to the tested pathogens, however, both of spent mushroom and sheep manure compost were more effective. This antagonistic effect was recorded by many authors to be results of fungal conidial inhibition (Hoitink & Fahy, 1986; Deborah, 1988; Elad & Shtienberg, 1994; McQuiken *et al*, 1994; Yohalem *et al.*, 1994; Theodore & Toribio, 1995 and Zhang *et al.*, 1998). It was also reported that compost extract of manure-straw mixtures lost activity on filter sterilization or autoclaving (McQuiken *et al*, 1994), as well, it was found that extracts

produced from sterile spent mushroom substrate were virtually ineffective compared with those non-sterile compost (Yohalem *et al.*, 1996). This antagonistic effect of compost extract against some severe economic phytopathogenic fungi and subsequent control of the disease could be explained by the occurrence of many antagonistic actinomyces, bacteria and yeasts in the compost (Hoitink & Fahy 1986; Deborah, 1988; McQuiken *et al*, 1994; Yohalem *et al.*, 1994). Compost extract may exert its effect on the pathogen *in vitro* through many mechanisms among which the most common in the inhibition of pathogen spore germination or antagonism (Budde and Weltzien, 1990). El-Masry *et al.* (2002) also found that compost water extractbproduce clear inhibition zones against *Pythium debaryanum*, *F. oxysporium f.* sp. *lycopersici* and *Sclerotinia bataticola*. The microflora which found in compost extract have an important role in suppressing the growth of tested fungi. They added that compost extract contained neither antibiotics nor siderophores. The presence of protease, lipase and β-1,3 glucanse (lysogenic enzymes) in compost extract indicate a possible role in fungal degradation. The characterization of the antagonistic substrates in the compost extract was determined on the basis that it can contain one or more anti-substances such as antibiotics, siderophores, lysogenic enzymes and volatile compounds (El-Masry *et al.*, 2002).

Isolation trials from the tested types of compost revealed the presence of many types of fungi, bacteria and actinomyces. Moreover, sheep manure extract with or without additives contained the highest number of microbial types which was reflected the microbial activities and hence, suppressive effect on the tested pathogens. This relation was also reported by other authors (Mandelbaum and Hadar, 1990; Inbar *et al.*, 1991; Boehm and Hoitink, 1992; Lewis *et al.*, 1992). All the tested types of compost were characterized by the high concentrations of macro-, and microelements, however, compost types enriched with additives proved to have higher content of N and P. Mineral activity, mineral nutrient availability and soil-borne disease incidence are interrelated (Huber and Wilhelm, 1998). Disease suppression, generally, was associated with the level of N, P, Ca and Mg as well as microbial activity (Lumsden *et al.* 1983 and Huber & Wilhelm, 1998). The Ca content of soil has been associated with suppressiviness to damping-off caused by soil-borne pathogens (Kao and Ko, 1986).

According to the obtained data, heavy metal are present in the all tested types of compost, however, their concentration did not reach toxic level to plants (Liphadzi & Kirkham, 2005). The obtained results clearly

showed significant inhibition of the tested root rot and damping-off pathogens *in vitro* by different types of compost. Thus, compost extracts, especially those amended by additives, may be considered a promising measure to control plant diseases caused by soil-borne fungi. However, in order to make progress in this area, it is going to be necessary to look more carefully into the microbial, process during composting. In this area as well, compost retains the potential to significantly increase its value, which could provided it with a very pre-eminent place in sustainable agriculture (Inbar *et al.*, 1991; Lewis *et al.*, 1992).

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Table (1): Frequency percentages of the fungi isolated from tomato plants showing damping off and root rot symptoms collected from different Governorates.

Isolated fungi	Frequencies of the recovered fungi			The isolated fungi (%)
	EL.Behera	Alex-	El-Fayoum	
Alternaria sp.	11.38	7.96	9.57	9.69
Aspergillus flavus	1.63	2.65	0.87	1.71
Aspergillus niger	3.25	0.88	3.48	2.56
Fusarium moniliforme	8.94	8.85	7.83	8.55
Fusarium oxysporum	14.63	18.58	17.93	16.81
Fusarium solani	8.13	11.50	6.96	8.83
Helminthosporium sp.	1.63	0.88	1.74	1.42
Macrophomina phaseolina	1.88	3.54	4.35	4.27
Mucor sp.	0.81	1.77	0.00	0.85
Penicillium sp.	2.44	0.00	1.74	1.42
Pythium debaryanum	8.13	7.08	9.57	8.26
Pythium ultimum	13.01	15.93	16.52	15.10
Rhizoctonia solani	14.63	15.04	13.04	14.25
Rhizopus stolonifer	2.44	3.54	1.74	2.56
Sclerotium rolfsii	3.25	1.77	2.61	2.56
Trichoderma sp.	0.81	0.00	2.61	1.14
Total samples	123	113	115	

Table (2): Infection percentage of some tomato damping-off and root rot pathogens on different tomato cultivars.

Tested isolates	Infection (%)			Mean
	Peto 86	Castle Rock	Super Strain B	
Fusarium oxysporum I	79.17*	62.50	70.83	**70.83^{ab}**
Fusarium oxysporum II	75.00	54.17	62.50	**63.89^{abc}**
Fusarium oxysporum III	50.00	45.83	50.00	**48.61^{d}**
Pythium ultimum I	62.50	41.67	54.17	**52.78^{cd}**
Pythium ultimum II	70.83	54.17	62.50	**62.50^{bc}**
Pythium ultimum III	66.67	54.17	54.17	**58.33^{cd}**
Rhizoctonia solani I	70.83	54.17	62.50	**62.50^{bc}**
Rhizoctonia solani II	83.33	62.50	75.00	**73.61^{a}**
Rhizoctonia solani III	58.33	37.50	45.83	**47.22^{d}**
Control	0.00	0.00	0.00	**0.00^{e}**
Mean	**61.67^{a}**	**46.67^{b}**	**53.75^{ab}**	
L.S.D0.05 (Pathogens)		6.4		
L.S.D0.05 (Cultivars)		7.72		
L.S.D0.05 (Interaction)		(NS)		

*Value are means of 3 replicates. Eight plants per each. NS : not significant..

Table (3): Efficacy of different types of tea compost with or without additives on growth of tomato root rot pathogens.

Treatments	Inhibition (%) Tomato root rot pathogens							Mean
	F. ox.	*F. sol.*	*A. alt.*	*R. sol.*	*P. ulti.*	*P. deb.*	*M. ph.*	
Sheep C.T.A	88.33	43.06	30.74	82.41	54.17	55.83	84.26	62.69[a]
Sheep C.T	87.13	42.59	36.11	82.41	54.72	49.91	84.07	62.42[a]
Chicken C.T.A	59.35	42.41	61.39	64.26	66.20	50.28	50.19	56.30[b]
Chicken C.T	61.11	39.72	53.80	59.44	68.15	46.39	52.04	54.38[b]
Trufgrass C.T.A	56.67	25.46	44.44	61.57	64.91	9.07	78.06	48.60[d]
Trufgrass C.T	53.61	20.56	38.52	67.31	65.93	3.70	71.30	45.85[e]
Alfalfa hay C.T.A	33.70	13.61	51.48	3.80	1.20	23.43	6.85	19.15[f]
Alfalfa hay C.T	31.02	14.81	47.96	4.72	0.00	20.46	5.37	17.76[f]
Wheat straw C.T.A	17.59	10.09	3.06	8.98	0.00	0.00	4.17	6.27[g]
Wheat straw C.T	16.76	9.17	2.04	8.70	0.00	0.00	1.39	5.44[g]
Mushroom C.T	75.09	72.22	59.54	31.94	73.61	39.26	12.31	52.00[c]
S. mushroom CT	81.67	52.69	77.31	79.91	51.11	45.37	71.67	65.67[a]
Control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00[h]
Mean (pathogens)	50.93[a]	29.72[e]	38.95[c]	42.73[b]	38.46[d]	26.44[f]	40.13[c]	
L.S.D0.05 pathogen	1.06							
L.S.D0.05 Compost	1.95							
L.S.D0.05 Concentrations	0.89							

CTA= compost tea with additives, CT= compost tea, F.ox= *Fusarium oxysporum*, F.sol= *Fusarium solani*, A.alte=*Alternaria alternarnata*, R.sol= *Rhizoctonia solani*, P.deb=*Pythium debaryanum*, P.ult= *Pythium ultimum*, M.ph= *Macrophomina phaseolina*.
*Com= compost

Table (4): Efficacy of different concentrations of the tested compost extracts on the mycelial growth of the tested root rot agents.

Compost	Con.	Inhibition (%) Root rot pathogens							Mean
		F. ox.	*F. sol.*	*A. alte.*	*R. sol.*	*P. ult.*	*P. deb.*	*M. ph.*	
Sheep C.T.A	5	82.78	38.06	23.33	70.83	40.56	45.00	76.39	53.85
	10	91.11	41.94	24.44	85.28	51.67	51.94	85.28	61.67
	15	91.11	49.17	44.44	91.11	70.28	70.56	91.11	72.54
Sheep C.T	5	81.39	36.67	28.06	73.61	36.11	41.67	78.33	53.69
	10	88.89	46.11	34.72	82.50	56.94	44.17	82.78	62.30
	15	91.11	45.00	45.56	91.11	71.11	63.89	91.11	71.27
Chicken C.T.A	5	34.17	27.50	39.17	64.17	46.94	36.39	41.94	41.47
	10	55.83	45.56	66.94	55.83	63.61	47.50	40.83	53.73
	15	88.06	54.17	78.06	72.78	88.06	66.94	67.78	73.69
Chicken C.T	5	41.39	24.44	32.22	49.44	50.83	34.44	40.83	39.09
	10	53.33	43.06	55.56	55.56	64.17	46.11	52.78	52.94
	15	88.61	51.67	73.61	73.33	89.44	58.61	62.50	71.11
Trufgrass C.T.A	5	35.00	14.44	27.22	46.67	52.22	0.00	56.67	33.17
	10	60.00	22.78	46.67	56.11	57.50	11.39	86.39	48.69
	15	75.00	39.17	59.44	81.94	85.00	15.83	91.11	63.93
Trufgrass C.T	5	33.33	9.72	21.67	48.89	48.33	0.00	47.50	29.92
	10	56.94	16.94	40.83	72.22	61.11	0.00	76.11	46.31
	15	70.56	35.00	53.06	80.83	88.33	11.11	90.28	61.31
Alfalfa hay C.T.A	5	13.06	4.44	43.06	0.83	0.00	14.72	0.00	10.87
	10	30.28	13.06	51.67	2.22	0.00	23.33	8.61	18.45
	15	57.78	23.33	59.72	8.33	3.61	32.22	11.94	28.13
Alfalfa hay C.T	5	7.22	3.33	39.72	2.78	0.00	13.06	1.11	9.60
	10	30.56	19.72	45.28	5.00	0.00	22.78	5.56	18.41
	15	55.28	21.39	58.89	6.39	0.00	25.56	9.44	25.28
Wheat straw C.T.A	5	2.22	0.83	0.00	4.17	0.00	0.00	0.00	1.03
	10	10.00	13.89	3.89	8.33	0.00	0.00	4.44	5.79
	15	40.56	15.56	5.28	14.44	0.00	0.00	8.06	11.98
Wheat straw C.T	5	3.33	1.11	0.00	5.28	0.00	0.00	0.00	1.39
	10	5.83	11.39	2.78	7.22	0.00	0.00	0.00	3.89
	15	41.11	15.00	3.33	13.61	0.00	0.00	4.17	11.03
Mushroom C.T	5	61.94	45.28	41.67	10.83	56.11	29.17	0.00	35.00
	10	75.83	84.17	63.06	34.17	80.28	38.06	4.72	54.33
	15	87.50	87.22	73.89	50.83	84.44	50.56	32.22	66.67
Spent mushroom C.T	5	66.67	37.22	61.94	66.67	28.89	28.06	40.83	47.18
	10	87.22	54.44	82.22	85.83	61.39	49.44	84.44	72.14
	15	91.11	66.39	87.78	87.22	63.06	58.61	89.72	77.70[a]
Control		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Con. × pathogen	5	35.58	18.70	27.54	34.17	27.69	18.65	29.51	27.41[c]
	10	49.68	31.77	39.85	42.33	38.21	25.75	40.92	38.36[b]
	15	67.52	38.70	49.47	51.69	49.49	34.91	49.96	48.82[a]
L.S.D0.05 Compost × con.		3.39			L.S.D0.05 Con. × Pathogen				2.38
L.S.D0.05 Con.		0.89			L.S.D0.05 Compost × con. × Pathogen				8.97

CTA= compost tea with additives, CT= compost tea, F.ox= *Fusarium oxysporum*, F.sol= *Fusarium solani*, A.alte=*Alternaria alternamata*, R.sol= *Rhizoctonia solani*, P.deb=*Pythium debaryanum*, P.ult= *Pythium ultimum*, M.ph= *Macrophomina phaseolina*.

Con.=concentration

Table (5): Effect of different types of compost tea on inhibiting of tomato root rot pathogens.

Treatments	Inhibition (mm) Tomato root rot pathogens							Mean
	F. ox.	*F. sol.*	*A. alt.*	*R. sol.*	*P. ulti.*	*P. deb.*	*M. ph.*	
Sheep C.T.A	38.17	18.25	25.17	37.92	20.00	16.25	21.67	**25.35^{a}**
Sheep C.T	36.67	20.67	21.83	37.25	20.25	13.75	22.08	**24.64^{a}**
Chicken C.T.A	17.92	21.25	12.75	31.17	31.08	12.00	10.75	**19.56^{c}**
Chicken C.T	21.42	17.25	14.08	30.75	29.42	12.75	10.83	**19.50^{c}**
Trufgrass C.T.A	12.83	11.00	14.58	17.67	7.92	10.00	17.58	**13.08^{d}**
Trufgrass C.T	14.33	11.67	16.00	16.83	6.75	8.33	16.33	**12.89^{d}**
Alfalfa hay C.T.A	7.67	4.75	9.92	14.08	8.25	4.92	7.92	**8.21^{e}**
Alfalfa hay C.T	5.67	6.92	9.50	13.08	7.25	4.25	6.83	**7.64^{e}**
Wheat straw C.T.A	9.42	6.67	8.42	7.83	0.00	5.83	11.75	**7.13^{e}**
Wheat straw C.T	8.50	7.58	7.00	8.42	0.00	5.75	11.08	**6.90^{e}**
Mushroom C.T	25.50	16.42	22.92	27.58	24.75	11.83	20.25	**21.32^{b}**
S. mushroom CT	30.42	18.92	18.92	29.92	21.58	12.92	22.75	**22.20^{b}**
Control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00^{f}**
Mean (pathogens)	**17.58^{b}**	**12.41^{d}**	**13.93^{c}**	**20.96^{a}**	**13.64^{c}**	**9.12^{e}**	**13.83^{c}**	
L.S.D$_{0.05}$ pathogen	0.72							
L.S.D$_{0.05}$ Compost	1.00							
L.S.D$_{0.05}$ Concentrations	0.44							

CTA= compost tea with additives, CT= compost tea, F.ox= *Fusarium oxyspoium*, F.sol= *Fusarium solani*, A.alte=*Alternaria alternamata*, R.sol= *Rhizoctonia solani*, P.deb=*Pythium debaryanum*, P.ult= *Pythium ultimum*, M.ph= *Macrophomina phaseolina*.
*Com= compost

Table (6): Effect of compost tea concentrations on inhibition of tomato root rot pathogens.

Compost	Con.	Inhibition (mm) Tomato root rot pathogens							Mean
		F. ox.	*F. sol.*	*A. alte.*	*R. sol.*	*P. ulti.*	*P. deb.*	*M. ph.*	
Sheep C.T.A	5	32.25	14.00	20.25	33.00	11.00	11.25	9.50	18.75
	10	37.25	17.25	26.50	36.75	23.50	16.00	24.50	25.96
	15	45.00	23.50	28.75	44.00	25.50	21.50	31.00	31.32[a]
Sheep C.T	5	30.50	14.75	18.75	31.75	12.00	8.00	10.50	18.04
	10	36.25	22.25	21.25	37.25	22.00	13.25	26.25	25.50
	15	43.25	25.00	25.50	42.75	26.75	20.00	29.50	30.39[a]
Chicken C.T.A	5	14.75	14.75	9.25	23.75	19.50	10.75	8.00	14.39
	10	16.75	20.75	11.25	31.25	33.75	12.25	10.50	19.50
	15	22.25	28.25	17.75	38.50	40.00	13.00	13.75	24.79
Chicken C.T	5	16.00	12.25	11.75	22.75	16.50	10.25	6.50	13.71
	10	19.75	14.75	14.25	32.75	31.50	12.75	11.00	19.54
	15	28.50	24.75	16.25	36.75	40.25	15.25	15.00	25.25
Trufgrass C.T.A	5	10.25	8.50	8.75	9.50	0.00	0.00	9.50	6.64
	10	12.50	10.50	14.50	17.75	7.50	10.75	17.00	12.93
	15	15.75	14.00	20.50	25.75	16.25	19.25	26.25	19.68
Trufgrass C.T	5	12.00	8.75	9.50	12.00	0.00	0.00	10.50	7.54
	10	14.75	12.75	15.50	15.75	7.00	8.75	16.25	12.96
	15	16.25	13.50	23.00	22.75	13.25	16.25	22.25	18.18
Alfalfa hay C.T.A	5	0.00	1.75	5.75	9.25	0.00	0.00	0.00	2.39
	10	9.50	4.50	9.50	10.75	9.50	0.00	5.50	7.04
	15	13.50	8.00	14.50	22.25	15.25	14.75	18.25	15.21
Alfalfa hay C.T	5	0.00	4.25	7.00	7.50	0.00	0.00	0.00	2.68
	10	8.50	6.75	8.25	12.25	7.50	0.00	6.75	7.14
	15	8.50	9.75	13.25	19.50	14.25	12.75	13.75	13.11
Wheat straw C.T.A	5	8.25	3.25	0.00	2.50	0.00	0.00	11.50	3.64
	10	8.75	7.75	12.25	7.75	0.00	7.25	11.75	7.93
	15	11.25	9.00	13.00	13.25	0.00	10.25	12.00	9.82
Wheat straw C.T	5	7.25	4.50	0.00	2.25	0.00	0.00	10.50	3.50
	10	8.00	8.25	10.25	8.25	0.00	6.75	11.50	7.57
	15	10.25	10.00	10.75	14.75	0.00	10.50	11.25	9.64
Mushroom C.T	5	20.75	10.00	18.75	21.25	20.50	6.75	15.75	16.25
	10	26.50	16.25	22.50	29.00	23.25	11.50	21.75	21.54
	15	29.25	23.00	27.50	32.50	30.50	17.25	23.25	26.18
Spent mushroom C.T	5	24.50	10.50	12.00	23.75	15.25	7.50	16.50	15.71
	10	31.50	20.75	19.50	30.50	22.00	12.75	22.25	22.75
	15	35.25	25.50	25.25	35.50	27.50	18.50	29.50	28.14
Control		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Con. × pathogen	5	13.58	8.25	9.37	15.33	7.29	4.19-	8.37	9.48[c]
	10	17.69	12.50	14.27	20.77	14.42	8.62	14.23	14.64[b]
	15	21.46	16.48	18.15	26.79a	19.19	14.56	18.90	19.36[a]
L.S.D0.05 Compost × con.		1.67			L.S.D0.05 Con. × Pathogen				1.16
L.S.D0.05 Con.		0.44			L.S.D0.05 Compost × con. × Pathogen				4.58

CTA= compost tea with additives, CT= compost tea, F.ox= *Fusarium oxysporum*, F.sol= *Fusarium solani*, A.alte=*Alternaria alternamata*, R.sol= *Rhizoctonia solani*, P.deb=*Pythium debaryanum*, P.ult= *Pythium ultimum*, M.ph= *Macrophomina phaseolina*. Con.=concentration

Table (7): Microorganisms isolated from different types of compost.

Isolates	Sheep compost		Chicken compost		Mushroom compost	Spent mushroom compost
	With additive	Without additive	With additive	Without additive		
Fungi						
Aspergillus sp.	A	P	P	P	P	P
Rhizopus sp.	P	A	A	P	P	P
Penicillium sp.	P	P	P	P	P	P
Trichoderma spp.	P	P	A	P	A	P
Fusarium spp.	P	P	A	A	A	A
Bacteria						
Bacillus spp.	P	P	P	P	P	P
Pseudomonas spp.	P	P	P	P	A	A
Corynebacterium sp.	P	P	A	P	P	A
Micrococcus sp.	P	A	P	A	A	A
Actinomycetes	P	P	P	P	A	A
Sacharomyces	P	P	P	A	P	A

A = Absent P = Present

Table (8): Chemical analysis of different types of compost.

Chemical analysis	Sheep compost		Chicken compost		Mushroom compost	Spent mushroom compost
	With Additives	Without additives	With Additives	Without additives		
PH	6.8	7.4	8.53	8.3	6.5	7.1
E.C	3.4	4.5	2.1	2.3	1.9	2.7
Carbon %	38.2	31.2	36.2	32.5	32.4	40.4
C/N ratio	13.8	16.0	12.8	14.7	16.17	24.05
Macronutrients						
N%	2.76	1.95	2.82	2.21	1.94	1.68
P%	2.73	2.70	4.815	3.66	4.48	0.170
K (mg/kg)	55	55	190	155	145	30
Micronutrients						
Fe (mg/L)	3.353	3.574	12.95	17.925	5.191	5.0
Mn (mg/L)	1.226	1.310	1.747	1.896	1.565	1.304
Zn (mg/L)	1.297	0.749	5.675	5.525	4.15	0.346
Heavy metals						
Cd (mg/L)	0.013	0.031	0.0	0.024	0.009	0.016
Pb (mg/L)	0.314	0.328	0.249	0.288	0.276	0.328
Ni (mg/L)	0.360	0.319	0.378	0.426	0.264	0.383

الملخص العربى

التأثير التضادى لمستخلصات الكومبوست على نمو المسببات المرضية لأعفان جذور الطماطم

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تم عزل ودراسة القدرة المرضية لمسببات أمراض أعفان الجذور وموت البادرات التى تصيب العديد من أصناف الطماطم و كان اكثرها تكرارا فطريات فيوزاريوم اكسيسبورم، بيثيوم التيميم، ريزوكتونيا سولاني والتى تم اختبار قدرتها الإمراضية على إصابة ثلاثة أصناف من الطماطم (كاستل روك وسوبر ستراين بى وبيتو ٨٦) حيث تم إختبار ثلاث عزلات من كل فطر. أظهرت النتائج أن الفطر ريزوكتونيا سولاني كان أكثرها قدرة إمراضية وإتضح أيضا أن صنف بيتو ٨٦ كان أكثر الأصناف قابلية للاصابة. كما تم أيضا دراسة تأثير أنواع مختلفة من مستخلصات الكومبوست على تقليل معدل نمو مسببات اعفان الجذور وذلك باستخدام ثلاث تركيزات (٥, ١٠, ١٥%) وأظهرت النتائج أن فطر الفيوزاريم أوكسيسبورم وريزوكتونيا سولاني كانا أكثر الفطريات حساسية للمعاملة. بينما كان أعلى التركيزات فاعلية هو ١٥% وأقلها ٥%. وكذلك تم عزل الكائنات الحية بالكومبوست وإجراء التحليل الكيميائى لأنواع الكومبوست الأكثر تأثيراً حيث أظهر التحليل الكيميائي محتويات عالية من كل من العناصر الكبرى والصغرى خصوصا أنواع الكومبوست المتخمرة بالإضافات. ومن ناحية أخرى، كان تركيز العناصر الثقيلة في أنواع الكومبوست المختبرة أدنى من الحد السام لنباتات أصناف الطماطم المختبرة.