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Research Article

Using Commercial Compost as Control Measures against Cucumber Root-Rot Disease

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Five commercial composts were evaluated to suppress the root-rot pathogens (*Fusarium solani* (Mart.) App. and Wr, *Pythium ultimum* Trow, *Rhizoctonia solani* Kuhn, and *Sclerotium rolfsii* Sacc.) of cucumber plants under *in vitro* and greenhouse conditions. *In vitro* tests showed that all tested unautoclaved and unfiltrated composts water extracts (CWEs) had inhibitor effect against pathogenic fungi, compared to autoclaved and filtrated ones. Also, the inhibitor effects of 40 bacteria and 15 fungi isolated from composts were tested against the mycelial growth of cucumber root-rot pathogens. Twenty two bacteria and twelve fungal isolates had antagonistic effect against root-rot pathogens. The antagonistic fungal isolates were identified as 6 isolates belong to the genus *Aspergillus* spp., 5 isolates belong to the genus *Penicillium* spp. and one isolate belong to the genus *Chaetomium* spp. Under greenhouse conditions, the obtained results in pot experiment using artificial infested soil with cucumber root-rot pathogens showed that the compost amended soil reduced the percentage of disease incidence, pathogenic fungi population, and improved the cucumber vegetative parameters as shoot length, root length, fresh weight, and dry weight. These results suggested that composts are consequently considered as control measure against cucumber root-rot pathogens.

1. Introduction

Fusarium solani, *Pythium ultimum*, *Rhizoctonia solani*, and *Sclerotium rolfsii* were considered the most important soil-borne pathogens which cause cucumber root-rot disease [1–4]. Suppression of these plant pathogens is considered an urgent need for present agriculture practices. Therefore, the use of compost to suppress the root rot pathogens has been extensively reviewed by many workers [5–8]. Different mechanisms were suggested to explain the role of compost application to control soil-borne plant pathogens such as enhancement beneficial microorganisms which secrete lytic enzymes and antibiotic, containing microorganisms which competed for nutrients, or activation of disease-resistance genes (induce resistance) in plants [6, 9].

Moreover, compost suppressive effects against several soil-borne plant pathogens were recorded such as *Pythium* spp. [10, 11], *Phytophthora* spp. [6, 12], *Rhizoctonia* spp. [13], and *Fusarium* spp. [14]. Many studies revealed that *Bacillus* spp., *Enterobacter* spp., *Pseudomonas* spp., *Streptomyces* spp. and other bacterial genera, as well as *Penicillium* spp., *Aspergillus* spp., *Trichoderma* spp., *Gliocladium virens*, and other fungi, have been identified as biocontrol agents in compost-amended substrates [15–21].

This work aimed to study the inhibitor effect of five commercial composts against the common four high pathogenic root-rot pathogens, that is, *Fusarium solani*, *Pythium ultimum*, *Rhizoctonia solani*, and *Sclerotium rolfsii* and their role in improving some vegetative parameters of cucumber plants.

2. Materials and Methods

2.1. Isolation, Identification, and Pathogenicity Test of Cucumber Root-Rot Pathogens. Naturally root-rot infected cucumber plants were collected from some commercial plastic houses located at three Governorates, that is, Giza (El-Dokki

and El-Haram locations), Cairo (Gezerit El-Dahab location), and Qualubiyia (Toukh location) during 2010 and 2011 growing seasons. Small pieces (1 cm length) of diseased cucumber roots were cut and then disinfested by immersing in sodium hypochlorite (1%) for 5 min, then washed with serials of sterilized water and dried between two sterilized layers of filter paper. The root pieces were then put onto the surface of sterilized Petri dishes containing water agar medium. After 3 days of incubation at 25 ± 1°C, the fungal hyphal tip of developed colonies around the root pieces were picked up and transferred onto Potato Dextrose Agar (PDA) and incubated for 7 days at 25±1°C. The growing fungi were identified kindly at the Plant Pathology Department National Research Centre (NRC), Egypt, according to the morphological and cultural characters following the methods described previously [22–26]. The isolated fungi were maintained on PDA medium at 4°C for further studies.

Pathogenic ability of eight fungal isolates, that is, *Fusarium moniliforme*, *F. oxysporum, F. semitectum*, *F. solani, P. ultimum*, *R. solani*, *S. rolfsii*, and *Sclerotinia sclerotiorum*, was evaluated against cucumber Beit-Alpha cv. in pot experiments under greenhouse conditions [27]. The experiment was carried out in autoclaved (121°C for two hours) clay loamy soil (50% sand, 40% clay, and 10% silt) artificially infested with the tested fungal isolates. Fungal mass production used for soil infestation was obtained by growing the tested isolates on sand-barley medium. This natural medium was prepared by mixing sand and barley (1 : 1, w : w and 40% water); then the mixture in glass bottles with cotton plugs was sterilized three times (1 hr each time) at 121°C. The autoclaved medium was then inoculated individually with a 5 mm disk of each tested fungal isolate and incubated at 20 ± 2°C for 2 weeks [28]. Soils were infested individually at a ratio of 5% (w : w) with tested pathogenic fungal cultures and mixed thoroughly to ensure equal distribution of fungal inoculum, then filled in plastic pots (25 cm diameter) and irrigated every second day for 1 week before sowing. A set of pots were also amended with the same rate of sand-barley medium free of fungal inoculum and reserved as control treatment. Surface sterilized cucumber seeds Beit-Alpha cv. (using 3% sodium hypochlorite for 5 min, then picked up and air-dried) were planted in both infested and noninfested soils, five seeds per pot and five replicates (pots). The average percentage of pre- and postemergence root-rot incidence was recorded after 15 and 30 days from sowing, respectively. All of described procedures were repeated three times and the average percentages were calculated.

2.2. Composts. Commercial composts were purchased from the Egyptian Company for Solid Waste Utilization (ECARU), Giza, Egypt. Five types of compost, prepared aerobically for four months, were used in the present work as follows:

compost (A): a mixture of different aromatic plants, sugar beet, and sugarcane;

compost (B): a mixture of rice straw and animal wastes;

compost (C): a mixture of cotton straw and maize straw;

compost (D): a mixture of town refuses (domestic waste);

compost (E): a mixture of different agricultural residues.

All composts were tested for their efficacy to suppress cucumber root-rot pathogens under laboratory and greenhouse conditions.

2.3. Plant Material. Cucumber seeds (*Cucumis sativus* L.) cv. Beit-Alpha was used in this study.

2.4. Root-Rot Pathogens. *Fusarium solani*, *Pythium ultimum*, *Rhizoctonia solani*, and *Sclerotium rolfsii*, which considered the most virulent pathogens causing root-rot disease of cucumber, were used.

2.5. Laboratory Tests

2.5.1. Preparation of Compost Water Extract (CWE). The CWEs were prepared by vigorously shaking of mature compost, at the ratio of 1 : 2 (w/v) of compost (500 g) to sterile water (1000 mL), for 20 min. To remove large particles from compost mixture, aliquot of 250 mL of the mixture was filtrated by passing through sterile 3 layers of cheesecloth and then the filtrate was centrifuged at 500 rpm for 10 min to obtain active supernatant as stock solution. These procedures were carried out for the five used types of composts.

(1) Inhibitor Effect of Composts. The inhibitor effect of five tested composts as water extracts (CWEs) was examined against the tested pathogenic fungi *in vitro* using the methods of pouring plate, wells-cut diffusion, and dry weight of fungal mycelium [29].

(a) Pouring Plate Method. The unautoclaved and autoclaved of CWEs were tested for each tested compost against the pathogenic fungi using the pouring plate method. Aliquots of CWE supernatant stock solution were added to PDA medium to obtain three concentrations of 5, 10 and 15% (v/v). One disc (0.5 cm in diameter) of 7-day-old culture of each pathogenic fungus was separately placed onto the centre of plate containing CWE amended PDA medium. Another set of Petri dishes free of CWEs were used as the control. Five Petri dishes were used as replicates for each treatment as well as the control treatment. All plates were incubated at 25 ± 1°C until the control plate was fully covered with fungal mycelial growth. The linear radial mycelial growth of each pathogenic fungus was measured to determine the inhibitor effect of CWEs. The percentages of fungal growth reduction were determined according to the following formula:

$$\text{Fungal growth reduction } \% = \left(\frac{C - P}{C}\right) \times 100, \quad (1)$$

where C is the diameter of mycelial growth in control plates and P is the diameter of mycelial growth in treated plates.

(b) Well-Cut Diffusion Method. The unfiltered and filtered of CWEs of stock solution were tested against the pathogenic fungi using the well-cut diffusion method. The CWEs were filtered through 0.22 μm sterilized Millipore membrane filter. Forty mL of sterile PDA medium were used for each plate, three wells were then punched out using a sterile 0.5 cm cork bore, and each of the well bottoms was sealed with two drops of sterile PDA medium. Hundred microlitres of each unfiltered and filtered CWE was separately transferred into each well. The sterile water was used as control. One disc (0.5 cm diameter) of 7-day-old culture of each pathogenic fungus was centrally placed among the wells on the surface of PDA medium. Five Petri dishes were used as replicates for each treatments as well as the control. All plates were incubated at 25 ± 1°C for 7 days. After the incubation period, the clear inhibition zones from pathogenic fungus around CWEs wells were measured.

(c) Mycelium Dry Weight Method. The inhibition effect of the unfiltered CWEs was determined against the pathogenic fungi using the fungal mycelium dry weight method. Five milliliters of each CWE was individually added to sterile 95 mL of PDB (Potato Dextrose Broth) medium in flask of 250 mL. Then, each flask was inoculated with one disc (0.5 cm diameter) of 7-day-old culture of each pathogenic fungus. A blank was prepared by adding CWE to the PDB medium without any pathogenic fungus inoculation. The PDB medium inoculated with the pathogenic fungus only as the control. Five flasks were used as replicates for each treatment as well as both the control and the blank. The inoculated flasks were incubated at 25 ± 1°C for 7 days. The culture of PDB including the growing microorganisms in treatments, the control and the blank were filtered through 0.22 μm Millipore membrane filter. Then, the dry weight of Millipore membrane filter was determined after drying the membrane at 65 ± 1°C until constant weight. The dry weight reduction (%) of compost treatments was calculated according to the following formula:

$$\text{Dry weight reduction (\%)} = \frac{\text{Control} - (\text{Compost treatment} - \text{Blank})}{\text{Control}} \times 100, \quad (2)$$

where Blank is dry weight of microbial growth of microorganisms in compost without any pathogenic fungus, Control is dry weight of mycelial growth of pathogenic fungus without compost, and Compost treatment is dry weight of pathogenic fungus + compost.

(2) Isolation of Common Microorganisms from Composts. The common bacteria, fungi, and actinomycetes in fresh composts were isolated using the plate count dilution technique on selective media [14].

(3) Identification of Isolated Bacteria and Fungi. Identification of the isolated bacteria was carried out in the Plant Pathology Department, NRC, Giza, Egypt, according to the morphological and cultural characters described by [30, 31]. Identification of the isolated fungi was carried out in the Plant Pathology Department, National Research Centre (NRC), Egypt, according to the morphological and cultural characters described by [22, 24, 32].

(4) Assay of the Antagonistic Effect of Isolated Bacteria. The purified forty bacteria isolates were screened for their antagonistic effect against the tested pathogenic fungi using the method described by [14]. Each bacterial isolate was cultured (by streaking) on one side of 9 cm diameter Petri dish containing PDA medium and then a 5 mm plug from the leading edge of a 5-day-old culture of *F. solani*, *P. ultimum*, *R. solani*, or *S. rolfsii*, individually was cultured on surface of the medium at the opposite side of the same Petri dish. Five Petri dishes were used as replicates for each tested microorganism. Inoculated plates were incubated at 25 ± 1°C until the fungal growth of the control reached the edge of the plate. The growth area and reduction in mycelial growth of the pathogenic fungi were calculated according to [33].

(5) Assay of the Antagonistic Effect of Isolated Fungi. The antagonistic effect of fifteen fungi isolated from composts was evaluated against the tested pathogenic fungi. A 5-mm plugs from 5-day-old culture of each of *F. solani*, *P. ultimum*, *R. solani*, and *S. rolfsii*, were placed individually on one side of 9 cm diameter Petri dish containing PDA medium and then, 5 mm plugs from 5-day-old culture of the tested isolated fungus (selected from the compost) were placed on the opposite side of Petri dish. Five Petri dishes were used as replicates for each treatment. Inoculated plates were incubated at 25 ± 1°C, until the fungal growth of the control plates reached the edge of the plate. The growth area and reduction in mycelial growth of the pathogenic fungi were calculated according to [33].

2.6. Greenhouse Experiments. The effect of soil amendment with compost on cucumber root-rot disease incidence, the total microbial counts (fungi, bacteria, and actinomycetes), and some vegetative parameters of cucumber (Beit-Alpha cv.) grown in infested soil with root-rot pathogens under greenhouse conditions was evaluated.

A pot experiment was designed under greenhouse conditions using plastic pots (30 cm diameter) containing 5 kg of sterile sandy loam soil infested with the inocula of the fungi tested grown on barely grain at the rate of 4% (w : w) as described earlier. Infested potting soil was irrigated for 15 days before sowing. Infested soil was amended with 25 g//kg soil and mixed together, of each compost one week before seed sowing. Ten surface sterilized cucumber seeds (using 1% sodium hypochlorite for 5 min then picked up and air-dried) were sown in each pot and 5 pots were used for each treatment as replicates. Unamended infested pots were used as control.

Compost amended and unamended infested soils were used to study the following points.

2.6.1. Control of Cucumber Root-Rot Diseases. Disease assessments were recorded as the percentages of root-rot disease

incidence at pre- and postemergent stages after 10 and 30 days of seed sowing, respectively, and then three plants per pots were left up to 45 days to determine the effect of compost-amended soil on some vegetative parameters. Percentage of root rot incidence at the preemergence stage was calculated as the number of absent seedlings relative to the number of seeds sown. Meanwhile, the percentage of root rot incidence at the postemergence stage was calculated as the number of diseased plants relative to the number of emerging seedlings.

2.6.2. Effect of Compost-Amended Soil on the Total Microbial Counts. This experiment was conducted to assess the effect of compost-amended soil on the total microbial counts of fungi, bacteria, and actinomycetes as well as frequency of pathogenic fungi comparing with common saprophytic fungi of *Aspergillus* spp. and *Pencillium* spp., under artificial infection condition with tested pathogenic fungi in pots. The total microbial counts and frequency (%) of fungi were determined immediately before sowing and at the end of experiment (45 days) as a number of colony forming units (CFU) in one gram of dry soil using the poured plate method and dilution technique [14]. The frequency occurrence of pathogenic fungi, that is, *F. solani*, *P. ultimum*, *R. solani*, and *S. rolfsii* as well as common saprophytic fungi of *Aspergillus* spp. and *Penicillium* spp. were determined at dilutions of 10^{-4}, for each isolated fungus according to the following formula:

$$\text{Frequency percentage} = \frac{\text{Fungus number}}{\text{Total fungi number}} \times 100. \quad (3)$$

2.6.3. Effect of Compost-Amended Soil on Some Plant Vegetative Parameters. The vegetative parameters of cucumber plants, that is, shoot length, root length, fresh, and dry weights were determined at 45 days of plant grown in treated soil with compost and control treatments. A random sample of three cucumber plants of each treatment were removed carefully from the pots, then washed under running water to remove adhering particles. The averages of above vegetative parameters were determined according to [34].

2.7. Statistical Analysis. The obtained data were subjected to proper statistical analysis of variance according to [35]. Means of treatments were compared with *F* test and LSD at level of 0.05%.

3. Results

3.1. Cucumber Root-Rot Pathogens. Isolation trails from cucumber plants showed root-rot disease symptoms revealed that the 8 fungal species, that is, *Fusarium moniliforme* Sheld., *F. oxysporum* Schlecht ex. fr., *F. semitctum* Berk and Rav., *F. solani*, *P. ultimum*, *R. solani*, *S. rolfsii*, and *Sclerotinia sclerotiorum* (Lib.) de Barywere common fungi. Data presented in Table 1 showed that *F. solani*, *P. ultimum*, *R. solani*, and *S. rolfsii* proved to be highly pathogenic fungi that they were more able to attack cucumber roots and cause severe root-rot disease than other fungi. During preemergence growth stage, *P. ultimum* was highly pathogenic fungus that can attack the seed or seedling of cumber before it emerges above the soil surface, causing a seed or preemergence rot followed by *S. rolfsii*, *R. solani,* and *F. solani*. During postemergence growth stage, *P. ultimum* was highly pathogenic fungus that can attack the seedling of cumber after it emerges above the soil surface, causing damping-off and root-rot followed by *S. rolfsii*, *R. solani*, and *F. solani*.

Table 1: Pathogenicity tests of isolated fungi on cucumber (Beit-Alpha cv.) seeds under greenhouse conditions.

Isolated fungi	Root-rot disease incidence (%)	
	Pre-emergence stage	Post-emergence stage
Pythium ultimum	44.0	42.6
Rhizoctonia solani	30.0	35.3
Fusarium solani	20.0	25.0
Sclerotium rolfsii	34.0	42.3
Fusarium semitectum	0.0	2.0
Fusarium moniliforme	0.0	10.0
Fusarium oxysporum	0.0	20.0
Sclerotinia sclerotiorum	12.0	16.1
Control	0.0	0.0
LSD at 5%	3.93	4.77

3.2. Laboratory Tests

3.2.1. Effect of Composts on Root-Rots Pathogens In Vitro

(1) Poured Plate Method. Presented results in Table 2 showed that the unautoclaved compost water extract at concentrations of 5, 10, and 15% had inhibitor effect against tested pathogenic fungi compared to the control treatment. The compost (A) completely inhibited the growth of *F. solani*, *S. rolfsii,* and *P. ultimum* at all tested concentrations, meanwhile it reduced the growth of *R. solani* by 75.5%. Also, compost (B) at concentration of 15% completely inhibiting (100%) the growth of *F. solani* was observed followed by 83.3, 82.2, and 68.8% for the growth of *R. solani, P. ultimum,* and *S. rolfsii,* respectively. Meanwhile, it had the highest inhibitor effect against *R. solani*, *S. rolfsii* and *P. ultimum*. Results revealed that composts (C), (D), and (E) at concentration of 15% gave moderate inhibitor effect against *F. solani*, *R. solani, S. rolfsii,* and *P. ultimum*. No significant difference was recorded among the tested concentrations of different compost water extracts for reducing the mycelial growth of pathogenic fungi. On the other hand, concerning autoclaved CWEs, it is interesting to note that no inhibitor effect was obtained with autoclaved CWEs against the tested fungi.

(2) Wells-Cut Diffusion Method. Data presented in Table 3 indicated that the unfiltrate CWEs of stock solution reduced the mycelial growth of *F. solani*, *R. solani, S. rolfsii,* and *P. ultimum* observed as zone of inhibition. Compost (A) treatment resulted in zone of inhibited fungal growth measured as 36.0, 16.6, 4.6, and 17.3 mm of *F. solani*, *R. solani, S. rolfsii,* and *P. ultimum*, respectively. Compost (B) gave the inhibition zone of 17.3 and 4.7 mm against *R. solani* and *S. rolfsii,* respectively. Meanwhile, no growth of *F. solani* and *P. ultimum* was noticed.

Table 2: Mycelial growth reduction of tested pathogenic fungi in response to different concentrations of various compost water extracts *in vitro*.

Compost water extracts	Conc. (%)	Mycelial growth (cm) and growth reduction (%) of							
		Fusarium solani		*Rhizoctonia solani*		*Sclerotium rolfsii*		*Pythium ultimum*	
		Growth area	Red. (%)	Growth area	Red. (%)	Growth area	Red. (%)	Growth area	Red. (%)
A	5	NG	100	2.2	75.5	NG	100	NG	100
	10	NG	100	2.2	75.5	NG	100	NG	100
	15	NG	100	2.2	75.5	NG	100	NG	100
B	5	NG	100	1.6	82.2	2.9	67.7	1.6	82.2
	10	NG	100	1.6	82.2	2.9	67.7	1.6	82.2
	15	NG	100	1.5	83.3	2.8	68.8	1.6	82.2
C	5	4.6	48.8	5.2	42.2	6.3	30.0	4.0	55.5
	10	4.4	51.1	5.0	44.4	6.3	30.0	4.0	55.5
	15	4.0	55.5	4.8	50.0	6.2	31.1	3.8	57.7
D	5	4.0	55.5	4.7	47.7	6.2	31.1	3.7	58.8
	10	3.8	57.7	4.6	48.8	6.2	31.1	3.8	57.7
	15	3.5	61.1	4.4	51.1	6.0	33.3	3.6	60.0
E	5	3.4	62.1	4.2	53.3	5.7	36.6	3.4	62.1
	10	3.2	64.4	4.0	55.5	5.6	37.7	3.2	64.4
	15	3.2	64.4	3.9	56.6	5.4	40.0	2.9	67.7
Control	5	9.0	0.0	9.0	0.0	9.0	0.0	9.0	0.0
	10	9.0	0.0	9.0	0.0	9.0	0.0	9.0	0.0
	15	9.0	0.0	9.0	0.0	9.0	0.0	9.0	0.0
LSD at 5% between conc.		ns		ns		ns		ns	
LSD at 5% between CWE		0.22		0.26		0.25		0.20	

Table 3: Inhibition zone (mm) of mycelial pathogenic fungi caused by compost water extracts (CWEs) *in vitro*.

Pathogenic fungi	Inhibition zone (mm) by compost water extracts					
	A	B	C	D	E	Control
Fusarium solani	36.0	NG	17.5	17.0	16.8	0.0
Rhizoctonia solani	16.6	17.3	16.0	16.8	16.2	0.0
Sclerotium rolfsii	4.6	4.7	4.0	4.0	4.4	0.0
Pythium ultimum	17.3	NG	17.5	16.8	17.5	0.0
LSD at 5%	0.06	3.4	3.9	2.7	1.7	—

NG: no growth.

Table 4: Effect of compost water extracts at concentration of 5% on the dry weight (g) of pathogenic fungi in potato dextrose broth medium *in vitro*.

Compost water extracts	Dry weight (g) of pathogenic fungi				
	F. solani	*R. solani*	*S. rolfsii*	*P. ultimum*	Blank
A	0.22	0.48	0.62	0.28	0.11
B	0.79	0.87	0.99	0.78	0.75
C	0.36	0.64	0.81	0.42	0.31
D	0.33	0.63	0.82	0.37	0.13
E	0.54	0.63	0.81	0.51	0.41
Control	0.85	1.00	1.16	0.97	—
LSD at 5%	0.036	0.052	0.047	0.020	

Results also showed that composts (C), (D), and (E) gave moderate inhibition zone against *F. solani*, *R. solani, S. rolfsii,* and *P. ultimum*. On the other hand, the filtrates of CWEs had no inhibition effect against the mycelial growth of pathogenic fungi.

(3) Dry Weight Assay. Effects of CWEs at concentration of 5% on quantitatively dry weight of pathogenic fungal mycelium are shown in (Table 4). The compost treatments decreased the mycelial dry weight of pathogenic fungi, compared with the control, as an indication for inhibition effect of CWE. Results revealed that compost (B) showed highly inhibitor effect against mycelial dry weight of *F. solani*, *R. solani, S. rolfsii,* and *P. ultimum*, whereas the dry weight reduction (%) was 94.6, 87.5, 79.1, and 96.2%, respectively. Also, composts (A), (C), and (E) showed inhibition effect of about 87.5, 94.8 and 85.2%; 62.8, 67.7 and 77.6%; 56.4, 57.1 and 65.4%, and 82.2, 89.3 and 93.1% of *F. solani*, *R. solani, S. rolfsii,* and *P. ultimum*, respectively. On the other hand, the compost (D) showed moderate inhibition effect against of *F. solani*, *R. solani, S. rolfsii* and *P. ultimum* 76.8, 49.7, 40.5 and 75.1%, respectively Table 4.

Table 5: Morphological and cultural characters of isolated bacteria from different composts.

Bacterial isolate	Compost source	Morphological and culture characters	Bacterial genera
B_1	A, B	Rhizoid, flat, filamentous, smooth, opaque, brittle, Gram positive rods	*Bacillus* sp.
B_2	B	Irregular, flat, entire, rough, opaque, membranous, Gram negative short rods	Unidentified
B_3	A, E	Rhizoid, raised, erose, rough, translucent, brittle, Gram positive rods	*Bacillus* sp.
B_4	C, D	Rhizoid, flat, entire, rough, opaque, membranous, Gram negative short rods	Unidentified
B_5	A, D, E	Rhizoid, raised, filamentous, concentrically ringed, translucent, brittle, Gram positive, rods.	*Bacillus* sp.
B_6	B, E	Rhizoid, raised, entire, rough, opaque, brittle, Gram positive rods	*Bacillus* sp.
B_7	B, C, E	Rhizoid, flat, lobate, concentrically ringed, translucent, viscid, Gram positive rods	*Bacillus* sp.
B_8	A, B, D	Punctiform, raised, entire, smooth, translucent, butyrous, Gram positive rods	*Bacillus* sp.
B_9	C, D	Punctiform, raised, entire, rough, opalescent, viscid, Gram positive rods	*Bacillus* sp.
B_{10}	D, E	Irregular, raised, lobate, smooth, translucent, brittle, Gram positive rods	*Bacillus* sp.
B_{11}	A, B	Irregular, raised, undulate, smooth, opalescent, membranous, Gram positive rods	*Bacillus* sp.
B_{12}	A, C	Circular, flat, entire, smooth, translucent, viscid, Gram negative short rods	*Erwinia* sp.
B_{13}	B, A	Circular, umb onate, entire, rough, opaque, brittle, Gram negative short rods	*Pseudomonas* sp.
B_{14}	A	Punctiform, umb onate, entire, smooth, translucent, viscid, Gram negative short rods	*Erwinia* sp.
B_{15}	A	Circular, flat, convex, smooth, translucent, viscid, Gram negative short rods	*Erwinia* sp.
B_{16}	A, B, E	Punctiform, flat, entire, smooth, translucent, viscid, Gram negative short rods	Unidentified
B_{17}	B	Punctiform, convex, entire, smooth, translucent, brittle, Gram negative short rods	Unidentified
B_{18}	B	Punctiform, flat, entire, rough, opaque, membranous, Gram negative short rods	Unidentified
B_{19}	D, E	Punctiform, raised, entire, smooth, translucent, viscid, Gram negative short rods	Unidentified
B_{20}	E, C	Filamentous, umb onate, smooth, opaque, butyrous, Gram negative short rods	Unidentified
B_{21}	B	Punctiform, flat, undulate, smooth, translucent, viscid, Gram negative short rods	Unidentified
B_{22}	B	Punctiform, flat, umb onate, smooth, translucent, brittle, Gram negative short rods	Unidentified
B_{23}	A, E	Punctiform, flat, umb onate, rough, opaque, brittle, Gram negative short rods	Unidentified
B_{24}	A, E	Punctiform, raised, umb onate, rough, opaque, brittle, Gram negative short rods	Unidentified
B_{25}	A, B, C, D, E	Filamentous, umb onate, smooth, opaque, viscid, Gram negative short rods	Unidentified
B_{26}	E	Punctiform, flat, entire, rough, opaque, membranous, Gram negative short rods	Unidentified
B_{27}	B	Punctiform, flat, erose, smooth, translucent, brittle, Gram negative short rods	Unidentified
B_{28}	A	Punctiform, flat, umb onate, smooth, translucent, brittle, Gram positive rods	*Bacillus* sp.
B_{29}	B	Circular, umb onate, entire, rough, opaque, brittle, Gram negative short rods	*Pseudomonas* sp.
B_{30}	B, E	Circular, flat, entire, concentrically ringed, opaque, viscid, Gram negative short rods	*Erwinia* sp.
B_{31}	A, B	Circular, flat, entire, concentrically ringed, opaque, butyrous, Gram negative short rods	*Pseudomonas* sp.
B_{32}	D, A	Rhizoid, flat, filamentous, smooth, translucent, brittle, Gram positive rods	*Bacillus* sp.
B_{33}	A, D	Circular, flat, entire, rough, opaque, viscid, Gram negative short rods	*Erwinia* sp.
B_{34}	A, B	Circular, flat, entire, smooth, opaque, butyrous, Gram negative short rods	*Pseudomonas* sp.
B_{35}	A, B	Circular, flat, entire, concentrically ringed, opaque, viscid, Gram negative short rods	*Erwinia* sp.
B_{36}	C	Circular, umb onate, entire, rough, opaque, brittle, Gram negative short rods	*Pseudomonas* sp.
B_{37}	C	Punctiform, flat, entire, rough, opaque, membranous, Gram negative, short rods.	Unidentified
B_{38}	B, E	Irregular, raised, lobate, rough, opaque, membranous, Gram positive, rods.	*Bacillus* sp.
B_{39}	B, E	Punctiform, flat, entire, rough, opaque, membranous, Gram negative, short rods.	Unidentified
B_{40}	E, C	Irregular, umb onate, undulate, smooth, translucent, brittle, Gram positive, rods.	*Bacillus* sp.

3.3. Microbial Analysis of Composts

3.3.1. Microbial Counts. The obtained results showed that the total microbial counts of fungi, bacteria, and actinomycetes are slightly varied in five tested composts. A count of fungi was ranged from 5.6×10^4 to 51.4×10^4 CFU/g. The highest counts of fungi were found in compost (B) as 51.4×10^4, followed by 15.8×10^4 in composts (E), 7.6×10^4 in compost (C), 6.6×10^4 in compost (A), and 5.6×10^4 in compost (D), respectively. Meanwhile, the count of bacteria ranged from 8.2×10^7 to 21.6×10^7 CFU/g. The highest count of bacteria was found in compost (A) whereas it recorded as 21.6×10^7, followed by 20.0×10^7 in compost (B), 17.6×10^7 in compost (E), 8.4×10^7 in compost (C), and 8.2×10^7 in compost (D),

respectively. The count of actinomycetes ranged from 0.4×10^5 to 2.0×10^5 CFU/g. The highest count of actinomycetes was found in the compost (B) recorded as 2.0×10^5, followed by 1.2×10^5 in compost (A), 1.0×10^5 in composts (C) and (E), and 0.4×10^5 in compost (D), respectively.

3.3.2. Bacterial Isolates. Forty bacterial isolates were isolated from the tested five composts. Isolation trails followed morphological and cultural characters described by [30, 31]. Details of morphological and cultural characters and compost source are shown in (Table 5).

3.3.3. Antagonistic Effect of Isolated Bacteria. Results revealed that the forty isolated bacteria can be divided into three groups according to their antagonistic effect against the mycelial growth of cucumber root-rot pathogenic fungi *in vitro* (Table 6). The highest antagonistic effect of bacterial isolates group included 5 isolates of B_3, B_5, B_7, B_9, and B_{11} that highly reduced the radial mycelial growth of pathogens, whereas the mycelial growth reduction (%) was in the range of 24.4 to 57.8%. The antagonistic effect of bacterial isolates group was recorded for 17 isolates of B_1, B_2, B_4, B_6, B_8, B_{13}, B_{14}, B_{18}, B_{20}, B_{25}, B_{29}, B_{32}, B_{36}, B_{37}, B_{38}, B_{39}, and B_{40} that gave moderate antagonistic effect in reducing the radial growth of the same pathogens, whereas the reduction (%) of mycelial growth was recorded as a range of 10.0 to 46.7%. The nonantagonistic effect of bacterial isolates group included the 18 isolates of B_{10}, B_{12}, B_{15}, B_{16}, B_{17}, B_{19}, B_{21}, B_{22}, B_{23}, B_{24}, B_{26}, B_{27}, B_{28}, B_{30}, B_{31}, B_{33}, B_{34}, and B_{35}, where no mycelial growth reduction (%) was recorded.

3.3.4. Fungal Isolates. Fifteen fungal isolates were isolated from the tested five composts. Isolated fungi were identified as *Aspergillus* spp., *A. niger*, *Penicillium* spp., and *Chaetomium* spp. (Table 7). The isolated fungi were identified at the Plant Pathology Department, NRC, Egypt, according to the morphological and cultural characters following the methods described previously [22, 24].

3.3.5. Antagonistic Effect of Isolated Fungi. Effects of saprophytic fungi isolated from the tested composts against the cucumber root rot pathogens are shown in Table 7. Results showed that the *Aspergillus* sp. no. 1, isolated from all composts, showed high antagonistic effect against the radial growth of cucumber root-rot pathogens, reached 3.4 cm (62.2%) for *F. solani*, 4.4 cm (51.1%). Results also revealed that the *A. niger*, which isolated also from all composts, showed antagonistic effect against the radial growth of all cucumber root-rot pathogens where the mycelial reduction recorded as 57.7% (3.8 cm) for *F. solani*, 44.4% (5.0 cm) for *R. solani,* and 32.2% (6.0 cm) for *P. ultimum*. The fungus *Penicillium* sp. no. 2, isolated from composts A, B, and E, gave high antagonistic effect against the radial growth of cucumber root-rot pathogens, reached 60.0% (3.6 cm) for *F. solani*, 27.7% (6.5 cm) for *R. solani* and *S. rolfsii* as well as 46.6% (4.8 cm) for *P. ultimum*. The fungus of *Chaetomium* sp., isolated from compost (B), gave the radial myeclial growth reduction reached to 55.5% (4.0 cm) for *F. solani*, 40.0% (5.4 cm) for *R. solani*, 34.4% (5.9 cm) for *S. rolfsii,* and 33.3% (6.0 cm) for *P. ultimum*, respectively.

Table 6: Effect of the isolated bacteria from different composts on the mycelial growth reduction of tested cucumber root-rot pathogens.

Bacterial code	Mycelial growth reduction (%) of pathogenic fungi			
	F. solani	*R. solani*	*S. rolfsii*	*P. ultimum*
B_1	24.4	31.1	24.4	17.8
B_2	31.1	28.9	28.9	11.1
B_3	46.7	44.4	48.9	24.4
B_4	20.0	28.9	20.0	13.3
B_5	46.7	53.3	42.2	33.3
B_6	26.7	24.4	24.4	20.0
B_7	44.4	42.2	57.8	40.0
B_8	33.3	24.4	24.4	0.0
B_9	42.2	28.9	46.7	40.0
B_{10}	0.0	0.0	0.0	0.0
B_{11}	46.7	44.4	53.3	40.0
B_{12}	0.0	0.0	0.0	0.0
B_{13}	20.0	27.8	16.7	21.1
B_{14}	28.9	40.0	14.4	20.0
B_{15}	0.0	0.0	0.0	0.0
B_{16}	0.0	0.0	0.0	0.0
B_{17}	0.0	0.0	0.0	0.0
B_{18}	17.8	26.7	15.6	11.1
B_{19}	0.0	0.0	0.0	0.0
B_{20}	23.3	24.4	0.0	18.9
B_{21}	0.0	0.0	0.0	0.0
B_{22}	0.0	0.0	0.0	0.0
B_{23}	0.0	0.0	0.0	0.0
B_{24}	0.0	0.0	0.0	0.0
B_{25}	24.4	23.3	14.4	10.0
B_{26}	0.0	0.0	0.0	0.0
B_{27}	0.0	0.0	0.0	0.0
B_{28}	0.0	0.0	0.0	0.0
B_{29}	26.7	31.1	13.3	43.3
B_{30}	0.0	0.0	0.0	0.0
B_{31}	0.0	0.0	0.0	0.0
B_{32}	35.6	33.3	23.3	16.7
B_{33}	0.0	0.0	0.0	0.0
B_{34}	0.0	0.0	0.0	0.0
B_{35}	0.0	0.0	0.0	0.0
B_{36}	46.7	33.3	17.8	22.2
B_{37}	14.4	17.8	0.0	13.3
B_{38}	46.7	37.8	12.2	13.3
B_{39}	15.6	18.9	15.6	13.3
B_{40}	44.4	30.0	17.8	18.9
LSD at 5%	3.6	2.9	3.2	3.6

Table 7: Effect of fungi isolated from different compost samples on the radial growth of cucumber root-rot pathogens.

Fugal isolates	Compost	Mycelial growth (cm) of pathogenic fungi			
		F. solani	*R. solani*	*S. rolfsii*	*P. ultimum*
Aspergillus sp. 1	A, B, C, D, E	3.4	4.4	9.0	3.6
Aspergillus sp. 2	B, C, E	3.6	6.6	7.2	5.4
Aspergillus sp. 3	E	5.8	4.8	9.0	6.1
Aspergillus sp. 4	A, B, C, D, E	5.2	5.0	9.0	4.8
Aspergillus sp. 5	C	9.0	9.0	9.0	9.0
Aspergillus sp. 6	B, D	9.0	9.0	9.0	9.0
Aspergillus sp. 7	B, E	4.6	4.5	9.0	4.0
A. niger	A, B, C, D, E	3.8	5.0	9.0	6.0
Penicillium sp. 1	A, B, C, D, E	5.4	6.4	7.2	6.8
Penicillium sp. 2	A, B, E	3.6	6.5	6.5	4.8
Penicillium sp. 3	A, B, D, E	4.2	5.6	9.0	5.0
Penicillium sp. 4	B	6.0	4.7	9.0	4.8
Penicillium sp. 5	B	5.3	4.8	8.1	5.2
Penicillium sp. 6	B	9.0	9.0	9.0	9.0
Chaetomium sp.	B	4.0	5.4	5.9	6.0
Control		9.0	9.0	9.0	9.0
LSD at 5%		0.23	0.26	0.15	0.23

Table 8: Effect of potting soil amended with compost mixture on the percentage of root-rot diseases incidence of cucumber (Beit-Alpha cv.) grown in artificially infested soil with root-rot pathogens under greenhouse conditions.

Compost	Root rot diseases incidence (%) at pre- and postemergence stages							
	F. solani		*R. solani*		*S. rolfsii*		*P. ultimum*	
	Pre emergence	Post emergence	Pre emergence	Post emergence	Pre emergence	Post emergence	Pre emergence	Post emergence
A	10.0	11.6	14.0	11.6	22.0	12.8	28.0	16.7
B	10.0	6.6	12.0	8.8	14.0	9.4	18.0	12.2
C	18.0	16.9	28.0	21.9	28.0	22.4	34.0	30.4
D	16.0	16.6	18.0	17.2	26.0	16.0	32.0	23.7
E	14.0	11.6	14.0	11.6	24.0	13.2	28.0	19.5
Control	22.0	25.7	32.0	40.9	36.0	40.4	46.0	44.6
LSD at 5%	4.82	6.06	6.90	5.33	5.95	7.30	6.64	9.72

3.4. Greenhouse Experiments. The present study was designed to investigate the potential effect of soil amendment with different composts, made from composted agricultural wastes, against root-rot disease incidence, population of soil microflora as well as vegetative growth parameters of cucumber plants grown under artificial infestation with root-rot pathogens in pot experiment under greenhouse conditions.

3.4.1. Effect of Composts Amended Soil on Root-Rot Disease Incidence. Data presented in Table 8 showed that the root-rot disease incidence of cucumber recorded at pre- and postemergent stages was significantly decreased by composts application at rate of 25 g/kg soil in pot. For preemergent stage, compost (B) had a greater suppressive effect against the four pathogenic fungi, whereas the disease reduction reached to 54.5% for *F. solani*, 62.5% for *R. solani*, 61.1% for *S. rolfsii*, and 60.8% for *P. ultimum*. As for postemergent stage, composts (A) and (B) had a greater disease reduction reached which 54.8% and 74.3% for *F. solani,* 71.6% and 78.5% for *R. solani,* 68.3% and 76.7% for *S. rolfsii* and 62.5% and 72.6% for *P. ultimum*, respectively. Results also revealed that the other composts (C), (D), and (E) had the moderate suppressive effect against cucumber root-rot pathogens during both pre- and postemergent stages.

3.4.2. Microbial Count. The effects of compost-amended soil on the microbial counts of fungal, bacterial, and actinomycetes, before cucumber sowing (one week after compost incorporation) and after 45 days after sowing, in pots infested with the root-rot pathogens are shown in Table 9. Results showed that the total counts of fungi were in the range of 8.6 to 19.0×10^4 CFU/g and 9.2 to 19.4×10^4 CFU/g, compared with 11.6 to 19.8×10^4 CFU/g and 12.6 to 19.2×10^4 CFU/g in the control treatment before and after sowing, respectively. Meanwhile, bacterial total counts were in the range of 3.6 to 15.8×10^7 CFU/g and 7.2 to 26.6×10^7 CFU/g, compared

Table 9: Effect of potting soil amendment with compost mixture on total microbial counts in the rhizosphere of cucumber (Beit-Alpha cv.) plants grown in artificially infested soil with root-rot pathogens under greenhouse conditions.

Treatments	Potting soil infested with							
	F. solani		*R. solani*		*S. rolfsii*		*P. ultimum*	
	B	A	B	A	B	A	B	A
Total count of fungi (1×10^4 cfu/g dry soil)								
Compost (A)	11.2	12.2	10.0	11.0	9.6	9.8	9.6	10.0
Compost (B)	12.6	13.2	18.0	17.8	19.0	19.4	18.6	19.4
Compost (C)	10.2	10.4	11.0	10.8	14.8	14.2	15.0	15.2
Compost (D)	9.2	9.2	12.4	13.0	16.2	16.0	13.0	13.6
Compost (E)	8.6	9.2	11.2	10.8	11.6	11.2	11.2	11.4
Control	11.6	12.6	13.0	13.8	15.2	16.0	19.8	19.2
Total count of bacteria (1×10^7 cfu/g dry soil)								
Compost (A)	12.2	22.2	13.6	22.0	13.4	21.6	13.2	22.4
Compost (B)	15.8	26.4	14.8	24.6	14.2	26.6	13.8	24.2
Compost (C)	5.6	13.8	5.2	14.2	4.4	13.2	4.0	13.4
Compost (D)	4.4	12.6	3.6	12.2	4.2	7.2	3.6	11.2
Compost (E)	10.8	20.4	9.8	20.2	10.2	19.0	8.8	19.0
Control	1.4	4.6	1.2	7.4	1.6	8.6	1.6	7.4
Total count of actinomycetes (1×10^5 cfu/g dry soil)								
Compost (A)	3.4	12.6	3.4	13.2	4.4	11.8	3.0	12.8
Compost (B)	5.4	15.4	5.2	17.0	3.4	16.0	5.0	15.4
Compost (C)	3.4	14.4	3.0	14.8	2.6	14.2	3.2	14.4
Compost (D)	1.2	10.0	1.2	10.2	1.6	10.2	1.8	11.8
Compost (E)	3.2	12.6	2.6	13.4	3.0	13.2	1.6	10.8
Control	0.4	1.6	0.4	2.0	0.6	1.8	0.8	2.2
LSD at 5%	2.78	3.05	3.33	2.63	4.03	3.05	4.09	2.96

B: before sowing; A: after 45 days of sowing.

with 1.2 to 1.6 $\times$ 10^7 CFU/g and 4.6 to 8.6 $\times$ 10^7 CFU/g in the control treatment before and after sowing, respectively. Results also revealed that the total counts of actinomycetes were in the range of 1.2 to 5.4 $\times$ 10^5 CFU/g and 10.0 to 17.0 $\times$ 10^5 CFU/g, compared with 0.4 to 0.8 $\times$ 10^5 and 1.6 to 2.2 $\times$ 10^5 CFU/g in the control treatment before and after sowing, respectively. Compost (B) seems to highly increase the total count of fungi, bacteria, and actinomycetes. In general, the total counts of fungi, bacteria, and actinomycetes were significantly greater detected after 45 days of sowing than in both before sowing and the control treatment as well.

Populations of *F. solani*, *R. solani*, *S. rolfsii*, and *P. ultimum*, compared with the saprophytic fungi of *Aspergillus* spp. and *Penicillium* spp. in the composts-amended soil in the rhizosphere of pots experiment are listed in Table 10. All the tested composts significantly decreased the frequency occurrence of the pathogenic fungi, compared with the untreated soil. Compost (B) was the more effective in reducing the population of pathogenic fungi in before and after of sowing. The frequency percentages were 53.9 and 21.6% for *F. solani*, 60.8 and 23.4% for *R. solani*; 52.7% and 24.6% for *S. rolfsii*; 54.4% and 23.8% for *P. ultimum*, before and after sowing, respectively. Composts (A), (C), (D), and (E) had moderate effects against the pathogenic fungal population in pots. On the other hand, the effect of the tested composts on the frequency of occurrence of selected saprophytic fungi in the rhizosphere of composts-amended soil also are listed in Table 10. Application of all composts in the soil increased the frequency occurrence of both *Aspergillus* spp. and *Penicillium* spp., compared with the untreated soil.

3.4.3. Plant Growth Parameters. Results in Table 11 indicated that the composts-amended soil at the rate of 25 g/kg (compost/soil) significantly improved all plant growth parameters, that is, shoot length, root length, fresh weight, and dry weight under infested soil. Potting soil amended with composts (A) and (B) gave the highest shoot length, root length, fresh weights and dry weight under infested soil. Composts (C), (D), and (E) gave moderate increase in the plant growth parameters.

4. Discussion

The obtained results in the present study showed that the fungi of *F. solani*, *R. solani*, *S. rolfsii*, and *P. ultimum* were the common fungi in the rhizosphere of the cucumber plants and had the highest pathogenic effect to Beit-Alpha cultivar of cucumber plants in the pathogenicity tests. These results are in agreement with those recorded by [3, 4]. They reported that these pathogens considered the most important soil-borne pathogens which cause cucumber root-rot diseases.

In vitro tests, our results revealed that the unautoclaved and unfiltrated aqueous extracts of compost had inhibitor effect against the cucumber root-rot pathogens. They significantly reduced the mycelial growth and reduced the mycelial dry weight, compared with autoclaved and filtrated ones. These results are also in a harmony with those obtained by [29, 36, 37]. They reported that the diseases suppression by composts is due to biotic rather than biotic factors, in addition to the presence of protease, chitinase, lipase, and β-1, 3 glucanase secrete by microbes in unautoclaved and unfiltrated composts.

The microbial activity in composts is considered to be crucial in suppressive media. Therefore, the enumeration of microorganisms in the present research was made to know the microbial population in the tested composts because the plate counts method is a useful technique for isolating microorganisms [38]. Our results indicated that the different composts have the numbers of Gram positive and Gram negative bacteria which have suppressive effects against the mycelial growth of root-rot pathogens under *in vitro* conditions. Results also showed that some saprophytic fungi belonging to the following genera, that is, *Aspergillus*, *Penicillium*, and *Chaetomium*, which had suppressive effects against the mycelial growth of pathogens under *in vitro* conditions were common in tested composts. Similar results were also obtained by [17, 39]. They reported that the suppression capacity could be due to compost's recolonization by effective biocontrol agents after peak heating occurred in the composting process and the large numbers of microbes appeared in grape marc compost and most of them were Gram negative

Table 10: Effect of potting soil amended with compost mixture on the frequency occurrence (%) of fungal counts in the rhizosphere of cucumber (Beit-Alpha cv.) grown in artificially infested soil with root-rot pathogens under greenhouse conditions.

Treatments	Soil infestation	Frequency of occurrence (%) of soil fungi (1×10^4 cfu/g dry soil)							
		Total pathogenic fungi		*Aspergillus* spp.		*Penicillium* spp.		Other	
		B	A	B	A	B	A	B	A
Compost (A)	*F. solani*	64.8	37.8	19.8	26.9	15.4	27.2	—	8.1
	R. solani	66.4	44.9	22.4	26.4	11.2	19.9	—	8.8
	S. rolfsii	73.3	58.1	13.3	19.9	10.0	11.1	3.4	10.9
	P. ultimum	75.9	45.7	13.7	27.2	10.4	20.3	—	6.8
Compost (B)	*F. solani*	53.9	21.6	20.6	37.7	15.0	31.1	10.5	9.6
	R. solani	60.8	23.4	17.8	38.3	15.9	29.5	5.5	8.8
	S. rolfsii	52.7	24.6	22.8	37.1	17.4	31.5	7.1	6.8
	P. ultimum	54.4	23.8	21.1	34.8	19.2	32.7	5.3	8.7
Compost (C)	*F. solani*	51.8	35.0	19.6	34.8	15.9	22.7	9.8	7.5
	R. solani	50.0	38.5	20.5	28.8	20.5	27.0	8.9	5.7
	S. rolfsii	56.9	44.4	18.5	25.4	16.2	20.2	8.4	10.0
	P. ultimum	62.6	46.2	15.5	20.4	13.4	21.7	7.9	11.7
Compost (D)	*F. solani*	42.9	37.8	24.8	31.2	21.5	20.7	10.8	10.3
	R. solani	45.9	36.9	24.5	31.4	21.5	23.9	8.1	7.8
	S. rolfsii	50.9	41.5	18.4	28.4	18.4	20.8	12.3	9.3
	P. ultimum	55.0	34.1	22.6	26.1	15.2	26.1	7.2	13.7
Compost (E)	*F. solani*	50.0	25.7	23.3	33.6	23.3	26.2	3.4	14.5
	R. solani	56.6	27.6	23.2	33.9	20.2	27.1	—	11.4
	S. rolfsii	66.6	34.9	16.7	29.5	16.7	23.7	—	11.4
	P. ultimum	61.4	33.9	16.7	31.9	16.7	22.7	5.2	11.5
Control	*F. solani*	83.8	76.9	8.1	8.8	8.1	5.5	—	8.8
	R. solani	85.4	80.3	7.3	7.3	7.3	5.1	—	7.3
	S. rolfsii	87.9	85.7	6.2	6.1	5.9	2.1	—	6.1
	P. ultimum	89.8	85.0	5.1	5.6	5.1	3.8	—	5.6
LSD at 5%		8.57	11.25	5.97	8.56	5.65	9.23	6.19	n.s.

B: before sowing; A: after 45 days of sowing.

bacteria. In this concern, [40] also recorded that the Gram negative bacteria were found to be the predominant biocontrol agents in suppressive bark compost, while the Gram negative genera identified in mature compost as *Pseudomonas* (28%), *Serratia* (20%), *Klebsiella* (11%), and *Enterrobacter* (5%) and also Gram positive bacteria were identified as *Bacillus* spp. [41]. Furthermore, results obtained by [42–44] mentioned that the most dominant fungi cultured from composts are species of *Aspergillus*, *Chaetomium*, and *Pencillium*. Moreover, *in vitro* tests, the isolated fungi and bacteria from composts demonstrated their potential antagonistic effect against cucumber root-rot pathogens. The isolated fungi showed the three probable mechanisms of action: (i) mycoparasitism, involving direct contact between the tested antagonist and cucumber root-rot pathogens, (ii) production of antibiotic-type secondary metabolites, which spread through the medium, where the clear band that separates the antagonist from the pathogen, and (iii) competition for nutrients and space, where the growth in control was fast, than composts treatments. However, the bacteria only, showed the (ii) and (iii) mentioned mechanisms that they could inhibit cucumber root-rot pathogens [6].

In greenhouse experiments, our results revealed that the compost treatments were effective in reducing the pre- and postemergence root-rot disease of cucumber under artificiall infection conditions. These are may be due to the microbial population in compost amendments which play an important role in enhancing the competition and/or antagonism among microbes, leading to a decrease in the plant pathogens activity. Our results suggest that the maximum suppression of cucumber root-rot pathogens was obtained in compost amended potting soil with composts (A) and (B), while composts (C), (D), and (E) gave moderate suppression in this regard. These results indicated that the increase of rhizospheric population of *Aspergillus* spp. and *Penicillium* spp. may play an antagonistic role against *F. solani*, *R. solani*, *S. rolfsii* and *P. ultimum* which lead to reducing root-rot disease incidence of cucumber.

Our results showed that the total counts of fungi, bacteria, and actinomycetes in the rhizosphere of cucumber plants grown in compost amended soil were significantly higher than those in the unamended one. This is in harmony with the results obtained by [45]. They found that the frequency of occurrence of the tested pathogenic fungi was lower than

Table 11: Effect of potting soil amended with compost mixture on some vegetative parameters of cucumber (Beit-Alpha cv.) grown in artificially infested soil with root-rot pathogens under greenhouse conditions.

Treatments	Soil infested with	Cucumber vegetative parameters			
		Shoot length (cm)	Root length (cm)	Fresh weight (g)	Dry weight (g)
Compost (A)	*F. solani*	39.1	21.9	120.3	18.32
	R. solani	36.7	21.9	115.6	14.58
	S. rolfsii	43.4	23.1	121.9	22.48
	P. ultimum	44.7	23.8	129.7	27.21
Compost (B)	*F. solani*	43.8	24.3	137.0	28.84
	R. solani	41.2	23.4	134.1	27.11
	S. rolfsii	45.5	24.6	138.8	29.52
	P. ultimum	43.8	25.8	137.3	28.64
Compost (C)	*F. solani*	37.3	18.1	118.3	18.00
	R. solani	37.2	17.0	117.9	17.11
	S. rolfsii	37.9	18.9	119.9	18.31
	P. ultimum	38.4	19.0	120.8	18.62
Compost (D)	*F. solani*	35.8	18.6	118.2	17.81
	R. solani	35.0	19.2	118.0	17.00
	S. rolfsii	35.1	19.8	118.3	17.92
	P. ultimum	35.0	20.0	118.7	18.07
Compost (E)	*F. solani*	38.7	21.6	120.6	18.91
	R. solani	39.0	21.0	120.0	18.75
	S. rolfsii	39.1	21.7	120.7	18.93
	P. ultimum	39.1	21.7	120.9	18.94
Control	*F. solani*	33.0	17.0	112.4	10.58
	R. solani	32.8	16.5	111.4	10.35
	S. rolfsii	33.1	17.2	112.5	10.58
	P. ultimum	32.9	17.5	112.6	10.59
LSD at 5%		1.61	0.61	1.41	1.53

saprophytic fungi, whereas the number of colony forming units of bacteria and fungi increased when pig manure compost was added to soil. Furthermore, the obtained results also showed that the most predominant fungi isolated from the amended soil were *Aspergillus* spp. and *Penicillium* spp. These fungi were reported to have great inhibition effect on soil-borne pathogens [14].

In the present study, the composts treatment significantly increased the growth parameters such as shoot length, root length, fresh weight, and dry weight, compared with the control treatment. The highest increase in the growth parameters were obtained by compost amended soil with compost (B). Similar results are also obtained by [46]. They reported that the 54% of plant growth-promoting bacteria (PGPB) were isolated from farm waste compost (FWC) and 56% from rice straw compost (RSC) which significantly increased the shoot length, leaf area, root length density, and plant weight of Pearl millet. The maximum increase in plant weight was by *Serratia marcescens* EB67 (56%), *Pseudomonas* sp. CDB 35 (52%), and *Bacillus circulans* EB 35 [42]. Plant growth-promoting bacteria (PGPB) directly stimulate growth by nitrogen fixation [47], solubilization of nutrients [48], production of growth hormones, 1-amino-cyclopropane-1-carboxylate (ACC) deaminase, and indirectly by antagonizing pathogenic fungi by production of siderophores, chitinase, β-1,3-glucanase, antibiotics, fluorescent pigments, and cyanide [49]. In this concern, it was also reported that soil amendment with agricultural wastes alone or in combination with Biocontrol agents was recommended for controlling soil borne pathogens and increasing the yield of many crops; sugarcane bagasse degraded by *Trichoderma* spp. was used as soil amendment to improve growth and yield of rice and pea [50]. In the present study, the tested compost (A) (mixture of different aromatic plants, sugar beet and sugarcane) and compost (B) (mixture of rice straw and animal wastes) showed promising effective effect on root rot incidence, soil microbial counts, and plant vegetative growth as well. Also, in the newly cultivated soil organic material is frequently recommended to prevent the increase of pathogens, and this was attributed to unfavorable conditions that are produced by organic and biocompost soil amendments as well; such soil treatments enhance toxicity and antagonistic ability of biocontrol agents against soil borne plant pathogens. These probably contributed to the higher nutrient contents, which could be found with organic amendments [51, 52].

In the light of the present findings, it could be suggested that amending soil with composts is considered as potential biocontrol agent against cucumber root-rot pathogen and improves the plant growth as well.

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