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EVALUATION OF COMPOST AND COMPOST EXTRACT EFFICIENCY AS BIO-CONTROL AGENTS ON DAMPING-OFF DISEASE INCIDENCE OF FENUGREEK (*Trigonella foenum-greacum*)

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ABSTRACT

Compost and compost extract efficacy as bio-control agents for damping-off disease of fenugreek plants (*Trigonella foenum-greacum*) was evaluated. The disease causative fungus, *Fusarium solani* (Mart.) Sacc, was isolated from El Sharkia Governorate. A pots experiment was carried out for fenugreek cultivation using different combinations of compost, compost extract, and *F. solani*. Incidence of damping-off, plant growth parameters, and populations of bacteria, fungi, and actinomycetes were determined. The results showed that fenugreek plants were highly affected by pre-emergence damping-off incidence (23.33%), and to a lesser extent by post-emergence damping-off (16.66%). Applying the recommended dose of compost (RDC) and irrigation with compost extract (CE) almost prevented the pre- and post-emergence damping-off (3.33% for both). Such result was concomitant with a decrease in the total number of fungi in most treatments, and a significant increase ($P \leq 0.05$) in the total number of bacteria and actinomycetes after 30 and 45 days of cultivation. Actinomycetes showed more obvious average increase of 0.84 log cfu/g from the cultivation time till 45 days. Plant growth parameters (height and numbers of leaves) were significantly improved ($P \leq 0.05$) due to the compost and compost applications, regardless of the inoculation with *F. solani*. We recommend using compost and compost extract as an environmentally friendly alternative to fungicides for reducing damping-off disease incidence, in addition to their role as a safe and non-chemical source of fertilizers.

Key words: Compost extract, biological control, damping-off, fenugreek, *Fusarium solani*.

INTRODUCTION

Agricultural sustainability depends greatly on the development of strategies that reduce the need for costly external inputs (such as agrochemicals) and reduce the environmental hazards often associated with the excess use of these inputs. Such approach is materialized in the science of agroecology, which is the application of the ecological principles to the management of a sustainable agroecosystem. Biological control, through the use of microorganisms, offers an alternative and attractive approach for plant diseases control. This has become an important principle for sustainable agriculture, since biocontrol agents are easy to deliver, may activate plant resistance mechanisms like systemic/induced resistance and thereby indirectly improve plant growth and yields (Dukare *et al.*, 2011).

The use of disease suppressive composts has been proposed as an environmentally-friendly substitute for soil fumigation. During composting process, organic matter undergoes fundamental biological, chemical and physical changes; prominent among these is the development of suppressiveness against several soilborne fungal diseases (Nelson and Hoitink, 1982). Compost-based suppression of wide range of major soilborne diseases has been

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demonstrated in the last decade as a promising option (Craft and Nelson, 1996; Nelson and Boehm, 2002; Nakkeeran *et al.*, 2005 and Santos *et al.*, 2008).

Damping-off is a serious disease that affects both germinating seeds and young seedlings, and is caused by several soilborne fungi including *Fusarium solani* (Yangui *et al.* 2008). Application of fungicides contributes to high productivity through increasing and stabilizing yields and reducing production cost. However, their long-term usage can have a negative impact on the environment. The Environmental Protection Agency (EPA) has removed several fungicides from the market because of ground water contamination and harmful effects on wild life and human health (Crnko *et al.*, 1992).

Compost and compost extracts applied to the soil, improve its quality by altering its chemical and physical properties, increasing organic matter content, water holding capacity, overall diversity of microbes, providing macro- and micro-nutrients essential for plant growth and suppressing diseases, which indirectly contribute to plant growth enhancement (Scheuerell and Mahaffee, 2004 and Heather *et al.*, 2006). Compost may be extracted with water at widely ranging ratios of 1:1 (dry w/w) to 1:60 (dry w/w). Such extracts are sometimes treated with additional ingredients and/or diluted before application (Shrestha *et al.*, 2011). The resulting extract (or tea) is applied to plants or soil for putative fertility and disease control benefits (Scheuerell and Mahaffee, 2004; Litterick *et al.*, 2004). The compost extract industry, although small, is estimated to be growing at 25 percent per year (Carpenter-Boggs, 2005).

Fenugreek (*Trigonella foenum graecum*) is an annual herb that belongs to the family *Leguminosae* widely grown in Egypt and Middle Eastern countries. The seeds of fenugreek contain lysine and L-tryptophan rich proteins, mucilaginous fibers and other chemical constituents (Bukhari *et al.*, 2008). Researchers have reported that adding various organic compost to the soil resulted in marked promotion in different growth characters, yield, and chemical constituents of various medicinal plants (Khalil 2002). Despite all these data, and to the best of our knowledge, there has been no published research on effect of compost and compost extract on the fenugreek damping-off, microbial and growth parameters.

In view of the above, this study was carried out in order to: 1) evaluate the efficacy of the compost and compost extract as biocontrol agents against *Fusarium solani* (Mart.) Sacc., the causal fungus of damping-off disease in fenugreek plants, and 2) determine its role in advancing soil microbial composition, and hence, improving plant growth parameters.

MATERIALS AND METHODS

Isolation and Identification of the Causal Organism from Fenugreek Rotted Roots

Roots of fenugreek thought to be infected with damping-off were carefully collected from Bani Amer village, Zagazig city, at El-Sharkia Governorate. They were then, transferred to the Plant Pathol. lab. , Agric. Bot. and Plant Pathol. Dept., Fac. of Agric., Zagazig Univ. The roots were cut into small pieces, surface sterilized by immersing in 2% sodium hypochlorite solution for two minutes, then washed thoroughly with sterilized distilled water. The pieces were dried between two layers of sterilized filter papers, planted on plain agar in Petri-dishes, and then incubated at 28°C for 3-5 days. All the dishes were daily examined binocularly for fungal growth, and then the growing fungi were picked up and sub-cultured on potato-dextrose agar (PDA) at 28°C for further investigations. Cultures from the isolated fungi were purified using a hyphal tip and/or single spore techniques. The purified fungi were identified using morphological and microscopic characteristics according to Nelson *et al.* (1983) and Leslie and Summerell (2006), where the most dominant fungus was identified as *Fusarium solani* (Mart.) Sacc, and assumed to be the causal organism of the damping-off, and was used for the pathogenicity test.

Pathogenicity Test

Pathogenicity test of the fungus was carried out according to Dugan *et al.* (2007), under greenhouse conditions at the Fac. of Agric., Zagazig Univ. Plastic pots (20 cm diameter) were sterilized by immersing in 5% formalin solution for 15 minutes, then left for several

days to get rid of the poisonous effect of the formalin. The inoculum was prepared by growing *Fusarium solani* (Mart.) Sacc. in 500 ml conical flask containing 200 ml of autoclaved potato-dextrose broth and incubated at 28°C for 7 days. The sterilized pots were filled with clay-loam soil (Table 2) and inoculated with the fungal inoculums, with three replicates for each treatment. The fungal growth (1x 10^7 spores/ml) was mixed with soil at the rate of 4% (v/w) of soil, then watered and left for 15 days before sowing to stimulate the fungal growth. The control pots were left without inoculation, and all pots were irrigated to maintain water content at 50% of the W.H.C. throughout the experiment. The seeds of fenugreek were sown at the rate of 10 seeds/pot. Disease incidence was recorded as the percentage of pre-emergence damping-off, post-emergence damping-off, and healthy survivals after 15, 30, and 45 days of sowing, respectively. The inoculated fungus was re-isolated from the infected plants and examined microscopically to confirm that it is the original fungus.

Preparation of Compost Extract and Sampling Regimes

Garbage compost was obtained from the Cairo Organic Fertilizers Company, Cairo, Egypt. It has an organic carbon of 30%, total nitrogen of 1.0%, moisture of 35%, and pH 7.5±0.2. Compost extract was prepared in Agric. Microbiol. Dept. Lab., Fac. of Agric., Zagazig Univ., Egypt, according to the method of Ingham (2005) with some modifications. One kilogram fresh weight of garbage compost was sealed in a cotton bag and submerged into 20 L tap water in 40 L plastic bucket, and each was amended with 0.5% (v/v) molasses. The water used was pump aerated for 30 min to remove chlorine before addition to the compost. Compost soaking was done in the lab at room temperature (average 25°C) for 48 h, while being aerated continuously (10 L/min air delivery per bucket through air stones).

The parameters of pH, EC and percentages of total nitrogen, phosphorus and potassium were determined after 48hr of incubation according to the method of A.O.A.C. (2002). Humic and fulvic acids were determined according to the method outlined by Kononova (1961), and all the previous physico-chemical analyses are listed in Table 1.

Microbial populations in the garbage compost extract, *i.e.* bacteria, actinomycetes and fungal populations were determined using plate count technique. Bacteria were enumerated on nutrient agar (Difco, 1985) and incubated at 30°C for 2 days. Actinomycetes were enumerated on starch casein agar (Conn and Leci, 1998) and incubated at 28°C for 7 to 14 days, while fungi were enumerated on Martin's streptomycin rose bengal agar (Martin, 1950), and incubated at 25°C for 3–5 days, with three replicates of all microbial counts.

Physico-chemical, Mechanical and Microbiological Analyses of Soil under Investigation

Physico-chemical and mechanical analyses of the soil were carried out in the laboratory of Soil Sci. Dept., Faculty of Agric., Zagazig Univ., according to Jackson (1970) and listed in Table 2. Microbial populations were undertaken directly in specimens of soil samples collected at 0, 15, 30 and 45 days after cultivation to determine total fungi, bacteria, and actinomycetes. Plate count technique was followed for total count of bacteria (Difco, 1985), actinomycetes (Conn and Leci, 1998) and fungi (Martin, 1950).

Effect of Compost and Compost Extract on the Percentage of Damping-off and Soil Microbial Composition

To study the effects of compost and compost extract on the percentage of damping-off disease, microbial populations, and growth parameters of fenugreek (Giza 1 cultivar, obtained from Agronomy Dept. Agric. Res. Center. Giza, Egypt), a pots experiment was carried out. The experiment was comprised of 27 pots (20 cm diameters), each was filled with 4 kg of non sterile soil, then divided into 9 groups and amended as follows:

1. A control of uninoculated soil.
2. Soil inoculated with *Fusarium solani*.
3. Soil amended with the recommended dose of compost "RDC" (1% w/w).
4. Soil amended with RDC and inoculated with *F. solani*.

Table 1. Physico-chemical analyses of garbage compost extract under investigation

Parameters	pH	E.C (ds/m)	Total N (mg/L)	Total P (mg/L)	Total K (mg/L)	Humic acid (g/L)	Fulvic acid (g/L)
Compost extract sample	7.2	0.63	3.5	23.9	450.0	0.67	1.04

Table 2. Physico-chemical and mechanical analyses of the soil under investigation

Type of soil analyses	Physical analyses			Mechanical analyses				Chemical analyses						
								Cations (mg/l)				anions(mg/l)		
	pH	EC ds/m	OM%	Sand %	Silt %	Clay%	Soil type	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3+HCO_3^-	Cl^-	SO_4^{--}
Results	7.32	1.7	1.33	35.0	31.6	33.3	Clay loam	14.8	3.3	3.01	1.9	2.2	8.1	4.2

5. Soil amended with RDC and irrigated with compost extract "CE".
6. Soil amended with RDC, irrigated with CE and inoculated with *F. solani.*
7. Soil amended with RDC, irrigated with diluted CE (1:1 v/v) with water and inoculated with *F. solani.*
8. Soil amended with RDC, irrigated with diluted CE (1:2 v/v) with water and inoculated with *F. solani.*
9. Soil amended with RDC and irrigated with diluted CE (1:3 v/v) with water and inoculated with *F. solani.*

The recommended dose of compost used in this study was 1% w/w (Crecchio *et al.,* 2004). The high concentrations of compost extract used in these treatments were employed because of the method of application in soil for acting as biofungicide, unlike the low concentrations commonly used in the foliar applications as fertilizers. Ten surface sterilized seeds of fenugreek were sown in each pot. Data were recorded after 15, 30 and 45 days of sowing as the percentage of damping-off disease incidence, healthy survival plants, and microbial enumerations of total fungi, bacteria and actinomycetes.

Plant growth parameters

After 45 days of sowing, two growth parameters were recorded: plant height and number of leaves/ plant, both represented the means of five randomly chosen plants from each pot.

Statistical Analysis

Data recorded in three replicates for the parameters in various treatments were subjected to the analysis of variance (ANOVA) according to Snedecor and Cochran (1980) using SPSS statistical package version 11.0 (SPSS Inc., Chicago, IL, USA). Differences in means were compared at $P \leq 0.05$.

RESULTS AND DISCUSSION

Fungus Identification and Pathogenicity Test

According to the identification criteria, the prevailing fungus isolated from the infected roots was proven to be *Fusarium solani* (Mart.) Sacc.. Data presented in Table 3 indicate that the treatment containing *Fusarium solani* (Mart.) Sacc. gave much less percentage of healthy survival plants (60%) compared to the control (83.33%). It also shows that fenugreek plants were affected by pre-emergence damping-off incidence (23.33%) more than it did with post-emergence damping-off (16.66). Disease incidence might be attributed to one or more of the environmental factors including soil types, soil moisture content, plantation distance, differences in sowing dates, agricultural practices used, cultivars, fungal strength and interaction between the host and the pathogenic fungi (Roy, 1997).

Table 3. Pathogenicity tests of the isolated fungus causing damping-off disease in fenugreek plants

Treatments	Pre-emergence damping-off %	Post-emergence damping-off %	Healthy survival %
Control	13.33	3.33	83.33
***Fusarium solani* (Mart.) Sacc.**	23.33	16.66	60.00

Effect of Compost and Compost Extract on Microbial Population Counts in Soil Cultivated with Fenugreek

Initially, the microbial count in the garbage compost extract were determined before adding to the soil, to get a clue about its microbial profile and the putative effect. The microbial count in the garbage compost extract showed an average of 8.5 log cfu/ml of bacterial total count, 5.7 log cfu/ml of actinomycetes total count, and 3.76 log fp/ml of fungal total count. The results presented in Table 4 show the microbial populations in soil samples affected by the different treatments of compost, compost extract, and *F. solani* during the time course of the experiment, in order to study their effects on fenugreek plants. In general, the populations of the different microorganisms are increasing in proportion with increasing the soil content of compost and compost extract. That is a known fact for the organic matter when it is introduced to soil (Brady and Weil, 1999). This can be explained by the increased nutrition supplement due to the compost and compost extract (Heather *et al.*, 2006). The treatments containing compost extract, exhibited a significant decrease ($P \leq 0.05$) in fungal populations after 45 days in contrast with the time of cultivation, and with a lesser extent with the 15 days period. Bacterial populations showed significant increase in almost all treatments that contained compost alone, or mixed with compost extract, as compared to the control or the treatment of the fungus alone. There was also a significant increase in actinomycetes populations in all treatments containing compost after 30 and 45 days compared to the compost-free treatments. It is common for the actinomycetes in a microbial community to increase in numbers in late stages after other microorganisms consume the easily degradable compounds, then actinomycetes start to utilize the more stable compounds (Gagnon *et al.*, 2001). At the end of the experiment, total fungal counts were decreased in most treatments, while total counts of actinomycetes were markedly increased compared to most counts of the earlier periods. This could be due to the antibiotic agents that might be produced by actinomycetes, inhibiting other microorganisms, and allowing for competition balance in favor of the actinomycetes (Craft and Nelson, 1996). The suppressiveness phenomenon of the investigated compost and compost extract might be attributed to other mechanisms, including: competition for nutrients (Hoitink and Boehm, 1999), competition for penetration sites (Takenaka *et al.*, 2008); hyperparasitism (Danon *et al.*, 2007) and induction of plant systematic resistance (Kavroulakis *et al.*, 2005). The collective data obtained here are in compatibility with Nelson and Boehm (2002), who reported that compost and compost extracts are known to provide one of the richest sources for suppressing disease-causing microorganisms in nature.

Table 5 shows the collective mean counts of the same microbial group both across different times and different treatments. Even though the fungal populations generally decreased non significantly ($P \leq 0.05$) over the different periods, the positive effect of the compost and compost extract in decreasing the pathogenic fungus populations was manifested in the significant decrease of fungal counts in all treatments containing compost or compost extract and the fungus, as compared to the treatment containing the fungus only. Such effect could be attributed to the more robust nature of the beneficial microorganisms relative to pathogens, where they can better survive environmental stresses and use the available nutrients more efficiently. Consequently, beneficial microorganisms have more chance to

Table 4. Changes in microbial populations of fungi, bacteria, and actinomycetes in the soil of cultivation, during the time course of the experiment.

Time	Treatment [a]	Microbial populations [b] (log10 CFU/g [d.w. soil])		
		Fungi	Bacteria	Actinomycetes
At cultivation time	Control	2.57 d	7.15 c	3.57 d
	Inoculated with *F. solani*	3.90 ab	7.10 c	3.67 d
	RDC	3.72 c	7.69 b	4.78 c
	RDC + *F. solani*	3.88 ab	7.69 b	4.74 c
	RDC + CE	3.85 b	7.85 a	4.81 c
	RDC + CE + *F. solani*	3.98 ab	7.87 a	4.80 c
	RDC + CE diluted 1:1 + *F. solani*	3.98 ab	7.81 ab	4.74 c
	RDC + CE diluted 1:2 + *F. solani*	3.97 ab	7.80 ab	4.77 c
	RDC + CE diluted 1:3 + *F. solani*	3.95 ab	7.81 ab	4.77 c
After 15 days of cultivation	Control	2.82 d	7.43 bc	3.59 d
	Inoculated with *F. solani*	3.87 b	7.54 b	3.58 d
	RDC	3.70 c	7.86 a	4.92 b
	RDC + *F. solani*	3.85 b	7.78 ab	4.84 bc
	RDC + CE	3.81 b	7.89 a	4.96 b
	RDC + CE + *F. solani*	3.91 ab	7.88 a	4.97 b
	RDC + CE diluted 1:1 + *F. solani*	3.83 b	7.89 a	4.92 b
	RDC + CE diluted 1:2 + *F. solani*	3.85 b	7.91 a	4.88 bc
	RDC + CE diluted 1:3 + *F. solani*	3.86 b	7.90 a	4.89 bc
After 30 days of cultivation	Control	2.53 d	7.61 b	3.65 d
	Inoculated with *F. solani*	4.36 a	7.62 b	3.68 d
	RDC	3.73 c	7.92 a	5.24 a
	RDC + *F. solani*	3.91 ab	7.85 a	5.49 a
	RDC + CE	3.84 b	7.94 a	5.90 a
	RDC + CE + *F. solani*	3.87 b	7.95 a	5.58 a
	RDC + CE diluted 1:1 + *F. solani*	3.83 b	7.94 a	5.45 a
	RDC + CE diluted 1:2 + *F. solani*	3.82 b	7.96 a	5.36 a
	RDC + CE diluted 1:3 + *F. solani*	3.81 b	7.94 a	5.35 a
After 45 days of cultivation	Control	2.53 d	7.62 b	3.73 d
	Inoculated with *F. solani*	4.38 a	7.65 b	3.74 d
	RDC	3.75 c	7.94 a	5.62 a
	RDC + *F. solani*	3.87 b	7.88 a	5.86 a
	RDC + CE	3.71 c	7.94 a	5.98 a
	RDC + CE + *F. solani*	3.73 c	7.97 a	5.96 a
	RDC + CE diluted 1:1 + *F. solani*	3.75 c	7.96 a	5.87 a
	RDC + CE diluted 1:2 + *F. solani*	3.77 c	7.96 a	5.78 a
	RDC + CE diluted 1:3 + *F. solani*	3.79 bc	7.95 a	5.72 a

[a] RDC, Recommended dose of compost; CE, compost extract.

[b] Numbers in the same column with different letters are significantly different ($P \leq 0.05$).

Table 5. Collective microbial populations ($\overline{X} \pm$ SE) in the soil as affected by the time course of the experiment and different treatments.

	Means of microbial populations [b] (log_{10} CFU/g [d.w. soil])		
	Fungi	bacteria	Actinomycetes
Time			
Before cultivation	3.76 ± 0.09 a	7.64 ± 0.06 c	4.52 ± 0.16 c
After 15 days of cultivation	3.72 ± 0.07 a	7.79 ± 0.04 b	4.62 ± 0.11 c
After 30 days of cultivation	3.74 ± 0.10 a	7.86 ± 0.03 a	5.08 ± 0.10 a
After 45 days of cultivation	3.70 ± 0.09 a	7.87 ± 0.03 a	5.36 ± 0.17 a
Treatments [a]			
Control	2.61 ± 0.08 d	7.45 ± 0.06 c	3.63 ±0.08 c
Inoculated with *F. solani*	4.13 ± 0.11 a	7.48 ± 0.07 c	3.67 ±0.07 c
RDC	3.73 ± 0.03 c	7.85 ± 0.02 ab	5.14 ±0.10 b
RDC + *F. solani*	3.88 ± 0.04 b	7.80 ± 0.03 b	5.23 ±0.15 ab
RDC + CE	3.80 ± 0.02 bc	7.90 ± 0.01 a	5.41 ±0.16 a
RDC + CE + *F. solani*	3.87 ± 0.02 b	7.91 ± 0.02 a	5.33 ±0.16 ab
RDC + CE diluted 1:1 + *F. solani*	3.84 ± 0.02 bc	7.90 ± 0.02 a	5.24 ±0.15 ab
RDC + CE diluted 1:2 + *F. solani*	3.85 ± 0.02 bc	7.91 ± 0.02 a	5.20 ±0.13 ab
RDC + CE diluted 1:3 + *F. solani*	3.85 ± 0.02 bc	7.90 ± 0.01 a	5.18 ± 0.12 ab

[a] RDC, Recommended dose of compost; CE, compost extract.

[b] Population means in the same column followed by different letters are significantly different ($P \leq 0.05$).

- Numbers related to the different times, express the means of microbial counts in different treatments. Numbers related to the different treatments, express the means of microbial counts in different times.

colonise different surfaces and probably parasitise pathogenic microorganisms (Scheuerell, 2003; Hoitink and Boehm, 1999; Wu *et al.*, 2007). In contrary of fungal populations, bacterial and actinomycetes mean numbers increased significantly over the time, especially actinomycetes that increase 0.84 log cfu/g from the cultivation time till 45 days. Similar population trend was demonstrated by Arslan *et al.* (2008) and Zhang *et al.* (2012).

Effect of Compost and Compost Extract on Reducing Percentage of Damping-off Disease Incidence

Data presented in Table 6 indicate that the lowest percentage of pre- and post-emergence damping-off in fenugreek plants (3.33%) occurred in soil treated with the recommended dose of compost (RDC) and irrigated with compost extract (CE). Consequently, the highest percentage of healthy survived plants (93.34%) was in the same treatment. On the contrary, soil inoculated with *Fusarium solani* (Mart.) Sacc. exhibited the highest percentage of pre- and post-emergence damping-off in fenugreek plants being 23.33 and 16.66%, respectively. Meanwhile, treatments of RDC + CE diluted to 1:1, 1:2 and 1:3 of the soil infested with *F. solani* (Mart.) Sacc. resulted in moderate percentage of healthy survived plants, being 86.67 %, 80.01 % and 76.68%, respectively, with significant differences between the treatments. Thus, compost and compost extract suppressiveness against *Fusarium solani* (Mart.) Sacc. was enhanced with the combination between compost and compost extract. Control of plant diseases by compost might be due to the activities of beneficial microbes supported by organic components of the compost. It has been reported that compost extracts are natural disease inhibitors due to the presence of beneficial microorganisms and chemical inhibitors such as phenols and amino acids (Siddiqui *et al.*, 2008). In addition, antibiotics which can accumulate in compost extract during production were reported to enhance the innate defense responses of the plant (Scheuerell, 2003).

Table 6. Effect of compost and compost extract on damping-off disease incidence of fenugreek, under greenhouse conditions

Treatments	Pre-emergence damping-off %	Post-emergence damping-off %	Healthy survival %
Control	13.33	3.33	83.34
Inoculated with *F. solani*	23.33	16.66	60.01
RDC	10.00	3.33	86.67
RDC + *F. solani*	16.66	13.33	70.01
RDC + CE	3.33	3.33	93.34
RDC + CE + *F. solani*	6.66	3.33	90.01
RDC + CE diluted 1:1 + *F. solani*	10.00	3.33	86.67
RDC + CE diluted 1:2 + *F. solani*	13.33	6.66	80.01
RDC + CE diluted 1:3 + *F. solani*	16.66	6.66	76.68
LSD $_{(5\%)}$	1.40	0.94	3.80

Influence of Compost and Compost Extract on Growth Parameters of the Plants

Growth parameters of fenugreek plants as affected by compost and compost extract application were measured after 45-days of cultivation (Table 7). Plant height was significantly ($P \leq 0.05$) promoted by treatment with compost and compost extract compared to the control. In general, plant height of fenugreek ranged from 12.30 to 18.60 cm/plant. Plant height was only 12.30 cm/plant when treated with the fungus alone, which is significantly lower than the control (14.20 cm) and all other treatments. The largest values of plant height were recorded in the treatments of RDC + CE and RDC, both in pathogen-free soil, showing 18.60 and 17.30 cm/plant, respectively.

In spite of the obvious positive effect for the used additives on the number of leaves, it was not as much as the effect on plant height. Mean number of leaves recorded the highest value (14.00) in RDC + CE in pathogen-free soil, followed by RDC + CE + *F. solani* (13.50), and the same value for RDC in pathogen-free soil. While there was a significant increase in plant height due to the addition of CE as compared to the RDC + *F. solani* (16.80 vs. 15.00), such significance did not exist in the number of leaves. Similarly, for the plant height, the significant increase of the treatment containing RDC + CE + *F. solani* over the one with 1:3 diluted CE, did not materialize for the number of leaves. The numbers of leaves were significantly increased by the application of compost and compost extract compared to the control, and the same happened when *F. solani* was included in most treatments.

Thus, the obtained results indicated that using compost and compost extracts resulted in a substantial enhancement of fenugreek plants growth either grown in the presence or absence of *F. solani*. This enhancement might be due to the stimulation of growth by directly improving the nutrient availability, or indirectly by promoting the cation exchange capacity of plants (Ingham, 2005). It can also be explained by the suppressive effect of compost tea on plant pathogens as observed in this study, and as manifested by the considerable increase in the numbers of actinomycetes over the time, shown in Tables 4 and 5. Siddiqui *et al.* (2008) suggested that the use of compost extracts would be highly beneficial as environmentally friendly application, and might be used as an alternative for inorganic fertilizers/fungicides to enhance plant growth and reduce disease incidence, and thus, resulting in higher yield.

Table 7. Effect of compost and compost extract on growth parameters of fenugreek seedlings under greenhouse conditions

Treatments	Plant height (cm)	Number of leaves/plant
Control	14.20	12.66
Inoculated with *F. solani*	12.30	10.00
RDC	17.30	13.50
RDC + *F. solani*	15.00	13.00
RDC + CE	18.60	14.00
RDC + CE + *F. solani*	16.80	13.50
RDC + CE diluted 1:1 + *F. solani*	16.33	13.00
RDC + CE diluted 1:2 + *F. solani*	16.33	13.00
RDC + CE diluted 1:3 + *F. solani*	15.80	13.00
LSD $_{(5\%)}$	0.83	0.60

Conclusion

The use of compost and compost extracts have greatly reduced the pre- and post-emergence damping-off incidence, and showed enhanced growth effects on fenugreek plants grown either in the presence or absence of *F. solani*. Such enhancement was concomitant with an increase in the populations of actinomycetes, and to a lesser extent with the populations of bacteria. The use of compost and compost extract is highly beneficial as environmentally friendly application, and can be used as an alternative for inorganic fertilizers/fungicides to enhance plant growth and reduce disease incidence, and therefore, resulting in higher yield.

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تقييم فاعلية الكمبوست ومستخلص الكمبوست كوسائل للمكافحة الحيوية على معدل حدوث مرض موت البادرات فى الحلبة

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تم فى هذه الدراسة تقييم فاعلية الكمبوست ومستخلص الكمبوست فى المقاومة الحيوية لمرض موت البادرات فى نبات الحلبة. وقد تم عزل الفطر المسبب للمرض (فيوزاريوم سولانى) من محافظة الشرقية. وتم عمل تجربة أصص لزراعة نبات الحلبة بإستخدام مخاليط مختلفة من الكمبوست ومستخلص الكمبوست و فطر الفيوزاريوم سولانى، وتم تقدير معدل حدوث موت البادرات ومقاييس النمو للنبات وأعداد البكتيريا والفطريات والأكتينوميسيتات. أوضحت النتائج أن نباتات الحلبة تأثرت بشدة بموت البادرات قبل الإنبات (٢٣,٣٣%)، وبمستوى أقل بموت البادرات بعد الإنبات (١٦,٦٦%). وقد أدى استخدام الكمبوست بالجرعة الموصى بها، والرى بمستخلص الكمبوست إلى إنخفاض كبير فى معدل الإصابة إلى ٣,٣٣% سواء قبل أو بعد الإنبات. هذه النتيجة صاحبها إنخفاض فى العدد الكلى للفطريات فى معظم المعاملات، وزيادة معنوية فى العدد الكلى للبكتيريا والأكتينوميسيتات بعد ٣٠ و ٤٥ يوما من الزراعة. كما أظهرت الأكتينوميسيتات مستوى أعلى لمتوسط الزيادة وصل لوغاريتم ٠,٨٤ مستعمرة/جم بعد ٤٥ يوم مقارنة بوقت الزراعة. معايير نمو النبات (طول النبات وعدد الأوراق) تحسنت بشكل معنوى نتيجة إضافة الكمبوست ومستخلص الكمبوست، بصرف النظر عن وجود الفطر من عدمه. من هذه الدراسة، نوصى باستخدام خليط الكمبوست ومستخلص الكمبوست كبديل للمبيدات الفطرية حيث أنه صديق للبيئة ويعمل على تقليل الإصابة بمرض موت البادرات، بالإضافة لدوره كمصدر آمن للأسمدة الغير كيميائية.

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