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Potential Impact of Compost Tea on Soil Microbial Properties and Performance of Radish Plant under Sandy Soil conditions - Greenhouse Experiments

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ABSTRACT

Compost tea application to the soil improves soil properties and decreasing the need for chemical fertilizer as well as promoting the growth of plant. Therefore, an experiment was conducted at the greenhouse of Faculty of Agriculture, Zagazig University, Egypt during to examine the effect of tea compost combined with chemical nitrogen on microbial populations, plant growth and nutrient uptake of radish plant in a sandy soil. The results indicated that population of bacteria, aerobic N2-fixing bacteria and fungi were significantly affected by tea composts while actinomycetes were not affected by the same treatments. Total number of leaves per plant was higher in tea composts and chemical nitrogen either individually or combined. Sprayed and irrigated plant with T2 gave the highest value of fresh and dry weight of roots (31.80 g plant-1 and 3.47 g plant-1, respectively) as well as, highest fresh and dry weight of shoots (54.10 g plant-1 and 6.58 g plant-1, respectively). It was observed that application of compost tea increased N, P and K uptake of radish leaf were about 150%, 92% and 253%, respectively compared with control. Interestingly, Compost tea combined with application of N mineral fertilizers was the best management system for Promoting radish growth and increasing soil microorganisms, nutrient uptake and decrease need for chemical fertilizer and that will lead to sustainable agriculture.

INTRODUCTION

Tea compost is the commercially and anecdotally popularized term for an infusion where compost is steeped in water for a period of time with the aim of transferring soluble organic matter, beneficial micro-organisms and macro- and micro-nutrients into solution. The use of tea compost in organic agriculture is gaining popularity for improving soil biology and fertility (NOSB, 2004).Tea compost was initially promoted in

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the USA as a natural disease-control product, however, the scope of its usage is broadened. The best method of tea compost production is currently under debate. Tea compost can be prepared aerobically (aerated tea) or anaeraobically (non-aerated tea), but little scientific debate exists about which method is superior for agricultural purposes (Brinton *et al.,* 2004). Proponents of aeration claim that non-aerated tea compost supports the growth of pathogens but some studies have shown otherwise (Ingram and Millner, 2007). The effects of tea compost on soil fertility and subsequently, plant growth have not been investigated (OFRF, 2001). Hegazy *et al.* (2013) recommend using compost and compost extract as an environment friendly alternative to fungicides for reducing damping-off disease incidence. As well as, using bio-fertilizer combined with organic and inorganic nitrogen could be reducing the need for chemical fertilizers and that will lead to sustainable agriculture (EL Sabagh *et al.,* 2015a). Tea compost is gaining much interest due to its nutritional, bio-stimulation and disease suppression benefits to the plants (Hegazy *et al.,* 2015).

Tea compost improves soil quality by altering its chemical and physical properties. It increases organic matter content, water holding capacity, overall diversity of microbes. It also provides macro- and micro-nutrients, essential for plant growth and suppressing diseases, which indirectly contributes to enhance plant growth (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 tea extract is very useful for increasing fertility and disease control (Litterick *et al*., 2004). Possible benefits of tea compost include: (1) increasing the biomass and species diversity of microbes, (2) increasing the numbers of predator organisms (Ingham, 1999), (3) enhancing the ability of soil to hold nutrients and retain water, (4) reducing fertilizer use and leaching into ground water (Pant *et al*., 2009), (5) reducing salt accumulation in soils, (6) improving the soils pH buffering ability through microbe diversity (Radovich and Arancon, 2011).Therefore, the present study was conducted to assess the effects of four tea composts made with different supplements on plant growth and nutrient uptake of radish as well as the population of soil microbial diversity.

MATERIALS AND METHODS

Location and soil type:

The pot experiment was conducted at the Dept of Agric. Microbiology, Faculty of Agriculture, Zagazig University, Egypt. This was to examine the effect of different types of tea composts on soil microorganisms and growth and nutrient uptake of radish plants cultivated in sandy soil.

Preparation of tea compost:

Solid compost made up of town-refuse compost, which 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 of 7.5±0.2. Tea compost (water extract of compost) was prepared in the Zagazig University, Egypt, following the method of Ingham (2005) with some modifications (Hegazy *et al.*, 2015). One kilogram fresh weight of garbage compost was sealed in a cotton bag and submerged into 20 L of tap water in 40 L plastic bucket, and each was amended with 0.5% (v/v) molasses. The used water 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 96 hours and it was continuously aerated (10 L/min air delivery per bucket through air stones). Four types of compost teas were prepared. The first (T1) without supplement, the second (T2) was supplemented with NH_4NO_3 (1g L^{-1}), the third (T3) was supplemented with KH_2PO_4 (1g L^{-1}) and the forth (T4) was supplements with NH_4NO_3 (0.5g L^{-1}) plus KH_2PO_4 (0.5g L^{-1}). The parameters of pH, EC and percentages of total nitrogen, phosphorus and potassium were determined in compost teas at the end of incubation according to the method of AOAC (2002). These parameters are represented in Table 1.

Table 1: Properties of the compost tea used in this study.

Treatments	pH	E.C. (dsm^{-1})	Total N (mg L^{-1})	Total P (mg L^{-1})	Total K (mg L^{-1})
(T1) compost tea without supplemented	7.4	1.67	1.73	16.80	453.0
(T2) compost tea + NH_4NO_3	7.3	2.65	35.22	16.73	451.0
(T3) compost tea + KH_2PO_4	7.5	2.68	1.76	156.94	875.5
(T4) compost tea + NH_4NO_3+ KH_2PO_4	7.4	3.36	19.56	79.73	641.0

Microbial populations in the tea composts i.e. bacteria, aerobic N2-fixing bacteria, actinomycetes and fungal populations were determined. Bacteria were enumerated on nutrient agar (Difco, 1985), Aerobic N2-fixing bacteria

(ANFB) was done using the most probable number (MPN) technique of Abd-El-Malek (1971) on Ashby modified medium. Actinomycetes were enumerated on starch casein agar (Conn and Leci, 1998), whereas fungi were enumerated on Martin's rose bengal agar (Martin, 1950).The microbial population in microbe-enriched compost teas are represented in Table 2.

Table 2: Microbial populations in microbe-enriched compost teas.

Microorganisms	Compost teaT1	Compost tea T2	Compost tea T3	Compost tea T4
Bacteria (log10 $CFUml^{-1}$)	7.71	7.48	7.65	8.90
ANFB (log10 $CFUml^{-1}$)	3.44	1.34	3.15	2.15
Actinomycetes (log10 $CFUml^{-1}$)	2.35	2.72	2.59	2.64
Fungi (log10 $CFUml^{-1}$)	2.72	2.50	2.78	2.71

Experimental design and studied treatments:

The greenhouse experiment was carried out to examine the effect of using the above mentioned tea composts combined with two levels of chemical nitrogen fertilizers on soil microbial populations and growth of radish. Radish seeds were obtained from the Horticulture Research Institute (HRI), Agricultural Research Center (ARC), Giza, Egypt. The soil was distributed in plastic pots (Ø=20 cm, height=25 cm) made of polyvinyl chloride (PVC) at the rate of 6 kg/pot. The seeds were sown on the 8^{th} of October 2014. The experiment was designed a randomized complete block with three replications. Plants were thinned to one plant per pot after 15 days of sowing. There were ten treatments as follows: control, full dose of N-fertilizers (FDN), which contain (240 kg N ha^{-1}) as ammonium sulphate, FDN + T1, FDN + T2, FDN + T3, FDN + T4, 0.5FDN + T1, 0.5FDN + T2, 0.5FDN + T3 and 0.5FDN + T4. These treatments were randomly arranged in the experimental pots. All pots received equal amounts of mineral P and K fertilizers according to the fertilizer recommendations for radish plants in sandy soils (100 kg P ha^{-1} and 50 kg K ha^{-1}). Phosphorus was added during soil preparation. Nitrogen and potassium were added into four portions every 15 days intervals beginning after 15 days from transplanting. The other normal agricultural treatments for growing radish plants were practiced. Plants were sprayed with tea composts in four portions every 15 days intervals beginning after 15 days from transplanting. Also all of the studied treatments irrigated with one liter of tea compost per pot just before cultivation except control and FDN treatments which were received one liter of tap water per pot.

Analysis of soil and plant materials:

The physio-chemical properties of the studied soil were carried out on a surface (0-30cm) sample from an arable field near Salhia city (Table 3).

Table 3: Some physico-chemical and properties of the soil under investigation

Physical analyses				Chemical analyses									
Sand %	Silt %	Clay%	Texture	pH	EC ds m^{-1}	OM%	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3+HCO_3^-	Cl^-	SO_4^-
64.0	29.3	6.7	Sandy	7.46	1.78	0.16	4.8	3.3	6.1	1.9	4.2	8.1	4.2

The properties of the soil were determined according to the methods described by Page *et al.* (1982) and Klute (1986). The collected plant samples were separated into leaves and roots, dried at 70° C temperature and digested using a mixture of concentrated sulfuric (H_2SO_4) and perchloric (HClO) acids (1:1). Nitrogen was determined by the micro- Jheldahl method, P was determined in the acid mixture by the molybdate stannous chloride method and K was measured by the flame photometer. Fe, Mn and Zn were measured by the atomic absorption apparatus. These determinations were carried out according to methods described by Cottenie *et al.* (1982).

Soil microbiological analysis:

Microbial population was determined directly in soil samples. Soil samples were collected after 0, 4 and 8 weeks from seeding. This was to determine total bacteria, ANFB, and fungi using plate count of most probable number (MPN) technique, bacteria on nutrient agar after incubation at 30°C for 2 days (Difco, 1985*)*. Enumeration of potential strict aerobe N_2-fixing bacteria was done using the most probable number (MPN) technique of Abd-El Malek (1971) on Ashby modified medium incubated at 30°C for 7 days, whereas enumeration of aerobe N_2-fixers was done as surface pellicle formation. Actinomycetes were enumerated on starch casein agar incubated at 28°C for 7 to 14 days (Conn and Leci, 1998). Fungi were enumerated on Martin's rose bengal agar, incubated at 25°C for 3-5 days *(*Martin, 1950*)*. All enumerations were carried out in three replications.

Statistical Analysis:

Data recorded in the different treatments were subjected to the analysis of variance (ANOVA) according to Snedecor and Cochran (1980). This was done using SPSS statistical software package version 16.0 (SPSS Inc., Chicago, IL, USA) to quantify and evaluate the sources of variation. Duncan's multiple range test (DMRT) was applied to compare the mean performances of different treatments for the specific parameters under study. The rankings were denoted by superscripts in the relevant Tables. Differences in means were compared at $P \leq 0.05$.

RESULTS AND DISCUSSION

Microbial Population in Soil:

The effect of tested treatments at different times on population of bacteria, aerobic N_2-fixing bacteria, actinomycetes and fungi in the soil are presented in Table 4. Population of bacteria, aerobic N_2-fixing bacteria and fungi were significantly affected by the treatments, whereas actinomycetes were not significantly affected by these treatments. The population of bacteria at just before spwing under control and FDN treatments was the minimum values and there was no significant differences between them.the other treatments came in the second group without significant differences between them. After 8 weeks of cultivation, bacterial counts were higher when compared with those at the other time intervals. Bacterial counts were higher in the soil treated with tea composts. Carbon energy sources leaked from root stimulates the number of heterotrophic bacteria and free-living N_2-fixers the root zone of soil (Herman *et al.,* 1993), particularly where, organic matter is introduced to soil. This can be explained by the increased nutrition supplement due to the compost and tea compost (Heather *et al.,* 2006). In general, the populations of bacteria increasing in proportion with increasing the soil content of compost and tea compost. The aerobic N_2-fixing bacteria, as affected by the tested treatments (Table 4). at just before cultivation, it can be classified into two category, the first category comprised (all treatments received compost teas) without significant differences between them, the control and FDN treatments came in the second category without significant differences between them. These results may be due to the compost teas contained high amounts aerobic N_2-fixing bacteria. The results showed counts of aerobic N_2-fixing bacteria in the soil as affected by different treatments of compost teas combined with two N doses. Treatments containing high dose of N, exhibited a significant decrease in aerobic N_2-fixing bacterial count after 4 weeks of cultivation compared with counts after 8 weeks. Also, soils with high contents of N had the lowest counts of N_2 fixing bacteria (Herman *et al.,* 1993). Increasing the nitrogen in the soil, reducing the numbers of nitrogen-fixing bacteria and reducing the nitrogen fixation process are consistence very well with the finding of Harper *et al.*(1997). Adding ammonium nitrate alone resulted in decreasing microbial populations in all cases, more prominently in aerobic N_2 fixing bacteria, which is reasonable since this group of bacteria is known to be negatively affected by the presence of a nitrogen source in the media (Hegazy *et al.*, 2015). Hegazy *et al*..(2013) reported that the total fungal counts in soil were decreased by treated with compost tea. 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. The suppressiveness phenomenon of the investigated compost and compost extract might be attributed to other mechanisms, including: competition for nutrients (Hoitink and Boehm, 1999).

Effect tea composts with N_2- fertilizers on growth parameters:

The total number of leaves per plant was higher in the treatments of compost teas and mineral nitrogen singly or in any combination. The increases ranged from 42.9% to 100% (Table 5). Compost tea was reported to enhance the growth of melons (Bernal-Vicente *et al.*, 2008) and of okra (Siddiqui *et al.*, 2008), maize (Abd el-wahed et al., 2015) and canola (EL Sabagh et al., 2016b). Table 5 and Figure 2 show the growth parameters of radish under different treatment as number of leaves per plant, root fresh and dry weight, shoots fresh and dry weight. Plant sprayed with compost tea T2 gave the highest fresh and dry weight of roots (31.80 g plant^{-1} and 3.47 g plant^{-1}, respectively) as well as the highest fresh and dry weight of shoots (54.10 g plant-1 and 6.58 g plant-1, respectively). While the lowest values of fresh and dry weight of root were noticed in the control treatment (8.67 g plant^{-1} and 0.49 g plant^{-1}, respectively) as well as the lowest fresh and dry weight of shoots (9.17 g plant^{-1} and 0.86 g plant^{-1}, respectively). Plants which received mineral N gave the highest number of leaf amounting to 100%.). Sifola and Barbier (2006) reported that organic N, as well as organic-inorganic N combinations increased plant growth**.**

The influence of tea composts and N-fertilizer on N, P and K uptake of radish plants:

Data in Table 6 show the N, P and K uptake (mg pot^{-1}) in root and shoot of radish under the different treatments. Soil amended with FDN+T2 gave the most efficient treatment that the NPK-uptake of root and shoot was the highest value compared to the other treatments. That FDN+T2 gave the highest NPK-uptake of shoots (83.40 mg pot^{-1}, 29.50 mg pot^{-1}, and 180.10mg pot^{-1}, respectively) as well as the highest NPK-uptake of roots (45.20 mg pot^{-1}, 11.60 mg pot^{-1}, and 107.31 mg pot^{-1}, respectively). Elsherbeny *et al.*, (2012) reported a decrease in P content in plant treated by inorganic fertilizer compared with plant P content in plant treated by humic and tea compost. Moreover, leaf P and K uptake affected by increasing compost tea ratios. Application of compost tea with or without N dosage increased leaf N and K uptake. The wide ratio of compost: water increased N uptake in turnip plant. Also, the lowest uptake of P and K were given by the non-treated plants.

T1: compost tea without supplemented, T2: compost tea supplemented with NH_4NO_3, T3: compost tea supplemented with KH_2PO_4 and T4: compost tea supplemented with NH_4NO_3 + KH_2PO_4. Sampling date (SD): fertilization (F) In the all tables: Numbers in the same column with different letters are significantly different ($P \leq 0.05$).

Use of compost, tea compost or bio-fertilizer increased plant macronutrient content, and this is related to a positive effect on increasing the root surface area unit of soil volume, water use efficiency and photosynthetic activity, which directly affect physiological processes *(*Siddiqui *et al.*, 2011*).* Hirzel *et al.*, (2012) reported that adding tea compost to the soil without fertilization did not affect ryegrass dry matter but it has a positive effect on the treatments with solid composts. Tea compost sources and N dosages individually increased N, P and K uptake. Siddiqui *et al.*, (2011) also found that application of tea compost increased N, P and K soil content compared with inorganic fertilizer alone, and the increase depended on compost tea ratios. Favorable effect of tea compost on plant growth could be attributed to the enhancement of soil physical, chemical and biological properties. It has been reported that adding organic materials, together with microbial activity, improves soil health and fertility. These changes often result in improving plant growth (Antolan *et al.*, 2005, EL Sabagh et al., 2015b; EL Sabagh et al., 2016a). Soil N-content was increased with the individual treatments than with the combined treatments with compost tea and with inorganic fertilizer. Positive effects are indications of equilibrium in nutrients and water at plant root zone as well as vital hormones and enzymes. Tea compost provided significantly greater amounts of P to the soil than same source of compost, these results agree with those Hargreaves *et al.*, (2008)**.** Continued use of tea compost supplement increased soil fertility as well as N, P and K content of the soil Siddiqui *et al.*, (2011).

Table 4: Changes in microbial populations of bacteria, aerobic N_2-fixing bacteria actinomycetes and fungi in the soil of cultivation, during the time course of the experiment.

Treatment	Microbial populations (log10 CFUg^{-1} [d.w. soil])															
	Bacteria				Aerobic N_2fixing bacteria				Actinomycetes				Fungi			
	At cultivation time	After 4 weeks	After 8 weeks	Av.	At cultivation time	After 4 weeks	After 8 weeks	Av.	At cultivation time	After 4 weeks	After 8 weeks	Av.	At cultivation time	After 4 weeks	After 8 weeks	Av.
Control (without any additives)	6.30b	7.15b	7.35a	6.93b	3.31b	5.80a	6.11a	5.40a	3.44	3.78	4.47	3.90	2.57	3.11	3.21	2.96b
Full dose of chemical N_2 (FDN)	6.30b	7.40a	7.92a	7.42b	3.28b	3.13c	3.20c	3.54b	3.44	3.81	4.50	3.92	2.57	3.25	3.35	3.06b
FDN + T1	7.90a	7.79a	7.87a	7.85a	4.82a	3.89 a	3.15c	5.62a	4.65	4.99	5.68	5.11	3.72	2.98	2.99	2.95a
FDN + T2	7.93a	7.69a	7.85a	7.89a	4.81a	3.25c	3.30c	3.78b	4.61	4.95	5.60	5.05	3.70	2.45	2.66	2.99a
FDN + T3	7.95a	7.69a	7.80a	7.71a	4.20a	3.10c	3.30c	3.53b	4.19	4.53	5.22	4.65	3.70	2.46	2.59	2.58b
FDN + T4	7.94a	7.65a	7.79a	7.55b	4.13a	3.12c	3.25c	3.50b	4.21	4.55	5.24	4.67	3.85	2.41	2.54	2.60b
0.5FDN + T1	7.71a	7.64a	7.79a	7.38b	4.11a	3.15c	3.34c	3.53b	4.13	4.47	5.16	4.59	3.81	2.40	2.53	2.58b
0.5FDN + T2	7.59a	7.59a	7.73a	7.64b	4.20a	4.24b	4.68b	4.37a	4.14	4.48	5.17	4.60	3.91	2.44	2.57	2.64b
0.5FDN + T3	7.83a	7.59a	7.74a	7.52b	4.31a	4.26b	4.60b	4.39a	4.19	4.53	5.22	4.65	3.83	2.40	2.53	2.59b
0.5FDN + T4	7.68a	7.55a	7.73a	7.32b	4.30a	4.26b	4.65b	4.40a	4.15	4.49	5.18	4.61	3.85	2.38	2.51	2.58b
Sampling date av.	7.19	7.79	7.96		4.39a	4.02b	4.23a		4.16b	4.51a	5.19a		3.44	2.65	2.79	
LSD (0.05)	SD	F	SD × F		SD	F	SD × F		SD	F	SD × F		SD	F	SD × F	
	0.63	0.85	1.62		0.31	1.30	1.42		0.85	NS	NS		NS	0.78	NS	

Table 5: Effect of four types of compost tea and/or chemical N_2- fertilizers on radish growth parameters.

Treatment	No. Leaves/ plant	Root F.W (g plant^{-1})	Root D.W (g plant^{-1})	Shoot F.W (g plant^{-1})	Shoot D.W (g plant^{-1})
Control(without any additives)	9.00 c	8.67 c	0.49 c	9.17 d	0.86 e
Full dose of N_2 (FDN)	14.00 a	31.77 a	2.47 ab	46.17 a	3.57 b
FDN + T1	11.33 b	24.67 ab	1.63 b	27.73 c	2.40 cd
FDN + T2	12.67 b	31.80 a	3.47 a	54.10 a	6.58 a
FDN + T3	13.67 c	28.80 a	3.41 a	34.73 b	3.61 b

FDN + T4	12.00 b	21.20 b	3.34 a	38.70 b	3.98b
0.5FDN + T1	12.67 b	25.77ab	4.27 a	35.93 b	4.45ab
0.5FDN + T2	11.67 b	24.23ab	3.69 a	32.13bc	2.92 d
0.5FDN + T3	11.33 b	22.47ab	3.93 a	33.93 b	2.36 d
0.5FDN + T4	10.33bc	19.96bc	3.46 a	27.80c	2.73 d

Table 6: Influence of compost tea types and inorganic fertilizer on N, P and K radish plants uptake (mg pot-1).

Treatment	Shoot nutrient uptake (mg pot^{-1})			Root nutrient uptake (mg pot^{-1})		
	N uptake (mg pot^{-1})	P uptake (mg pot^{-1})	K uptake (mg pot^{-1})	N uptake (mg pot^{-1})	P uptake (mg pot^{-1})	K uptake (mg pot^{-1})
Control(without additives)	33.41 d	15.35 c	50.95 d	18.76 d	5.31 c	40.10 c
Full dose of N_2 (FDN)	68.10 b	22.65 b	98.67 c	38.52 b	8.30 b	73.62 b
FDN + T1	41.25 c	16.22 c	128.60 b	30.60 c	8.90 b	81.59 b
FDN + T2	83.40 a	29.50 a	180.10 a	45.20 a	11.60 a	107.31 a
FDN + T3	74.37a	18.76bc	67.74 cd	39.15 b	5.40 c	56.30bc
FDN + T4	68.57 b	21.50 b	101.01bc	38.35 b	9.02 b	56.09bc
0.5FDN + T1	66.14 b	23.58 b	88.76 c	37.78 b	8.08bc	57.16bc
0.5FDN + T2	50.17 b	16.41 c	59.11 d	27.01 c	7.88 c	55.52bc
0.5FDN + T3	49.87 b	20.90 b	55.01 d	39.57 b	6.37 c	54.79b c
0.5FDN + T4	43.93 c	20.02 b	61.94 d	28.80 c	6.65 c	50.60bc

Conclusion:

In the light of above discussion, it could be accomplished that that , using of compost teas combined with chemical nitrogen fertilizers significantly increased the population of bacteria, aerobic N_2-fixing bacteria and fungi in sandy soil as well as promotion growth of radish plant . Plants sprayed and irrigated with compost tea T2 gave the highest fresh and dry weight of roots as well as the highest fresh and dry weight of shoots furthermore, increased N, P and K uptakes. The populations of the different microorganisms were greater in the treatments of compost teas, and increased with time as well. Accordingly, Compost tea combined with application of N mineral fertilizers compost at the appropriate rate and time is crucial to maximize their beneficial effects consequently , could be improve soil microorganisms, nutrient uptake and as well as, Promoting radish growth that will lead to decrease need for chemical fertilizer and sustainable agriculture.

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