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The Effect of Compost Tea on Some Growth and Yield Parameters and Soil Chemical Properties of Greenhouse Tomato (*Solanum lycopersicum* L.)

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ABSTRACT

The research was conducted within a greenhouse setting to explore the impact of various compost tea application rates on the growth of 'Hazera 395' tomatoes. Additionally, the study aimed to compare the efficacy of soil-applied compost tea versus foliar application methods, all conducted under greenhouse conditions. Utilizing a split-plot design with three replications, soil and foliar applications were designated as main plots, while six compost tea concentration treatments (v/v) were allocated to sub-main plots. These concentrations included: zero treatment (control), as well as extracts of 1:1, 1:25, 1:50, 1:75, and 1:100 compost to water ratios. Notably, soil-applied compost tea significantly enhanced nitrogen (N) and potassium (K) availability compared to foliar application. Moreover, the 1:25 compost tea extract, whether applied to soil or foliage, notably improved vegetative growth parameters such as stem internode count, plant height, and leaf count per plant. Both soil and foliar application of compost tea resulted in significant increases in yield and average fruit weight. In summary, this research advances scientific knowledge by elucidating the effects of compost tea application rates and methods on tomato growth under controlled greenhouse conditions, offering valuable insights for agricultural practices aimed at improving crop productivity and sustainability.

Keywords: compost tea, greenhouse tomato, vegetative growth, fruit weight, macronutrients.

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) belongs to the family Solanaceae. Peralta and Spooner (2007) suggested that the southwest coast of South America could be the origin of the crop. In terms of both labor and external inputs, organic greenhouse tomato production is more intensive than conventional production. Organic greenhouse tomato production requires proper soil management, particularly soil fertility management, which is mainly improved by supplying the soil with composted material (Abubaker 2014). Organic fertilizer encompasses a diverse range of organic amendments applied to soils, with exceptions made for direct excreta deposition by grazing animals. This category includes compost, wood chips, biochar, animal feces, hay, husk, and geotextile (Al-Taey et al., 2019; Hani et al., 2019; Al Tawaha et al., 2021;). Organic or natural fertilizers originate from natural sources, containing at least one essential nutrient vital for plant nourishment(Singh et al., 2023a,b,c; Al Tawaha et al., 2023; Al Tawaha et al., 2024; Singh et al., 2024). Compost can be used for planting and growing plants including tomatoes (Ullah, 2021 and Růžek *et al*., 2015). However, composts and other solid manures take a while to break down in the soil to become available to plants(Imran et al., 2022; Amanullah et al., 2022; Qaisi et al., 2023;). Therefore, for the successful growing of tomatoes, the use of compost tea could have an important role in terms of supplying nutrients and increasing the organic matter content which is very important since it improves the soil's physical properties and the cation exchange capacity (CEC).

On the other hand, compost tea, a nutrient-dense solution enriched with beneficial microorganisms, is crafted by blending aerobic compost with water. Its brewing duration varies, spanning from a few days to over two weeks, with the option for active ventilation. Additionally, nutrients like molasses, casein, and biocarbon may be incorporated during the brewing process. This versatile concoction serves as a preventive measure against diseases when applied. Compost tea with its high nutrient content and rapid availability makes it a great growth stimulant for plants (Tafaghodinia and Kamalpour, 2008). It has been demonstrated that the consumption of compost tea leads to an increase in the amounts of chlorophyll, as well as growth and development(Segarra et al., 2009). Furthermore, Catello *et al*. (2016) mentioned that compost tea products may potentially induce a positive effect on treated crops, including disease-suppressing and bio-stimulating plant growth status. In Jordan, compost use has become a well-established practice over the last few years. Abubaker (2013 and 2014) reported that the compost manure treatments increased soil N, P, K, Ca, and Mg. Moreover, Tsado (2014) indicated that compost application increased tomato growth and yield compared to N:P:K chemical fertilizer.

Hence, it is pertinent to explore how tomatoes cultivated in an organic system respond to compost tea, considering both application rates and methods. This study, conducted in a greenhouse environment, aimed to assess the effects of compost tea on specific growth and yield attributes of 'Hazera 395' tomatoes. It sought to evaluate various application rates and compare soil application with foliar application of compost tea.

MATERIALS AND METHODS

Study location

The study was conducted in a greenhouse at Palestine Technical University Research Station during the spring 2017 growing season. Transplants of tomato variety (Hazerah 395), as being the most popular tomato variety planted under greenhouse conditions in the area were used. The average temperature and relative humidity in the greenhouse were 27 °C and 75–80% under 18/6 h (light/dark) photoperiod.

Preparation of compost tea

Compost was purchased from a local nursery. Compost made from plant and animal sources was completely fermented under aerobic conditions. The completely fermented compost was analyzed for the following: organic matter: 37%, pH: 7.5, N: 2.2%, P: 0.6% and K: 1% and was used to extract compost tea. Aerated compost tea was prepared weekly in a 10 L bucket, with 0.4 l of compost and 2 L of tap water (1:5, v: v), adapted from Weltzien (1991) and Kim *et al*. (2015).

Soil chemical properties

Soil chemical properties were analyzed before planting and after the termination of the greenhouse study. For the determination of total nitrogen, the Kjeldahl procedure (Bremner and Mulvancy. 1982) was utilized. Available phosphorus was measured by a spectrophotometer (Olsen and Sommers, 1982). A flame photometer according to Knudsen *et al*. (1982) was used to measure the available potassium. Soil chemical properties before transplanting were as follow: 7.1, 0.47 mS/cm, 0.17, 40.0, and 200 for pH, EC, N%, P (mg/kg), and K (mg/kg), respectively.

Plant growth and yield parameters

Plant vegetative parameters including internode number, plant height, stem diameter, and leaf number per plant were recorded throughout the growing season. In addition, the number of days for flowering, the number of clusters per plant, the number of fruits per cluster, fruit weight, and the total yield were also recorded as indicators for yield potential.

Experimental design and treatments

A split plot design with three replications was used as the experimental design. Application types including 100 ml of the solution to the soil and foliar applications were assigned in the main plots, meanwhile, treatment concentrations of the compost tea were randomly arranged in the sub-main plots. Treatment included six concentrations (compost tea: water; v/v) in each main plot: zero treatment as the control, 1:1, 1:25, 1:50, 1:75, and 1:100. Both application types and concentrations started in the second week of transplanting and continued at weekly intervals throughout the growing season. No other fertilizer types were applied during the greenhouse study.

Statistical analysis

Analysis of variance and mean separation were conducted using the least significant differences (LSD) at a 5% level of probability using the SAS program.

RESULTS AND DISCUSSION

Soil chemical analysis at the end of the study is shown in Table 1. Results showed that neither soil pH nor electrical conductivity was significantly affected by the compost tea treatments, and soil or foliar applications. Soil pH is one of the soil properties that does not easily change by soil-applied amendments for being buffered by the cation exchange capacity and/or calcium carbonate. In addition, soil pH at the level of bulk soil does not respond to soil amendments in the short term. However, it might change at the level of the rhizosphere, which cannot be detected using the traditional pH analysis method. Moreover, it should be noted that pH and EC were determined in 1:2.5 soil: water extracts. Concerning soil EC, it is unusual that soil EC is not affected by the soil-applied compost tea. The possible reasons for such observation can be related to the method of compost tea application to soil, soil sampling, irrigation method, and depth, prevalent climatic conditions, plant nutrient uptake rate, and soil extraction method.

The soil's primary macronutrients, N, P, and K increased by decreasing the compost tea: water extraction ratio. Results demonstrated that concentrated compost tea (1:1 CT: W extracts) significantly increased soil N, P, and K mainly as compared with the control soil. However, soil P was not significantly affected by the foliar-applied

Table 1. Some soil chemical properties at the end of the harvest season of 'Hazera 395' tomato treated with compost tea under greenhouse conditions

Treatment		Soil chemical properties				
		pH (1:2.5 water susp.)	EC mS/cm (1: 2.5)	N%	P avail. (ppm)	K avail. (ppm)
Soil application	0 CT	7.1 a	0.47 a	0.17 c	40 b	200 b
	1 CT: 100 W	7.1 a	0.47 a	0.20 abc	44 b	218 ab
	1 CT: 75 W	7.1 a	0.46 a	0.21 abc	45 ab	220 ab
	1 CT: 50 W	7.1 a	0.47 a	0.22 abc	50 ab	223 ab
	1 CT: 25 W	7.2 a	0.48 a	0.25 a	58 a	225 ab
	1 CT: 1 W	7.2 a	0.48 a	0.25 a	58 a	230 a
	$LSD_{0.05}$	0.15	0.07	0.06	13	28
Foliar application	0 CT	7.1 a	0.46 a	0.16 b	41 a	195 b
	1 CT: 100 W	7.1 a	0.46 a	0.16 b	42 a	198 b
	1 CT: 75 W	7.1 a	0.47 a	0.17 b	44 a	207 ab
	1 CT: 50 W	7.1 a	0.47 a	0.20 ab	45 a	210 ab
	1 CT: 25 W	7.1 a	0.47 a	0.22 a	46 a	217ab
	1 CT: 1 W	7.1 a	0.47 a	0.22 a	46 a	225 a
	$LSD_{0.05}$	0.13	0.06	0.04	9	25
Signifiant level	Soil application	NS	NS	*	*	*
	Foliar application	NS	NS	*	NS	*
	Soil x Foliar	NS	NS	*	NS	*

Note: CT – compost tea, S0 – control, S1:1= 1 compost: 1 water, 1 compost: 25 water, 1 compost: 50 water, 1 compost: 75 water, and 1 compost: 100 water.

compost tea. This could be attributed to the high amounts consumed by tomato plants during the season or the so-called "luxury consumption" especially of P and K. Moreover, the concentrations of soil K and Olsen-P in the control treatment are already high (200 and 40 mg/kg, respectively), which could mask the effect of increasing the concentration of soil K and P on some growth and yield parameters due to the soil- or foliar-applied compost tea.

Concerning soil N, its concentration at the end of the experiment might not be of great importance. The form of applied N along with soil- or foliar-applied compost tea might be of greater importance. Compost tea might contain both soluble inorganic and organically-complexed N. Soluble inorganic N could be immediately taken up by plants, adsorbed on the exchange sites on the solid phase, and/or leaching, while organically-complexed N formed a slow-release source of N for plants throughout the growing period or at least during the vegetative growth stage resulting in improving some growth and yield parameters of compost tea-treated plants mainly at the 1:1 CT: W extracts. At this extracting ratio, soluble organic carbon-containing compounds were also concentrated leading to the better activity of soil microorganisms. Concerning vegetative growth parameters as shown in Table 2 (Figure 1), the number of stem internodes, plant height, and the number of leaves per plant was significantly increased mainly by the soil- and foliar-applied 1:1 CT: W extracts as compared to the control treatment. Stem diameter was also significantly increased by the foliar-applied 1:1 compost tea extracts.

Zaccardelli et al. (2018) conducted a study investigating the effects of foliar application of compost tea on poblano pepper crops (*Capsicum annuum* L.) over a two-year period. They observed a 21.9% increase in fruit yield per plant during the first year and a 16.3% increase during the second year. Furthermore, when compost tea was applied to the soil (drenching) for lettuce and rutabaga (swede) crops, they achieved yield increases of 24% and 32%, respectively. Additionally, there were improvements in chlorophyll content, as well as physiological and nutritional status. Similar findings were reported by Pane et al. (2014). Previous studies have documented the use of compost tea on tomato plants, revealing a threefold increase in root dry weight among treated plants. Additionally, it was observed that

Table 2. Number of 'Hazera 395' tomato stem internodes, height, stem diameter and number of leaves treated with compost tea under greenhouse conditions

Treatment		Vegetative Growth Parameter			
		Number of stem internodes	Plant height (cm)	Stem diameter (mm)	Number of leaves/ plant
Soil application	0 CT	17.7 b	135 b	10.3 a	14 b
	1 CT: 100 W	18.3 ab	137 b	10.7 a	16 ab
	1 CT: 75 W	20.0 ab	144 b	11.4 a	16 ab
	1 CT: 50 W	20.7ab	165 a	11.5 a	18 ab
	1 CT: 25 W	22.1a	170 a	12.0 a	19 a
	1 CT: 1 W	22.1a	170 a	12.6 a	19 a
	$LSD_{0.05}$	4.1	19	3.1	4.3
Foliar application	0 CT	17.0 b	127 c	10.1 b	14 b
	1 CT: 100 W	17.3 b	135 bc	10.2 b	16 b
	1 CT: 75 W	20.0 ab	135 bc	11.0 ab	17 ab
	1 CT: 50 W	20.7 ab	150 ab	12.4 ab	19 a
	1 CT: 25 W	23.1 a	160 a	13.1 a	21 a
	1 CT: 1 W	23.3 a	166 a	13.3 a	21 a
	$LSD_{0.05}$	4.5	17.7	2.8	4.5
Significant level	Soil application	*	*	NS	*
	Foliar application	*	*	*	*
	Soil x Foliar	NS	NS	NS	NS

Note: CT – compost tea, S0 – control, S1:1 = 1 compost: 1 water, 1 compost: 25 water, 1 compost: 50 water, 1 compost: 75 water. and 1 compost: 100 water.

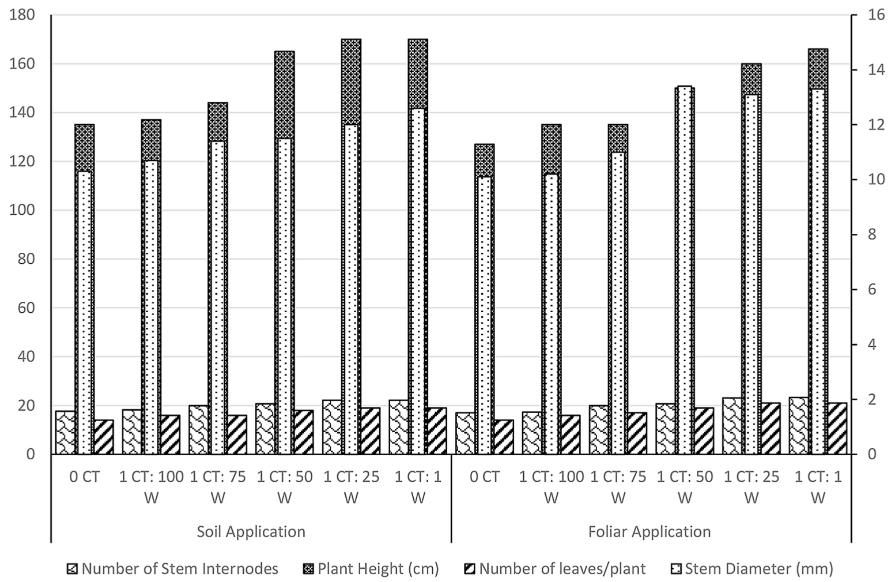

Figure 1. Number of 'Hazera 395' tomato stem internodes, height, stem diameter and number of leaves treated with compost tea under greenhouse conditions

compost tea had a suppressive effect on Fusarium oxysporum (Morales-Corts et al.2018). González-Solano et al. (2013) discovered that applying vermicompost tea to lettuce, basil, and coriander resulted in a comparable increase in dry biomass weight to that achieved with the Steiner treatment. Marín et al. (2014) reported that applying compost tea (specifically grape marc) without aeration to pepper seedlings led to an increase in root weight. Ingham (2005) asserted that the enlargement of root size is attributed to the presence of nutrients and growth-promoting compounds in vermicompost or compost teas.

Our results showed that soil- and foliar-applied compost tea significantly improved the measured vegetative growth parameters of tomato plants mainly due to the increase in soil N, P, and K, particularly for the 1:1 CT: W extracts indicating that tea compost is a good alternate for chemical fertilizers particularly for organic agriculture and can be commercially prepared from locally composted organic agricultural wastes. With regard to yield parameters, promising data were obtained as shown in Table 3 (Figure 2).

The 1:1 CT: W extracts, equally for soil- and foliar-applied compost tea, significantly decreased the number of days to flowering compared to the control treatment. Such observation is of great importance, particularly for farmers who intend to achieve higher returns. The number of days to flowering in soil- and foliar-applied tea compost decreased from 43 days to 38 days. The early flowering might be attributed to more available macronutrients in the concentrated compost tea at the early growth stages. In contrast with soil-applied compost tea, foliar-applied compost tea significantly increased the number of fruits per cluster from 5.5 to approximately 7 compared to the control treatment. A foliar application might have enhanced the nutrient uptake and translocation as compared to the soil-applied compost tea. As a matter of fact, nutrients applied to the soil are tremendously subject to interaction with the solid phase of the soil, thus influencing their movement in soil and uptake by plants. Our findings are in agreement with the results reported by Tafaghodinia and Kamalpour (2008). Furthermore, Sári and Forró (2008) mentioned that the productivity of a growing medium is determined mainly by its ability to supply nutrients and its structure availability. *Previous studies* have *reported* that organic fertilizer had the ability to improve not only the physical and chemical qualities of soil, but also the characteristics of soil microbes (Al Tawaha et al. 2022; Khalid et al., 2022; Alomari et al. 2023; Karnwal, et al., 2023).

Average fruit weight was also significantly affected by the soil- and foliar-applied 1:1 CT: W extracts. Average fruit weight significantly increased from 88.7 and 85.4 g to 111.9 and 112.4 g respectively for the control and soil- and foliar-applied compost tea. The same trend was observed for the yield of tomato plants. Tomato yields were significantly affected by soil and

Table 3. Number of days for flowering, number of clusters/plant, number of fruits/cluster, fruit weight, and total yield of 'Hazera 395' tomato treated with compost tea under greenhouse conditions

Treatment		Potential yield				
		Days to flowering	No. of clusters / plant	No. of fruits / cluster	Fruit weight (g)	Yield T/ Ha
Soil application	0 CT	43 a	8.1 a	5.2 a	88.7 b	8.3 c
	1 CT: 100 W	43 a	8.6 a	6.0 a	95.1 b	9.5 c
	1 CT: 75 W	41ab	9.0 a	6.4 a	98.2 ab	10.0 bc
	1 CT: 50 W	41 ab	9.1 a	6.9 a	110.0 a	12.5 ab
	1 CT: 25 W	38 b	9.3 a	7.3 a	110.5 a	12.9 a
	1 CT: 1 W	38 b	9.3 a	7.6 a	111.9 a	13.4 a
	$LSD_{0.05}$	3.9	1.8	2.5	14.0	2.7
Foliar application	0 CT	43 a	8.0 a	5.5 b	85.4 c	8.0 d
	1 CT: 100 W	42 ab	8.7 a	6.2 ab	93.1 bc	10.1 cd
	1 CT: 75 W	40 abc	9.2 a	6.8 ab	100.3 ab	11.0 bc
	1 CT: 50 W	39 bc	9.2 a	7.3 a	104.1 ab	12.0 abc
	1 CT: 25 W	39 bc	9.6 a	7.6 a	109.3 a	13.5 ab
	1 CT: 1 W	38 c	9.2 a	7.3 a	112.4 a	14.1 a
	$LSD_{0.05}$	3.8	1,7	1.7	14.3	2.8
Significant level	Soil application	*	NS	NS	*	*
	Foliar application	*	NS	*	*	*
	Soil x Foliar	NS	NS	NS	NS	NS

Note: CT – compost tea, S0 – control, S1: 1 = 1 compost: 1 water, 1 compost: 25 water, 1 compost: 50 water, 1 compost: 75 water, and 1 compost: 100 water.

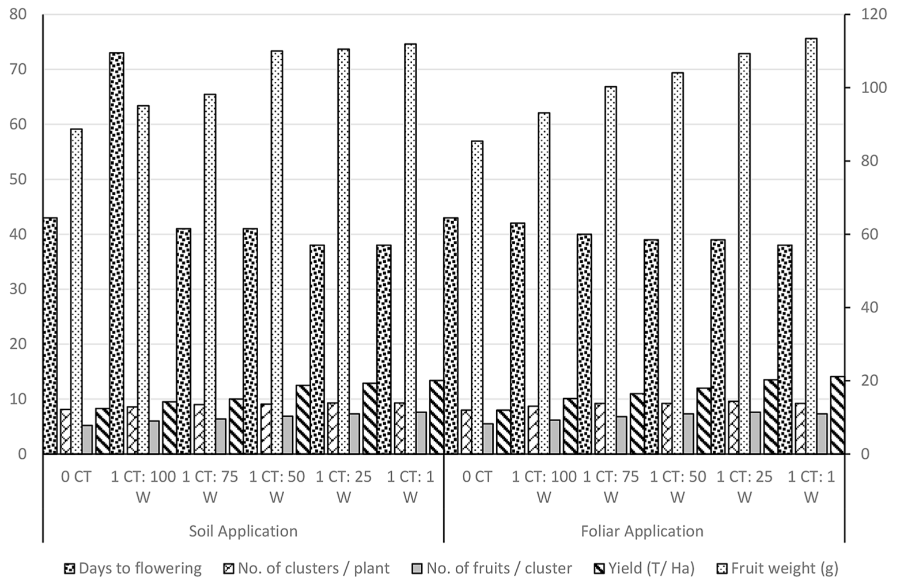

Figure 2. Number of days for flowering, number of clusters/plant, number of fruits/cluster, fruit weight, and total yield of 'Hazera 395' tomato treated with compost tea under greenhouse conditions

foliar application regimes particularly for the 1:1 CT: W extracts as shown in Table 3 (Figure 2). The highest yields (13.4 and 14.1 T/Ha respectively for soil- and foliar-applied compost tea) were recorded in 1 CT: 1 W treatment compared to the control. In their study, González-Solano et al. (2013) found that the use of vermicompost tea resulted in comparable stem length (dry weight) values in basil when compared to the Steiner solution. However, when vermicompost tea was used in lettuce and coriander plants, higher stem length values were obtained compared to the Steiner solution. According to Marín et al. (2014), pepper seedlings fed with compost tea made from grape marc without aeration experienced an increase in dry stem weight. Regarding the leaf dry weight, it applies to 3 out of the 7 samples. This further suggests that the additional amounts of nutrients added along with the compost tea contributed to the observed increase in the yield as reported by Catello et al. (2016). Such an increase in yield (5.1 to 6.1 T/ha) without using synthetic fertilizers would maximize the profit of the growers and orient farmers towards organic agriculture.

CONCLUSIONS

Given the pressing need to safeguard soil health and sustainability, especially in the face of challenges posed by a burgeoning global population and the depletion of fertile land due to inadequate land management and agricultural policies, it becomes imperative for farmers to prioritize techniques that bolster soil quality. Among these methods, biochar and compost play pivotal roles in enriching soil quality by replenishing nutrients and organic matter. Embracing compost water extracts as eco-friendly alternatives to chemical fertilizers holds significant importance. The scientific novelty of this study lies in its exploration of how different application rates of compost tea affect the growth of 'Hazera 395' tomatoes in a greenhouse environment, alongside a comparison of soil-applied versus foliar application methods. While previous research has touched on the use of compost tea in agriculture, this study goes further by systematically examining the impact of various concentrations of compost tea on plant growth parameters.The findings contribute to our understanding of how compost tea promotes plant growth and improves nutrient availability, particularly nitrogen (N) and potassium (K). The significant enhancement in vegetative growth parameters observed with the 1:25 compost tea extract highlights its potential for maximizing plant productivity. Furthermore, comparing soil and foliar application methods provides valuable insights into the most effective approach for applying compost tea. The notable increases in yield and average fruit weight resulting from both methods underscore the practical benefits of using compost tea in greenhouse tomato cultivation. In summary, this research advances scientific knowledge by examining the effects of compost tea application rates and methods on tomato growth under controlled greenhouse conditions. These insights offer valuable guidance for agricultural practices aimed at enhancing crop productivity and sustainability.

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