Assessment of Yield of Tomato (*Lycopersicon esculentum* Mill.) and Soil CO_2 Emissions as Influenced by Compost Doses and Irrigation Regimes

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Abstract**—** *Tomato (Lycopersicon esculentum Mill.) is one of the most important vegetables cultivated in Togo. Water stress constitutes one of limiting factors of production in dry season. Compost use improves soil properties and crop production but may lead to soil CO_2 emission into atmosphere. This study assessed the influence of compost doses and irrigation regimes on tomato yield and soil CO_2 emission. Trial agronomics were conducted in dry season in year 2018 and 2019 in a randomized complete block design with three repetitions. Treatments included control plots, compost plots and chemical fertilizer plots. Water was supplied according to three irrigation regimes of 1, 2 and 4 days interval. Tomato fruits were harvested when color was yellowish red. Soil CO_2 emission measurement was conducted in four months (120 days) during field experiment from January to April in 2019. Soil samples were collected from plots and incubated in laboratory. Soil CO_2 emission was measured every day during 28 day's incubation using 0.1 N HCl after precipitating the carbonate with a BaCl2 solution by alkali back-titrating. The results shown that highest tomato yield and highest soil CO_2 emission were recorded on plots treated with compost and submitted to two days interval irrigation while the lowest values of these parameters were obtained from control plots and treated plots submitted to daily and four days interval irrigation.This was noted that CO_2 emission from soil samples collected in third and fourth months of field experiment were more than those of first and second months.*

Keywords**— *Togo, household waste compost, irrigation interval day, tomato yield, soil CO_2 emission.***

I. INTRODUCTION

In West Africa, cultural methods in many cases still remain ancestral characterized by the use of rudimentary tools and low use inputs (improved seeds, mineral and organic fertilizers etc.), thus contributing to the continuous soil degradation. Farmers traditionally relied on long fallow periods to restore land fertility. However, population increasing has shortened the fallow periods and decreased the available agricultural land. Furthermore, farmers remove crop residues from the field and use them for feeding their livestock or as fuel to cook their food. Crops are grown continuously on poor soils. Especially with continuous cultivation, physical properties and productivity of many soils commonly decline due to decrease in organic matter content (Lal, 1986). The red soil called "Terre de Barre" in coastal region of Togo does not escape this reality. These soils are overused and do not have the necessary time to replenish their organic matter stock. Demographic pressure and excess land use have led to a total depletion of these soils, resulting in a decrease in the stock of organic carbon and a destructuring of the surface horizons, reducing mainly food crop production (maize, cassava, cow pea, tomato etc.).

Researchers have shown that application of waste composts at reasonable rates improves soil physical properties, increases available soil nutrient levels and plant growth (Hossain et al. 2017; Coulibaly et al. 2019). According to Edwards and Araya (2009), compost increases soil fertility by holding and gradually releasing nutrients and building up organic matter levels in the soil, improves also the water holding capacity of the soil and makes crops better able to survive droughts.

On another side, the vegetable fields are small sizes about 0.25 – 0.50 ha in Togo where tomato (*Lycopersicon esculentum* Mill.) is one of the most important vegetables and cultivated in almost all parts of the country. Water stress constitutes one of the most important factor limiting plant growth and yield in dry season when the incidence of pests and diseases is minimal. Field water management practices is the most influential factors affecting crop yield particularly in irrigated agriculture (Al-Omran et al., 2005). Irrigation regime improves water use efficiency and has significant effect on the growth and yield of crops (Gudugi et al. 2012).Compost use in cropping systems may lead to soil CO_2 emission into atmosphere although the processes involved are not fully understood. Barton et al. (2016) reported that incorporating organic matter alters soil greenhouse gas emissions and increases grain yield in a semi-arid climate. Compost is known for its efficacy on agricultural productivity increase, but little is known about its effectiveness on tomato productivity in Southern Togo.The objective of this study was to assess the influence of household waste compost doses and irrigation regimes on the yield of tomato and the soil CO_2 emissions in coastal region of Togo.

II. MATERIALS AND METHODS

2.1 Field experiments

Field experiments were carried out at the University of Lome in the Teaching Research and Demonstration Farm of Agronomic School during two dry seasons in 2018 and 2019. The land had been cropped previously for many years. The soil type was a ferrallisol locally called "Terre de Barre" that developed from a continental deposit (Saragoni et al., 1991). This soil is red, deep and suitable for almost all crops. The particle size distribution analysis revealed that soil surface layer (0 - 15 cm) of experimental site was loamy sand. For this study, the land was manually ploughed and divided into plots with plot area of 3.84 m^2 (2.4 m x 1.6 m). Each plot was separated from the adjacent by 1 m interval while the replicates were separated by 1.5 m interval. Tomato (*Lycopersicon esculentum* Mill.) mongal F1 variety, a high-yielding hybrid cultivar, was used. The tomato seedlings were raised in the nursery for three weeks before transported on plots and planted at a spacing of 0.5 m. The treatments were arranged in a randomized complete block design. Each treatment was replicated three times. There were five treatments per block where T0 refers to control plots without any compost use while T20, T30 and T40 refer to plots treated with compost at 20 t ha^{-1}, 30 t ha^{-1} and 40 t ha^{-1} doses respectively and T_{MF} refers to mineral fertilizers NPK 15-15-15 and Urea (46% N) applied at 0.2 t ha^{-1} and 0.1 t ha^{-1}doses respectively. These treatments were in combination with three irrigation regimes (interval of 1, 2 and 4 days). The compost used was produced with 70% of household solid urban wastes collected from Agbalepedogan district in Lome mixed with 30% poultry manure (Alate et al., 2019). It was applied at the beginning of tomato cultivation before transplanting the young tomato plants. It was spread on the soil surface after ploughing and mixed with the topsoil at about 15 cm depth. Preventive phytosanitary treatments were performed against potential pests and diseases of tomato.

2.2 Irrigation regimes

Irrigation scheduling, including 1, 2 and 4 days interval irrigation, was applied during all experimental period. At each irrigation event, an amount of water corresponding to field capacity water content in 15 cm soil depth was applied. Irrigation was applied manually using a watering can with capacity known in order to make sure that all the experimental plots received the same amount of water. The combined effect of compost doses and irrigation regimes on yield of tomato and soil CO_2 emission was evaluated.

2.3 Soil sampling, incubation and CO_2 emission measurement

The soil samples collected in topsoil at about 15 cm depth on each experimental plot were dried, sieved at 2 mm and homogenized before the beginning of incubation in laboratory. The study was conducted in four months (120 days) during field experiment from January to April in year 2019. The protocol was adapted to those of Rahman (2013). Twenty five grams of each dry soil sample was incubated at 30°C in hermetically sealed glass vial of 1000 ml volume. The soil water content has been adjusted to 25% (i.e. 12.5 g of demineralized water for the 50 g of soil). The sodium hydroxide (NaOH, 1N) solution (20 ml 1.0 N NaOH + 25 ml distilled water) was prepared for trapping CO_2. The trap solution in plastic pill box was placed in the vial of 1000 ml volume containing soil sample. The CO_2 released during the incubation is trapped in 15 ml of sodium hydroxide (NaOH, 1N) contained in plastic pill boxes put with the soil in the glass vials. For each treatment, three repetitions are performed. The measurements were carried out every day during 28 days of incubation. At each measurement, the pillboxes are sacrificed for evaluation of the amount of CO_2 released inside the glass vials and soda solution (NaOH, 1N) is renewed. After each measurement, the NaOH vials are changed and the jars aerated. The humidity of the soil samples is checked and adjusted on the eighth, sixteenth and twenty-fourth day. The CO_2emission was measured from the soil using 0.1 N HCl after precipitating the carbonate with a $BaCl_2$ solution by back-titrating the alkali. The alkali solution pillboxes were removed and titrated with 0.1 N HCl solution using phenolphthalein indicator and $BaCl_2$ solutions. Controls for this experiment consist of glass vial without soil sample but with the alkali of same strength was used. The alkali solutions from the control were titrated to determine the quantity of alkali that has not reacted with CO_2 excess $BaCl_2$. The determination of the CO_2 emitted is done on 10 ml of trap solution (NaOH) taken after his homogenization in the pillbox. A few drops of phenolphthalein were added as indicator, and titrated with 0.1 N HCl directly in the beaker. The volume of acid needed to titrate the alkali was noted. The amount of CO_2emittedwas calculated using the following formula:

$$\text{Milligram of } CO_2 = [(B - V).N.E]/M$$

where ***B*** is the volume of HCl used to titrate the control (mL), ***V*** the volume of HCl used to titrate the sample (mL), ***N*** the normality of HCl, ***E*** (= 22) the molar mass of CO_2 divided by 2 (because 2 mol of OH^- is consumed by 1 mol of CO_2), M = soil weight.

2.4 Tomato fruit harvest

When the fruits turned yellowish red, they were harvested at a regular interval from each plot. Fruits were picked by hand at 3 days interval during three weeks. The tomato fruits were sorted into categories marketable and unmarketable (cracked fruits, unripe fruits, tiny fruits, fruits having blossom - end rot, diseased, malformed and damaged by insect pests). The first harvest in all treatments was considered as early ripening. The fruits of all pickings were added up and total yield was expressed in ton per hectare.

2.5 Statistical analysis

Tomato total yield data were grabbed into the Excel spreadsheet and analysis of variance (ANOVA) was carried out with the CropStat software. Means comparisons between treatments were performed with Newman & Keuls test at the threshold of 5%.

III. RESULTS AND DISCUSSION

3.1 Influence of compost doses and irrigation regimes on tomato total yield

Total yields of tomato which included early ripening yield, marketable yield and unmarketable yield were presented in Table 1. The highest values of tomato yield (14.20 t ha^{-1} - 30.59 t ha^{-1}) were recorded on plots treated with compost and mineral fertilizers and submitted to two days interval irrigation, while the lowest values (3.58 t ha^{-1} - 11.63 t ha^{-1}) were recorded on control plots and plots treated with compost and mineral fertilizers but submitted to daily and four days interval irrigation. It was noted that the yields of tomato were proportional to compost doses. This explained that tomato yield was influenced by compost doses applied and irrigation regimes. The tendency these results may be attributed to the fact that adequate watering conditions led to the development of an abundant ovules per floret consequently higher yield fruit under irrigation regime of two days interval. Our results were in line with the findings of Gudugi et al. (2012) who suggested that number of tomato fruits had been related with irrigation intervals.

TABLE1
EFFECT OF COMPOST DOSES AND IRRIGATION REGIMES ON TOTAL YIELD OF TOMATO

Treatments	Irrigation interval days	Total yield (t ha^{-1}) Year 2018	Total yield (t ha^{-1}) Year 2019
T0	daily	4.05±0.02g	3.62±0.01g
	2 days	4.19±0.02g	3.65±0.01g
	4 days	3.92±0.03g	3.58±0.02g
T20	daily	7.45±0.02f	8.49±0.01f
	2 days	14.20±0.04d	17.79±0.02c
	4 days	7.42±0.03f	8.53±0.01f
T30	daily	10.37±0.04e	11.57±0.01d
	2 days	20.12±0.04b	25.56±0.03b
	4 days	7.40±0.03f	10.25±0.02e
T40	daily	10.39±0.03e	11.63±0.01d
	2 days	24.84±0.02a	30.59±0.03a
	4 days	7.48±0.03f	10.26±0.02e
T_{MF}	daily	10.35±0.03e	11.70±0.03d
	2 days	18.54±0.02c	25.41±0.02b
	4 days	7.41±0.03f	10.24±0.03e

In Table 1, T0 refers to control plot without any compost use while T20, T30 and T40 refer to compost applied at 20 t ha^{-1}, 30 t ha^{-1} and 40 tha^{-1} doses respectively. T_{MF} refers to mineral fertilizers NPK 15-15-15 and Urea (46%) applied at 0.2 t ha^{-1} and 0.1 t ha^{-1} respectively. In a column, treatment mean values followed by same letter are not significantly different at the threshold of 5%.

Decreasing yield recorded on plots irrigated every day may be explained by the excess irrigation which would lead to water draining past the root zone, leaching nutrients and reducing water and nutrient use efficiency. This explains that water use efficiency rides with increase of water supply up to a certain point. According to Prihar et al. (1985), water supply has been observed to increase fertilizer use efficiency by increasing the availability of applied nutrients. Too much water in the root zone would reduce also the amount of oxygen available and leading to plant stress (Morard et al, 2000; Boru et al., 2003; Iwasaki, 2008; Rajanna et al., 2018). In conditions of too frequent irrigation, the roots were without air after each irrigation until the free water has drained from the soil profile. During this time, plant growth and development nearly would stop.

In other hand, the reduction in yield of plants irrigated at four days interval indicated that these plants were subjected to water deficit stress and yield decreasing may be explained by effect of water deficit stress (Bouazzama et al., 2012; Dhakar et al., 2018). Decreasing yield recorded from these plants may be explained by the high percent abortion observed on these severe stressed plants due to the fact that as the water stress increased, the number of ovules per floret decreased. Lower soil moisture may lead to the flower abortion and fewer fruits. Adams et al. (2001) reported that poor fruits set were observed at high temperatures. In this study, temperature in the air was higher during the experiment because conducted in dry and hot season. Birhanu and Tilahun (2010) reported a decreased number and sizes of tomato fruits from plants subjected to moisture stress. The same observation of water stress on tomato yield parameters was also reported by Zotarelli et al. (2009).

3.2 Influence of compost doses and irrigation regimes on soil CO_2 emissions

Although soil CO_2 emissions were measured every day during 28 days of incubation, because of general tendency of results obtained, only the results of twenty four hours of incubation, those of fourth, eighth, sixteenth and twenty eighth days incubation have been recorded in Tables 2 to 6.

TABLE 2
RESULTS OF SOIL CO_2 EMISSION (mg) IN TWENTY-FOUR HOURS OF INCUBATION

Treatments	Irrigation interval days	First month Year 2019	Second month Year 2019	Third month Year 2019	Fourth month Year 2019
T0	daily	0.60±0.02	0.78±0.02	0.96±0.02	1.10±0.01
	2 days	0.88±0.02	1.41±0.02	1.76±0.02	2.10±0.01
	4 days	0.40±0.03	0.44±0.03	0.52±0.03	0.60±0.02
T20	daily	0.77±0.02	0.99±0.02	1.20±0.02	1.38±0.01
	2 days	1.06±0.04	1.70±0.04	2.13±0.04	2.56±0.02
	4 days	0.35±0.03	0.39±0.03	0.46±0.03	0.53±0.01
T30	daily	0.78±0.04	1.02±0.04	1.25±0.04	1.41±0.01
	2 days	1.47±0.04	2.35±0.04	2.94±0.04	3.52±0.03
	4 days	0.72±0.03	0.79±0.03	0.94±0.03	1.08±0.02
T40	daily	0.88±0.03	1.14±0.03	1.41±0.03	1.58±0.01
	2 days	1.73±0.02	2.77±0.02	3.47±0.02	4.16±0.03
	4 days	0.75±0.03	0.83±0.03	0.98±0.03	1.13±0.02
T_{FM}	daily	0.69±0.03	0.89±0.03	1.10±0.03	1.20±0.03
	2 days	0.80±0.02	1.28±0.02	1.60±0.02	1.92±0.02
	4 days	0.37±0.03	0.41±0.03	0.48±0.03	0.55±0.03

In Table 2, T0 refers to control plot without any compost use while T20, T30 and T40 refer to compost applied at 20 t ha^{-1}, 30 t ha^{-1} and 40 tha^{-1} doses respectively. T_{MF} refers to mineral fertilizers NPK 15-15-15 and Urea (46%) applied at 0.2 t ha^{-1} and 0.1 t ha^{-1} respectively.

TABLE 3
RESULTS OF SOIL CO_2 EMISSION (mg) AT FOUR DAYS INCUBATION

Treatments	Irrigation interval days	First month Year 2019	Second month Year 2019	Third month Year 2019	Fourth month Year 2019
T0	daily	0.56±0.02	0.73±0.02	0.90±0.02	1.01±0.01
	2 days	0.75±0.02	1.20±0.02	1.50±0.02	1.80±0.01
	4 days	0.35±0.03	0.39±0.03	0.46±0.03	0.53±0.02
T20	daily	0.56±0.02	0.73±0.02	0.90±0.02	1.00±0.01
	2 days	0.73±0.04	1.17±0.04	1.47±0.04	1.75±0.02
	4 days	0.29±0.03	0.32±0.03	0.38±0.03	0.44±0.01
T30	daily	0.75±0.04	0.97±0.04	1.20±0.04	1.35±0.01
	2 days	1.17±0.04	1.87±0.04	2.34±0.04	2.81±0.03
	4 days	0.44±0.03	0.48±0.03	0.57±0.03	0.66±0.02
T40	daily	0.85±0.03	1.10±0.03	1.35±0.03	1.52±0.01
	2 days	1.55±0.02	2.48±0.02	3.10±0.02	3.72±0.03
	4 days	0.54±0.03	0.59±0.03	0.70±0.03	0.81±0.02
T_{FM}	daily	0.69±0.03	0.89±0.03	1.10±0.03	1.24±0.03
	2 days	0.73±0.02	1.17±0.02	1.46±0.02	1.73±0.02
	4 days	0.33±0.03	0.37±0.03	0.43±0.03	0.50±0.03

In Table 3, T0 refers to control plot without any compost use while T20, T30 and T40 refer to compost applied at 20 t ha^{-1}, 30 t ha^{-1} and 40 tha^{-1} doses respectively. T_{MF} refers to mineral fertilizers NPK 15-15-15 and Urea (46%) applied at 0.2 t ha^{-1} and 0.1 t ha^{-1} respectively.

TABLE 4
RESULTS OF SOIL CO_2 EMISSION (mg) AT EIGHT DAYS INCUBATION

Treatments	Irrigation interval days	First month Year 2019	Second month Year 2019	Third month Year 2019	Fourth month Year 2019
T0	daily	0.50±0.02	0.65±0.02	0.80±0.02	0.90±0.01
	2 days	0.60±0.02	0.96±0.02	1.20±0.02	1.44±0.01
	4 days	0.32±0.03	0.35±0.03	0.42±0.03	0.48±0.02
T20	daily	0.37±0.02	0.48±0.02	0.79±0.02	0.67±0.01
	2 days	0.52±0.04	0.83±0.04	1.04±0.04	1.25±0.02
	4 days	0.20±0.03	0.22±0.03	0.26±0.03	0.30±0.01
T30	daily	0.40±0.04	0.51±0.04	0.63±0.04	0.71±0.01
	2 days	0.90±0.04	1.45±0.04	1.81±0.04	2.17±0.03
	4 days	0.41±0.03	0.45±0.03	0.54±0.03	0.62±0.02
T40	daily	0.49±0.03	0.64±0.03	0.79±0.03	0.91±0.01
	2 days	1.31±0.02	2.10±0.02	2.62±0.02	3.15±0.03
	4 days	0.36±0.03	0.40±0.03	0.47±0.03	0.54±0.02
T_{FM}	daily	0.49±0.03	0.64±0.03	0.79±0.03	0.89±0.03
	2 days	0.70±0.02	1.12±0.02	1.40±0.02	1.68±0.02
	4 days	0.31±0.03	0.34±0.03	0.40±0.03	0.46±0.03

In Table 4, T0 refers to control plot without any compost use while T20, T30 and T40 refer to compost applied at 20 t ha^{-1}, 30 t ha^{-1} and 40 tha^{-1} doses respectively. T_{MF} refers to mineral fertilizers NPK 15-15-15 and Urea (46%) applied at 0.2 t ha^{-1} and 0.1 t ha^{-1} respectively.

TABLE 5
RESULTS OF SOIL CO_2 EMISSION (mg) AT SIXTEEN DAYS INCUBATION

Treatments	Irrigation interval days	First month Year 2019	Second month Year 2019	Third month Year 2019	Fourth month Year 2019
T0	daily	0.33±0.02	0.43±0.02	0.53±0.02	0.59±0.01
	2 days	0.55±0.02	0.88±0.02	1.10±0.02	1.32±0.01
	4 days	0.22±0.03	0.24±0.03	0.29±0.03	0.33±0.02
T20	daily	0.32±0.02	0.42±0.02	0.51±0.02	0.58±0.01
	2 days	0.43±0.04	0.70±0.04	0.86±0.04	1.03±0.02
	4 days	0.16±0.03	0.18±0.03	0.21±0.03	0.24±0.01
T30	daily	0.27±0.04	0.36±0.04	0.44±0.04	0.49±0.01
	2 days	0.44±0.04	0.71±0.04	0.88±0.04	1.06±0.03
	4 days	0.40±0.03	0.44±0.03	0.51±0.03	0.59±0.02
T40	daily	0.40±0.03	0.51±0.03	0.63±0.03	0.71±0.01
	2 days	1.17±0.02	1.87±0.02	2.34±0.02	2.81±0.03
	4 days	0.31±0.03	0.34±0.03	0.41±0.03	0.47±0.02
T_{FM}	daily	0.34±0.03	0.44±0.03	0.54±0.03	0.60±0.03
	2 days	0.60±0.02	0.96±0.02	1.20±0.02	1.44±0.02
	4 days	0.26±0.03	0.29±0.03	0.34±0.03	0.40±0.03

In Table 5, T0 refers to control plot without any compost use while T20, T30 and T40 refer to compost applied at 20 t ha^{-1}, 30 t ha^{-1} and 40 tha^{-1} doses respectively. T_{MF} refers to mineral fertilizers NPK 15-15-15 and Urea (46%) applied at 0.2 t ha^{-1} and 0.1 t ha^{-1} respectively.

The results presented in Tables 2 to 6 revealed the variation of soil CO_2 emissions. It was noted that soil CO_2 emission values depended on the irrigation regime, the nature of fertilizer (compost or mineral fertilizer), the dose of compost, number of days incubation (date of measurement of soil CO_2 emission) and the period of soil sampling. The highest soil CO_2 emission values were recorded on the plots irrigated at two days interval regardless fertilizer nature and compost dose, while the lowest values were obtained both on the control plots and on the plots receiving compost or mineral fertilizer and submitted to daily and four days interval irrigation. These results suggested that soil moisture and organic matter level affects microbial activities and soil respiration, which indirectly affected CO_2 emission. Irrigation at two days interval could enhance soil wetting-drying cycles, and thus increased the CO_2 fluxes by promoting microbial activities and respiration (Guo et al. 2017). The higher soil CO_2 emissions were potentially resulted from the effect of increased oxygen and soil microbial (Guadie et al. 2014).

TABLE 6
RESULTS OF SOIL CO_2 EMISSION (mg) AT TWENTY EIGHT DAYS INCUBATION

Treatments	Irrigation interval days	First month Year 2019	Second month Year 2019	Third month Year 2019	Fourth month Year 2019
T0	daily	0.07±0.02	0.13±0.02	0.16±0.02	0.19±0.01
	2 days	0.18±0.02	0.22±0.02	0.28±0.02	0.34±0.01
	4 days	0.09±0.03	0.15±0.03	0.19±0.03	0.24±0.02
T20	daily	0.15±0.02	0.17±0.02	0.21±0.02	0.23±0.01
	2 days	0.19±0.04	0.22±0.04	0.29±0.04	0.36±0.02
	4 days	0.17±0.03	0.20±0.03	0.24±0.03	0.25±0.01
T30	daily	0.20±0.04	0.22±0.04	0.23±0.04	0.29±0.01
	2 days	0.32±0.04	0.36±0.04	0.39±0.04	0.42±0.03
	4 days	0.24±0.03	0.25±0.03	0.26±0.03	0.30±0.02
T40	daily	0.21±0.03	0.28±0.03	0.34±0.03	0.38±0.01
	2 days	0.40±0.02	0.64±0.02	0.80±0.02	0.96±0.03
	4 days	0.28±0.03	0.36±0.03	0.38±0.03	0.42±0.02
T_{FM}	daily	0.10±0.03	0.13±0.03	0.16±0.03	0.18±0.03
	2 days	0.16±0.02	0.25±0.02	0.33±0.02	0.35±0.02
	4 days	0.14±0.03	0.17±0.03	0.19±0.03	0.22±0.03

In Table 6, T0 refers to control plot without any compost use while T20, T30 and T40 refer to compost applied at 20 t ha^{-1}, 30 t ha^{-1} and 40 tha^{-1} doses respectively. T_{MF} refers to mineral fertilizers NPK 15-15-15 and Urea (46%) applied at 0.2 t ha^{-1} and 0.1 t ha^{-1} respectively.

Irrigating too frequently could have negative impact on microbial population. In this case of daily irrigation, the microorganisms could have insufficient air. This explained the low values of soil CO_2 emission noted on plots submitted to daily irrigation. The low CO_2 emission from plots irrigated at four days interval indicated that these plots were subjected to high water deficit stress. Decreasing CO_2 emission recorded from these plots may be explained by the low microbial activities and respiration due to the water deficit stress increases. Our results were in line with the findings of Hou et al. (2019) who concluded that deficit irrigation effectively reduced CO_2 emissions from winter wheat field soils in northwest China.

It was noted that the soil CO_2 emission increased throughout the field experiment. Soil CO_2 emissions of third and fourth months were more than those of first and second months (Tables 2 to 6). These observations were in accordance with the study of Russell (1973) which stated that the presence of crops on the field affected (increased) CO_2 emissions from the soil. Soil CO_2 emission increasing in the two last months of field experiment was also in line with the finding of Han et al. (2012) who reported that the presence of vegetation or crop affected CO_2 fluxes primarily by photosynthesizing and by increasing the total ecosystem respiration.

However, CO_2 emission decreased gradually during day's incubation. Results of soil CO_2 emission in twenty-four hours of incubation were more than those recorded at four, eight, and sixteen and twenty eight day's incubation (Tables 2 to 6).All these variations in soil CO_2 emissions may be explained by the abundance or rarity of microorganisms in the soils sampled and incubated. From this view point, monitoring the soil CO_2 emission during incubation mean to measure the respiration of microbial populations in the soil. Our results suggested that the application of household solid urban waste compost increased soil microbial populations and soil CO_2 emissions. The levels of soil CO_2 emission observed in this study were in line with the findings of several authors. Previous studies had found that crop root and soil microbial respiration were the main sources of soil CO_2 emissions. Researchers performed a long-term fertilization study on wheat and maize growing season and observed that the highest soil CO_2 flux was found from organic fertilizer treatment (Galic et al. 2019). Compost application may be associated with increased amount of carbon available that increased the microbial activity and thus stimulated respiration of autotrophic and heterotrophic microorganisms in the soil (De Urzedo et al. 2013; Carmo et al. 2014).

IV. CONCLUSION

The influence of compost doses and irrigation regimes on tomato yield and soil CO_2 emissions was assessed. Tomato yield and soil CO_2 emission values were proportional to compost doses applied. These results indicated that the application of household solid urban waste compost increased soil microbial populations and consequently soil CO_2 emissions. The highest tomato yield and the highest soil CO_2 emission values were recorded on the plots irrigated at two days interval regardless fertilizer nature and compost doses. As our experiments were relatively short, to better assess the CO_2 emissions from compost applied to soil, long-term experiments are needed for a more reliable conclusion on the effect of applying household urban solid waste compost on soil carbon dynamics.

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REFERENCES

[1] *Adams, S.R.*, Cockshull, K.E. and Cave, C.R.J. (*2001*). *Effect of temperature on the growth and development of tomato fruits*. Annals of Botany, 88(5):869–877.

[2] Alate, K.K.A., Mawussi, G., Ayisah, K.D. and Sanda, K. (2019). Agronomic potential value of household urban solid wastes by composting and composts quality assessment. International Journal of Agricultural Research, Innovation and Technology,9(2): 1-8.

[3] Al-Omran, A.M., Sheta, A.S., Falatah, A.M. and Al-Harbi, A.R. (2005). Effect of Drip Irrigation on Squash (*Cucurbitapepo*) Yield and Water-use Efficiency in Sandy Calcareous Soils Amended with Clay Deposits. *Agricultural Water Management*, 73: 43-55.

[4] Barton, L., Hoyle, F.C., Stefanova, K.T. and Murphy, D.V. (2016). Incorporating organic matter alters soil greenhouse gas emissions and increases grain yield in a semi-arid climate. *Agriculture, Ecosystems&Environment*, 231: 320-330.

[5] Birhanu, K. and Tilahun, K. (2010). Fruit yield and quality of dripped-irrigated tomato under deficit irrigation. African journal of food agriculture, Nutrition and Development, 10(2): 2139-2151.

[6] Boru, G., Vantoai, T., Alves, J., Hua D. and Knee, M. (2003). Responses of soybean to oxygen deficiency and elevated root-zone carbon dioxide concentration. Annals of Botany, 91: 447-453.

[7] Bouazzama, B., Xanthoulis, D., Bouaziz, A., Ruelle, P. and Mailhol, J.-C. (2012). Effect of water stress on growth, water consumption and yield of silage maize under flood irrigation in a semi-arid climate of Tadla (Morocco). Biotechnology, Agronomy, Society and Environment, 16(4): 468-477.

[8] Carmo, J.B., De Urzedo, D.I., Filho, P.J.F., Pereira, E.A. and Pitombo, L.M. (2014). CO_2 emission from soil after reforestation and application of sewage sludge. Bragantia, 73(3): 312-318.

[9] Coulibaly, S.S., Kouassi, K.I., Koffi, K.K. and Zoro, B.I.A. (2019). Effect of compost from different animal manures on maize (*zea mays*) growth. Journal of Experimental Biology and Agricultural Sciences, 7(2): 178-185.

[10] De Urzedo, D.I., Franco, M.P., Pitombo, L.M. and Carmo, J.B. (2013). Effects of organic and inorganic fertilizers on greenhouse gas (GHG) emissions in tropical forestry. Forest *Ecology* and *Management*,310: 37-44.

[11] Dhakar, R., Chandran, M.A.S., Nagar, S., Kumari, V.V., Subbarao, A.V.M., Bal, S.K. and Kumar P.V. (2018). Field crop response to water deficit stress: Assessment through crop models. Advances in Crop Environment Interaction, 11: 287-315.

[12] Edwards, S. and Araya, H. (2009). The Tigray Project: organic agriculture with smallholder farmers in a mountainous environment. Ecology & Farming, 28-30.

[13] Galic, M., Bilandzija, D., Percin, A., Sestak, I., Mesic, M., Blazinkov, M. and Zgorelec, Y. (2019). Effects of agricultural practices on carbon emission and soil health. Journal of Sustainable Development of Energy, Water and Environment Systems,7(3): 539-552.

[14] Guadie, A., Xia, S., Zhang, Z., Zeleke, J., Guo, W., Ngo, H.H. and Hermanowicz, S.W. (2014). Effect of intermittent aeration cycle on nutrient removal and microbial community in a fluidized bed reactor-membrane bioreactor combo system. *Bioresource Technology,* 156: 195-205.

[15] Gudugi, I.A.S, Odofin, A.J, Adeboye, M.K.A. and Oladiran, J.A. (2012). Agronomic characteristics of tomato as influenced by irrigation and mulching. Advances in Applied Science Research, 3(5): 2539-2543.

[16] Guo, S., Qi, Y., Peng, Q., Dong, Y., He, Y., Yan, Z. and Wang, L. (2017). Influences of drip and flood irrigation on soil carbon dioxide emission and soil carbon sequestration of maize cropland in the North China Plain. Journal of Arid Land,9(2): 222-233.

[17] Han, G.X., Yang, L.Q., Yu, J.B., Wang, G.M., Mao, P.L. and Gao, Y.J. (2012). Environmental controls on net ecosystem CO_2 exchange over a reed (Phragmites Australis) Wetland in the yellow River Delta, China. Estuaries and Coasts, 36(2): 1-3.

[18] Hossain, M.Z., von Fragstein und Niemsdorff, P. and Heß, J. (2017). Effect of different organic wastes on soil properties and plant growth and yield: A review.Scientia Agriculturae Bohemica, 48(4): 224-237.

[19] Hou, H., Yang, Y., Han, Z., Cai, H. and Li, Z. (2019). Deficit irrigation effectively reduces soil carbon dioxide emissions from wheat fields in Northwest China. Journal of the Science of Food and Agriculture, 99(12): 5401-5408.

[20] Iwasaki, Y. (2008). Root zone aeration improves growth and yields of coir-cultured straw berry (*Fragaria ananassa* Duch.) during summer. *Acta Horticulturae*, 779: 251-254.

[21] Lal, R. (1986). Conversion of tropical rainforest: Agronomic potential and ecological consequencies. Advances in *Agronomy*, 39: 173-263.

[22] Morard, P., Lacoste, L. and Silvestre, J. (2000). Effect of oxygen deficiency on uptake of water and mineral nutrients by tomato plants in soilless culture. Journal of Plant Nutrition, 23(8):1063-1078.

[23] [Prihar, S.S., Gajri, P.R. and Arora, V.K. (1985). Nitrogen fertilization of wheat under limited water supplies. Fertilizer Research, 8:1-8.

[24] Rahman, M.M. (2013). Carbon dioxide emission from soil. Agric. Res 2(2): 132-139.

[25] Rajanna, G.A., Dass, A. and Paramesha, V. (2018). Excess Water Stress: Effects on Crop and Soil, and Mitigation Strategies. Popular Kheti, 6(3): 48-53.

[26] Russell, E.W. (1973). Soil conditions and plant growth (10th ed.), Longmans, London, UK, pp 403-405.

[27] Saragoni, H., Olivier, R. and Poss, R. (1991). Dynamique et lixiviation des éléments minéraux. Agronomie Tropicale, 45(4): 259-273.

[28] Zotarelli, L., Scholberg, J.M., Dukes, M.D., Munoz Carpena, R. and Icerman, J. (2009). Tomato yield, biomass accumulation, root distribution and irrigation water use efficiency on a sandy soil, as affected by nitrogen rate and irrigation scheduling. Agricultural Water Management, 9(6): 23-34.