

# Organic Treatment effects on Ferritic soil quality and Tomato (*Lycopersicon esculentum* Mill.) Yield

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**Abstract**— The impact of the combination of plant (*Tithonia diversifolia*) (Td) plus cow dung (Cd) as biofertilizer and aqueous extract of *Callistemon citrinus* (CAL) leaves as biofungicide on physicochemical properties, and the microbial biomass in carbon (MBC) and nitrogen (MBN) of soil and on tomato yield were assessed under field condition. The experimental design was a complete block design with 2 factors (soil amendment and plant sprays) and 3 repetitions. The soil treatment included organic amendment (OA): Td + Cd at the ratio of 3:4 (w/w)/plant; inorganic amendment (IA): 21:8:8 NPK (26.2g/plant) and potassium sulfate (4g/plant); and control (unamended soil). The field treatments were plants sprayed with: 5% (w/v) CAL; 5% (w/v) Mancozeb (M); and water (W). All amendments except IA did not significantly modify the soil organic matter ( $<2.4\text{mg.kg}^{-1}$ ) and organic carbon content. An increase of 23.15% and 30.60% of calcium concentration and cation exchangeable capacity (CEC) respectively, was recorded in OA soil compared to the soil before cultivation (SBC) ( $P<0.05$ ). Copper and zinc contents in OA soil were reduced respectively by 49% and 48.5% compared to SBC. The highest concentration of MBC was recorded in OA.M plot. The different combine treatments (OA.CAL, IA.M, and OA.M) increased tomato yield by 3.4; 3; and 5.3 fold, respectively compared to their controls. This study provided new information about the organic amendment on soil and plant sprayed with *C. citrinus* extract as a green alternative to conventional input that might improve soil quality and crop yield.

**Keywords**— microbial biomass, organic inputs, soil physicochemical properties, tomato.

## I. INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is among the most important fruit vegetables in the world due to the high potential health-promoting properties and their contents in flavonoids, carotenoids, and vitamins (Aghofack-Nguemezi and Schawb, 2014). Tomato yield and production were 188t/ha, 182301395tons and 12.1t/ha, 1279853 tons respectively in the world and Cameroon (FAOSTAT, 2019). Pests and diseases are among the most important constraints of tomato culture in Cameroon. The farmers currently apply conventional agrochemicals in an abusive and inappropriate manner (Konje et al. 2019). The use of pesticides and their residues poses a real public health problem to farmers, consumers and the environment (Zinkakuba et al. 2019). It is therefore urgent to search for alternative methods that are

environmentally friendly and with fewer health risks to the consumers.

The disease control of crops through the use of plant-based biopesticides and antagonistic microorganisms has become an interesting alternative (Olanya and Larkin, 2006). In Cameroon, local plant extracts have been reported as having inhibitory properties *in vitro* and *in vivo* against various pathogens (Goufo et al. 2010; Ndonkeu et al. 2013; Mekam et al. 2019). Botanicals with antifungal compounds have been identified and can be exploited for the management of plant diseases because they have low mammalian toxicity, target specificity, biodegradability and contain many active ingredients (Kagale et al. 2004). *Callistemon citrinus* because of its antifungal activity notably against *Phytophthora infestans* of tomato (Galani et al. 2013; Dakole

et al. 2016), on *Alternaria padwickii* and *Bipolaris oryzae* of rice (Nguefack et al. 2013) is used as a biocontrol agent.

To achieve high tomato yield, farmers used chemical fertilizers, which could be responsible for soil acidification and the decrease in the microbiological activity of soils (Monkiedje et al. 2006). Also, the use of agrochemicals causes the long-term accumulation of heavy metals in water and soil. These heavy metals are assimilated by plants and enter the food chain causing animal and human health problems (Zwolak et al. 2019). As well, the rising costs of inorganic fertilizers made them too expensive.

*Tithonia diversifolia* (Asteracea) green biomass is an effective source of nutrients and has been used successfully to improve soil fertility and crop yields in Kenya (Jama et al. 2000). Aguyoh et al. (2010) reported a significant and positively correlated increase in a total yield of watermelon with increasing application rates of *T. diversifolia* manure. In that study, *T. diversifolia* application enhanced the total yield of watermelon by between 8.5% and 31% compared to the control. *T. diversifolia* can improve the physical and chemical properties of soil and increase nutrients in the soil (Crespo et al. 2011) and maintain soil fertility for a long period (Babajide et al. 2008).

Cattle manure used for its added value for soil carbon sequestration, and its capacity for storing and releasing nutrients over a longer period (Diacono and Montemurro, 2010). In Uganda, although a significant number of farmers have adopted the use of cattle manure on their farms, they normally use it untreated and directly from animal barns (Komakech et al. 2014). According to Adegunloye et al. (2007), the C: N ratio in cow dung manure is an indication that it could be a good source of protein for the microbes involved in the decomposition of organic matter.

Each amendment applied to the soil may not contain all required nutrients in a high amount at the same time. Therefore, to have a balanced nutrient supply, the addition of more than one amendment to the soil may be required. Adekiya (2018). Consequently, in this work, it was planned to test a biofertilizer made of a mixture of Td + Cd. The present study aimed to evaluate the impact of the combination of plant (*Tithonia diversifolia*) (Td) plus cow dung (Cd) as biofertilizer and aqueous extract of *Callistemon citrinus* (CAL) leaves as biofungicide on physicochemical properties and the microbial biomass in carbon (MBC) and nitrogen (MBN) of soil and on tomato yield in field condition.

## II. MATERIAL AND METHODS

### 1.1 Experimental site

The experiment was conducted at Nkolbisson-Yaounde (Eloundem) Centre Region of Cameroon from December to May 2018. The study site is located at an altitude of 711m above sea level and situated at latitude 3°51'14"N and longitude 11°44'26"E. The annual rainfall distribution is bimodal (lighter rains between March and June and a more intense rainy season between September and November) with peak rainfall in May and October. The area has a mean annual rainfall of approximately 1500-2000mm and a mean annual temperature of 24.7°C. The relative humidity range between 50 and 80% in the dry season and 70 and 90% in the rainy season. The most dominant soil types at Nkolbisson is ferritic and acidic (pH 5- 6).

### 1.2 Field design

The variety of tomato (Cobra) seeds used was produced by the French firm TECHNISEM. Tomato seeds were sown in nursery beds enriched with the mixture of *Tithonia diversifolia* (Td) leaves and cow dung (Cd) powders at the dose of 312.5 and 250 g/m<sup>2</sup>, respectively. The tomato plants used were 35 days old and had three to four true fully expanding leaves.

The field experiment was laid out in a complete block design, with 9 plots per block and three repetitions. Each plot contained 16 plants and made up of 4 rows. Tomato seedling transplanting was done at an interval of 0.5m between rows and 0.5m between plants of the row. In each plot, 16 pockets were dug and each filled with organic amendment (*Tithonia diversifolia* leaves (75g/plant) and cow dung (100g/plant) powders) one week before transplanting. In the inorganic plots, 21:8:8 N/P/K (26.2g/plant) was applied one week after transplanting and potassium sulfate (50% K<sub>2</sub>O and 45% SO<sub>3</sub>) (4g/plant) at fruit set stage. Organic and inorganic nitrogen was applied an equivalent of 5g of N/plant. Plants were sprayed 10 times (twice/month) with water, 5% of both biopesticide, and chemical pesticide. The biopesticide was obtained by soaking the powder of dried leaves of *Callistemon citrinus* in water for 24 hours. The chemical fungicide was mancozeb.

### 1.3 Soil sampling

In each plot, the soil was sampled at a depth of 0-20 cm in three different areas diagonally. All sample soils were mixed to form a composite. 0.5 kg of the composite was air-dried, ground, and sieved (<0.25 mm). Then serve as a substrate for the physicochemical analysis. A part of the composite was sieved (<0.5 mm) and then stored at 4°C until microbial biomass analyses.

### 2.4 Physicochemical analyses

Soil properties were observed both before and at the end of the experiment. Granulometry was determined by the

Robinson-Köhn pipette method. Soil pH was measured in 1:2.5 soil to solution ratio in distilled water (pH-H2O). Organic carbon (OC) was estimated by oxidation with potassium dichromate and titration with ferrous sulfate (Walkley and Black, 1934). Total nitrogen was estimated by the Kjeldahl method. Iron, copper, lead, and zinc were determined colorimetrically after reduction with dithionate-citrate-bicarbonate (DCB). Available phosphorus was determined by the Bray II method (Bray and Kurtz, 1945). Calcium was estimated by a complexometric and titrimetric method with tetra acetic ethylene diamine acid of an ammonium acetate extract at pH 7 of the sample. Cation exchange capacity (CEC) was determined by percolating 2.5g of soil with 100mL of 1N ammonium acetate buffered at pH 7, removing the excess with ethanol and displacing the absorb  $\text{NH}_4^+$  ions with 1N KCl, determining the collected  $\text{NH}_4^+$  ions by distillation and titration with 0.01N sulfuric acid.

### 2.5 Study of soil microflora

Microbial biomass was determined by fumigation-extraction (Chaussod et al. 1988; Wu et al. 1990). Carbon determination was done by Walkley and Black (1934) and nitrogen determination by Kjeldahl. The coefficients used to determine the biomasses were:  $\text{KeC} = 0.38$  and  $\text{KeN} = 0.68$ .

### 2.6 Tomato yield

From each plot, matured tomato fruits were harvested each week and total fruit weight was determined. Fruit product data were summed up of the total fruit weight from consecutive harvests and converted into tons per hectare to estimate the fruit yield.

### 2.7 Statistical analysis of data

The results were subjected to statistical analysis using IBM SPSS Statistics 22 software, particularly variance analysis (ANOVA) and significant differences were assessed using the Student Newman Keuls (SNK) test at the 5% probability threshold. XLSTAT 2007 software was used for the Principal Component Analysis (PCA).

## III. RESULTS AND DISCUSSION

### 3.1 Effects of organic amendment on soil physicochemical properties

The effect of different amendments on soil granulometry showed some variations in particle contents (Table1). The silt content was above 45%, and double that of sand. Clay and sand contents from soil samples collected before cultivation (SBC) and control soil, were significantly ( $P < 0.05$ ) lower, compared to those of organic amended (OA) and inorganic amended (IA) soils. Based on the USDA textural diagram, the texture observed in SBC and control

soil was silty clay loam and clay loam in OA and IA soils. Silt clay texture was favourable for tomato cultivation.

The carbon-nitrogen ratio (C:N) was found to be 8 in OA soil combined to plant treated with the aqueous extract of *C. citrinus* (OA.CAL). Also, C:N was less than 14 in SBC, IA soil, OA soil combined to plant treated with mancozeb (OA.M) and 16.75 on the control soil combined to plant treated with water (Control.W) (Table 2). IA.CAL soil (C:N = 8) with the same soil organic matter (SOM) content as SBC soil (C:N = 11) had higher total nitrogen (TN) concentration. Hubert and Schaub (2011) showed that high carbon-nitrogen ( $\text{C:N} \geq 13.70$ ) made decomposition slow to difficult and did not allow good mineralization of organic matter. Soils, where plants have been sprayed with water, had the lowest amounts of available phosphorus (P) ( $P < 0.05$ ). This could be explained by the fixation of available phosphorus in these soils by protons and cations such as  $\text{Ca}^{++}$  and thus transforming it into a compound not assimilable by the plant (Rivaie et al. 2008). The highest P content ( $15.64 \text{ mg.kg}^{-1}$ ) of about 2 fold that of SBC ( $P < 0.05$ ) was recorded in OA.CAL soil. Similar content in SOM (2%) was recorded in all treated soils except for IA.M (2.92%) and IA.W (3.75%) soils ( $P < 0.05$ ). The variation in SOM could be explained by the rapid supply of IA soil by chemical fertilizer. Beside, Dieye et al. (2016), showed that the mineralization of *T. diversifolia* was slow and progressive. The 26% reduction of TN OA soil compared to SBC, could be explained by high C:N (14) observed in OA soil. Bationo et al. 2008 suggested that rapid decomposition of SOM could result in loss of nutrients through volatilization, leaching; whereas, for slow mineralization of SOM, minerals will have a higher retention time in the soil.

The TN content increased respectively, in IA.M ( $1.31 \text{ g/kg}$ ), IA.CAL, and IA.W soils where it reached  $1.92 \text{ g/kg}$ . These results differed from those obtained by Hafifah et al. (2016), where *T. diversifolia* and cow manure mixture was significantly enriched in OC and TN than the NPK. This could be explained by the high levels of fertilizer used in their study of  $1.35 \text{ t/ha}$  NPK,  $4.08 \text{ t/ha}$  *T. diversifolia* and  $12.93 \text{ t/ha}$  cow manure; the type of crop (cauliflower) and the date of collection of soil samples at the end of the cultivation, which was 30 days. The Control.W soil had the lowest nitrogen content, 1.67 times less than in the SBC. The nitrogen decrease in control soil could be explained by the use of existing nitrogen in the soil for the development of soil microorganisms and even the growth of tomato plants. These results corroborate those of Hafifah et al. (2016), who recorded a 1.83-fold decrease in the total nitrogen content of the control soil compared to the initial soil when the cauliflower was grown.

Calcium (Ca) concentration and cationic exchange capacity (CEC) were similar in OA and IA soils and were higher than in SBC and control soils ( $P < 0.05$ ) (Table 3). This increase could be explained by their relatively high clay content, able to bind to organic matter to form the humic argil adsorbent complex. The latter plays an important role in the cation exchange capacity (CEC) for storing many nutrients in the soil and the water retention capacity or Useful Reserve Hubert and Schaub (2011). Also,  $\text{Ca}^{2+}$  stabilizes the adsorbing complex by creating a calcium bridge that consolidates the connection between humus and clay. The pH values of the different soils were similar ( $P < 0.05$ ) and varied between 6.52 and 7.05. The pH did not vary during the culture and remained neutral. The soil pH, less than 6.0 tends to be acidic with very high exchangeable aluminum that restricts the growth of most crops (Fairhurst, 2012). Copper (Cu) concentration was reduced by 46.1, 50.7 and 51.9% respectively, in OA.CAL, OA. M, and OA.W soils compared to SBC with the highest Cu concentration ( $20.53 \text{ mg.kg}^{-1}$ ) ( $P < 0.05$ ). This decrease could be explained either by the chelation and precipitation of copper by organic matter present in these soils or by the use of copper by the plant for the maturity of fruits (López-Vargas et al. 2018). All IA soils had a similar Cu content but showed a reduction of 41% compared to SBC soil ( $P < 0.05$ ). The increase of Cu in IA.M soil compared to OA.M soil could be due to the supply of these soils by chemical inputs. The iron (Fe) concentration of SBC was identical to that of IA soil and with a decrease of 7.4 and 4.42% respectively, in OA.W and OA.M soils ( $P < 0.05$ ). The concentration of Zn varied according to the nature of sprayed products. The Zn lowest concentration was recorded in OA soils ( $18.8 \text{ mg.kg}^{-1}$ ), representing 48.5% decrease compared to SBC. This could be due to the complexation of free Zn with organic matter (Angelova et al. 2013). In control soil, mancozeb further increased the soil Zn concentration followed by CAL extract ( $P < 0.05$ ). The further increase of Zn to mancozeb plots could be attributed to its Zn as component chemical composition. In general, there was no accumulation of heavy metals in OA soil. This phenomenon could prevent the long-term onset of soil toxicity.

### 3.2 Effects of organic amendment on soil microbial biomass

Microbial biomass in carbon (MBC) was enriched in OA and IA soils than SBC and control soil ( $P < 0.05$ ) (Table 4). These amended soil also had high clay content. In 2007, Kasel and Bennett reported that an increase in soil-clay increases soil micropores hence limiting the development of microorganism predators and thus a protective effect on total microbial biomass. The highest MBC value was recorded from OA.M soil with an increase of 5.8% and 42.65%, as compared respectively to IA.M soil,

and SBC ( $P < 0.05$ ). High soil microbial biomass often leads to high nutrient availability to crops thus enhancing both the microbial biomass turnover and the degradation of non-microbial organic materials (Tu et al. 2006). In the amended soil, MBC vary as a function of the nature of the sprayed products. The MBC content with respect to SBC ( $P < 0.05$ ) increased by 20.27% in IA.W and OA.W soils; 25.16% in OA.CAL soil; 34.3% in IA.CAL and IA.M soils; 42.64% in OA.M soil. The lowest values of microbial biomass in nitrogen (MBN) were recorded in OA.W soil ( $0.7 \text{ mg N.kg}^{-1}$ ) and OA.CAL ( $0.8 \text{ mg N.kg}^{-1}$ ). A five (5) % increase in MBN was observed in OA.M soil as compared to IA.M soil ( $P < 0.05$ ).

### 3.3 Effects of organic amendment on tomato yield

The tomato yield was a function of the amendment (Fig 1). The highest yields (107 to  $7.33 \text{ t/ha}$ ) were recorded from OA soils, followed by IA soils with yield values ranging from 60.2 to  $8 \text{ t/ha}$ . Control soils had the lowest yields ( $P < 0.05$ ). Tomato yield of OA.M plot was 1.8 fold higher than that of IA M plot ( $P < 0.05$ ). OA CAL plot increased tomato yield by 21% compared to IA CAL plot ( $P < 0.05$ ). Ghorbani et al. (2008) found that cattle manure in Iran did not give a good yield of tomato compared to the use of chemical fertilizers. The highest increase of tomato yield obtained with OA.M in this study might be explained by the application of green manures which reduced soil bulk and increased porosity, nutrient content (Adekiya, 2019). Easily available and excessive nitrogen fertilization from inorganic fertilizers delays maturity and may reduce tomato yield. Delayed maturity results in foliage exposed to potential infection for a longer time, increasing the risk of fruit diseases (Ghorbani et al. 2008). The yield increases with the nature of sprayed products; it was higher when the plants were treated with mancozeb fungicide, followed by CAL extract and finally water ( $P < 0.05$ ).

### 3.4 Main Component Analysis between some indicators of soil and different amendments

The correlation diagram (Fig2) showed that fertility indicators such as P, MBN, TN, and SOM contributed to the formation of the F2 factor and other fertility indicators contributed to the formation of the F1 factor. MBC was strongly correlated with total nitrogen with a correlation coefficient ( $r = 0.801$  to  $P < 0.05$ ). Partey et al. (2017), who reported that soil treatment with *T. diversifolia* recorded the greatest effect on the increase of mineral N, soil microbial biomass and  $\beta$ -glucosidase activities, obtained similar correlation results. The MBN was negatively correlated with P ( $r = -0.751$   $P < 0.05$ ). There were strong correlations between clay and Ca ( $r = 0.865$   $P < 0.05$ ), clay and cation exchange capacity ( $r = 0.845$   $P < 0.05$ ), with a very strong correlation between Ca and CEC ( $r = 0.932$ ). The yield was



correlated with the adsorbent complex (CEC, Ca, clay). Control soils were negatively correlated to tomato yield and the adsorbing complex. Houot and Chaussod (1995) found a positive correlation between microbial biomass and soil carbon content on wheat-beet rotation conducted with different fertilization types and levels. They also noted

decreasing biomass values according to the types of fertilization in the following order: farm fertilizer>mineral fertilization> no fertilization.

#### IV. FIGURES AND TABLES

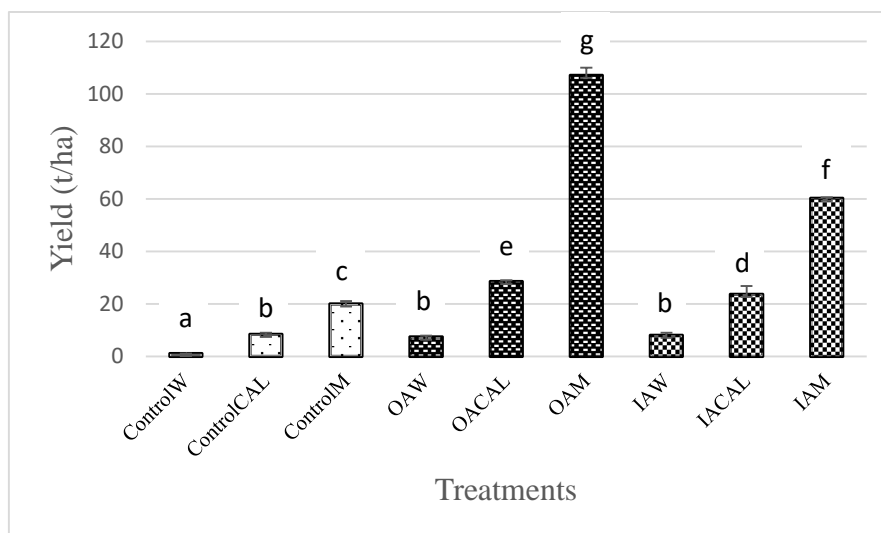


Fig 1: Tomato yield production

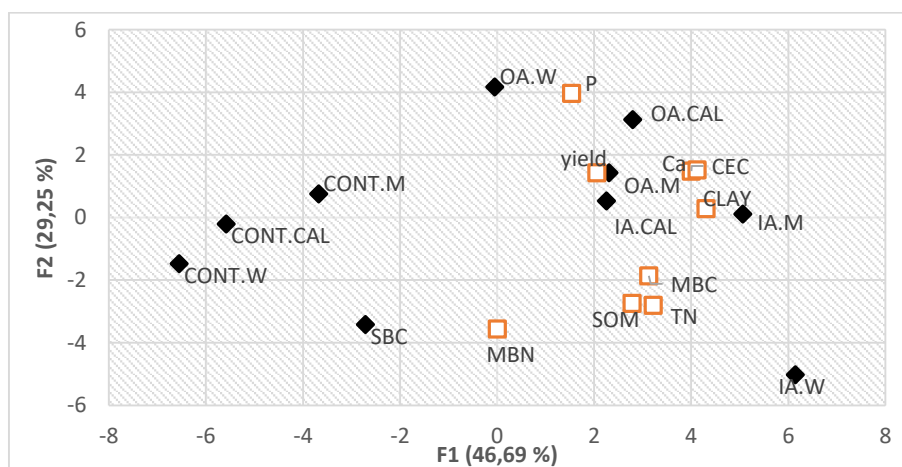


Fig 2: correlation diagram between some soil indicators and different amendments

Table 1: Granulometry of soil collected at the beginning and end of *Lycopersicon esculentum* field cultivation

Variables	Clay (%)	Silt (%)	Salt (%)
<b>SBC</b>	29.66 <sup>a</sup>	52 <sup>d</sup>	18.33 <sup>a</sup>
<b>Control.W</b>	29 <sup>a</sup>	51.66 <sup>d</sup>	19.26 <sup>b</sup>
<b>Control.CAL</b>	29 <sup>a</sup>	51.5 <sup>d</sup>	19.5 <sup>bc</sup>
<b>Control.M</b>	29.66 <sup>a</sup>	51.5 <sup>d</sup>	19.5 <sup>bc</sup>
<b>OA.W</b>	30.33 <sup>ab</sup>	48 <sup>c</sup>	21.5 <sup>c</sup>
<b>OA.CAL</b>	33.66 <sup>c</sup>	46.66 <sup>b</sup>	20.5 <sup>c</sup>
<b>OA.M</b>	32.33 <sup>abc</sup>	46.57 <sup>b</sup>	22.5 <sup>d</sup>
<b>IA.W</b>	33.33 <sup>bc</sup>	45 <sup>a</sup>	22 <sup>d</sup>
<b>IA.CAL</b>	31 <sup>ab</sup>	45.75 <sup>ab</sup>	23.5 <sup>e</sup>
<b>IA.M</b>	33.33 <sup>bc</sup>	45 <sup>a</sup>	21.75 <sup>d</sup>

Numbers followed by different letter notation in the same column are significantly different based on the Student Newman Keuls (SNK) test at the 5% level.

Table 2: Macroelements of soil collected at the beginning and end of *Lycopersicon esculentum* field cultivation

Variables	C:N	OC (%)	P (mg.kg <sup>-1</sup> )	SOM (%)	TN (g.kg <sup>-1</sup> )
<b>SBC</b>	11±1b	1.37±0.04bc	7.96±1.08c	2.36±0.28a	1.23±0.07d
<b>Control.W</b>	16.75±0.25e	1.24±0.01ab	5.95±0.2ab	2.13±0a	0.74±0a
<b>Control.CAL</b>	14.75±0.75d	1.35±0.1bc	9.71±0.18d	2.3±0.17a	0.9±0bc
<b>Control.M</b>	13.75±0.25cd	1.24±0.01ab	10.53±0.26d	2.13±0a	0.9±0bc
<b>OA.W</b>	14.75±0.25d	1.25±0ab	4.14±0.33a	2.16±0.1a	0.86±0b
<b>OA.CAL</b>	14.25±0.75cd	1.39±0.08c	15.54±0.65f	2.39±0.14a	0.96±0.01b
<b>OA.M</b>	12.75±0.25c	1.28±0.03abc	10.76±0.05d	2.2±0.04a	0.99±0.01c
<b>IA.W</b>	11.5±0.5c	2.18±0.05e	6.57±0.22b	3.75±0.07c	1.92±0.05g
<b>IA.CAL</b>	8±1a	1.18±0.07a	11.79±0.47e	2.03±0.11a	1.44±0.03f
<b>IA.M</b>	13.25±1.25cd	1.69±0.05d	11.98±0.23e	2.92±0.16b	1.31±0.08e

Numbers followed by different letter notation in the same row are significantly different based on the Student Newman Keuls (SNK) test at the 5% level.

Table 3: Mineral elements of soil collected at the beginning and end of *Lycopersicon esculentum* field cultivation

Variables	SBC	Control.W	Control.CAL	Control.M	OA.W	OA.CAL	OA.M	IA.W	IA.CAL	IA.M
<b>Ca<sup>++</sup> (cmol<sup>(+)</sup>.kg<sup>-1</sup>)</b>	12.18±0.52 <sup>b</sup>	11.41±0.22 <sup>ab</sup>	10.64±0.34 <sup>a</sup>	12.47±1.49 <sup>b</sup>	15.88±0.12 <sup>c</sup>	16.07±0.26 <sup>c</sup>	15.63±0.1 <sup>c</sup>	15.77±0.34 <sup>c</sup>	15.8±0.01 <sup>c</sup>	15.81±0 <sup>c</sup>
<b>CEC (cmol<sup>(+)</sup>.kg<sup>-1</sup>)</b>	30.81±1.53 <sup>a</sup>	33.61±1.13 <sup>b</sup>	34.3±0.02 <sup>b</sup>	38.62±3.37 <sup>c</sup>	43.5±0.24 <sup>d</sup>	45.68±0.89 <sup>d</sup>	44.1±0.22 <sup>d</sup>	46.7±0.76 <sup>d</sup>	46.52±0 <sup>d</sup>	46.03±0.63 <sup>d</sup>
<b>pH</b>	6.8±0.62 <sup>a</sup>	6.55±0.05 <sup>a</sup>	7.05±0.05 <sup>a</sup>	6.75±0.25 <sup>a</sup>	6.52±0.02 <sup>a</sup>	6.62±0.07 <sup>a</sup>	6.57±0.02 <sup>a</sup>	6.67±0.27 <sup>a</sup>	6.8±0.15 <sup>a</sup>	6.8±0.1 <sup>a</sup>
<b>Cu (mg.kg<sup>-1</sup>)</b>	20.53±0.38 <sup>d</sup>	11.64±0.04 <sup>c</sup>	11.67±0.17 <sup>c</sup>	12.03±0.1 <sup>c</sup>	9.88±0.18 <sup>a</sup>	11.06±0.09 <sup>b</sup>	10.12±0.18 <sup>a</sup>	12.04±0.36 <sup>c</sup>	12.04±0.09 <sup>c</sup>	12.08±0.2 <sup>c</sup>
<b>Fe (mg.kg<sup>-1</sup>)</b>	84.96±0.78 <sup>d</sup>	83.8±0.2 <sup>d</sup>	77±0.1 <sup>a</sup>	80.72±0.22 <sup>c</sup>	78.67±1.27 <sup>b</sup>	84.64±0.74 <sup>d</sup>	81.2±1.7 <sup>c</sup>	83.08±0.17 <sup>d</sup>	83.59±0.63 <sup>d</sup>	83.7±0.29 <sup>d</sup>
<b>Zn (mg.kg<sup>-1</sup>)</b>	28.98±0.69 <sup>e</sup>	19.89±0 <sup>b</sup>	21.35±0.29 <sup>c</sup>	22.94±0.5 <sup>d</sup>	17.79±0.14 <sup>a</sup>	19.35±0.05 <sup>b</sup>	19.36±0.56 <sup>b</sup>	21.95±0.07 <sup>c</sup>	23.63±0.01 <sup>d</sup>	22.9±0.36 <sup>d</sup>

Numbers followed by different letter notation in the same row are significantly different based on the Student Newman Keuls (SNK) test at the 5% level

Table 4: microflora of soil collected at the beginning and end of *Lycopersicon esculentum* field cultivation

Variables	MBC (mg.kg <sup>-1</sup> )	MBN (mg.kg <sup>-1</sup> )
<b>SBC</b>	440.36±0.93 <sup>a</sup>	0.9±0 <sup>e</sup>
<b>Control.W</b>	455.37±0.42 <sup>a</sup>	0.89±0.01 <sup>e</sup>
<b>Control.CAL</b>	478.21±5.95 <sup>b</sup>	0.82±0 <sup>c</sup>
<b>Control.M</b>	462.88±8.17 <sup>a</sup>	0.85±0 <sup>d</sup>
<b>OA.W</b>	534.24±5.64 <sup>c</sup>	0.7±0 <sup>a</sup>
<b>OA.CAL</b>	551.17±3.75 <sup>d</sup>	0.8±0.01 <sup>b</sup>
<b>OA.M</b>	628.16±5.63 <sup>f</sup>	0.89±0.02 <sup>e</sup>
<b>IA.W</b>	524.85±3.76 <sup>c</sup>	0.9±0.01 <sup>e</sup>
<b>IA.CAL</b>	586.83±3.1 <sup>e</sup>	0.85±0.02 <sup>d</sup>
<b>IA.M</b>	596.31±13.08 <sup>e</sup>	0.85±0 <sup>d</sup>

Numbers followed by different letter notation in the same row are significantly different based on the Student Newman Keuls (SNK) test at the 5% level

## V. CONCLUSION

From this study, it established that organic amendment combined with treatment of tomato plants with extract of *Callistemon Citrinus* improved soil quality by increasing available phosphorus, calcium, cation exchange capacity, and by reducing soil heavy metal accumulation. Therefore, it constitutes an environment eco-friendly integrated strategy for soil fertilization. Also, the combination of organic amendment and chemical pesticide (mancozeb) spraying improved MBC concentration and tomato yield. This combination could be a solution in crop production management. Whereas, low concentration of organic amendment did not increase SOM content and thus there need for further investigation to establish an optimum concentration of organic inputs.

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