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Full Length Research Paper

Effects of Organic Amendments to Soil on Pepper crop (*Capsicum Annuum, L.*) under green house

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This study aims to assess the impact of four types of organic amendments on soil fertility and pepper crop (*Capsicum annuum, L.*) cv. starter and chargui under greenhouse. Six treatments have been proposed: cattle manure (T1) 55 t.ha^{-1}, commercial compost of German origin (T2) 1 t.ha^{-1}, mixture of 27.5 t.ha^{-1} of T1 + 0.5 t.ha^{-1} of T2 (T3), commercial compost of French origin (T4) 2 t.ha^{-1}, Tunisian commercial compost (T5) 10 t.ha^{-1}, and a control (T0) without amendment. Soil pH has remained alkaline with a slight downward trend. The composts T2 and T4 produced a significant increase in EC compared to control and showed the lowest CEC. Organic amendments contribute in a significant improvement of the OM content of the soil, nitrogen, phosphorus and exchangeable potassium levels compared to control. For the starter cv. composts T4 and T2 have achieved the yield of 9.5 and 9.4 kg. m^{-2} with increases of 16% and 15% compared to control. For cv. Chargui all treatments had a significant effect on the cumulative yield at 210 DAP and are classified as follows T3> T5> T2> T4> T1> T0 with respective yields of 9.8; 8.8; 8; 7.9 and 7.6 kg.m^{-2}, with an increase of 29% and 16% for T3 and T5 compared to control. The chemical properties of soil have shown large variations depending on the type of organic amendment applied. The combined treatment of compost and manure (T3) showed the best rate of phosphorus, magnesium, and calcium and best CEC. Mineral fertilization for this treatment may be revised downward. Organic amendments showed significant effect on pepper yield, with a different varietal behavior towards treatments.

Keywords: Compost, organic amendment, pepper, Nitrogen, phosphorus, potassium, yield.

INTRODUCTION

Several developing countries, including Tunisia, have experienced in the sixties of last century revolution in agriculture which is called "Green Revolution". This innovation has been accompanied by a transfer of technology and progress in chemistry and biotechnology (Venturini, 2007). This progress has made available to farmers new varieties adapted to the local bio-climate, mineral fertilizers and multiple herbicides (Beji, 2010). This development allowed for Tunisia to achieve agricultural products representing more than 12% of national Gross Interior Product, which has improved the level of self-sufficiency and meet the food needs of a population in constant increase (Bachta, 2008)

However, excessive use of chemicals is causing an agricultural intensification resulting in a pressure on the ecosystem triggering the decline of soil fertility (Laurence, 1998; Delate, 2002; Ibrahima et al. 2010). Indeed, the use of fertilizers and pesticides is common in intensive vegetable crops (Odet et al., 1989). Such conventional crops in the open field or greenhouse require use of considerable quantities of inputs such as fertilizers and pesticides. Soil organic matter (OM) mineralization processes generates remarkable decreases in their rates (Thuriès et al., 2000; Bressoud and Arrufat, 2009). OM levels in Tunisian soil were postponed too low and usually at values below 1% (Ben Hassine H. et al., 2006; Snoussi Ben Othman 2008). The OM back ground to replenish its reserves are insufficient (Ben Hassine et al. 2006). Therefore, agriculture is facing a major challenge: optimizing production while taking care not to exhaust the

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Table 1: Major elements content in each Organic amendment (g/kg) and treatment (Kg/Ha) used.

Treatment	N (g/kg)	P (g/kg)	K (g/kg)	N (g/Ha)	P (g/Ha)	K (g/Ha)
Tercie	0	0	0	0	0	0
DM	2.76*	2.64*	4.92*	151.5	145.2	270.6
CG	10	20	30	10	20	30
CGDM				50.9	52.6	150.3
CF	30	20	30	60	40	60
CT	17.5	2.5	9.7	175	25	97

* Obtained from the average of the results of analyzes of three samples

Table 2: initial soil state Characterization:

Texture			Chemical characterization							
Clay %	Loam %	Sand %	pH	CE ($dS.m^{-1}$)	M.O (%)	Ntot ($mg.kg^{-1}$)	P ($mg.kg^{-1}$)	K ($mg.kg^{-1}$)	Ca ($mg.kg^{-1}$)	Mg ($mg.kg^{-1}$)
4,7	70,3	25	7,6	4,9	1,7	123,5	365	800	207	93

soil to maintain its fertility for future generations. To address this inescapable dilemma, it is essential to examine the physicochemical soil dynamics to preserve and improve its structural state. Thus, a regular intake of humic amendments good qualities, while respecting the proper application method is essential since soil fertility is closely linked to its OM rates. The aims of this work is the assessment of the impact of four organic amendments (manure, compost) on soil fertility and yield of two varieties chargui and starter of pepper crop

MATERIELS AND METHODS

Methodology

This work aims to study the effects of organic fertilization in basal dressing on greenhouse pepper. It offers to compare 6 treatments:

*T0 a control treatment for which no OM input is performed;
*T1 treatment for which 55 $t.ha^{-1}$ of well-rotted cow manure are made;
*T2 treatment to which German commercial compost containing 85% OM is brought at 1 $t.ha^{-1}$;
*T3 treatment T2 for which previous compost is brought at 0.5 $t.ha^{-1}$ (50% of the recommended dose) in addition to 27.5 $t.ha^{-1}$ (50% of the usual dose under green house) of well-rotted manure;
*T4 treatment for which French commercial compost containing 60% OM is taken at 2 $t.ha^{-1}$;
*T5 treatment to which Tunisian commercial compost containing 70% OM is taken at 10 $t.ha^{-1}$;

The dose of manure was chosen considering the type of soil (loam-sandy), the initial OM content (1.7%) and the practices of the majority of farmers in the region. For the commercial composts used in this experiment, the doses were suggested by the technical direction of the respective companies responsible for the marketing of each product. Table 1 summarizes the contributions of major elements in $g.kg^{-1}$ of each product and $kg.ha^{-1}$ of each proposed treatment. Moreover all treatments received the same mineral fertilization supplement calculated on the basis of exports of pepper crop for a yield objective of 80 $t.ha^{-1}$ according to the method of Odet et al. (1989).

Experimental device

The experiment was conducted at Soukra (Tunisia), located at 36 ° 52' N 10 ° 15' E, in three greenhouses oriented North-South. Planting was done in twin rows of Starter variety (V1) and Chargui variety (V2) of pepper. The experimental design adopted is a split-plot in 6 repetitions with 2 variation factors: organic amendments and pepper varieties.

Measured parameters

Initial soil state characterization was performed before any addition of OM.

Planting was carried out one week after the application of treatments. The evaluation of the soil fertility status in the first 20 cm was carried out 130 days after planting DAP. The parameters measured for the soil samples are: Soil pH, Electrical conductivity (EC), Organic Matter (OM) determined by the method of Walkley and Black, as amended by Naanaa and Susini (1988), total Nitrogen (Ntot) by the Kjeldahl method, Phosphorus assimilated by the method of Olsen, Potassium exchangeable by flame spectrophotometry, sulphate by gravimetry, calcium and magnesium per-metric Complexo EDTA, and the Cation

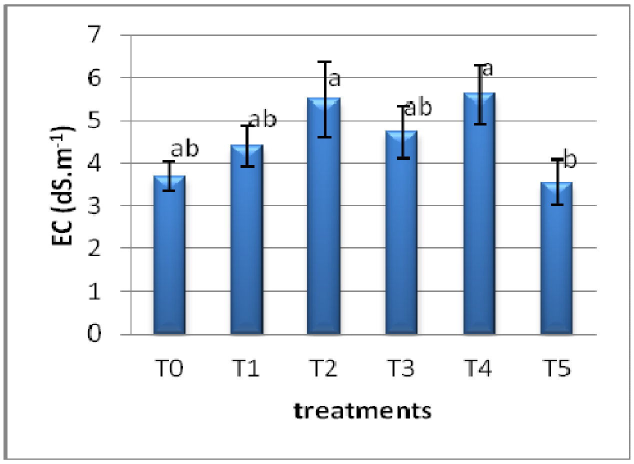

Figure 1: Effect of organic amendments on the EC of the soil ($dS.m^{-1}$),

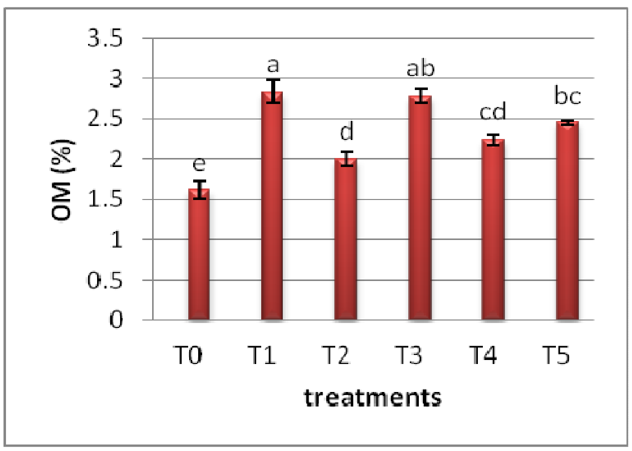

Figure 2 : Effect of treatments on soil OM.

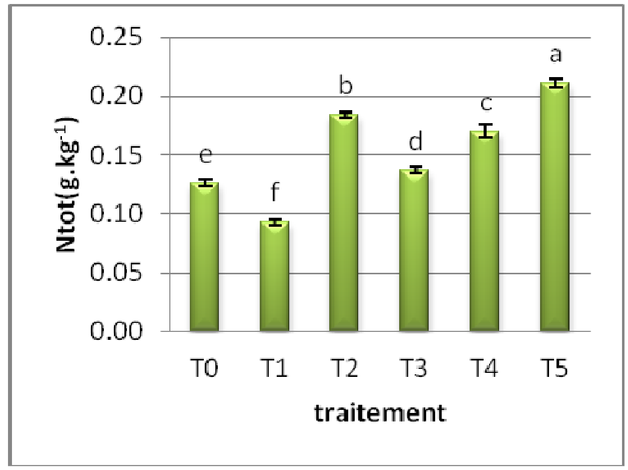

Figure 3 : Effect of treatments on soil total nitrogen (Ntot).

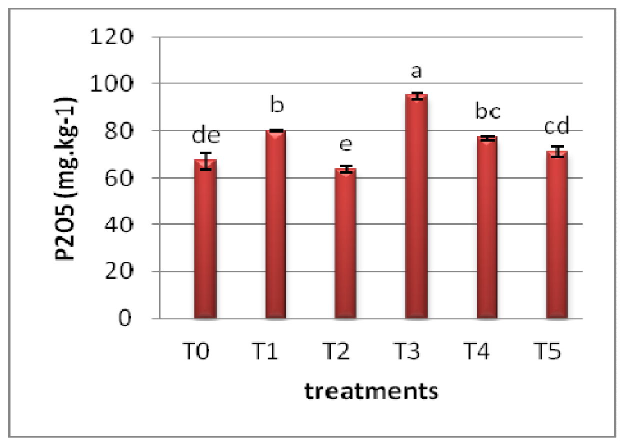

Figure 4: Effect of treatments on soil phosphorus (P_2O_5).

Exchangeable Capacity (CEC) of the soil. Yield at 150 (DAT) and cumulated yields at 210 DAT: Number of harvested fruit (NFY), fruit weight harvested (WFY) and precocity (P) calculated by the ratio of WFY 150 DAT and cumulative WFY 150, 157, 185 and 210 DAT.

Statistical Analysis

Analysis of variance (ANOVA) of data for measured parameters was carried out by SPSS statistical program version 20, and means comparison was performed by Duncan test at 5% level.

RESULTS AND DISCUSSION

Experimental soil samples were collected on the horizon 0-20 cm before application of the amendments and 130 DAP of pepper crop and were analyzed.

Experimental soil initial characterization

Particle size analysis of the study plot soil states that the texture is loam sandy according to the textural triangle GEPPA (Baize and Jabiol, 1995). Initial soil state characterization reveals that it is alkaline (pH = 7.63); its EC is 4.9 $dS.m^{-1}$ and its OM was 1.7% (Table 2).

Effect of the organic amendments application on soil

The assessment of soil fertility status showed that the pH of the soil samples of various treatments remained alkaline, pH was not significantly affected by the addition of organic matter to all treatments (Table 3). The French compost (T4) and the Tunisian compost (T5) showed a slight tendency to decrease. Composted OM contribution to reducing soil pH could take place following the increased mineralization of OM which is a common cause of soil acidification (Rowell and Wild, 1985; Hartemink, 1998).

Table 3: Effects of organic amendments on pH, CEC (meq/100g), Ca and Mg (mg.kg^{-1}), standard error (s.d.).

Treatments	pH		CEC		Ca		Mg	
	Means	s.d.	Means	s.d.	Means	s.d.	Means	s.d.
T0	7.63 a	0.08	11.07 d	0.13	207.47 b	7.46	93.28 bc	4.15
T1	7.57 a	0.09	13.68 c	0.30	265.87 ab	26.29	85.76 c	4.14
T2	7.53 a	0.07	10.59 d	0.20	251.20 b	6.14	108.80 bc	8.36
T3	7.54 a	0.11	15.75 a	0.30	312.53 a	34.61	166.56 a	10.46
T4	7.44 a	0.07	9.34 e	0.18	246.40 b	20.05	118.00 b	15.18
T5	7.45 a	0.09	15.00 b	0.29	227.20 b	10.40	79.60 c	14.02

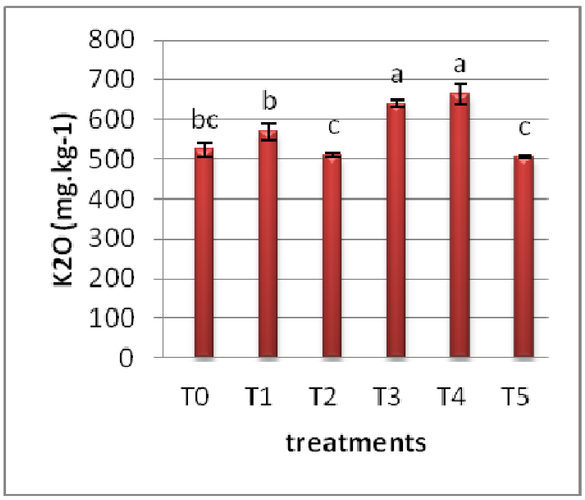

Figure 5 : Effect of treatments on soil potassium (K_2O).

The organic amendments applied had a significant effect on the EC (Figure 1). T2 and T4 treatments can significantly increase the EC versus control, respectively 5.6 and 5.5 (dSm-1). Casado-Vela et al. (2007) found that the soil EC varies according to the compost applied amount, crop conditions and the sampling stage. Madejón et al. (2001) noted a slight increase in soil salinity in both compost and inorganic fertilizer treatments. Electrical conductivity is widely used as a reliable indicator of the salinity of soils. Because of this, soil EC is among the most useful and easily obtained properties of soil that influences crop productivity (Corwin and Lesch 2003). Several authors claim that fertilizers should never exceed the salinity limit value of 3000 µS cm^{-1} in order to avoid excessive EC values measured in soils (Soumare et al., 2003, Amir et al., 2005). Indeed, these salinity values may become more binding for crops insofar they block the minerals uptake (Doucet, 2006). Note that the soil initial state (T0) has a moderate rate of OM 1.7%. All the treatments led to a significant increase in the soil rate of OM (Figure 2). T1 and T3 treatments significantly contribute to increase this rate to reach 2.83% and 2.79% respectively. This could be explained by the manure doses recommended by the treatments in question are respectively 55 t.ha^{-1} and 27.5 t.ha^{-1}.

All treatments applied increases OM compared to the control (Figure 2). This result seems to be obvious because several studies have so far shown that repeated intake of manure enriches the soil with OM (Beauchemin et al., 1990; N'Dayegamiye and Coté, 1996. Madejón et al, 2001). The Nitrogen monitoring by the Kjeldahl method was used to estimate the content of soil ammonium nitrogen (NH4 +) and nitrate nitrogen (NO3). The organic amendments increase the soil nitrogen content to 183 and 211 mg.kg^{-1} respectively for T2 and T5 treatments. The superiority of T5 treatment is expected that the recommended dose of this compost provides to bring the highest dose of nitrogen. The high nitrogen availability due to treatment T2 showed good maturity of the compost, which applied even in small doses, readily releases the nitrogen in the soil (Table 1). Treatments can be classified as follows T5>T2>T4> T3≥T0≥T1. Several authors claim that more nitrogen in organic amendments applied, the higher its rate increases at soil level (Madejón et al., 2001; Casado-Vela et al., 2007). The phosphorus in horticultural soils is key to the development of cultures. The phosphorus content was significantly affected by the organic amendments ($p<0.05$). T3 and T1 treatment showed the highest values relative to control respectively 95.04 and 80.14 mg.kg^{-1} soil (Figure 4). Casado-Vela et al. (2007) found comparable values in open fields (close to 80 mg.kg^{-1}) but almost reduced to half under green house (40-45 mg.kg^{-1}). The soil exchangeable potassium is an indication of the production potential of the soil. T3 and T4 treatments were significantly superior to the control and other treatments respectively 663.6 and 640.2 mg.kg^{-1} soil (Figure 5). Potassium showed a decrease in JAP 130 with respect to the initial state of the soil. The same trend was observed by Casado-Vela et al. (2007). The monitoring of the CEC showed that treatments carried significantly affect this parameter, the CEC was highest at 15.75 and 15.00 meq /100 g soil for T3 and T5 respectively compared to control T0 at 11.07 meq/100g soil, and classifies the CEC of treatments as follows T3>T5>T1>T0≥T2>T4.

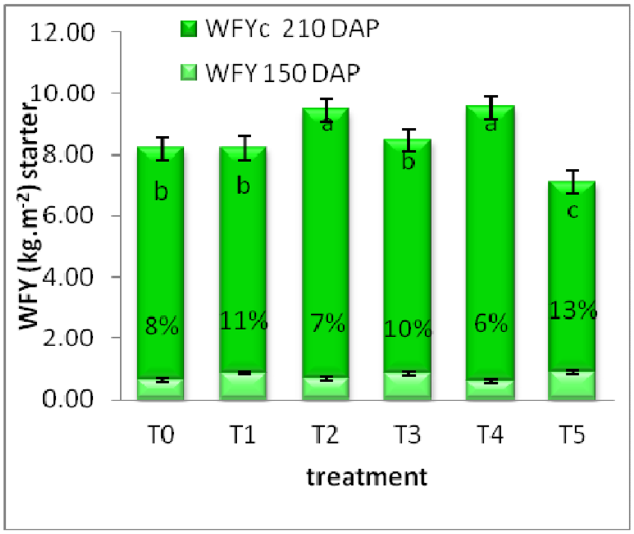

Figure 6 : Effect of treatments on yield of pepper WFY(kg.m^{-2}) cv. starter at 150 DAP, cumulative yield at 210 DAP and precocity (%) .

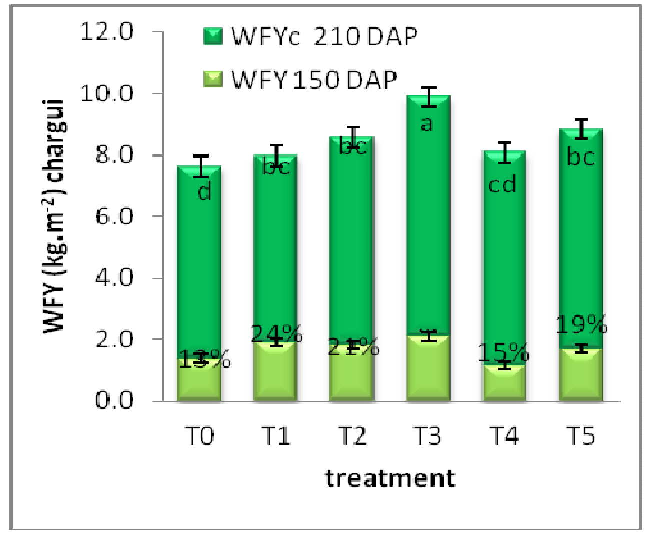

Figure 7 : Effect of treatments on yield of pepper WFY(kg.m^{-2}) cv. chargui at 150 DAP, cumulative yield at 210 DAP and precocity (%) .

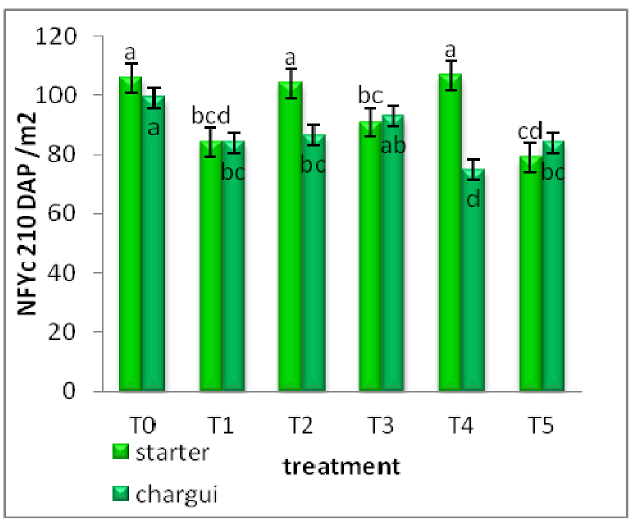

Figure 8 : Effect of treatments on the cumulative

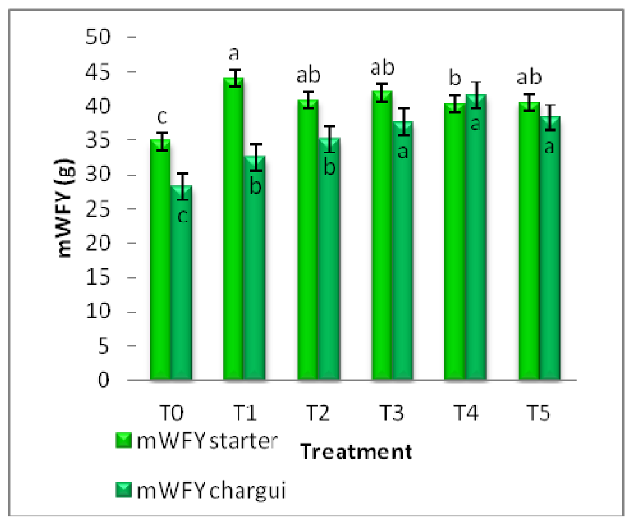

Figure 9: Effect of treatments on the mean weight of fruit yielded (mWFY) (g) cv. starter and chargui.

These CEC values are considered very high for sandy and loam soils for T3 and T5 and low for other treatments to potassium (K_2O). The bars represent the standard error, the treatments affected the same letter are not significantly different ($p<0.05$).

A loamy soil as classified Doucet (1992) and by Metson (1961) reported by Hazelton and Murphy (2007). The Frensh and German composts (T4 and T2) applied alones showed the highest soil EC and the lowest CEC. However the combined treatment T3 (German compost and cow manure) showed The highest CEC, and tend to have EC low than T2 an T4. The monitoring of calcium and magnesium showed a significant difference between treatments and the treatment T3 allows a to have soil more provided in this two constituent to 312.53 mg.kg^{-1} and 166.56 mg.kg^{-1} respectively. Calcium increases to 130 JAP compared to the initial state for all the organic soil treatments, the same for the Magnesiumg for treatments T2, T3 and T4, although pepper crop was in full fruiting stage. Casado- Vela et al. (2007) found this upward trend at the stage 200 days after germination and after crop pulling.

Effects of organic amendment on pepper yield

The harvest of pepper crop started from 150 DAPS. Five harvests were made up to 210 DAP when all treatments have reached the expected yield except T5 for starter variety. Fresh fruits harvested from each treatment were counted and weighed. Organic amendments showed significant effect on pepper yield, with a different varietal behavior towards treatments. Indeed, for the starter variety composts T4 and T2 have achieved the yield of 9.5 and 9.4 kg. m^{-2} with increases of 16% and 15% compared to control. While compost T5 has caused yield drop of 13% compared to control, but it allowed to have the best precocity yield rate of 13% realized at 150 DAP of its cumulative yield at 210 DAP (Figure 6). For variety Chargui all treatments had a significant effect on the cumulative yield at 210 DAP and are classified as follows T3> T5> T2> T4> T1> T0 with respective yields of 9.8; 8.8; 8; 7.9 and 7.6 kg.m^{-2}, with an increase of 29% and 16% for T3 and T5 compared to control. In addition, a significant improvement of precocity was observed with rates of 24%, 21%, 21% and 19% respectively for T1, T2, T3 and T5 treatments compared to control which records 13% (Figure 7). Organic amendments showed a repressive effect on the total number of fruit produced 210 DAP, where T0 was above all treatments for var. Chargui, and above T1, T3 and T5 then similar to T2 and T4 for var. starter (Figure 8). However, the caliber of harvested fruits expressed by the average weight of harvested fruits increased significantly for all treatments of both pepper varieties tested. Indeed, the mean weight of starter fruit yielded (mWFY) was 44, 42, 41, 41 and 40 g respectively for the T1, T3, T5, T2 and T4 treatments against 35 g for T0, and the mWFY of Chargui was 42, 38, 38, 35 and 32 g respectively for T4, T5, T3, T2 and T1 treatments against 28 g for T0.

Several authors confirm the positive effects of organic amendments on the pepper yield (Maynard, 2000; Alburquerque et al., 2006). The effect of organic amendments on the number of fruits produced is controversial. Shrestha et al. (2013) reports that the compost applied alone does not increase the number of pepper fruit product compared to the combined application of compost with human urine, while Gopinath et al. (2008) reported that organic manure in combination with inorganic fertilizers allows increasing the number of product sweet pepper fruit.

CONCLUSION

The chemical properties of soil have shown large variations depending on the type of organic amendment applied. Soil pH has remained alkaline with a slight downward trend. The composts T2 and T4 produced a significant increase in EC compared to control and showed the lowest CEC. The contribution of organic amendments is actively involved in preserving and maintaining the fertility of these soils which resulted in a significant improvement of the OM content of the soil, phosphorus and exchangeable potassium levels comp-
-ared to the control. While treatments help to improve total nitrogen, the contents of soil nitrogen are considerably low and the mineral fertilization is indispensable and should be more divided. The combined treatment of compost and manure (T3) showed the best rate of phosphorus, magnesium, and calcium and best CEC. Mineral fertilization for this treatment may be revised downward. Organic amendments showed significant effect on pepper yield, with a different varietal behavior towards treatments. For the starter variety composts T4 and T2 have achieved the yield of 9.5 and 9.4 kg. m^{-2} with increases of 16% and 15% compared to control. For variety Chargui all treatments had a significant effect on the cumulative yield at 210 DAP and are classified as follows T3> T5> T2> T4> T1> T0 with respective yields of 9.8; 8.8; 8; 7.9 and 7.6 kg.m^{-2}, with an increase of 29% and 16% for T3 and T5 compared to control.

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