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RESEARCH ARTICLE

The use of composted poultry manure as an organic amendment: Effects on soil physicochemical properties and Mentha Spicata L. yield.

Aboutayeb Rachid [1],*, Elgharous Mohamed [2], Abail Zhor [2], Faouzi Badr [3] and Koulali Yahya[1]

1. Department of biology, health and Environment, Faculty of Sciences and Techniques, University Hassan 1th, Settat, Morocco.
2. Regional Center of Agricultural Research, Settat, Morocco
3. National Office for Food Safety, Service Plant Protection, Settat, Morocco

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Corresponding Author

Rachid ABOUTAYEB

Abstract

In this study, we investigated the short-term effect of composted chicken and turkey manures compost on soil properties of cultivated horizon (0-20 cm) under Mentha Spicata L.; the field experiment was conducted using a randomized complete block design. In total, 27 plots were arranged; it consisted of 9 treatments and 3 repetitions. Applied treatments included a control (T), spreading of chicken manure's compost at 5, 10, 20 and 40 t / ha and turkey manure's compost at 5, 10, 20 and 40 t / ha. The results obtained showed that the application of poultry manure compost improves several soil properties. It induced a significant increase in the soil organic matter, total nitrogen, nitrates (NO3-), phosphorus and potassium content depending on the amount applied. An increase in electrical conductivity was registered. It spent from 0.35 to 0.6 dS/m. This increase is due to the accumulation of salts in the soil surface after application. Also, a slight acidification was recorded after compost application. A resistance to acidification has been recorded in the amended plots. This acidification is probably due to mineralization of organic matter activated after incorporation of compost into the soil. Furthermore, the production of spearmint was significantly higher in amended plots. Improving production reached 83% in plots (CFPC4) compared to the control (T).

Introduction

Poultry litter present environmental and Health Risks Because of their high contents of nitrogen and high density of pathogens (Aboutayeb et al , 2013). Agricultural intensification and livestock have a negative impact on soil quality which constitutes one of our most precious natural resources. It involved a loss of soil organic matter, fertility reduction, erosion and environmental degradation (Abbasi et al, 2012; Tiwari et al , 2008).

In this case, careful soil management is the key to sustainable agricultural (Mosaddeghi et al, 2009). In arid and semi-arid areas, low soil organic matter (SOM) content and water availability are often the main limiting factors for plant growth and production (Fereidooni et al, 2013). The organic amendments are increasingly used for their potential to restore biological, physical and chemical soil properties (Jemai et al, 2011).

The intensification of poultry production, in Chaouia Ouardigha Region, requires efficient treatment of chicken and turkey manures. Composting is an alternative manure management; it stabilizes the organic matter and sanitizes manure by reducing weed seeds and pathogens (Gil et al, 2008). This is a method that keeps the nutrients and

minimizes the risk of significant production of greenhouse gas emissions (Thangarajan et al, 2013) and improves the characteristics of manure (Escudero et al, 2012). The products of this technique called "Compost" are primarily organic materials. It contributes to increase fertility and soil biological activity (Houot et al, 2009). Composts poultry's manures are particularly rich in nitrogen and phosphorus (Moral et al, 2009). It is used as an affordable source of fertilizer on organic farms (Lyimo et al, 2012; Znaidi, 2002).
Among the environmental benefits of compost application, we include the reduction of the mineralization and nitrate leaching (Evanylo et al, 2008). However, Composted Poultry Manure is not used at large scales in developing countries due to little knowledge, limited research and farmers' ignorance regarding the use of Best Manufacturing Practices for productive farming (Farhad et al , 2013). The objective of this study is to evaluate the short-term impact of the spreading of composted poultry (chicken, turkey) manure on soil physicochemical properties and Mentha Spicata L. yield.

1 MATERIALS AND METHODS

1.1 SITE DESCRIPTION AND EXPERIMENTAL DESIGN

The study was conducted, in 2013, at the center of agricultural qualification Ouled moumen (CAQ), Settat, Morocco in North West of Africa. The region has a semi arid climate. The area is situated at 32°57'54"N - 07°39'42"W.
A field experiment was conducted using a randomized complete block design with 3 blocks, 9 treatments and 3 replications. Poultry manure was collected from poultry farm at Settat and composted at CAQ. There were 9 treatments by block: control (unfertilized plots) (T), and 4 levels of application for each of chicken manure compost (CFPC) and turkey manure compost (CFDC): 5 t/ha (CFPC1), 10t/ha (CFPC2), 20 t/ha (CFPC3), 40t/ha (CFPC4), 5 t/ha (CFDC1), 10t/ha (CFDC2), 20 t/ha(CFDC3) and 40t/ha (CFDC4). Composts were incorporated in soil.
The experimental site covers an area of 104 m^2. In total, 27 plots (2*2m) were arranged. On each elementary plot of 4 m^2, the Spearmint cuttings were planted in the month of May 2013.

2.2. ANALYSIS OF SOIL AND COMPOSTED POULTRY MANURES

Soil samples were obtained and analyzed for some characteristics before the initiation of the experiment (**Table 1**). Soil samples were collected from each plot at 0 to 20 cm depth from 4 different locations and mixed well. After sampling, a sub sample of about half kg of soil was taken, air dried and passed through 2mm sieve and used for the determination of physical and chemical characteristics.
Bouyoucous' densimeter method was used to determine soil texture, which was obtained by fitting the percentages of clay, silt and sandy fractions. The texture of soil was loam clay sandy. pH and electrical conductivity (EC) (1:2 w/v Sample-water extract) were measured using a pH meter electrode and a conductivimeter respectively.
Organic carbon (OC) was determined by titration using potassium dichromate and the Walkley-Black Wet digestion method was used for the determination of soil organic matter (Walkley and black, 1934). Organic matter (OM) was calculated according to the equation (OM = 1,724 OC). Organic nitrogen concentrations for soil and composts were determined according to the Kjeldahl method.
Nitrates are determined by complexation with chromotropic acid and measuring the absorbance in a spectrophotometer at 410 nm (Hadjidemetriou, 1982). Ammounium was determined colorimetrically at 636 nm. Phosphorus was determined by colorimetry at 882 nm (Olsen, 1954) and potassium by extraction with ammonium acetate and determination using a flame photometer (Knudsen, 1982).

2.3. Statistical analysis:

Statistical analyses were conducted using SPSS 17.0 software. Treatments differences were tested by one-way analysis of variance (ANOVA) at a significance level of 5%. The correlation was performed by Pearson test (P> 0.05).

2 RESULTS AND DISCUSSION

3 PROPERTIES OF SOIL AT DEPTH (0-20 CM) BEFORE EXPERIMENTATION.

Property	Mean	Standard deviation
Clay (%)	18.0	1.1

Silt (%)	54.0	3.1
Sand (%)	28.0	2.0
CaCO3 (%)	16.1	0.8
Organic matter (%)	4.87	0.05
Total nitrogen (%)	0.19	0.01
Nitrates (ppm)	38.9	1.3
Phosphorus (ppm)	9.8	1.0
Potassium (ppm)	191.2	4.6
pH	7.92	0.52
EC (dS/m)	0.25	0.03

The poultry litter used in the present study was collected and transported to CAQ where they were composted aerobically in a heap for 5 months. The composition of compost spread is shown in Table 2.

Table 2. Characterization of composted poultry manures applied on soil experimentation.

	Compost of chicken manure		**Compost of turkey manure**	
Property	**Mean**	**Standard deviation**	**Mean**	**Standard deviation**
PH	7.29	0.13	6.9	0.06
Dry matter (%)	73.08	4.15	63.2	11.37
EC (dS/m)	6.60	0.55	7.00	0.00
OC (%)	23.4	2.48	17.7	1.88
OM (%)	40.3	4.28	30.52	3.24
N total (%)	2.51	0.37	2.23	0.11
C/N	9.53	2.06	7.95	0.80
NO3 (ppm)	10.36	1.77	7.59	1.36
NH4 (ppm)	6.06	0.71	4.89	1.21
NH4/NO3	0.59	0.09	0.66	0.22
Phosphorus (ppm)	4511	571	7316	3041
Potassium (ppm)	1101	296	1069	182

3.1. pH:

Soil pH in the top 20cm of the soil profile registered a slight acidification. The pH decreased with 0.48 to 0.85 unit (**Fig.1**). This acidification can be explained by the mineralization of ammonium and proton H + release and production of organic acids (Zhao et al, 2009 ; Aboutayeb et al, 2014). The high content of organic material reduces the effect of acidification of the soil which means that there is a resistance of the soil acidification because high levels of organic matter (Mustin, 1987). An extension of experience in time could highlight this trend.

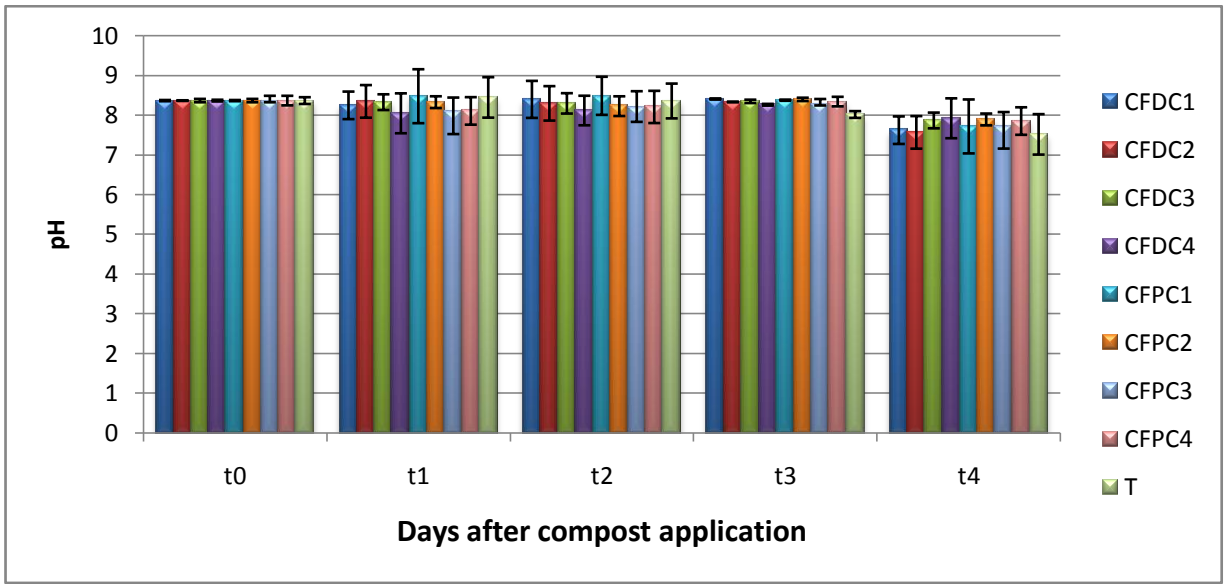

Fig. 1. Effect of composted poultry manure treatments on soil pH at depth of 0-20 cm (t0: 1st, t1: 45th, t2: 90th, t3: 135th, t4: 180th days).

3.2. Electrical conductivity (EC):

The EC is significantly affected by compost application. It showed a tendency to increase from 0.35 to 0.6 dS/m (**Fig.2**). This trend is due to bringing salt by spreading composts and pH decrease (Ju et al, 2007).

Several studies have shown that the use of compost may present some risks limiting horticultural production due to the presence of heavy metals and the risk of phytotoxicity caused by excessive intake of salt (Moral et al, 2009; Ribeiro et al, 2000). These levels of EC are not likely to make a phytotoxicity of spearmint that tolerates relatively high salinities.

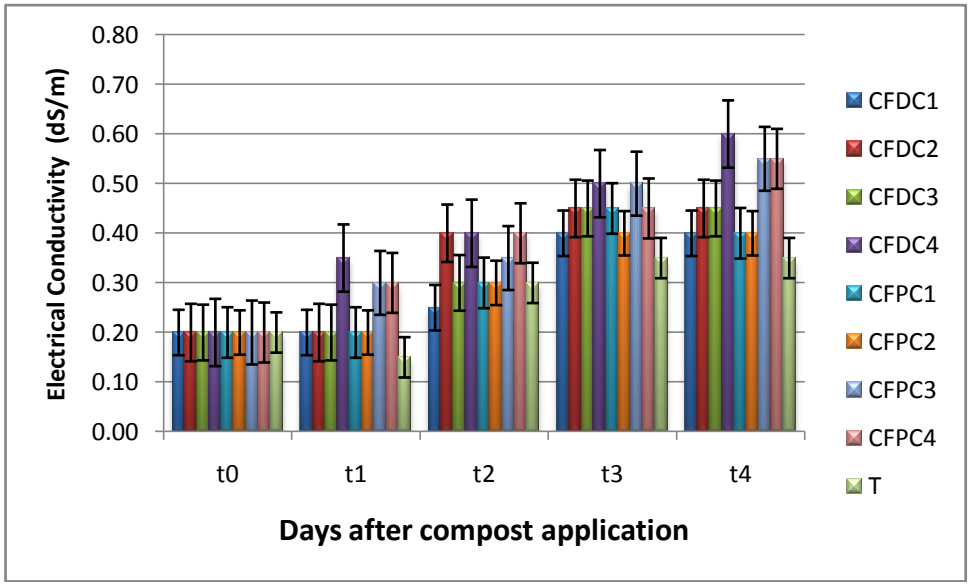

Fig. 2. Effect of composted poultry manure treatments on soil Electrical conductivity at depth of 0-20 cm

3.3. Organic matter (OM):

Intensive agricultural systems consume large amounts of organic matter (Mustin, 1987). Mineralization of OM and inadequate intake of exogenous organic matter lead to falling levels of OM in soils.

After spreading compost, the organic matter content registered an increase depending on the amount applied. Organic matter in elementary plots was significantly affected; she spent from 5.00% in the control to 5.87 and 5.96% in CFPC4 and CFDC4 respectively (**Fig. 3**). This increase is due to the spreading of compost, and the incorporation of crop residues following tillage.

This may be explained by the incorporation of manure's compost which helps to sequester more carbon in the soil (Jemai et al, 2009) and stimulate native soil microfauna involved in the humification process (Houot et al, 2009). Several authors have observed a general improvement in soil properties after optimum use of compost manure farm at 25 and 50 t / ha (Moral et al, 2009).

This increase of OM improves soil physical properties such as water retention, soil structure and porosity (Gil et al, 2008). Several authors showed the presence of a correlation between the amount of organic amendment applied annually and increasing the organic matter content in the soil (Elherradi et al, 2003). The addition of compost allowed even in the short term to increase the OM content in the surface layer (0-20 cm). The OM content in herbs and incorporated into the soil after tillage has increased the Soil OM content (Thuriès et al, 2000). It could be concluded that Organic Matter is rapidly renewed in the surface horizon (Ibrahima et al, 2009; Feller et al 1993).

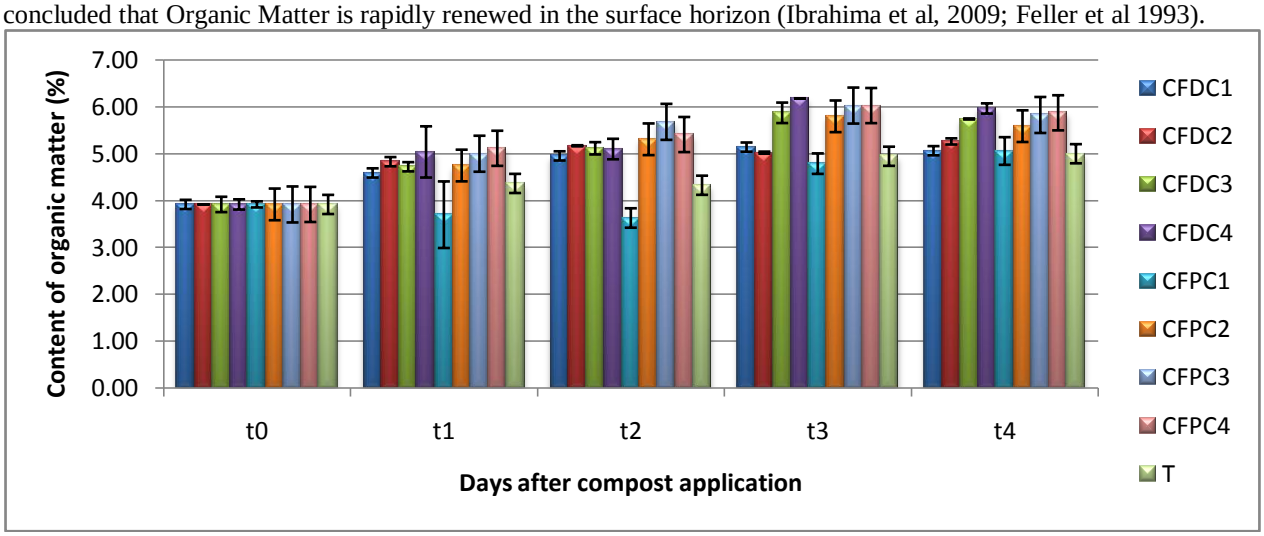

Fig. 3. Effect of composted poultry manure treatments on soil organic matter content at depth of 0-20 cm

3.4. Total nitrogen:

Soils amended with composted poultry manure show a higher level of total nitrogen than unamended soil. Nitrogen levels have decreased slightly in the Control plots soil. This decrease can be explained by the mineralization and consumption of nitrogen. We also report that total nitrogen content increases depending on the amount applied compost (**Fig. 4**). These contents recorded a significant difference between treatments. These have raised from 0.17 to 0.24% for the control (T) and CFDC4 respectively.

An important application of compost increased the content of soil nitrogen significantly. It allows restoring the levels of nitrogen in the soil and reduces nutrient losses to surface and groundwater through a stable matrix water and humified organic matter (Lyimo et al, 2012).

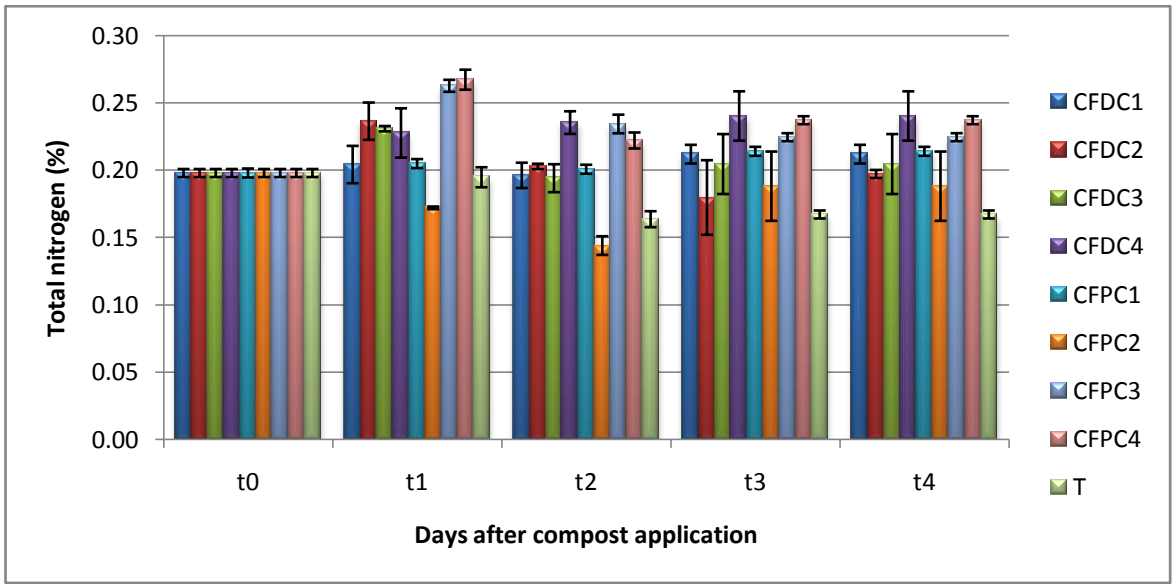

Fig. 4. Effect of composted poultry manure treatments on soil total nitrogen content at depth of 0-20 cm

3.5. Nitrates (NO_3^-)

After compost application, the nitrates (NO_3^-) content in the top 20 cm of elementary plots was significantly higher in plots amended. The evolution of nitrate can be divided into two phases: The first phase is characterized by increased levels of nitrates following the mineralization of organic nitrogen by nitrification. The second phase is marked by the fall of nitrate content following consumption by cuttings of mint. At the end of the experiment, the highest levels were recorded in the amended plots in large quantities (Fig. 5).

It should be noted that at the request of plants nitrate, some plots showed no nitrates which can be explained by insufficient intake of nitrates in compost. Several studies have focused on the evaluation of the rate of mineralization of compost. These studies have reported that rates of mineralization are ranging from 25 to 55% depending on the type of compost (Elharradi et al, 2003). The application of compost coupled with efficient irrigation and good knowledge of the needs of the plant (Evanylo et al, 2008), has positive effects on the control of nitrate released.

It can be concluded that the application of compost, even at high doses, does not present a potential risk of environmental contamination by nitrate leaching (Escudero et al, 2012).

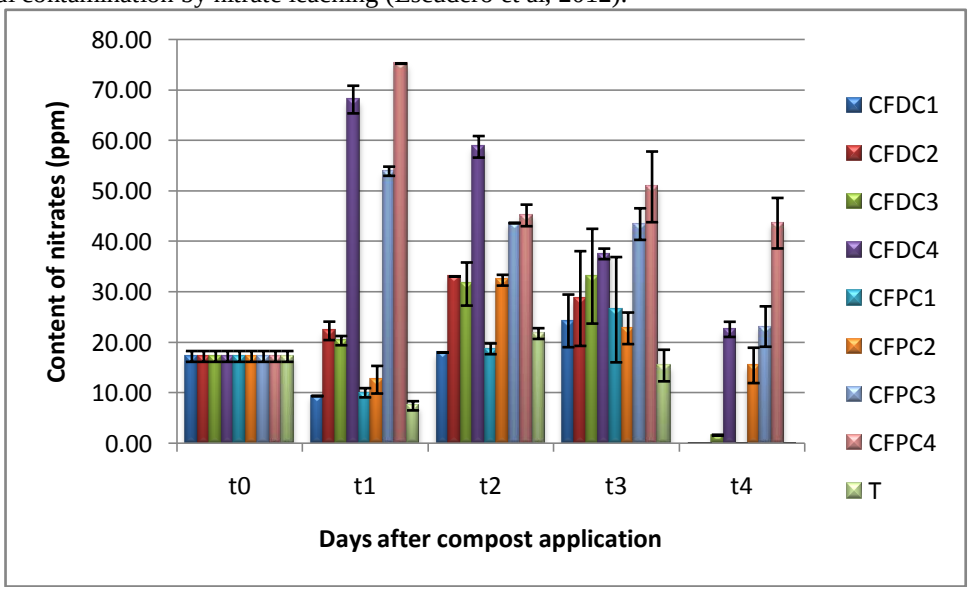

Fig. 5. Effect of composted poultry manure treatments on soil nitrates content at depth of 0-20 cm.

3.6. Phosphorus:

The application of compost enriched soil organic phosphorus. The microorganisms mineralize and make it bioavailable which induced a significant change in the levels of phosphorus in the soil. The slightly alkaline pH and the addition of organic matter favor the availability of phosphorus (Duchaufour, 1970). The latter is used for both the growth of the microorganisms and mint.

Like nitrates, phosphorus levels has increased with treatment. This trend may be due to the mineralization of organic phosphorus released under bioavailable form for the plant that absorbs it for its root growth. Application of compost resulted in significant levels of organic phosphorus in the soil (Gil et al, 2008). However, some countries have restricted the use of composts in relation to the amount of phosphorus as the case of Sweden (22 to 35 kg P / ha / year) and Denmark (20 kg P / ha / year) while some authors recommended an intake of between 50 and 68 kg P / ha per year as a good Agricultural Practice (Moral et al, 2009).

It could be deduced that phosphorus content showed a significant increase due to the spreading of compost. However, excessive application of compost may present environmental risks associated with high phosphorus content (Evanylo et al, 2008).

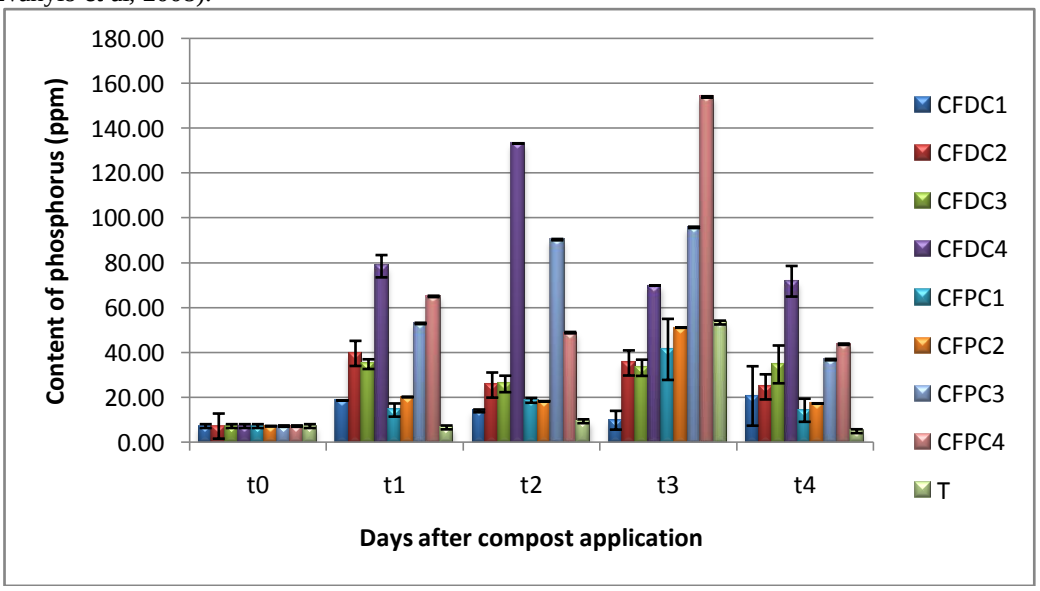

Fig. 6. Effect of composted poultry manure treatments on soil phosphorus content at depth of 0-20 cm.

3.7. Potassium (K):

Spreading compost revealed a significant change in soil levels of potassium. At the end of the experiment, these levels ranged from 208 to 386 ppm for CFPC1 and CFDC4 plots respectively (**Fig. 7**). The increase is due to the addition of potassium to the soil after application. These levels vary depending on the amount applied.

Some authors have recorded significant increases in potassium (Gil et al, 2008) while other studies have shown that the application of compost did not reveal a significant difference between treatments (Patra et al, 2000). Furthermore, the Pearson coefficient showed a significant correlation between the electrical conductivity and the contents of potassium.

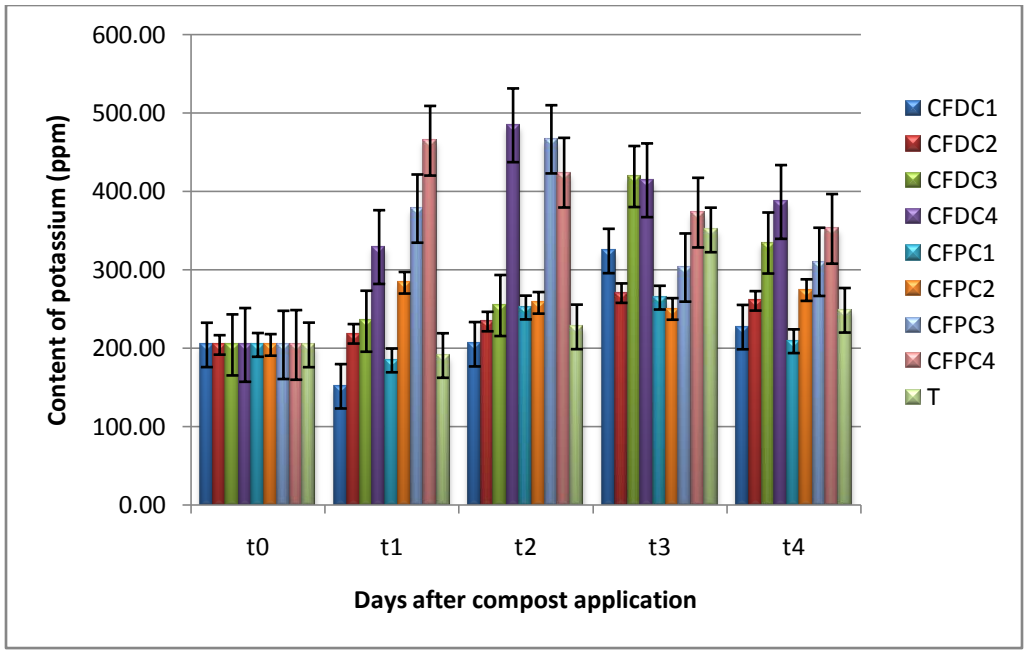

Fig. 7. Effect of composted poultry manure treatments on soil potassium content at depth of 0-20 cm

3.8. Cultivation of mint:

Spearmint or Mentha spicata L. is an aromatic plant widely consumed in Morocco. It is produced for local consumption and for export (Bensabah et al, 2013). In this experiment, spreading compost was completed 70 days before planting mint. The application of compost at different doses had a significant impact on improving the yield of mint; it leads to improvement of the production of mint which varied from 4.4 to 8.1 t / ha for control (T) and CFPC4 plots respectively (**Fig. 8**).

This improvement in production is due to the intake of major nutrients and improving the OM content in the soil. These results confirm the findings of other studies that have shown the beneficial effects of compost on agricultural production (Gil et al, 2008). It has been shown that the application of organic matter on the soil improves the retention of moisture, the soil structure and dynamics of nutrients which favorably affects the production of cultures (Ram et al, 1997; Bansal et al, 1971, Yadav et al 1994). Furthermore, the size of the plant and the dry matter production are significantly influenced by the application of nitrogen above 160 kg N / ha (Ram et al, 1997).

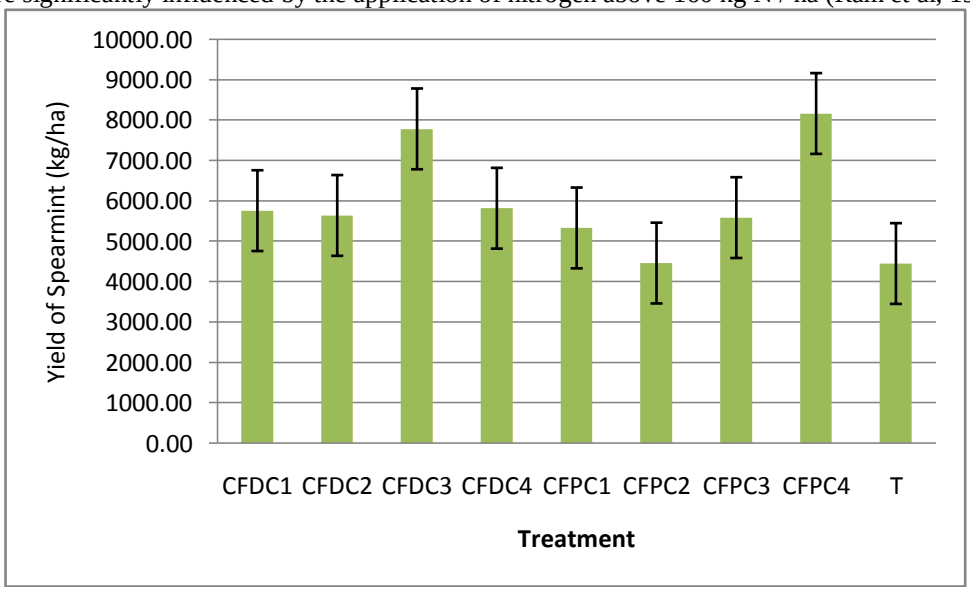

Fig. 8. Effect of composted poultry manure treatments on yield of Mentha Spicata L. (Spearmint).

4 CONCLUSION

Problems and challenges related to the use of poultry manure can be avoided by composting (Farhad et al, 2013) which is a cheap, efficient and sustainable treatment of the manure (Moral and al, 2009). The application of organic amendments could be an effective alternative to maintain an adequate input of organic matter (Ros et al., 2003; Liu et al., 2007) which improves soil properties, fertility and resistance to water and wind erosion (Celik et al, 2004; Carter et al, 1999).

In this study, spreading the compost induced improving of soil properties including the content of organic matter, nitrogen, phosphorus, potassium and nitrates.

Positive effect on the performance of the culture of mint and growth may be affected by the improvement of organizational status of soil after spreading the compost of poultry manure which is a rich source of organic matter and provides large quantities of important nutrients for plant growth. Consequently, the average yields were significantly affected.

In conclusion, the compost of poultry manure can be an alternative valuation of manure and reducing the use of chemical fertilizer. The application of composted manure is indeed a desirable practice for ecological restoration of degraded cropland soils and alleviating the constraints to sustainable cropping systems in arid and semi-arid environments (Ros et al, 2003).

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