J. of Soil Sciences and Agricultural Engineering, Mansoura Univ., Vol. 10 (11):693-697, 2019

Journal of Soil Sciences and Agricultural Engineering

Journal homepage: www.jssae.mans.edu.eg
Available online at: www.jssae.journals.ekb.eg

Assessment the Effect of Compost Amendments on Soil Characteristics and Barley Plant

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ABSTRACT

This study aimed to evaluate the effects of three different types of commercial compost, i.e., Animal Manure Compost (AMC), Crop Manure Compost (CMC) and Town Refuse Compost (TRC) on some chemical and spectroscopic characteristics of sand soil, as well as growth and yield barley plant (*Hordum vulgar* cv. Giza 123). They were individually applied at rate of 2% (oven-dry basis) and incubated for 56 days, and then Humic Acids (HA) and Fulvic Acids (FA) fractions were extracted and analyzed using total acidity and UV-Vis spectroscopy. From UV-Vis absorption spectra the absorbance ratios E_4/E_6 have been calculated. Soil pH, EC, and organic carbon content were determined. In addition, compost-N mineralization and nitrification rates were assessed. The results showed that the soil treated with organic amendment had higher values of organic matter, EC and available N as Compared with the unamend soil. Soil compost amendments had positive effect on mineralization, as the Net-N release increased with incubation time. The E_4/E_6 ratios of HA fraction in soil treatments ranged from 3.2 to 7.6, while the E_4/E_6 ratios of FA were higher than that of HA values (4.3-9.5). On the other hand, total acidity of function group for FAs was much greater than that for HAs (0.6-10.6 meq g^{-1} fulvic material). The results showed that addition of composts significantly (at $P \leq 0.05$) increased barley grain, straw weight and total yield compared to control (no compost application).

Keywords: Compost; Humus; N release; soil fertility; soil chemical characteristics

INTRODUCTION

Soil organic matter (SOM) is an important part of top quality agricultural soils because it affects several soil processes (Causarano *et al*., 2008). The SOM content and quality are necessary for the maintenance of soil fertility and productivity. Therefore, strategies are required to restore SOM lost through oxidation in cultivated areas. Composting the organic residues is attractive, because it converts them into environmentally safe products (Rivero *et al*., 2004). Compost can be used as a fertilizer because of its high nutrient content, making both a quantitative and qualitative contribution to the SOM and acting as an organic amendment. The impacts of compost application on SOM and humic substances have largely been analyzed using chemical and spectroscopic approaches (Busato *et al*., 2010).

The chemical and spectroscopic techniques give us info concerning the composition, functionalities and structural, chemical and spectroscopic characteristics of SOM and humic substances, as well as parameters associated with the degree of humification, such as the carbon/nitrogen (C/N) and carbon/hydrogen (C/H) atomic ratios as disclosed by elemental composition; and the E_4/E_6 ratio (The E_4/E_6 ratio indicates absorption of excitation wavelength at 465 nm / emission wavelength at 665 nm for humic substances using ultraviolet and visible light (UV-VIS) spectrophotometer (Silva *et al*., 2018).

Barley plant is one among the foremost necessary cereal crops in Egypt. It's really important and can be considered as a moderate salt tolerant plant crop in arid regions, also as in poor soils (Abd El-Hady, 2007). The aim of this study was to assess the impact of constant rate of organic amendment on (i) some chemical characteristics in sand soil, (ii) evaluate compost effect on net N release from compost amended soil, (iii) evaluate data obtained through chemical and spectroscopic methods concerning the changes in the humification process of soil organic matter after compost applications, and (iv) assess the effect of compost amendments on growth and yield of barley plant.

MATERIALS AND METHODS

The soil used for laboratory incubation was a sandy, collected from the surface layer (0- 30 cm) from Cairo-Alexandria Road, (30º 11' North, 30º 47' East). Three types of commercial compost were used as soil amendments; Animal Manure Compost (AMC), Crop Manure Compost (CMC) and Town Refuse Compost (TRC). Before any experimentation, the soil and composts were air dried, crushed, sieved (2-mm sieve), and thoroughly mixed, separately, for homogeneity. Composts analyses at the beginning of incubation (t = 0) are shown in Table (1). The incubation experiment was performed using batch methods.

Batch incubation method

Incubation was depended on gathering and mixing both soil and compost in closed plastic vials almost as described by Mulvaney *et al*., (2001). The vials were closed, and then batch method the soil was incubated with the three composts, separately, along with control that contained only soil, where 98 gm (dry-weight equivalent) of soil was mixed thoroughly, for homogeneity with 2 gm compost, except for the control. At the beginning of the batch incubation, water sufficient was added to each vial to increase soil moisture to the field capacity (FC), which represents the optimum moisture content for the growing of microorganism (Linn and

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DOI: 10.21608/jssae.2019.67361

Doran, 1984). The prepared vials were capped and incubated at 25ºC. Moisture content was preserve by adding distilled water, as needed on a weekly basis, according to weight loss. At each incubation time (0, 1, 7, 14, 28 and 56 days) available N forms (NH_4^+, and NO_3^-), were extracted according to methods as described by Wilke, (2005).

Pot Experiment

Barley (*Hordum vulgar* cv. Giza 123) plant was sown in pots in a completely randomized design with three replications. Pots measured 25 cm in diameter and 35 cm in height, sandy soils mixed with 2% compost then the pots were filled with a15kg of the used soil and planted with 20 seeds from barley plant. The recommended rates of inorganic fertilizers from Nitrogen (30 kg fed^{-1}), P_2O_5 (15 kg fed^{-1}) and K_2O (25 kg fed^{-1}) in the form of Ammonium sulfate, super phosphate and potassium sulfate were added as basic dose to all pots. Barley plant was harvested after 45 days from planting, and separated into grains and straw.

Physical and chemical analysis

All tests were performed at constant dry weight. Soil particle size was determined by the sieving method (ASTM International, 2007). The field capacity for soil was determined from the soil characteristic curve using ceramic plates as described by (Ryan *et al*., 2001a). The field capacity of the sandy soil considered as the amount of water at 0.1 bars, (Ryan *et al*., 2001a). The percent of water at field capacity for sandy soil was 15%. The pH and EC was measured in a 1:10 soil/water extract as described by (Ryan *et al*., 2001b). Total organic carbon (TOC) was determined as describe by Walkely-Black (1934) and Nelson and Sommers, (1982). Total nitrogen (TN) was measured by Kjeldahl method as described by Bremner and Mulvaney (1982). Available mineral nitrogen (AN) in extract solution was measured using the method as described by (Blakemore *et al*., 1987).The humic acid (HA) and fulvic acid (FA) fractions were extracted according to method developed by the International Humic Substances Society (IHSS) (Swift 1996). Total acidity of humic substances was measured according to conventional methods as described by Schnitzer and Khan (1972). To calculate the E_4/E_6 ratio of FA and HA; E_{465}/E_{665} ratios were measured by dissolving 1 mg of HA or FA in 10 ml of $NaHCO_3$ 0.05 solutions buffered to pH 7.5 and measuring absorbance at 465 and 665 nm; the ratio of absorbance at these two wave-lengths is referred to as the E_4/E_6 ratio.

Statistical analysis

Means comparisons between treatments by the least significant difference (LSD) test were performed to evaluate the statistical significance of the impact of addition composts on barley grain, straw weight and total yield by using COSTAT computer software at a significant level of P≤0:05. Furthermore, a Pearson correlation coefficients (r) analysis was carried out to observe the degree of association between some of the studied variables.

RESULTS AND DISCUSSION

Soil and composts characteristics

The results showed that the investigated composts have normal pH values, while EC values were of acceptable for CMC acidic compost only, as the pH and EC values for a hypothetically ideal substrate suggested by Centemero *et al*., (1999) should be 6.8-7.3 and lower than 2.1dS m^{-1}, respectively. In addition, the main characteristics of the soil sample used in this investigation is presented in Table (1), was it showed a normal soil pH and EC values for these soil and was in the normal range. In addition; the particle size distribution of the investigated soil is 87% sand, 5% silt and 8% clay.

Table 1. Some chemical properties of the investigated soil and composts.

Samples	pH	EC (dS m^{-1}) Soil extract (1:10)	TOC (%)	TN (%)	AN (ppm)	
Soil control	7.81	0.50	0.09	0.008	0.75	
AMC	7.53	4.50	15.20	1.22	115.31	
TRC	6.52	3.51	19.62	1.82	180.43	
CMC	6.10	2.62	23.75	2.34	210.26	

AMC: Animal Manure Compost; CMC: Crop Manure Compost; TRC: Town Refuse Compost; EC: Electrical conductivity; TOC: Total organic carbon; TN: Total Nitrogen; AN: Available Nitrogen.

Effect of composts on soil characteristics

pH values

Table (2) showed that CMC treatment had the lowest pH values throughout the incubation experimental, in the initial pH (1:10) of CMC compost was 6.10. For all soil treatments the pH values were lower than that of the tested control, which indicated the effective role of all the investigated composts in lowering soil pH with different values.

Table (2) showed also that the magnitude of pH differences throughout the incubation experiment was larger in the soil control compared to those for the compost-treated soils. This might be rendered to the lower buffering capacity of sandy soil compared to that of organic matter. The high buffering of OM resisted the large pH changes resulted from either the production of organic acids or the production of ammonium throughout the decomposition of tested compost. Weaver *et al*., (2004) stated that soil pH buffering capacity increased with increasing OM % and clay content.

Table 2. Some chemical characteristics of the investigated soil at the end of the incubation period (56 days).

Treatments	pH	EC	HA	FA	TA_{HA}	TA_{FA}	E_4/E_{6HA}	E_4/E_{6FA}
	Soil extract (1:10)	(dS m^{-1})	(%)		(meq g^{-1})			
Soil control	7.81	0.50	0.15	0.05	0.4	0.6	3.2	4.3
Soil-AMC	7.60	1.80	0.25	0.10	7.5	8.5	5.3	7.5
Soil-TRC	7.31	1.52	0.30	0.15	7.8	9.5	6.8	8.4
Soil-CMC	7.10	1.14	0.35	0.20	8.4	10.6	7.6	9.5

Soil-AMC: Animal Manure Compost-amended soil; Soil-CMC: Crop Manure Compost-amended soil; Soil-TRC: Town Refuse Compost-amended soil; EC: Electrical conductivity; HA: humic acid; FA: fulvic acid; TA_{HA}: Total acidity for humic acid; TA_{FA}: Total acidity for fulvic acid E_4/E_6 ratio= ratio of absorbance's at 465 and 665 nm.

Electrical conductivity

Electrical conductivity (EC) showed an increasing trend with the amending of composts to the soil (Table 2). Amending of composts to the soil increases the salt content as well as soil EC, especially if high raw material of compost is applied, because of the high salinity of composts (Gonzalez *et al*., 2010). Table (2) showed general increase in soil-EC values (1:10) for all the investigated composts. This could be attributed to the accumulation of the mineralized products in the batch incubation which considered as a closed system. With respect to the effect of compost, AMC treatment showed the highest EC values, followed by TRC and CMC which reflected their initial EC values 4.50, 3.51 and 2.62 dS m^{-1}, respectively.

Mineralization (ammonification and nitrification)

Ammonium release curves of the batch incubation experiment for the investigated composts were presented in Figs. (1-3). These ammonium peaks could be related to the availability of the easily decomposable dissolved organic matter (DOM), It was clearly noticed that the largest ammonium peaks were obtained after 7 days of incubation for Crop Manure Compost (CMC) which had initial value OM (40.85%).This could be attributed to the low ability of sandy soil to reserve NH_4^+. After the 7th day of incubation, the released-NH_4^+ sharply decreased followed by slight and steady decrease started from the 28th day, especially for AMC treatment. Released curves of nitrate from the investigated composts in the batch incubation experiment were shown in Figs. (1-3).

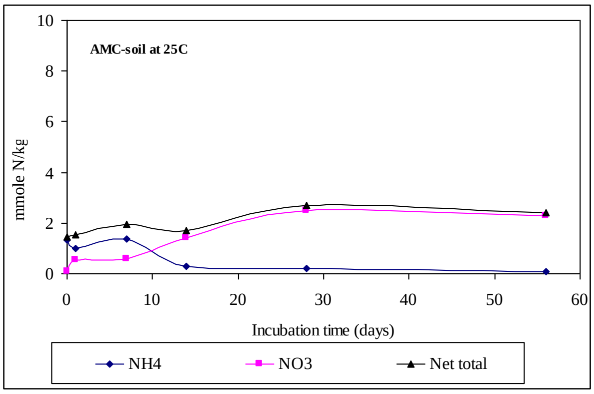

Fig. 1. Net total, ammonium (NH_4^+) and nitrate (NO_3^-) nitrogen (N) released from AMC-soil during 56-days laboratory incubation.

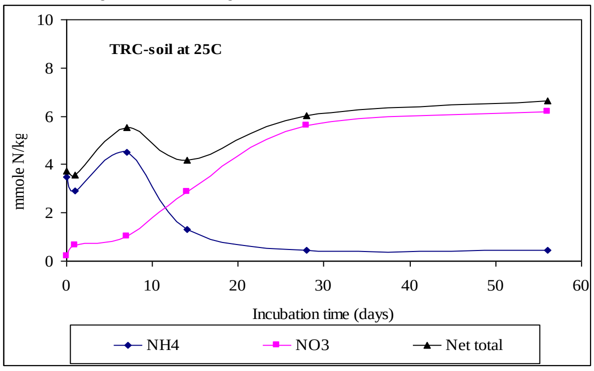

Fig. 2. Net total, ammonium (NH_4^+) and nitrate (NO_3^-) nitrogen (N) released from TRC-soil during 56-days laboratory incubation.

Released nitrate quantity increased until it reached the maximum at the end of the incubation cycle. In all the investigated treatment, compost of Crop Manure (CMC) released the highest quantities of nitrate especially after 28 days of incubation. The increasing trend of NO_3^- quantity after 28 days of incubation in all the investigated composts and soils was found to be inversely related to that of ammonium. This could be attributed to the formation of nitrate on the account of ammonium through the nitrification process. The obtained data showed also that the increase in NO_3^- quantity after 28 days of incubation is accompanied by a gentle decreasing trend in soil-pH. This could be confirmed by the highly significant and negative correlations coefficient between NO_3^- concentration and soil pH, Nielsen *et al*., (1996).

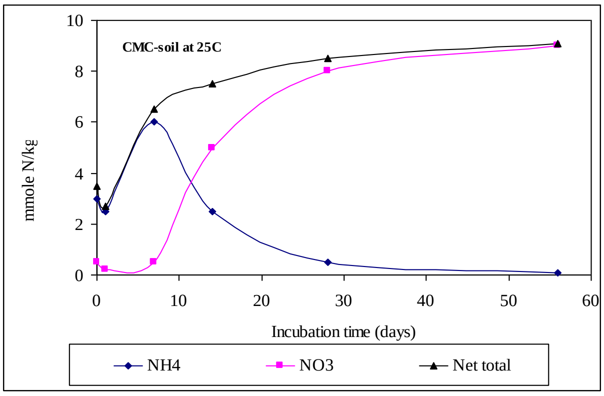

Fig. 3. Net total, ammonium (NH_4^+) and nitrate (NO_3^-) nitrogen (N) released from CMC-soil during 56-days laboratory incubation.

Total acidity and E_4/E_6 ratios

The results show that the relative percentages of humic acids in all the soil-composts were higher than fulvic acids, indicating humic acid formation through higher polymerization (Table 2). Among the soil-composts, Soil-CMC treatment had highest FA and HA percentages (0.20-0.35%, respectively). The lowest FA and HA percentages was observed in soil-AMC treatment (0.10-0.25%, respectively).

The results of functional groups revealed that the content of total acidity was higher in FA's than in those from HA's (Table 2). Higher total acidity (meq g^{-1} FA) values were observed in Soil-CMC (10.6) and Soil-TRC (9.5) whereas, lower values for Soil-AMC (8.5). Similar to FA, HA total acidity (meq g^{-1} HA) was higher in Soil-CMC (8.4) and Soil-TRC (7.8) and lower in Soil-AMC (7.5). The variations in total acidity may be attributed to the inherent differences in chemical composition and molecular weights of HA and FA.

Spectroscopic methods were used to characterize the humification degree of humic substances, including measured of the E_4/E_6 ratio (the ratio of absorbance at 465 nm to at 665 nm) and often used as an indicator for maturity and stability of humic substances (Li *et al*., 2009). In the present study, the value E_4/E_6 ratios of fulvic acids were found higher than humic acids (Table 2). The lower value of the E_4/E_6 ratio (humification index) for HAs confirmed the presence of humic substance (HS) with higher molecular weight and humification degree.

The E_4/E_6 ratios of HA fraction in soil treatments ranged from 3.2 to 7.6, the values of FA were higher than that of HA values (4.3-9.5), suggesting fact that the FA's have more aliphatic compounds than HA's fractions. Generally, the HAs with ratio of < 5.0; while, FAs > 5.0, serves as an index of humification and ratio narrows with increasing molecular weight and condensation, Similar observations were confirmed by Sharan *et al*., (2014).

Table (3) showed the correlation co-efficient matrix, The 'r' co-efficient data shows poor relation between EC and pH, moderate relation between pH, $E_4/E_{6\ HA}$, while high relation between pH, TA_{HA}, TA_{FA} and $E_4/E_{6\ FA}$.

Table 3. Correlation coefficients (r) analysis of the estimated parameters of incubation experiment.

	pH	EC	HA	FA	TA $_{HA}$	E_4/E_6 $_{HA}$	TA $_{FA}$	E_4/E_6 $_{FA}$
pH	1.00**							
EC	-0.39	1.00**						
HA	-0.97**	0.45	1.00**					
FA	-0.99**	0.36	0.98**	1.00**				
TA $_{HA}$	-0.81**	0.58	0.92**	0.83**	1.00**			
E_4/E_6 $_{HA}$	-0.78*	-0.27	0.71*	0.80*	0.45	1.00**		
TA $_{FA}$	-0.86**	0.57	0.95**	0.88**	0.99**	0.51	1.00**	
E_4/E_6 $_{FA}$	-0.94**	0.49	0.99**	0.95**	0.96**	0.65	0.98**	1.00**

EC: Electrical conductivity; HA: humic acid; FA: fulvic acid; TA $_{HA}$: Total acidity for humic acid; TA $_{FA}$: Total acidity for fulvic acid; E_4/E_6 $_{HA}$: ratio of absorbance's at 465 and 665 nm for humic acid; E_4/E_6 $_{FA}$: ratio of absorbance's at 465 and 665 nm for fulvic acid; *, **Significant at *P* = 0.05 and *P* = 0.01 levels, respectively.

Effect of Compost amendment on yield of barley plant

The yield determining components of barley crop such as straw and grain yield were a significant increase in grain, straw weight and total yield compared to the control treatment by compost application (Table 4). The highest percent increase in straw yield (42.44%), grain yield (75.21.73%) and total yield (52.07%) was recorded in the treatment Soil-CMC as compare with Soil control, followed by Soil-TRC and Soil-AMC, respectively, The lowest values recorded in the treatment receiving no compost. This may be due to the ability of compost to support the growth plant with micro and macro nutrients need for their growth, these results conformity with the findings of Tra *et al.*, (2013). Data also, observed that application composts increased crop index and harvest index compared the soil control. It has been noticed that composts were markedly increased in the crop index and harvest index in sandy soil. In addition, the relative increase (RI %) of total yield weight of barley plant ranged from 16.56% with the treatment of Soil-AMC to 52.07% with the treatment of Soil-CMC. The relative increase of total yield weight of barley plant differed significantly between the studied treatments (Table 4).

Tabl 4. Effect of compost treatments on grain, straw and total yield of barley plant.

Treatments	Grain	Straw	Total yield	CI	HI	RI
	(g pot^{-1})			(%)		
Soil control	3.55^d	8.53^c	12.08^d	41.62^c	29.39^c	0^d
Soil-AMC	4.53^c	9.55b^c	14.08^c	47.43^b	32.17^b	16.56^c
Soil-TRC	5.61^b	10.91^b	16.52^b	51.42^a	33.96^a	36.75^b
Soil-CMC	6.22^a	12.15^a	18.37^a	51.19^a	33.86^a	52.07^a
$LSD_{0.05}$	0.56	1.14	1.03	0.89	1.18	2.76

Soil-AMC: Animal Manure Compost-amended soil; Soil-CMC: Crop Manure Compost-amended soil; Soil-TRC: Town Refuse Compost-amended soil; CI: crop index= grain/straw x100; HI: harvest index= grain/total yield x100; (RI): Relative Increase= (Total yield treatment-Total yield control)/ (Total yield control) x100; Values followed by the same letter(s) in a column are not significantly different at p = 0.05 according to Least Significant Difference (LSD).

CONCLUSION

Rational soil application of treated compost may be the solution for get back degraded soil through enhancing soil fertility. The incorporation of compost positively improved the chemical properties of soil after 56 days of incubation experimental, including pH, HA, FA, and functional groups. CMC-soil had the highest ameliorant ability followed by TRC-soil, and AMC-soil. Generally; results detect that amending of compost to soil can amelioration soil chemical and spectroscopic properties.

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تقييم تأثير إضافة الكمبوست على خصائص التربة ونبات الشعير

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تهدف هذه الدراسة إلى تقييم تأثير إضافة ثلاثة أنواع مختلفة من الكمبوست, كمبوست حيواني (AMC), كمبوست نباتي (CMC) وكمبوست قمامة (TRC) على بعض الخصائص الكيميائية والطيفية للتربة الرملية, وكذلك نمو وإنتاج محصول الشعير (*Hordum vulgar* cv. Giza 123). تم إضافة الثلاثة أنواع المختلفة من الكمبوست بشكل فردي بمعدل 2 ٪ (علي أساس الوزن الجاف) إلي التربة وحضنت لمدة 56 يوما, تم الحصول علي مفصولات الأحماض الدبالية (HA) وأحماض الفالفيك (FA) وباستخدام التحليل الطيفي تم حساب نسب الإمتصاصية E_4/E_6. أيضا تم قياس pH, EC, ومحتوى الكربون العضوي, بالإضافة إلى ذلك تم تقييم معدلات تمعدن الكمبوست. أوضحت النتائج أن التربة التي تمت معاملتها بالكمبوست كانت لها قيم أعلى في كلا من المادة العضوية, EC, النيتروجين الميسر مقارنة بالتربة غير المعاملة. وكان لإضافة الكمبوست للتربة تأثير إيجابي على التمعدن, حيث زاد إنطلاق صافي النيتروجين خلال وقت التحضين. تراوحت نسب E_4/E_6 لمفصول HA في التربة المعاملة بالكمبوست من (3.2 إلى 7.6), وكانت قيم FA أعلى من قيم HA (4.3-9.5). ومن ناحية أخرى, كانت الحموضة الكلية للـ FAs أكبر بكثير من تلك الموجودة في HAs حيث تراوحت القيم بين ($0.6\text{-}10.6\ meq\ g^{-1}$). أظهرت النتائج أن إضافة الكمبوست للتربة (عند $P \leq 0.05$) أدى الى زيادة كلا من حبوب الشعير ووزن القش والمحصول الكلي مقارنة بمعاملة الكنترول.