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Short Term Impacts of Amending Calcareous and Non-Calcareous Sandy Soils with Organic Amendments and Their Extracts: Effects on Soil Biota, Soil Physical and Chemical Characteristics

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Abstract

In arid and semi-arid soils, organic residues undergo rapid degradation and their consequences are positive on both soils and living biota. Probably, humic substances, which are organics that resist biodegradation, can bring further positive consequences on soil characteristics and biota living therein on the short run. To investigate this hypothesis, a pot experiment was conducted using two sandy (calcareous vs non calcareous) soils amended with organic substances (compost and biogas manure) and their extracts (humic acid (HA) and fulvic acid (FA)). Applications of compost and biogas manure were based on a constant N-input, equivalent to 36 kg N ha^{-1}, while in case of organic extract treatments, soils received supplementary doses of ammonium sulphate (20.5%N) to raise N-content in soils to the recommended dose. Control treatments, that received a full dose of N as ammonium sulphate, were also considered for data comparison. The experimental design was a complete randomized one. All pots were planted with faba bean seeds and incubated under the greenhouse conditions for 80 days. Results indicated that organic applications stimulated total counts of soil bacteria and fungi by the end of the experimental period. These organic treatments increased significantly values of soil EC and CEC. On the other hand, their impacts on soil bulk density and pH were not detectable. Further significant improvements in soil chemical characteristics and total bacterial and fungal counts were attained owing to application of the organic extracts (HA or FA) as compared to their sources; yet, organic manures retained higher residual organic carbon (ROC) than their extracts did. In conclusion, application of organic amendments and especially their extracts recorded positive impacts on soil characteristics on the short run; yet, improvements in soil bulk density are mostly related to long term microbial activities.

Key words: sandy soils; calcareous sandy soil; humic substances; compost; biogas; soil biota; soil characteristics.

Introduction

Plant residues are important sources of soil organic carbon (SOC) and nutrients that are needed for soil biota **(Liu *et al.*, 2009)** and plant growth **(Abbas *et al.*, 2011; Farid *et al.*, 2014; Farid *et al.*, 2018; Zhang *et al.*, 2020).** These residues may also lessen soil degradation **(Diacono and Montemurro, 2011)**. For this reason, recycling organic amendments is an important protocol to increase soil health **(Urra *et al.*, 2019)** and sustainability **(Scotti *et al.*, 2015)**. It is worthy to mention that the effects of soil organic amendments are detectable on soil characteristics **(Hao *et al.*, 2008; Wei *et al.*, 2016; Elcossy *et al.*, 2020)**, yet these effects might not be noticeable on some soil physical properties, particularly bulk density on the short run **(Brye *et al.*, 2005)**. On the other hand, the degradation of organic amendments in arid and semi-arid soils seemed to be high **(Abdelhafez *et al.*, 2018; Guo *et al.*, 2019),** because of the warm climate dominating in such an arid region which consequently accelerates the decomposition of the organic amendments **(Thakur *et al.*, 2018)**, even the relatively resistant organic pools **(Fang *et al.*, 2005)**. Moreover, soil fungal activities were stimulated due to the organic applicants on the short run and such increases recover soil quality and fertility **(Tayyab *et al.*, 2019)**. Thus, we believe that amending poor structural soils of low fertility with organic amendments might result in considerable improvements in soil characteristics and the biota living therein on the short term.

Humic substances (HS) are of special concern in this study because they are the main reservoirs of C in the biosphere, comprising up to 70% of soil organic matter (SOM) **(Grinhut *et al.*, 2007)**. It involves humic acid, fulvic acids **(Nardi *et al.*, 2017)** and humin **(Lipczynska-Kochany, 2018A)**. These substances coat soil minerals and therefore improve their characteristics **(Ghabbour *et al.*, 2004)**. Moreover, HS are resistant against biodegradation **(Lipczynska-Kochany, 2018B)** and can be retained in soil for longer time periods (vs organic amendments) **(Gerke, 2018)**. The presence of Ca which is the dominant cation in calcareous soils may affect sorption of humic substances on clay minerals **(Majzik and Tombácz, 2007)** and this may probably increase/decrease the positive effects of the applied amendments to ameliorate calcareous soils.

The current study investigates the potential impacts of amending soils with different organic amendments i.e. compost , biogas manure as well as humic and fulvic acids extracted from these amendments beside of combinations of the aforementioned amendments, on stimulating soil biota; beside of improving soil physical and chemical characteristics. This study was conducted under the controlled greenhouse conditions to monitor precisely such effects while considering the following two hypotheses.

H1: Application of organic residues stimulates total counts of soil biota (bacteria and fungi) in the sandy soils whether they were non-calcareous or calcareous and this may increase degradation of the organic matter and consequently lessen considerably residual organic carbon by the end of the growing season.

H2: These applications significantly improve soil physical and chemical characteristics on the short run.

Materials and Methods

Surface soil samples were collected from two areas to represent a non-calcareous sandy soil from El Dair (Qalubia Governorate, Egypt) and a calcareous sandy one from El-Nubaria (Beheira Governorate, Egypt). Soil samples were air dried, finely ground to pass through a 2 mm sieve then analyzed for their particle size distribution and chemical properties according to **Klute (1986)** and **Sparks *et al*. (1996)**, respectively Results of analyses are presented in Table 1.

Table 1. Particle size distribution and chemical properties of the investigated soils.

Property	El Dair (sandy non-calcareous) soil	Nubaria (sandy calcareous) soil
Particle size distribution %		
Sand	91.8	94.9
Silt	2.2	2.3
Clay	6.0	2.8
Textural class	Sand	Sand
Soluble Cations ($mmol_c$ L^{-1})		
Ca^{2+}	6.50	22.8
Mg^{2+}	3.75	17.9
Na^{+}	3.14	9.80
K^{+}	0.61	0.50
Soluble anions ($mmol_c$ L^{-1})		
CO_3^{--}	0.00	0.00
HCO_3^{-}	2.50	2.00
Cl^{-}	2.50	25.00
SO_4^{--}	9.00	24.00
pH*	7.65	8.2
EC**, dS m^{-1}	1.4	5.0
Soil organic matter, g kg^{-1}	3.3	7.1
CEC, cmolc kg^{-1}	13.5	13.9
$CaCO_3$, g kg^{-1}	15	223
Bulk density, Mg m^{-3}	1.6	1.4

Soil pH was determined in a soil: water suspension (1:2.5) and soil EC was determined in a soil paste extract

Organic amendment sources:

Matured compost was prepared from both rice straw (50 kg) and farmyard manure (30 kg) supplemented with elemental sulfur (4 kg), rock phosphate (8 kg), zinc sulfate (0.4 kg) and urea (2 kg). This mixture was incubated under the aerobic heap conditions for three months. Biogas manure was obtained from the Training Center for Recycling of Agricultural Residues at Moshtohor (TCRAR), Soils, Water and Environment Research, Institute, Agricultural Research Center (Giza, Egypt). Physical and chemical characteristics of these amendments are presented in Table 2.

Table 2. Physical, chemical and biological properties of the compost and biogas manure under study.

Property	Compost	Biogas manure
Density Mg/m³	0.72	0.65
Moisture content %	23.70	9.30
pH (1:10 extract)	7.58	7.83
EC dSm^{-1} (1:10 extract)	4.17	3.15
Total-N %	28.3	26.0
Organic carbon (g kg^{-1})	494.60	514.0
C/N ratio	17.5:1	19.8:1
Total bacterial count cfu/gx10^7	7.3	5.80
Total fungal count cfu/gx10^5	3.90	4.20

Note: cfu. Indicates colony forming unit

Seeds source

Seeds of faba bean (*Vicia faba*, c.v Giza-2) were obtained from the Field Crops Research Institute, Agricultural Research Center, Giza, Egypt. *Rhizobium leguminosarium* (ICARDA441) inoculum was obtained from Biofertilizers Production Unit, Soils, Water and Environment Res. Inst. Agric. Res. Center, Giza, Egypt. Faba been seeds were successively washed with water, air dried, then soaked in cell suspension of rhizobium Sp.(1 mL contains about 8.4 $\times 10^7$ viable cell) for 30 min. Arabic gum (16%) was then added as an adhesive agent prior to inoculation; afterwards, these seeds were air dried for an hour before sowing.

Extraction and purification of humic and fulvic acids

Extraction of humic substances was carried out as outlined by **Sanchez – Monedero *et al.* (2002)**. Briefly, humic substances were extracted from compost and biogas manures after being treated with 0.5 N KOH solution. The supernatant was acidified by HCl (2*N*) to reach a pH value of 2.0 then left overnight. Precipitates, conventionally known as humic acid (HA), were separated from the soluble fulvic acids by centrifugation at 6000 rpm for 15 minutes. Afterwards, HA precipitate was washed several times with 0.05 N H_2SO_4 until the filtrate became colorless; thereafter, this precipitate was purified with electrodialysis and then air dried **(Chen and Schnitzer, 1978)**.

Purification of fulvic acid (the supernatant from the previous step) was carried out according to **Kononova (1966)** and **Susilawati *et al.*(2007)** as follows**:** fulvic acid solution was passed through activated charcoal followed by elution of the charcoal. Then, the solution was concentrated, transferred to membrane filter and elctrodialysed until the solution became free from Cl.

Elemental composition of the used amendments was estimated using gas chromatography on a Hewlett – Packard 185 Analytical Center, Faculty of Science, Cairo University. Oxygen was then calculated by subtraction of the percentages of C, H, N and S% from 100 and the results are presented in Table 3.

Table 3. Chemical composition of the investigated amendments (compost and biogas manures) and their extracted humic (HA) and fulvic (FA) acids.

	Compost			Biogas		
Character	**manure**	**HA**	**FA**	**manure**	**HA**	**FA**
C%	49.46	50.71	50.4	51.4	49.9	46
N%	2.83	3.1	2.72	2.60	2.85	2.75
H%	1.45	1.93	1.84	2.12	2.10	3.89
S%	3.76	3.96	3.14	3.68	4.15	3.46
O_2%	42.5	40.3	41.9	40.2	41	43.9
C/N ratio	17.5	16.4	18.5	19.8	17.5	16.7
C/H ratio	34.1	26.3	27.4	24.2	23.8	13.3
C/O ratio	1.2	1.3	1.2	1.3	1.2	1.05
O/H ratio	29.3	20.9	22.8	19	19.5	11.3
N/H ratio	1.95	1.6	1.5	1.3	1.4	0.4

The greenhouse experiment.

A pot experiment was conducted on November 2019 under the greenhouse conditions at the Training Center for Recycling of Agricultural Residues at Moshtohor (TCRAR), Soils, water and Environment Research Institute, Agricultural Research Center (ARC). The experimental design was a complete randomized one comprising three factors, in triplicates: two soil types (a calcareous soil and a non-calcareous sandy one), two organic resources (biogas and compost beside of their extracts i.e.HA and FA) .The treatments of the study were no organic additions (T_0), 100% organic-N (org-N) to satisfy the recommended N-dose (36 kg N ha^{-1} , T_1), 50% org+50% inorganic-N (T_2), 100% HA (74 L ha^{-1}, T_3), 50% HA (T_4), 100% FA (74 L ha^{-1}, T_5) and 50% FA (T_6). In humic and fulvic treatments (T_3-T_6), soils received supplementary doses of ammonium sulphate (20.5%N) to raise N-content to the recommended dose (for more details, see Table 4). Soil portions (equivalent to 2 kg) were mixed thoroughly with one of the abovementioned treatments and then received calcium superphosphate **(8.5%P)** and potassium sulphate **(48%K)** (after considering their contents in organic amendments) as follows: **75kg P ha^{-1}** and **48kg K ha^{-1},** respectively. Soils were then packed uniformly in plastic pots of 21 cm diameter and 16 cm height to maintain constant bulk densities of 1.60 and 1.44 Mg m^{-3} for non- calcareous and calcareous soils, respectively. Five bean seeds were sown in each pot and soils were irrigated with deionized water to bring soil moisture content to the field capacity; afterwards, irrigation was carried out every 5-7 days.

Two weeks after planting, seedlings of faba beans were thinned to 4 ones per pot. After 80 days of planting, soils were sampled and the following characteristics were determined: pH, EC, residual organic carbon (ROC), CEC and soil bulk density according to the standard methods of **Sparks *et al*. (1996)** and **Klute (1986)**. Determination of the total counts of bacteria and fungi in soil samples were determined according to **Reinhold *et al.*(1985)** as follows: one mL of the soil suspension (1:5, w:v) was poured on agar media in Petri dishes and then incubated for 7 days at 30ºC. Afterwards, total bacterial and fungal counts were assessed.

Table 4. Details regarding organic treatments and their extracts.

Factor one (Soil type, S)	Factor two (The organic amendment source)	Factor three Organic treatments
A non-calcareous sandy soil, S_1	Biogas, O_1	No organic amendment, T_0
A calcareous sandy soil, S_2	Compost, O_2	100% org-N, T_1
		50%inorg-N+ 50% org, T_2
		100% HA, T_3
		50% HA, T_4
		100% FA, T_5
		50%FA, T_6

Data Analyses

Data were statistically analyzed using PASW statistical software 18 through analysis of variance (ANOVA) and Dunken's test at 0.05 probability level. Graphs were plotted using SigmaPlot 10 software.

Results and Discussion

Effect of organic amendments and their extracts on soil bulk density

Analysis of variance revealed that soil bulk density was not significantly affected by either the source of the organic amendment (F=0.071, *P*=0.791), the type of the soil (F=2.631, *P*-0.110) or even the organic treatment (F=1.017, *P*-0.424) on the short run. Moreover, interactions among these three factors were of no significant effect on soil bulk density (F=0.328, *P*=0.920). These results contradict the findings which indicated that organic amendments find their way between soil particles **(Tobiašová *et al.*, 2016)**, then trapped in small pores forming aggregates **(Balesdent *et al.*, 2000)**to be partially protected against biodegradation **(Goebel *et al.*, 2009)**, while improved soil aggregation **(Farid *et al.*, 2014; Farid *et al.*, 2018; Mohamed et al., 2021)**. The other assumption presented by **Abdelhafez *et al.* (2018)** is more sensible which indicate that more stable organic components are built up in soil on the long run. These organic components may account for improving soil structure **(Elcossy *et al.*, 2020)**.

Table 5. Bulk density of the sandy non-calcareous and calcareous soils under study as affected by the application of organic and mineral fertilizers, either solely or in different combinations (Treatments from T_0 to T_6: see Table 4)

	Non-calcareous soil		Calcareous soil	
Treatment	Biogas manure	Compost	Biogas manure	Compost
	Soil bulk density, Mg m^{-3}			
T_0	1.61±0.25 ^{a}	1.61±0.25 ^{a}	1.42±0.37 ^{a}	1.42±0.38 ^{a}
T_1	1.42±0.03 ^{a}	1.43±0.24^a	1.37±0.5 ^{a}	1.25±0.37 ^{a}
T_2	1.40±0.18 ^{a}	1.59±0.25 ^{a}	1.31±0.23 ^{a}	1.36±0.26 ^{a}
T_3	1.25±0.03^a	1.40±0.07 ^{a}	1.43±0.05 ^{a}	1.18±0.02 ^{a}
T_4	1.31±0.44 ^{a}	1.34±0.29^a	1.37±0.18 ^{a}	1.38±0.18 ^{a}
T_5	1.54±0.13 ^{a}	1.51±0.06 ^{a}	1.49±0.05 ^{a}	1.34±0.02 ^{a}
T_6	1.25±0.06 ^{a}	1.40±0.03 a	1.43±0.46 ^{a}	1.18±0.25 ^{a}

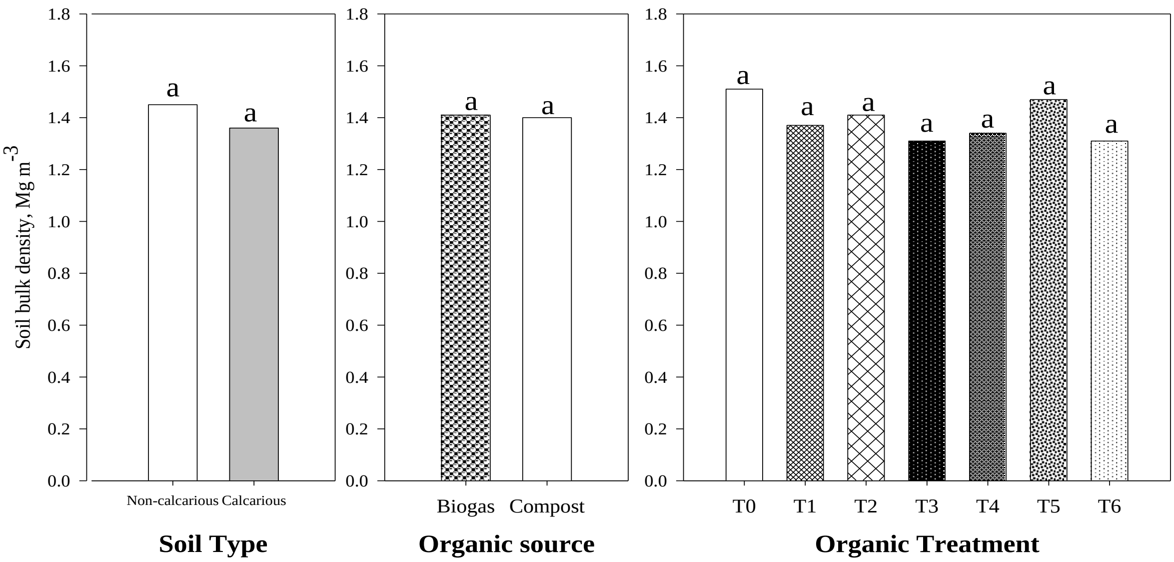

Fig. 1. Grand means of bulk density of the sandy soils under investigation as affected by organic and mineral-N fertilizers, applied either solely or in different combinations (Treatments from T_0 to T_6: see Table 4).

Effect of organic amendments and their extracts on soil chemical characteristics:

Effect on the residual organic carbon (ROC)

Residual organic carbon significantly increased in the investigated soils owing to the application of the organic treatments (F= 68.041, P<0.001) with no significant variations between the two sources of organic amendments (F = 0.518, P=0.475). Similar results indicated that organic applications significantly increased the residual soil organic carbon **(Mahmood *et al.*, 2017)**. These residues are important aspects of sustainable agriculture **(Kumari *et al.*, 2018)** because they improve soil physical and chemical characteristics, especially in soils of arid and semi-arid regions **(Hemmat *et al.*, 2010)**. The obtained results reveal that the application of organic manures (compost or biogas) reocrded the highest increases in the residual soil organic carbon, whose values exceeded those attained due to their extracts (more resistant organic components). Moreover, the recorded values exceeded the initial ones of the soils (1.914 g C kg^{-1} in the non-calcareous soil and 4.118 g C kg^{-1} in the calcareous soil) plus the amended C amounts through organic applications i.e. ≈0.264 g C kg^{-1} for compost and ≈0.299 g C kg^{-1}for biogas manure. The reasonable explanation for such increases is that these amendments enriched soils with organic substrates that are needed for soil biota **(Blankinship and Schimel, 2018)**; accordingly soil health improved considerably **(Williams *et al.*, 2020)**. This may increase the consequently the beneficial symbiosis between soil biota and the grown plants **(Majeed *et al.*, 2018)**. In such relations, plants get carbon from air **(Allen *et al.*, 2020)** and release it in soil in the form of exudates to stimulate soil biota **(Badri and Vivanco, 2009)**. This biota may utilize different organic sources to build up SOC **(Abdelhafez *et al.*, 2018)**, including exudates to increase residual SOC. The combined treatments between organic manures (compost and biogas) and inorganic-N gave higher significant increases in soil residual organic carbon than the treatments that received 100% humic or fulvic acid. These results confirm that the most resistant organic amendments are not always recommended to increase the residual organic carbon in soil. Inducing microbial activities might be the optimum solution for increasing C sequestration in soil while lessen global warming threat. Using managed organic input, as a technique for fulfilling the requirements of N is probably more preferable than using the traditional organic amendments that resist microbial degradation such as humic substances or biochars **(Abdelhafez *et al.*, 2017; Bassouny and Abbas, 2019; Abdelhafez *et al.*, 2020)**. Further studies are needed in this concern.

Results also reveal that the residual organic carbon significantly varied between the two soils of study (calcareous vs the non-calcareous one) (F=567.363, P<0.001). This might occur because SOC is somewhat higher in the calcareous soil than in the non-calcareous one (see Table 1). The combination between the three factors were of significant effect on ROC (F=8.425, P<0.001). The highest increases in this concern occurred in the calcareous soil amended with biogas manure, which recorded approximately 4.5 folds higher ROC than the control treatment.

Effect on Cation exchange capacity (CEC)

Analysis of variance revealed that the values of soil CEC did not significantly change between the two soils of study (F=1.611, P=0.210) or even due to the source of organic amendment (F=0.952, P=0.333). However, soil CEC varied significantly in soil according to the type of the organic treatment (F=4.283, P<0.001). In this concern, the organic amendment, when applied solely or in the combinations between FA/HA and mineral fertilizers, the highest CEC values were detected with no significant variations among these treatments (Table 6). Probably, humic acids (HAs) coated soil minerals **(Ghabbour *et al.*, 2004)** and exhibited many functional acidic groups e.g. carboxylic acids, carbonyl groups and phenolic hydroxyl groups that increased soil CEC **(Hankins *et al.*, 2006; Majzik and Tombácz, 2007; Rashid *et al.*, 2017)**. The combination between these three factors were of significant effect on soil CEC (F=2.814, P=0.018).

Table 6. Residual organic carbon and cation exchange capacity (CEC) of the sandy non-calcareous and calcareous soils under study as affected by the application of organic and mineral fertilizers, either solely or in different combinations (Treatments from T_0 to T_6: see Table 4)

	Non-calcareous soil		Calcareous soil	
Treatment	Biogas manure	Compost	Biogas manure	Compost
		Residual organic carbon, g kg^{-1}		
T_0	2.20±0.58^{i}	2.20±0.58^{i}	4.76±0.30^{g}	4.76±0.30^{g}
T_1	7.31±0.19^{b-d}	5.92±0.25^{ef}	9.98±0.30^{a}	3.90±0.20^{a}
T_2	3.72±0.20^{gh}	8.00±0.48^{b}	7.60±0.60^{bc}	3.70±0.17^{bc}
T_3	3.71±0.59^{gh}	3.31±0.55^{hi}	5.86±0.41^{f}	4.90±0.48^{f}
T_4	3.19±0.45^{hi}	3.48±0.31h	7.31±0.38^{b-d}	5.30±0.49^{b-d}
T_5	3.25±0.27^{hi}	3.71±0.42^{gh}	7.02±0.28^{b-e}	3.80±0.45^{b-e}
T_6	3.07±0.31^{hi}	3.31±0.24^{hi}	6.67±0.34^{c-f}	4.20±0.52^{c-f}
		Cation exchange capacity (CEC)		
T_0	14.7±1.5^{a-e}	14.7±1.0^{a-e}	12.5±1.1^{e}	12.5±1.5^{e}
T_1	15.0±1.2^{a-e}	15.6±1.8^{a-d}	12.0±1.6^{e}	15.0±1.7^{a-e}
T_2	14.5+1.9^{b-e}	15.5±1.9^{a-d}	16.7±1.6^{a-c}	13.8±1.7^{c-e}
T_3	17.0±1.0^{ab}	16.3±1.3^{a-c}	16.7±1.5^{a-c}	13.8±1.0^{c-e}
T_4	16.5±0.8^{a-c}	12.7±1.0^{de}	17.5±0.8^{a}	14.9±1.2^{a-e}
T_5	12.1±1.2^{a-c}	16.1±1.1^{a-c}	16.2±1.8^{a-c}	14.3±1.1^{b-e}
T_6	15.6±0.7^{a-d}	17.2±1.7^{ab}	15.7+1.6^{a-c}	16.0±1.6^{a-c}

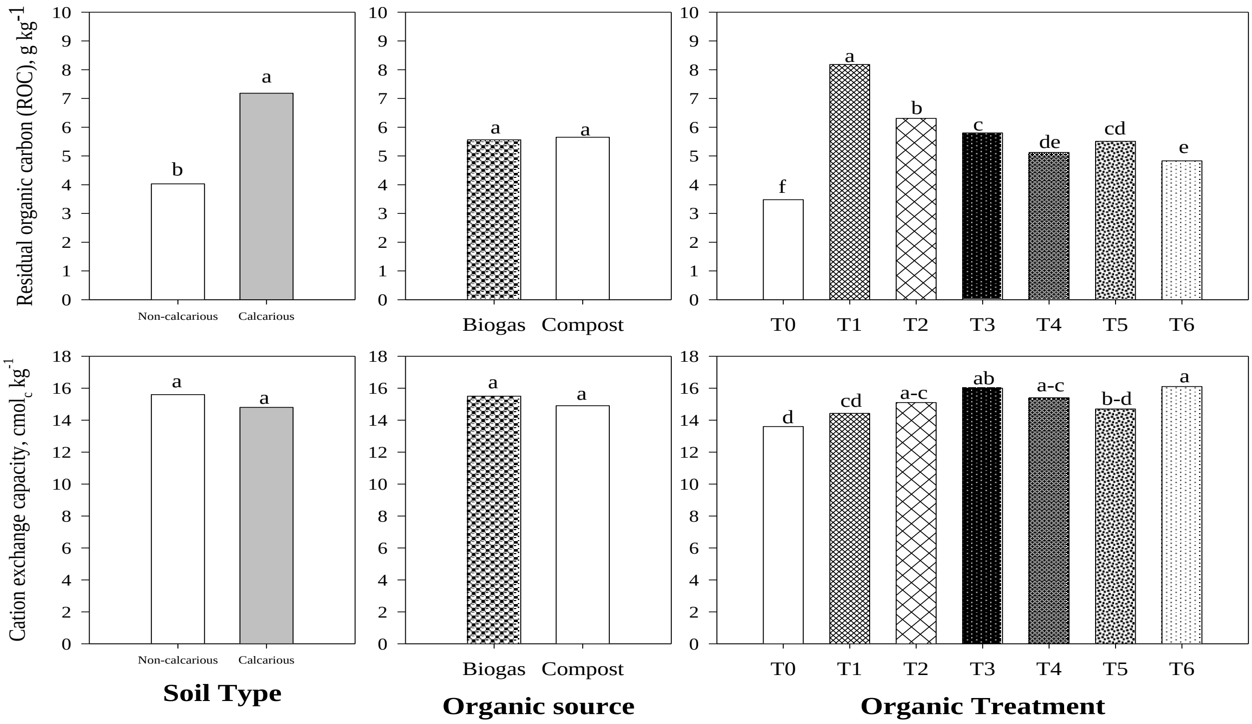

Fig. 2. Grand means of residual organic carbon and CEC of the sandy soils under study as affected by organic and mineral-N fertilizers, applied either solely or in different combinations treatments (Treatments from T_0 to T_6: see Table 4).

Soil pH

Soil pH did not change significantly owing to the source of organic amendment (F=0.008, *P*=0.929). Likewise, organic treatments recorded no significant effect on soil pH (F=0.253, *P*=0.956). These results did not agree with the findings of **Mahmood *et al.* (2017)** who indicated that application of organic amendments, regardless of their nature, significantly decreased soil pH. On the other hand, results obtained herein indicate that the pH values significantly varied between the two soils of study (F=7.850, *P*=0.007). This is probably due to the hydrolysis of calcium carbonate in the calcareous soil which accounted for such increases in soil pH according to the equation suggested by **Al-Busaidi and Cookson (2003)**.

$$CaCO_3(\text{calcite}) + 2H^+ \leftrightarrow Ca^{2+} + CO_2 + H_2O$$

Interactions among the investigated three factors were also of no significant effect on soil pH (F=0.883, *P*=0.513). These results sound reasonable in the calcareous soil where soil resist acidification according to **Zhang et al. (2016)**; however, in the non-calcareous soil which is characterized by its low buffering capacity **(Fest *et al.*, 2005)**, some other factors may contribute to increase soil buffering capacity in our case. Probably, mineralization of soil organic matter neutralized most of soil acidity **(Fujii *et al.*, 2017)**.

Soil EC

Soil EC was significantly affected by each of the investigated organic sources (F=4.758, *P*=0.033) and soil type (F=43.959, *P*<0.001) as well as the organic treatment (F=3.538, *P*=0.005). The values of EC obtained in the calcareous soil were higher than the corresponding ones of the non-calcareous one (Table 7). Application of the organic amendments significantly decreased soil EC, except for the application of HA and FA acids, which gave significant increases in soil EC when compared with the non-amended control. The increases in soil EC owing to the application of these organic acids were more pronounced with the application of compost rather than biogas manure. This might occur because of the mineralization of soil nutrients during organic matter decomposition **(Abdelhafez *et al.*, 2018)** and these nutrients were probably chelated in soluble forms **(Elshony *et al.*, 2019)**; thus soil EC increased significantly. Moreover, the EC values due to application of compost and its extracts were relatively higher than the corresponding values attained due to the biogas manure and its extracts. Interactions among the studied three factors were also of highly significant effect on soil EC (F=4.189, *P*=0.002). The highest increases in soil EC were attained in the calcareous soils amended with FA which was originated from biogas manure; while the lowest value was obtained in the same soil due to the application of biogas manure to satisfy 100% of N-needs.

Table 7. Soil pH and EC as affected by application of organic and mineral fertilizers, either solely or in different combinations (Treatments from T_0 to T_6: see Table 4)

	Non-calcareous		Calcareous soil	
	Biogas manure	Compost	Biogas manure	Compost
	Soil pH			
T_0	7.65±0.68^{a}	7.65±0.63^{a}	8.20±0.46^{a}	8.20±0.44^{a}
T_1	7.94±0.90^{a}	7.56±0.81^{a}	8.15±0.42^{a}	7.46±0.55^{a}
T_2	7.83±0.68^{a}	8.01±0.76^{a}	8.27±0.92^{a}	8.36±0.67^{a}
T_3	7.56±0.90^{a}	8.00±1.02^{a}	8.43±0.55^{a}	8.07±0.65^{a}
T_4	8.02±0.59^{a}	7.86±0.40^{a}	8.19±0.63^{a}	8.34±0.47^{a}
T_5	8.03±0.75^{a}	6.74±1.39^{a}	8.31±0.40^{a}	8.25±0.57^{a}
T_6	7.44±1.21^{a}	8.45±0.46^{a}	8.23±0.42^{a}	8.00±1.02^{a}
	Soil EC (dS m^{-1})			
T_0	0.48±0.10^{d-h}	0.48±0.02^{d-h}	0.78±0.05^{cd}	0.78±0.06^{cd}
T_1	0.49±0.03^{d-h}	0.67±0.04^{c-g}	0.42±0.45^{h}	0.75±0.26^{c-f}
T_2	0.73±0.04^{c-g}	0.47±0.15^{d-h}	0.77±0.02^{c-e}	0.50±0.09^{d-h}
T_3	0.46±0.13^{f-h}	0.49±0.15^{d-h}	0.65±0.10^{c-h}	1.26±0.12^{a}
T_4	0.38±0.12^{h}	0.47±0.09^{d-h}	0.77±0.07^{c-e}	0.75±0.10^{c-f}
T_5	0.46±0.06^{f-h}	1.16±0.08^{ab}	0.66±0.11^{c-h}	0.73±0.08^{c-g}
T_6	0.64±0.13^{c-h}	0.44±0.22^{gh}	1.16±0.26^{ab}	0.91±0.08^{bc}

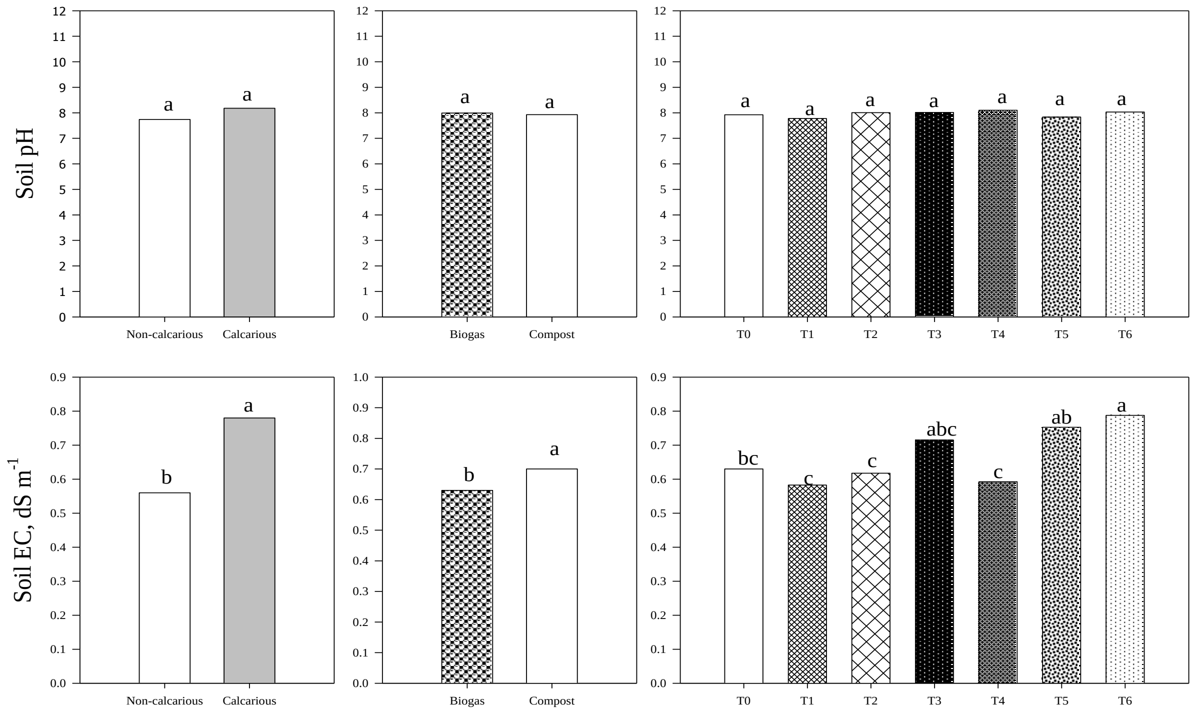

Fig 3. Grand means of soil pH and EC of the sandy non-calcareous and calcareous soils as affected by the application of organic and mineral fertilizers, either solely or in different combinations (Treatments from T_0 to T_6: see Table 4)

Effect of organic amendments and their extracts on soil biota

Total counts of bacteria

Analysis of variance revealed that the source of the organic amendment (F=50.148, *P*<0.001) as well as the different organic treatments (F=19.960, *P*<0.001) had significant effects on total bacterial counts in soil while these counts did not significantly vary (F=2.873, P=0.096) between the two soils under investigation. Although, the total bacterial count was higher due to compost manure than due to biogas manure; nevertheless, the organic carbon content was higher in biogas manure than in compost (see Table 2). Also, biogas manure exhibited higher C/N ratio than compost. Thus, the total bacterial counts were higher in soils that received biogas manure than those received compost (Fig.4). This carbon is used by soil biota as a source of energy **(Farid *et al.*, 2018; Mohamed et al., 2021)**. Concerning the effect of the organic treatments, it was found that HA and FA treatments exhibited the highest increases in the total bacterial counts. On the other hand, no significant effects were found for the combination among these three factors on total bacterial counts in soil (F=1.035, P=0.413) and the means of the studied treatments are shown in Table 8.

Total counts of fungi:

Table 8 and Figure 4 reveal that the total counts of fungi did not vary significantly between the two soils (calcareous vs non-calcareous) under investigation (F=0.058, P=0.811); yet fungal counts were higher in soils amended with organics originated from biogas manure than the corresponding ones originated from compost (F=165.6, P<0.001). Such increases might be attributed to the relatively higher contents of organic matter in biogas manure than in compost (see Table 2), which accelerated fungal growth. Fig 3 also shows that the organic treatment that induced the highest fungal growth was 50% HA, followed by FA treatments (100% and 50%). The combination among the studied three factors recorded further significant effects on fungal counts in soil (F=2.625, P=0.026). In this concern, the highest increases were recorded in, whether the non-calcareous or calcareous soils, amended with HA originated from biogas manure. Generally, total bacterial and fungal counts were higher in soils amended with the different organic amendments than those not amended with organic manures or their extracts. These biota increased soil capacity to do many beneficial ecosystem roles **(Moreno-Cornejo *et al.*, 2014)**.

Table 8. Total counts of bacteria and fungi in soil as affected by organic and mineral fertilizers, applied either solely or in different combinations

	Non-calcareous soil		Cal carious soil	
Treatment	Biogas manure	Compost	Biogas manure	Compost
		Total bacteria		
T_0	35.0±5.8^{h-j}	35.0±5.8^{h-j}	34.0±3.0^{ij}	34.0±2.95^{ij}
T_1	50.0±1.9^{b-e}	42.0±2.5^{e-i}	55.0±3.8^{abc}	39.0±2.0^{g-j}
T_2	39.0±4.5^{g-j}	31.0±2.8^{j}	44.0±3.9^{d-h}	37.0±3.8^{h-j}
T_3	56.0±2.0^{ab}	35.0±4.8^{h-j}	60.0±2.9^{a}	49.0±1.7^{b-f}
T_4	49.0±2.7^{b-f}	42.0±4.2^{e-i}	57.0±2.8^{ab}	53.0±4.5^{abc}
T_5	54.0±9.5^{a-c}	41.0+2.7^{f-i}	49.0±1.7^{b-f}	38.0±3.8^{h-j}
T_6	47.0±3.1^{c-g}	51.0±2.4^{bd}	40.0±3.4^{g-i}	42.0±5.2^{e-i}
		Total fungi		
T_0	18±3.7^{hi}	18±3.7^{hi}	26±1.3^{g}	26±1.2^{g}
T_1	38±1.4^{c-f}	21+3.0^{gh}	33±3.7^{f}	18±2.6^{hi}
T_2	43±4.8^{bc}	19±3.2^{ghi}	38±3.7^{cdef}	12±3.1^{i}
T_3	40±4.5^{b-e}	20±2.8^{gh}	51±2.9^{a}	15±1.8^{hi}
T_4	46±3.1^{ab}	41±2.7^{bcde}	47±4.5^{ab}	39±4.2^{c-f}
T_5	41±6.0^{b-e}	34±3.3^{ef}	44±5.8^{abc}	41±3.0^{b-e}
T_6	39±4.4^{c-f}	42±3.0^{bcd}	37±4.1^{c-f}	35±5.6^{d-f}

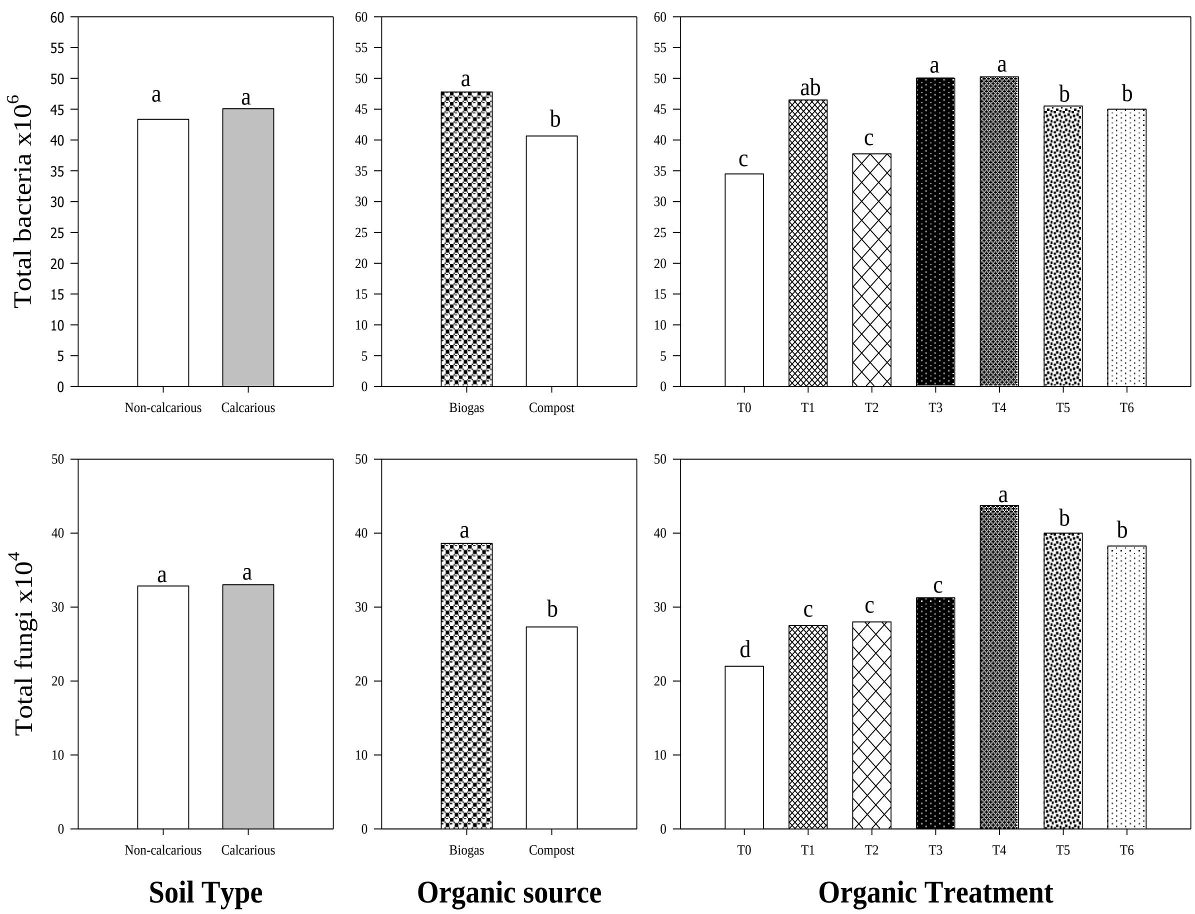

Fig.4. Grand means of total bacterial and fungal counts in sandy non-calcareous and calcareous soils as affected by organic and mineral-N fertilizers, applied either solely or in different combinations (Treatments T_0 to T_6: see Table 4).

Conclusion

Application of organic amendments and their extracts (HA and FA) recorded positive impacts on both soil chemical characteristics (except for soil pH) and soil biota on the short run; yet, their effects were not detectable on soil bulk density. In this concern, humic substances recorded more positive consequences on soil biota and the chemical characteristics of the studied sandy soils (calcareous and non-calcareous ones) than the organic sources of these extracts did. On the other hand, the organic sources could stimulate soil biota to build up higher soil organic carbon contents beyond those retained after the application of the humic substances. The above findings support partly the first and the second hypotheses which indicate that organic amendments have positive impacts on soil biota which may in turn improve soil chemical characteristics. It seems that physical changes are potentially related to long term microbial activities and their byproducts.

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التداعيات قصيرة الأجل لإضافة أنواع مختلفة من المحسنات العضوية ومستخلصاتها للأراضي الرمليه(الجيريه والغير جيريه) علي النشاط الحيوي، والخواص الطبيعية والكيميائية للتربه

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[1]قسم الأراضي والمياه- كلية الزراعة- - جامعة بنها- مصر.

[2] قسم الميكروبيولوجيا الزراعية- معهد بحوث الأراضى و المياه و البيئة- مركز البحوث الزراعية- الجيزة- مصر.

تعتبر إضافة المواد العضوية إلي أراضي المناطق القاحلة وشبه القاحلة ذات تأثير ايجابي على كل من خصائص التربة ونشاط الكائنات الحية النامي بها، مع العلم أن معدلات تحلل هذه المركبات العضوية في هذه المناطق مرتفعة ، أما إضافة المواد الدبالية، والتي تعتبر مواد عضوية أكثر مقاومة للتحلل البيولوجي ، قد ينتج عنها تأثيرات أفضل على كل من خواص التربة والكائنات الحية الموجودة بها في المدى القصير، وللتحقق من صحة هذه الفروض، فإنه أجريت تجربة اصص بإستخدام نوعين من أنواع الاراضي الرملية، احداها جيريه والاخر غير جيريه، وتم معاملة هذه الاراضي بمواد عضوية (سماد البيوجاز والكمبوست) بجانب مستخلصاتهما (حمض الهيوميك (HA) وحمض الفولفيك(FA))، وذلك بمعدل 36 كجم نتروجين/للهكتار، والتي تكافؤ الجرعة الجرعة التنشيطية الموصي بها لنبات الفول، وقد شملت التجربة ايضا معاملة الكنترول والتي تمت اضافة النتروجين اليها علي صورة كبريتات امونيوم، ثم تمت زراعة الاصص ببذور الفول الملحقه بالعقدين لمدة 80 يومًا، وكان تصميم التجربة تام العشوائية، وخلصت النتائج إلى أن الاضافات العضوية قد حفزت من العدد الكلي للبكتيريا والفطريات النامي في التربة، كما احدثت هذه المعاملات زيادة معنوية في قيم ملوحة التربة EC والسعة التبادلية الكاتيونية CEC، بينما لم يظهر تأثير هذه المعاملات على أي من الكثافة الظاهرية للتربة أودرجة حموضتها، واظهرت النتائج ايضا ان اضافة المستخلصات العضوية فد احدثت زيادات اكبر في اعداد البكتريا والفطريات عن تلك المتحصل عليها في حالة اضافة المحسنات العضوية نفسها، كما احذت تغيرات افضل في خواص التربة عن المتحصل عليها في حالة اضافة المحسنات العضوية نفسها، إلا أن كمية الكربون المتبقية في التربة بعد نهاية التجربة كانت أعلي في حالة اضافة المحسنات عن مستخلصاتها، ومما سبق يتضح أن الاضافات العضوية جميعها قد أحدثت تأثيرات ايجابية علي خواص التربة الكيميائية علي المدي القصير، خاصة مستخلصات الاسمدة العضوية، بينما كانت الخواص الطبيعية مرتبطة في الغالب بالأنشطة الميكروبية طويلة المدى.