Asian Journal of Advances in Agricultural Research

12(2): 24-34, 2020; Article no.AJAAR.54606
ISSN: 2456-8864

Soil Physicochemical Properties Variation in Black Soil after the Long-term Application of Different Organic Amendments

Yaa Opoku-Kwanowaa[1], Jinggui Wu[1*], Xiaodong Chen[1], Ahmed Sharaf[1] and Sonny Gad Attipoe[2]

[1]College of Resources and Environment Sciences, Jilin Agricultural University, Changchun 130118, People's Republic of China.
[2]Department of Management, Faculty of Agricultural Economics and Management, Jilin Agricultural University, Changchun 130118, People's Republic of China.

Authors' contributions

This work was carried out in collaboration among all authors. Author JW supervised the study, designed the study, conceptualization, fund and resources acquisition. Author YOK wrote the protocol, data curation and validation and also wrote the first draft of the manuscript. Author XC managed the software and formal analysis. Author AS performed the statistical analysis and data curation. Author SGA managed the literature searches and final editing and review of the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJAAR/2020/v12i230079
Editor(s):
(1) Dr. Ali E. Sharief, Professor, Department of Agronomy, Faculty of Agriculture, Mansoura University, Mansoura, Egypt.
Reviewers:
(1) Paola Taydé Vázquez Villegas, Instituto Tecnológico Superior de Cintalapa, México.
(2) Ningappa M. Rolli, BLDEA's Degree College, India.
Complete Peer review History: http://www.sdiarticle4.com/review-history/54606

Original Research Article

Received 01 December 2019
Accepted 05 February 2020
Published 13 February 2020

ABSTRACT

Aims: This research aimed to assess how the physicochemical properties of black soil respond to different organic amendments after 10 years of application.
Study Design: The experiment was established in 2010 and followed a randomized block design consisting of 24 plots (5 m × 5 m) 25 m^2 with eight treatments in three replicates.
Place and Duration of Study: The study site was located at the Jilin Agricultural University Research Farm, Northeast China (43°48′ N, 125°23′ E; km).
Methodology: The treatments for the study included an annual input of chemical fertilizer and organic amendments at the surface of the soil. The treatments were: Control (CK), chicken manure

**Corresponding author: Email: wujingguiok@163.com;*

(JM), fodder grass (FG), mushroom (MS), maize straw (MZ), tree leaf (TL), pig manure (PM) and cow manure (CM). Chemical fertilizers were added at the rate of 165 kg of N, 82.5 kg of P and 82.5 kg of K ha_1 per year. Application rates of organic materials were adjusted to similar amounts of organic matter (2000 kgha−1). In June 2019, soil samples were collected from each of the amended fields. In each field, three sampling points were randomly selected. Soil samples were collected from the 0 – 20 cm depth using a core sampler then taken to the laboratory for soil physicochemical properties analysis.

Results: Comparing the results of the organic treatments with CK, bulk density decreased by 5.6-18.0% while porosity, EC, pH, total N and SOC significantly increased in the organic treatments by 6.0-25.9%, 8.3-25.0%, 0.52-1.7%, 2.7-54.7% and 1.3-18.4% respectively. The textural class of soil under the different treatments did not change however, the distribution of soil particle size varied among the treatments, where high clay and silt content were recorded in the amended fields. Moreover, the application of different organic materials significantly affected the soil aggregate stability and this was attributed to the increase in organic matter content which accelerated important microbial activities in the soil to improve aggregation. At higher suction potentials, higher water contents were recorded in the organic amended fields mainly due to the improved physical properties of the soil.

Conclusion: The study results showed that the application of organic amendments greatly improves the physical and chemical properties of black soil. Therefore, using these organic amendments can serve as an effective strategy to enhance soil quality and fertility.

Keywords: Black soil; physicochemical properties; organic amendments; organic matter.

1. INTRODUCTION

Due to the increase in the human population, there have been several ways to protect natural resources and also use them in a manner that will ensure sustainability. Soil happens to be one of the important resources that need to be used sustainably. This is because it forms the basic material that supports plant life [1]. In order to be able to feed the increasing population, soils are subjected to huge stress ranging from fertilizer application, use of machinery, etc [2]. The effects of these stress are usually manifested through the physicochemical properties of the soil. The fertility and productivity of the soil usually depend on these physical and chemical properties.

According to Cooperband [3], the soil is made up of four primary components: mineral matter, air, water, and organic matter whereby each component plays a special function in the soil. However, soil organic matter is generally considered to be a line that combines the biological, chemical and physical properties of soil to promote soil fertility. It is related to many soil functions such as water retention and drainage, nutrient cycling, disease control, erosion control and pollution restoration [3]. Intensive agricultural systems have degraded soils by decreasing soil organic matter which in turn reduces soil fertility and increases soil erosion [4]. Several techniques have been developed to enhance soil organic matter since it plays a very important role in enhancing the properties of the soil. Soil physicochemical properties are highly dependent on the quantity and quality of organic matter in the soil [5,6]. For the past decades, soil organic amendment has been used to circumvent the loss of the organic matter in the soil since it has been proven to be an effective method for improving soil organic matter content [6]. It has been shown in previous studies that the use of organic materials as organic fertilizers serves as an effective way to manage agricultural waste which also improves the chemical, physical, and biological properties of the soil to promote the growth of plants [3,7,8].

Soil physicochemical properties form an important aspect of the soil since it determines the suitability of the soil for its planned use [9]. Also, the productivity and health of soil usually depend on its physicochemical properties [10]. The study site was set up in 2010 and the soil type is black soil. The black soil is characterized by its high fertility hence serves as the most important grain production area in China [11]. Amidst the high fertility of the soil, studies have reported that intensive agricultural production has led to a depletion of the black soil [8,12] however no study has been conducted to ascertain how the physicochemical properties of the black soil are affected by organic amendments application. The physical and chemical properties of soils are important indicators for assessing soil quality [13].

Therefore, understanding the beneficial relationship between soil organic amendments and the physicochemical properties of the black soil is very imperative in this era of soil degradation. This knowledge will, therefore, help practitioners and farmers to understand the appropriate organic amendment that will improve the productivity and health of their farm soils. We hypothesize that the application of organic amendments can improve soil physicochemical properties. The aim of this study is to determine how different organic amendment application affects the physicochemical properties of the soil.

2. MATERIALS AND METHODS

2.1 Study Site

The study site was located at the Jilin Agricultural University Research Farm, Northeast China (43°48′N, 125°23′E; km). The soil in the area was classified as Udic Mollisol according to the international soil taxonomy classification). The area has a typical continental temperate monsoon climate and the cumulative temperature (≥10C) is about 2950–3500°-days (C). The average precipitation is about 500–600 mm per year.

2.2 Experimental Design

The experiment was established in 2010 and followed a randomized block design consisting of 24 plots (5 m × 5 m) 25 m^2 with eight treatments in three replicates. The treatments for the study included an annual application of chemical fertilizer and organic amendments at the surface layer of the soil (0-20 cm). Table 1 shows the chemical composition of the seven organic amendments used in this study. The treatments were: control (CK), chicken manure (JM), fodder grass (FG), mushroom (MS), maize straw (MZ), tree leaf (TL), pig manure (PM) and cow manure (CM). Chemical fertilizers were added at the rate of 165 kg of N, 82.5 kg of P and 82.5 kg of K ha^{-1} per year. Application rates of organic materials were adjusted to similar amounts of organic matter (2000 kgha−1).

2.3 Soil Sampling

In June 2019, soil samples were taken from each of the amended fields. In each field, three sampling points were randomly selected. Soil samples were collected from the 0–20 cm depth using a core sampler then taken to the laboratory for soil physicochemical properties analysis.

2.4 Soil Laboratory Analysis

Soil compaction was evaluated using the bulk density of soil samples. The bulk density of the soil samples was analyzed on undisturbed samples which were collected using the core sampling method as described by [14] Using this method, soils were sampled or collected by drilling the core sampler into the soil. The core samples collected were oven-dried and the bulk densities were calculated by dividing the masses of the oven-dry soils by their respective volumes. The volumes will be determined by the volume of the core sampler used for the sampling.

Bulk density (BD) of the soil was calculated as;

$$\frac{mass\ of\ oven\ dry\ soil(g)}{volume(cm^3)}$$

Soil porosity was determined from soil particle density and bulk density using the Army, U.S. [15] equation shown below;

$$\text{Porosity (pt)} = 1 - \frac{bulk\ density\ (pb)}{particle\ density(pd)} * 100\%$$

where particle density was estimated to be 2.66 g/cm^3.

The soil water characteristics curve was determined using the pressure plate extractor, where about 7 data points were acquired from the air-entry value (suction) and the remaining water content in the soil [16].

Table 1. Chemical properties of the organic amendments used in this experiment

Organic amendment	pH	Organic matter/ (g kg−1)	Total N/ (g kg−1)	Total P/ (g kg−1)	Total K/ (g kg−1)
Maize straw	6.42	493	8.33	1.12	12.34
Fodder grass	6.69	343.60	15.29	2.74	10.82
Mushroom	7.09	248.79	11.27	1.78	7.26
Chicken manure	8.03	240.11	17.07	8.79	14.09
Cow manure	7.27	302	13.9	3.60	8.32
Pig manure	7.63	268.91	21.18	8.79	14.09
Tree leaf	6.14	371	9.91	1.02	4.05

The soil particle size distribution was determined following the hydrometer method [17]. Soil aggregate stability was determined by two methods; wet sieving and dry sieving methods [18,19]. In the dry sieving method, 500 g of soil was placed on topmost of a nest of seven flat sieves of mesh sizes 10, 7, 5, 3, 2, 1, 0.5, 0.25 and shaken for 5 min. The shaking and vibratory movement of the sieves was achieved mechanically using a dry-sieving machine having two rotors rated 0.18kW each, 1450r/min and vibration distance of <5 mm (soil dry pellet analyzer, model DM185, Chinese model). Prior to sieving, the nest of sieves together with a collection pan of the same size was placed beneath the nested sieve and held in place with a tight lid over the topmost sieve, to prevent no loss of soil particles during the sieving.

$$\text{MWDd} = \sum_{i=1}^{n} \text{Xi di}$$

Where MWDd = Mean-Weight Diameter of dry aggregates (mm), X = Mean Diameter of each size fraction (mm), di = proportion of total sample weight occurring in the corresponding size fraction.

In the wet sieving method, soil samples were separated into size fractions by hovering the nest of sieves (up and down movement) in a pool of water [18,20]. In this procedure, 50 g of soil from the different treatments was placed on the uppermost nest of the six flat sieves with sizes 5, 3, 2, 1, 0.50 and 0.25 mm. The sieves were lifted and lowered in the water with an amplitude of 4cm, and there were 35 of such oscillations per min. Prewetting was done by allowing the base of the topmost sieve to slightly touch the water level, such that the wetting was through sorption. Thereafter, the sieves were completely plunged in water for 5min, followed by manual oscillation for 1 min. Soil aggregates that were resistant to breaking (water-stable aggregates, WSAs) remained on the sieves. The aggregates were oven-dried at 105°C for 16.5 h to determine their weights.

$$WSA = \sum_{i=1}^{n} x_i w_i$$

Where WSA=weight of water-stable aggregates, I = each size fraction, n = the number of the different size fractions, w = [weight of a given size fraction/total weight of soil (50 g)]*100%.

Soil pH and electrical conductivity (EC) were determined by using a pH meter and EC meter respectively. Soil total nitrogen (TN) and soil organic carbon (SOC) were respectively determined using the Kjeldahl method [21] and the $K_2Cr_2O_7$ external heating method [22].

2.5 Statistical Analysis

Data on soil physicochemical properties under the different organic amendments were collected. The data were subjected to statistical analysis using ANOVA (Analysis of Variance). Duncan's new multiple range tests were used for multiple comparisons to compare treatment means to test their significance in variation. All data analysis was done using Microsoft Excel 13.0 and SPSS 17.0. Results were presented in tables and graphs.

3. RESULTS AND DISCUSSION

Table 2 shows the effect of the different treatments on bulk density, porosity, electrical conductivity, pH, soil particle size distribution (percentage of clay, sand, and silt), total nitrogen and Soil Organic Carbon (SOC).

3.1 Soil Bulk Density and Soil Porosity Variation under the Different Organic Amendments

The results showed that the application of organic amendments reduced the bulk density (BD) of the soil compared with the control. Among the organic amended fields, the BD of treatments JM, FG, TL, MZ and MS were lower but had no significant difference between them ($P < .05$). The highest BD was recorded in the control and the lowest was recorded in treatment FG. Some research works have proved that soil physical fertility is mainly improved by the addition of organic amendments which increases aggregate stability and decreases soil bulk density [23,24]. Hence Akgül and Özdemir [25] suggested that due to the importance of bulk density it can serve as a suitable indicator of soil quality assessment. The findings of this study showed that the amended fields recorded the lowest bulk densities compared with the control which had no organic amendment. The lower bulk density values recorded in the amended fields can mainly be attributed to the increased organic matter content in the soil. This is due to the fact that the addition of organic amendments improves the organic matter content of the soil thereby resulting in a reduction of the bulk density of the soil. This observation was consistent with the findings of Gardner et al. [26], Wang et al. [26] and Tejada et al. [27] who all reported a decrease in soil bulk density after the application of organic amendments.

Due to the inverse proportional relationship between bulk density and porosity, in most studies, a decrease in bulk density caused a rise in porosity [28,29,30]. Similar results were recorded for soil porosity, where the lowest porosity was observed in the control and the highest was observed in treatment FG. Also, the porosity of treatments JM, FG, TL, MZ, and MS were higher but had no significant difference between them (P < .05). In this study, the addition of organic amendments significantly increased the porosity of the soil. This could be attributed to the lower intrinsic density of organic material compared to mineral soils, which reduces the dry bulk density of soils receiving organic amendments thereby increasing the total porosity of the soil [28]. This result was consistent with past studies such as Pagliai and Vittori [31] and Pérès et al. [32], who also reported similar findings.

3.2 Effects of Different Organic Amendments on Soil Water Characteristics

Fig. 1 shows how the different organic amendments affected the water retention curves of the soils. At higher suctions, the highest water content was recorded in TL (44%) whiles the lowest was recorded in CK (18%). Throughout the incubation period, the water content reduced with an increase in suction however at 200 kPa, the water content increased for all the treatments with the exception of treatment PM. After 200 kPa, the water content subsequently reduced when the suction range was increased (Fig. 1). The soil-water characteristic curve helps to determine the infiltration rate of the soil and its ability to store and release water for plants' use [33]. The high water content in the organic amended fields at higher suction potentials can be attributed to the potential ability of the organic materials to improve aggregates stability, increase the porosity of the soil and decrease the bulk density thereby creating more pores for water storage [34]. Previous studies have reported that, various factors including the pore size distribution, organic matter content, and the soil bulk density influence the soil water retention characteristics [35,36,37].

3.3 Soil Particle Size Distribution under the Different Organic Amendments

The soil particle size distribution varied significantly comparing the other treatments to CK (P < .05) however in all the fields, the textural class was clay-loam. The soil particle size distribution was highly dominated by silt and clay for the organic amended area with % sand being the lowest. An opposite trend was observed for the control whereby the % sand was higher with low % silt and clay. The % silt and clay in the organic amended fields were between 31.40-40.11% and 34.07-39.1% respectively, which was higher than that of the control while the %sand in the control was 35.76% which was also higher than the organic amended fields. Aydinalp [38] and Ghiberto et al. [39] have reported that generally, the particle size distribution of mollisols follows an ascending order of sand, clay, and silt. Thus, usually, the %silt and clay are higher than sand. High silt or clay content and low sand content are characteristic of the soil matrix of Mollisols. In the current study, the particle size distribution among the various treatments did not vary from that of a typical mollisol and the textural class for all the treatments was clay-loam. This is because soil particle size distribution forms one of the properties of soil which takes a long time to change with soil management practices [40]. The high silt and clay content in the organic amended fields could be a result of the high organic matter content in mollisols which causes clay and silt particles to bind to organic matter due to their mineralogy and surface charge properties [41,42]. The high clay and silt contents of the organic amended soils are also attributed to the high CEC with the organic matter found in the amendments [38].

3.4 Variation of Aggregate Stability under the Different Organic Amendments

From the results in Table 3, the different organic amendments affected soil aggregate stability differently. The water-stable aggregates for the organic material treatments were significantly higher compared with CK, with the exception of treatment PM which was higher than CK but had no significant difference (P < .05). The highest water-stable aggregates were recorded in MS while the lowest was recorded in CK. For the dry aggregate stability, although the recorded values for all the treatments ranged between 91-92.3%, however, the dry aggregate stability for the organic material treatments were significantly higher compared with CK (P < .05). In all, the organic material treatments improved the dry aggregate stability and water-stable aggregates by 0.21-1.1767% and 2.26-19.84% respectively. The MWDd and WSA values varied significantly

Table 2. Summary of results

Treatments	Bulk density (g/cm^3)	Porosity (%)	Electrical conductivity (mS/cm)	pH	% Clay	% Sand	% Silt	Total N g kg−1	SOC g kg−1
CK	1.55^{a} ±0.01	41.66^{d} ±0.45	0.12^{b} ±0.00	5.70^{c} ±0.01	31.00^{c} ±0.90	35.76^{a} ±1.02	33.23^{bc} ±0.42	0.73^{d} ±0.00	19.84^{e} ±0.33
PM	1.38^{c} ±0.02	47.96^{b} ±0.83	0.14^{ab} ±0.00	5.75^{b} ±0.00	38.94^{a} ±0.80	29.65^{b} ±0.78	31.40^{c} ±0.58	1.10^{ab} ±0.04	21.11^{cde} ±0.82
JM	1.28^{d} ±0.02	51.65^{a} ±0.75	0.13^{b} ±0.00	5.76^{ab} ±0.01	37.97^{a} ±0.75	28.34^{bc} ±1.06	33.67^{bc} ±1.21	1.13^{a} ±0.10	20.10^{de} ±0.43
MZ	1.28^{d} ±0.01	51.54^{a} ±0.59	0.13^{b} ±0.00	5.73^{b} ±0.01	34.07^{b} ±0.62	30.73^{bc} ±0.77	35.20^{b} ±1.05	0.86^{cd} ±0.01	22.63^{ab} ±0.55
MS	1.30^{d} ±0.02	50.51^{a} ±0.83	0.13^{ab} ±0.00	5.75^{ab} ±0.01	38.32^{a} ±1.23	25.92^{cd} ±0.14	35.32^{b} ±1.02	0.75^{d} ±0.01	21.36^{bcd} ±0.33
FG	1.27^{d} ±0.00	52.24^{a} ±0.33	0.15^{a} ±0.00	5.75^{b} ±0.01	37.41^{a} ±0.63	23.55^{de} ±0.48	39.03^{a} ±0.23	0.94^{c} ±0.03	22.25^{abc} ±0.25
CM	1.47^{b} ±0.01	44.66^{c} ±0.61	0.15^{a} ±0.00	5.80^{a} ±0.01	39.11^{a} ±0.60	28.59^{b} ±0.83	32.90^{bc} ±0.81	0.98^{bc} ±0.01	21.36^{bcd} ±0.33
TL	1.32^{d} ±0.01	50.31^{a} ±0.46	0.13^{b} ±0.00	5.70^{c} ±0.00	36.96^{a} ±0.80	22.92^{e} ±1.00	40.11^{a} ±0.24	0.98^{bc} ±0.03	23.51^{a} ±0.21

Note: values present are means and ±standard error. Different treatments in the same column followed by the same superscript for are not significantly different (P = .05) compared with the control. This was not consistent with the findings of Obalum et al. [43] where compost application and tillage did not influence the dry aggregate stability. The MWDd values for all the treatments ranged between 91-92.3% which generally implies that organic materials application was unlikely to influence wind erosion in the black soil since the soil aggregates from the different treatments were dominated by large particles (details not shown). However, the application of different organic materials significantly affected the soil dry aggregate stability. In addition, the high percentage of water-stable aggregates in the organic material treatments might be due to the increase in organic matter content which accelerated important microbial activities in the soil to improve aggregation [44]. Several studies such as Diacono and Montemurro [24], Annabi et al. [45], and Wang et al. [46] posited that the application of organic materials significantly improved soil aggregate stability.

3.5 The Variation of Soil pH and Electrical Conductivity under the Different Organic Amendments

Compared to the control, the pH of all the treatments varied significantly with the exception of treatment TL ($P < .05$). Among all the treatments the highest pH was recorded in the manure amended fields especially in treatment CM and the lowest was recorded in CK. This was due to the liming and buffering effect of CACO3 in cow manure [47,48]. Moreover, the nature of amendments affects the pH, thus if the applied amendment has a low pH, it will affect the pH of the soil and vice versa [49]. The high pH in the organic amended fields could have been due to any of the under mentioned mechanisms or combinations; proton consumption during the removal of carboxyl groups from the organic acids anions which occur during decomposition [50], proton consumption by functional groups associated with the organic materials [51] and the release of hydroxide ions from local anaerobic microsites during reduction reactions [52]. Similar results were reported by several authors [29,47,48]. Several studies have reported that the application of manure moves soil pH towards neutrality in alkaline and acidic soils thereby improving nutrient availability especially for phosphorus and other micronutrients [53,54]. This move towards neutrality favors plant growth and other beneficial microbial processes. Therefore, solid manure should be regarded not only as a source of nutrients but also as a beneficial soil conditioner [55].

Compared to CK, the EC of all the treatments varied significantly however, the EC of treatments MZ, JM and TL did not vary significantly compared with CK ($P < .05$). Among all the treatments highest EC was recorded in treatment CM and FG and the lowest was recorded in CK. Soil electrical conductivity (EC) is known to correlate with other soil properties including soil texture, cation exchange capacity (CEC), drainage conditions, organic matter level, salinity, and subsoil characteristics to directly affect crop productivity [56]. In the present study, the highest EC was observed in the amended fields. This may be due to the presence of saline ions in the organic amendments that were applied. The solubilization and mineralization processes that occur after the application of the organic amendments release soluble mineral nutrients that contain salt [57]. A similar result was reported by [34], who stated that there was an increase in soil EC after the application of biosolids. Also, manures are believed to contain salts due to the feed additives given to the livestock hence can increase soil EC when applied as a fertilizer [58].

3.6 Total Nitrogen and SOC under the Different Organic Amendments

Comparing all the treatments to CK the TN and SOC of all the treatments were significantly different ($P < .05$). Among all the treatments, the lowest TN and SOC were recorded in the control (CK) while the highest TN and SOC were recorded in JM and TL respectively. Among the organic amended fields, the TN and SOC of the treatments were significantly different with the exception of CM and TL which had no significant difference in TN content ($P < .05$). The application of organic amendments increased SOC content which is important for improving soil environment and promoting SOC storage [59]. The increase in SOC in the organic amended fields was attributed to the enhanced organic matter content with the addition of organic amendments. This enhances the soil structure to reduce the microbial degradation of organic materials [60]. Among the organic amendment treatments, TL recorded the highest SOC due to the higher lignin and polyphenols contents and higher lignin/N ratios in TL which reduces the rates of decomposition thereby increasing SOC accumulation in the soil [61]. Several studies

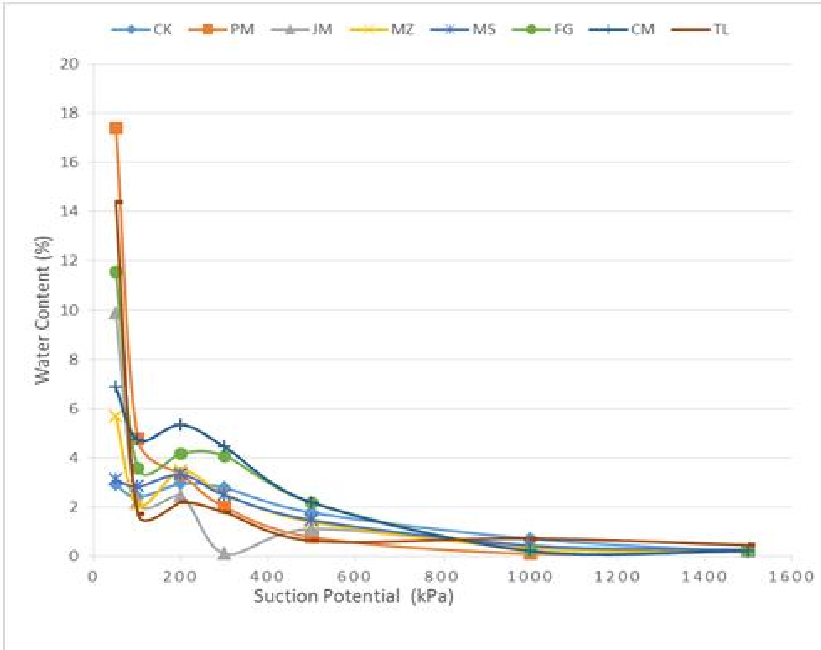

Fig. 1. Effects of organic amendments applications on soil water retention curves

Table 3. Aggregate stability analysis under the different organic amendments

Treatments	Wet aggregate stability % (WSA)	Dry aggregate stability % (MWDd)
CK	61.1000[d] (±1.33551)	91.0400[d] (±0.02022)
PM	63.3600[d] (±1.12907)	92.2167[a] (±0.15295)
JM	70.6467[c] (±0.57877)	91.2633[cd] (±0.07670)
MZ	70.5200[c] (±1.40627)	91.6810[b] (±0.04073)
MS	80.9467[a] (±1.50388)	91.2503[cd] (±0.12919)
FG	70.6133[c] (±1.19048)	91.5050[bc] (±0.13211)
CM	76.5200[ab] (±3.31888)	91.5783[b] (±0.04812)
TL	75.2200[bc] (±1.81960)	91.2650[cd] (±0.07461)

Note: Different treatments in the same column followed by the same superscript are not significantly different (P < .05). Numbers in parentheses are standard errors of the means

such as Fan et al. [8], Hu et al., [61] and Wu et al., [62] have reported similar results. TN also increased after the application of organic amendments compared with the control. This may be due to the initial high contents of nitrogen in the organic amendments. Similar results were reported by Frederickson et al. [63] and Oo et al. [30].

4. CONCLUSION

After studying the long-term effects of the organic amendment application on the physicochemical properties of soil, the results of this study showed that treatments that involved the application of organic materials significantly improved the physicochemical properties of the soil. This was mainly attributed to improved organic matter content. From the study, the different organic amendments had different effects on the physicochemical properties of the black soil. Comparatively, treatment FG highly improved most of the soil physicochemical properties tested in this study (BD, porosity, EC, and texture). As such, we recommend treatment FG as an effective treatment for ameliorating degraded soils in order to improve their quality and physicochemical properties. The findings of this study can help farmers, practitioners and managers to select appropriate organic amendments that will help to ameliorate degraded agricultural soil to promote socio-economic development. Further long term studies that go beyond 10 years can be carried out to know the long term effects of organic materials on soil properties.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Barreto R, Tsegaye T, Coleman TL, Shaffer D, Tadesse W. Land use effect on the distribution of soil physical and chemical properties under tropical rainforests of Puerto Rico. In IGARSS 2000. IEEE 2000 International Geoscience and Remote Sensing Symposium. Taking the Pulse of the Planet: The Role of Remote Sensing in Managing the Environment. Proceedings. 2000;5:1910-1914. (Cat. No. 00CH37120).
2. Stubenrauch J, Garske B, Ekardt F. Sustainable land use, soil protection and phosphorus management from a cross-national perspective. Sustainability. 2018; 10(6):1988.
3. Cooperband L. Building soil organic matter with organic amendments. Department of Soil Science and Center for Integrated Agricultural Systems, University of Wisconsin-Madison. 2002;14.
4. Montemurro F, Ciaccia C, Leogrande R, Ceglie F, Diacono M. Suitability of different organic amendments from agro-industrial wastes in organic lettuce crops. Nutr.Cycl. Agroecosyst. 2015;102:243–252.
5. Lee CH, Lee HS, Choi SL, Shin WK, Lee RS. Effects of organic matters application with the different levels of nitrogen fertilizer over a 5 year on the soil physico-chemical properties and rice yields. Korean Journal of Soil Science and Fertilizer. 1986;19(1): 25-31.
6. Bouajila K, Sanaa M. Effects of organic amendments on soil physico-chemical and biological properties. Institut National Agronomique de Tunisie (INAT) Adresse: 43, Avenue Charles Nicolle 1082-Tunis-Mahrajène, Tunisia; 2011.
7. Sharma M, Reynnells R. Importance of soil amendments: Survival of bacterial pathogens in manure and compost used as organic fertizliers. Microbiol. Spectr. 2016;4:1-13.
8. Fan W, Wu J, Li J. Hu J. Comparative effects of different maize straw returning modes on soil humus composition and humic acid structural characteristics in Northeast China. Chem. Ecol. 2018;34(4): 355-370.
9. Bhuyan SI, Momin KG. Role of soil physical properties in ecological restoration of coal mine land: A study in East Garo hills, Meghalaya. Int. J. Environ. Sci. 2015; 5(4):681-687.
10. Indoria AK, Sharma KL, Reddy KS, Rao CS. Role of soil physical properties in soil health management and crop productivity in rainfed systems – II. Management Technologies and Crop Productivity. Curr. Sci. 2016;320-328.
11. Giguere AT, Taylor AE, Suwa Y, Myrold DD, Bottomley PJ. Uncoupling of ammonia oxidation from nitrite oxidation: Impact upon nitrous oxide production in non-cropped Oregon soils. Soil Biol. Biochem. 2017;104:30-38.
12. Jiang CM, Yu WT, Ma Q, Xu YG. Zou H. Alleviating global warming potential by soil carbon sequestration: A multi-level straw incorporation experiment from a maize cropping system in Northeast China. Soil Till. Res. 2017;170:77-84.
13. Bastida F, Zsolnay A, Hernández T, García C. Past, present and future of soil quality indices: A biological perspective. Geoderma. 2008;147(3-4):159-171.
14. Sahlemedhin S, Taye B. Procedure for soil and plant analysis. Technical Paper. 2000; 74:110.
15. Army US. Laboratory soils testing. Engineer Manual EM. 1906;1110-2.
16. Gregorich EG, Carter MR. Soil sampling and methods of analysis. CRC Press; 2007.
17. Bouyoucos GJ. A recalibration of the hydrometer method for making mechanical analysis of soils 1. Agron. J. 1951;43(9): 434-438.
18. Kemper WD, Rosenau RC. Aggregate stability and size distribution. In A. Klute, Ed. Methods of soil analysis, Part 1, 2nd ed. American Society of Agronomy, Madison, WI. 1986;425–442.
19. Kemper WD, Chepil WS. Size distribution of aggregates. In: Black CA (Ed) methods of soil analysis. Part 1. Physical and mineralogical properties, including statistics of measurement and sampling, agronomy monograph 9.1. American Society of Agronomy, Soil Science Society of America Madison. 1965;9:499-510.
20. Bottinelli N, Angers DA, Hallaire V, Michot D, Le Guillou C, Cluzeau D, Heddadj D,

Menasseri-Aubry S. Tillage and fertilization practices affect soil aggregate stability in a Humic Cambisol of Northwest France. Soil Till. Res. 2017;170:14-17.
21. Artiola JF. Determination of carbon, nitrogen and sulfur in soils, sediments and wastes: A comparative study. Int J Environ Anal Chem. 1990;41(3-4):159-171.
22. Walkley A, Black IA. An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Sci. 1934;37(1):29-38.
23. Sun WT, Liang G, Bao HJ, Liu Y Sun ZX. Effect of different ratios of organic manure and chemical ferilizer on improving maize yield and soil physical properties. Chin. Agric. Sci. Bull. 2011;27:80-84.
24. Diacono M. Montemurro F. Long-term effects of organic amendments on soil fertility. In Sustainable Agriculture, Springer, Dordrecht. 2011;2:761-786.
25. Akgül M, Özdemir N. Regression models for predicting bulk density form measured soil properties. Tr. J. of Agriculture and Forestry. 1986;20:407-413.
26. Gardner WC, Broersma K, Naeth A, Chanasyk D Jobson AL. Influence of biosolids and fertilizer amendments on physical, chemical and microbiological properties of copper mine tailings. Can. J. Soil Sci. 2010;90(4):571-583.
27. Tejada M, Hernandez MT, Garcia C. Soil restoration using composted plant residues: Effects on soil properties. Soil Till. Res. 2009;102(1):109-117.
28. Larney FJ, Angers DA. The role of organic amendments in soil reclamation: A review. Can. J. Soil Sci. 2012;92(1):19-38.
29. Wang L, Sun X, Li S, Zhang T, Zhang W, Zhai P. Application of organic amendments to a coastal saline soil in north China: effects on soil physical and chemical properties and tree growth. PloS One. 2014;9(2):e89185.
30. Oo AN, Iwai CB, Saenjan P. Soil properties and maize growth in saline and nonsaline soils using cassava-industrial waste compost and vermicompost with or without earthworms. Land Degrad. Dev. 2015;26 (3):300-310.
31. Pagliai M, Vittori Antisari L. Influence of waste organic matter on soil micro and macrostructure. Bioresour. Technol. 1993; 43:205213.
32. Pérès G, Cluzeau D, Curmi P, Hallaire V. Earthworm activity and soil structure changes due to organic enrichments in vineyard systems. Biol. Fertil. Soils. 1998; 27(4):417-424.
33. Swanson DA, Savci G, Danziger G, Mohr RN, Weiskopf T. Predicting the soil-water characteristics of mine soils. In Tailings and Mine Waste. 1999;99:345-349.
34. Page-Dumroese DS, Ott MR, Strawn DG, Tirocke JM. Using organic amendments to restore soil physical and chemical properties of a mine site in northeastern Oregon, USA. Appl. Eng. Agric. 2018;34 (1):43-55.
35. Hillel D. Introduction to soil physics. Academic Press; 2013.
36. Mohawesh O, Fukumura K, Ishida T, Yoshino K. Soil hydraulic properties in a Cassava field as a function of soil dry bulk density. J. Jpn. Soc. Hyd. Water. Res. 2005;18(2):156-166.
37. Ouyang L, Wang F, Tang J, Yu L, Zhang R. Effects of biochar amendment on soil aggregates and hydraulic properties. J. Soil Sci. Plant Nut. 2013;13(4):991-1002.
38. Aydinalp C. Some important properties and classification of mollisols in northwestern Turkey. J. Cent. Eur. Agric. 2003;4(3):221-224.
39. Ghiberto PJ, Imhoff S, Libardi PL, Silva ÁPD, Tormena CA, Pilatti MÁ. Soil physical quality of Mollisols quantified by a global index. Sci. Agr. 2015;72(2):167-174.
40. Brady N, Weil R. The nature and properties of soils, 13th edition. Prentice Hall. Upper Saddle River, New Jersey; 2002.
41. Mtambanengwe F, Mapfumo P, Kirchmann H. Decomposition of organic matter in soil as influenced by texture and pore size distribution. Managing nutrient cycles to sustain soil fertility in sub-Saharan Africa. 2004;261.
42. Krull E, Baldock J, Skjemstad J. Soil texture effects on decomposition and soil carbon storage. In Net Ecosystem Exchange CRC Workshop Proceedings. 2001;103-110.
43. Obalum S, Uteau D, Peth S. Reduced tillage and compost effects on soil aggregate stability of a silt-loam Luvisol using different aggregate stability tests. Soil Till. Res. 2019;189:217-228.
44. Cosentino D, Chenu C, Le Bissonnais Y. Aggregate stability and microbial community dynamics under drying–wetting cycles in a silt loam soil. Soil Biol. Biochem. 2006;38(8):2053-62.

45. Annabi M, Le Bissonnais Y, Le Villio-Poitrenaud M, Houot S. Improvement of soil aggregate stability by repeated applications of organic amendments to a cultivated silty loam soil. Agr. Ecosyst Environ. 2011;144(1):382-9.
46. Wang F, Tong Y, Zhang J, Gao P, Coffie, J. Effects of various organic materials on soil aggregate stability and soil microbiological properties on the Loess Plateau of China. Plant Soil Environ. 2013; 59:162-168.
47. Eghball B. Liming effects of beef cattle feedlot manure or compost. Commun. Soil Sci. Plant Anal. 1999;30(19-20):2563-2570.
48. Whalen JK, Chang C, Clayton GW, Carefoot JP. Cattle manure amendments can increase the pH of acid soils. Soil Sci. Soc. Am. J. 2000;64(3):962-966.
49. Loper S, Shober AL, Wiese C, Denny GC, Stanley CD, Gilman EF. Organic soil amendment and tillage affect soil quality and plant performance in simulated residential landscapes. Hort. Science. 2010;45(10):1522-1528.
50. Yan F, Schubert S, Mengel, K. Soil pH increase due to biological decarboxylation of organic anions. Soil Biol. Biochem. 1996;28(4-5):617-624.
51. Wong MTF, Nortcliff S, Swift RS. Method for determining the acid ameliorating capacity of plant residue compost, urban waste compost, farmyard manure, and peat applied to tropical soils. Commun. Soil Sci. Plant Anal. 1998;29(19-20):2927-2937.
52. Azeez JO, Van Averbeke W X. Dynamics of soil pH and electrical conductivity with the application of three animal manures. Commun. Soil Sci. Plant Anal. 2012;43(6): 865-874.
53. Benke MB, Indraratne SP, Hao X, Chang C, Goh TB. Trace element changes in soil after long-term cattle manure applications. J. Environ. Qual. 2008;37(3): 798-807.
54. Hao X, Chang C. Effect of 25 annual cattle manure applications on soluble and exchangeable cations in soil. Soil Sci. 2002;167(2):126-134.
55. Schoenau JJ Davis JG. Optimizing soil and plant responses to land-applied manure nutrients in the Great Plains of North America. Can. J. Soil Sci. 2006; 86(4):587-595.
56. Grisso RD, Alley MM, Holshouser DL, Thomason W.E. Precision farming tools. Soil electrical conductivity; 2005.
57. Scotti R, Bonanomi G, Scelza R, Zoina A, Rao MA. Organic amendments as sustainable tool to recovery fertility in intensive agricultural systems. J. Plant Nutr. Soil Sci. 2015;15(2):333-352.
58. Goff JP. Macromineral physiology and application to the feeding of the dairy cow for prevention of milk fever and other periparturient mineral disorders. Anim. Feed Sci. Technol. 2006;126(3-4): 237-257.
59. Tripolskaja L, Romanovskaja D, Slepetiene A, Razukas A, Sidlauskas G. Effect of the chemical composition of green manure crops on humus formation in a Soddy-Podzolic soil. Eurasian Soil Sci. 2014;47(4):310-318.
60. Filip Z, Kubát J. Aerobic short-term microbial utilization and degradation of humic acids extracted from soils of long-term field experiments. Eur. J. Soil Biol. 2003;39:175–182.
61. Hu J, Wu J, Qu X, Li J. Effects of organic wastes on structural characterizations of humic acid in semiarid soil under plastic mulched dr irrigation. Chemosphere. 2018; 200:313-321.
62. Wu JG, Ren J, Zhao XY, Li JM. Morphology of humus in black soil as affected by fertilization method. Acta Pedologica Sinica. 2014;51(4):709–717.
63. Frederickson J, Howell G, Hobson AM. Effect of pre-composting and vermin-composting on compost characteristics. Eur. J. Soil Biol. 2007;43:S320-S326.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/54606