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PRELIMINARY EXPERIMENTAL ASSESSMENTS OF 12 DIFFERENT ORGANIC MATERIALS FOR SOIL QUALITY AND SOIL FERTILITY MANAGEMENT EXERCISES

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ABSTRACT

A preliminary experiment was conducted for 12 different organic materials to examine the physical, physico-chemical and chemical properties for soil quality and soil fertility rehabilitations. The results show that, the animal dung samples: cow, donkey, goat and sheep have common physical properties. Similarly, it appeared that the house-refuse and ani-cro-ber (combination of all materials) have the same physical properties. Leaf samples (*Acacia nilotica* and *Acacia. albida*) are types of organic materials, which show some similarities in their textural appearances but differed significantly in term of structure. Millet husk, wood ash and wood husk show unique physical properties. However, it is reported that nitrogen content for all the animal materials is above 2% but show a practical variation in term of phosphorus, potassium, calcium, and magnesium. Ani-cro-ber has the highest nitrogen content of 3.07% while wood-husk has very low content (0.98%). There is high potassium content in *Acacia nilotica* (2.01%), *Acacia albida* (1.87%) and ani-cro-ber (1.82%). Generally, with the exception of ani-cro-ber that has phosphorus content of 1.04%, all the remaining organic materials show low phosphorus contain of less than 1%. Calcium is high in ani-cro-ber (17.9%), wood ash (17.6%), and wood husk (16.3%), but very low in sheep dung (0.13%), cow dung (0.16%), millet husk (0.20%), goat dung (0.21%) and donkey dung (0.29%). Also, calcium is high in ani-cro-ber (5.39%), wood husk (4.11%), wood-ash (3.23%), and millet husk (2.88%). This finding suggests that organic materials should be widely used as good sources of essential soil nutrients and soil quality and soil fertility rehabilitations; and this is particularly important under poor soil condition.

Keywords: Organic materials, Properties, soil management

INTRODUCTION

Organic materials (plant and animal sources) have been widely accepted as important source of essential soil nutrients, and play a vital role in sustaining and improving soil structure, soil quality, soil function, soil health, soil fertility and overall crop performance in agricultural production (Usman, 2013). In the past 40 years, farmers in local areas of sub-Saharan Africa (s-SA) have been seeing the benefits of incorporating organic matter (decomposed plant and animal materials) in soil. Unfortunately, the development of inorganic fertilizer industries has put a barrier to that. This development of inorganic fertilizers, has led to most of the farmers in s-SA to abundant the use of organic manure (mixture of animals dung and urine), organic matter and organic materials. In recent time, farmers in s-SA have realised the disadvantages of compliant with inorganic fertilizers as major source of soil fertility management in the region. Also, corresponding problem to this is that most of the agricultural dryland soils in the region are infertile due to problems associated with erosion, desertification, and climate change impact (Put *et al.,* 2004; Usman, 2007). Because of these soil problems, farmers complained much about the annual yield reductions of their farm produce in the affected areas. It is one of the key goal of sound soil management creating a healthy soil environment that may retain balance nutrient status by protecting the surface soil cover from unacceptable changes such that its fertility will maintained over time (Omotayo and Chukwuka, 2009). Therefore, understanding the properties and functions of organic materials in soil could profitably be one of the sustainable remedy to s-SA farmers in these circumstances; for the reason that, decomposed organic materials in soil, protect soil against runoff, erosion, mass movement of fine soil particles and as such was considered enhance soil water, soil air (pore spaces), and soil productivity (NRCS, 2003; Usman, 2007, Usman, 2013). Organic materials are the storehouse of all essential soil and plant nutrient in soil. They are important components of soil fertility and are associated with a variety of other important soil physical, chemical, and biological characteristics (McDonald, 2010). Organic materials are potential important sources of micro and macro nutrients in agricultural soils environment (Hood, 2001). They affect physical, biological, chemical, and ecological processes in soil. They improve soil structural quality, soil water holding capacity, soil infiltration, soil organism biodiversity, and soil nutrient availability (FAO, 2005).

Generally speaking, little information on properties and functions of most used organic materials for soil quality management in many local areas of s-SA can be found. However, most of the studies on soil organic matter (SOM) characterisation, were considered (Evelyn *et al.,* 2004) largely moved away from definitions based solely on chemical extraction procedures, such as laboratory chemical analysis (Mitchell and Everest, 1995), humic and fulvic acids analysis (Reeves, 1997), qualitative spectroscopy [nuclear magnetic resonance (NMR)] and diffuse spectroscopy [reflectance infrared Fourier transform (DRIFT)] (Brian, 2002). The need for characterization based on combine physical and chemical assessments is needed, as physical separation of SOM (Evelyn *et al.,* 2004) relates better to the role that organic matter plays in soil structure and soil function (Lal, 2000; Brady and Weil, 2004). Therefore, to improve the standard balance of the morphological and genetic properties of the deteriorated agricultural soils in the s-SA, it is necessary to be able to address and understand the properties and functions of organic material in single and in combination. This demands understanding of the properties and behaviours of organic materials for soil quality and soil fertility functions. The main objective of this study was introductory report of the properties of 12 different organic materials for soil quality and soil fertility management processes. The study would profitably lead to more sustainable and permanent soil management, soil quality and soil fertility rehabilitations for high crop yield in agriculture.

MATERIALS AND METHODS

The study was conducted under three principal stages as described below:

First principal stage: Physical and physico-chemical assessment: At the beginning of this exercise, 11 samples of different organic materials were collected using tile spade shovel (animal, wood and house refuse sources) and by hand picking (crop and leaf source). All the samples were stalked separately in a clean experimental plastic rubber (Figure 1). The collection of these samples was partly made from house-hold cattle reared sites (animal source) and partly from cropping and forest-vegetation areas (crop and leaf sources). Experimentally, 500 ml of water was added to each sample after one day of collection and 1.1 kg of each was used to determine the physical and physico-chemical properties. In addition, 0.1 kg from each of the 11 samples were bulked together to have a unique representative sample (ani-cro-ber). The assessment was completed in a 3 week period from 25/12/2010 to 01/01/2011 (1st week), 02/01/2011 to 09/01/2011 (2nd week), and 16/01/2011 to 24/01/2011 (3rd week). The USDA-NRCS (2002) guidelines were used under this assessment.

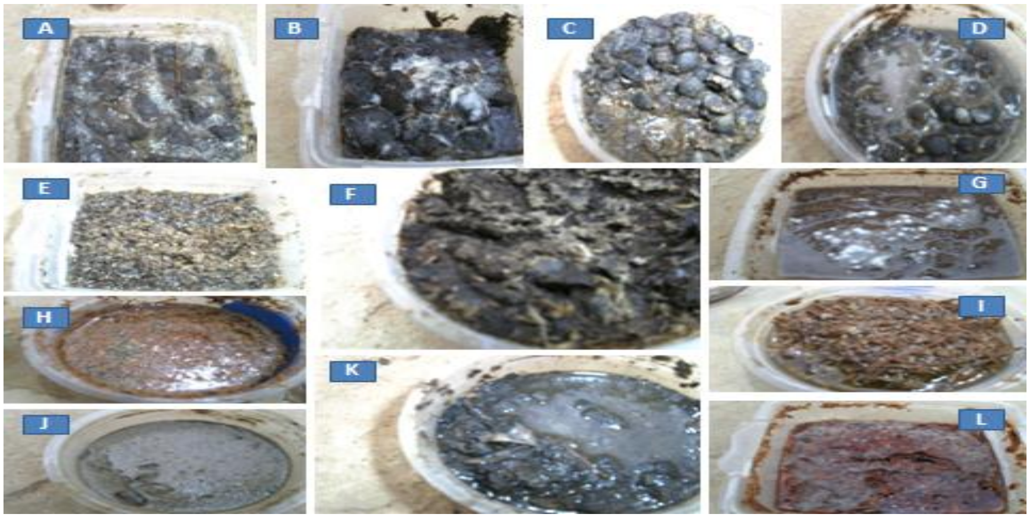

Figure 1: Different sources of organic materials used under first assessments:
(A) cow dung, (B) donkey dung, (C) sheep dung, (D) goat dung, (E) millet husk, (F) ani-cro-ber, (G) rice husk, (H) *Acacia nilotica*, (I) *Acacia albida*, (J) wood ash, (K) house refuse and (L) wood husk

Second principal stage: Chemical analyses: All the 12 organic samples were chemically analysed at Soil Research Institute, Kumasi, Ghana according to the general procedures described by Nelson and Sommers (1982) and that of Bray and Kurtz (1945) for the determination of total organic carbon, organic matter, nitrogen and exchangeable bases.

Third principal stage: statistical analysis of the chemical data: Cluster analysis was primarily used to classify and group the chemical components of different organic materials as well as different soil strata 'individually' treated with the same organic materials. The purpose of using this analysis was to determine the number of groups under the different organic materials as they are closely related to each other for best soil management combination. Addinsoft (2012) version 14.3.1.0 statistical software package was used.

RESULTS

The results of the assessments of 12 different organic materials are presented in Tables 1, 2 and 3. Tables 1 and 2 show the physical and chemical properties while the physic-chemical components are presented in Table 3.

Table 1: Physical properties of twelve different organic materials after one week of test

Organic material	Colour		Consistency	Structure	Texture
	Sample	Water			
Cow	Black	Dark	Soft-hard	Blocky (plate)	Cemetery
Sheep	Black	Ashy-black	Slight-hard	Sub-angular	Gravely
Goat	Dark	Darker	Slight-hard	Sub-angular	Gravely
Donkey	Black	Urea-dark	Soft	Blocky (round)	Cemented
Rice husks	Dark brown	Light-ash	Loose	Single-grain	Fine-husks
Millet husks	Light	Yellowish	Loose	Granular	Coarser
Acacia albida	Light brown	Light-grey	Loose	Massive-leafy	Fine-leafy
Acacia nilotica	Green	Light-green	Loose	Massive-leafy	Fine-leafy
Wood ash	Light grey	Lighter	Flowery	Massive	Ashy
Wood husk	Dark pink	Dark-pink	Loose	Granular	Woody
House refuse	Black-dark	Blacker	Clotted	Decomposed	Clay-loam
Ani-cro-ber	Dark-black	Darker	Hard	Granular	Cemented

Table 1 shows the physical properties of 12 organic samples under physical assessment. Animal dung samples: cow, donkey, goat and sheep have common physical properties. The colours appearance of these 4 animal samples are black and dark, the structures are blocky and sub-angular, the textures are cemented and gravely and consistencies are soft and slightly hard. Similarly, the house refuse and ani-cro-ber samples have the same physical properties, characterised by dark and black colour, clotted and hard consistency, decomposed and granular structure as well as cement textural nature. Leaf samples are types of organic materials, which show some similarities in term of texture (fine), consistency (loose) and colour (light green), but differed significantly in term of structure: *A. nilotica* has massive structure whereas *A. albida* has single-grain. For millet husk, texture is coarser, structure is granular, consistency is loose and colour is yellowish. However, wood ash and wood husk are two types of organic wood materials but differed significantly. Wood ash is characterised by light-grey colour, loose consistency, massive structure and texture is ashy whereas wood husk is characterised by dark-pink colour, loose consistency and granular and woody structure and texture respectively.

Table 2: Chemical properties of twelve different organic material samples

Sample Name	% Nitrogen	% Phosphorus	% Potassium	% Calcium	% Magnesium	Clus-Code
Cow	2.06	0.42	0.29	0.16	0.38	1
Sheep	2.92	0.68	0.41	0.13	0.68	1
Goat	2.56	0.70	0.38	0.21	0.63	1
Donkey	2.06	0.23	0.34	0.29	0.32	1
Rice husk	1.87	0.56	1.03	2.11	0.55	1
Millet husk	1.72	0.66	0.54	0.20	2.88	2
Acacia albida	1.19	0.37	1.87	1.02	0.91	2
Acacia nilotica	1.08	0.60	2.01	1.11	1.89	2
Wood ash	1.34	0.73	1.19	17.6	3.23	3
Wood husk	0.98	0.81	1.27	16.3	4.11	3
House refuse	2.21	0.48	0.11	1.60	0.57	1
Ani-cro-ber	3.07	1.04	1.82	17.9	5.39	3

A preliminary chemical analysis of these 12 organic samples is given in Table 2. The nitrogen content for all the animal dung is above 2%, however, a reasonable variation was observed in term of phosphorus, potassium, calcium, and magnesium. Ani-cro-ber has the highest nitrogen content (3.07%) and wood-husk has very low content (0.98%). There is high potassium content in *A. nilotica* (2.01%), *A. albida* (1.87%) and ani-cro-ber (1.82%). With the exception of ani-cro-ber (1.04%), all the organic materials have low phosphorus content (below 1%). Calcium is high in ani-cro-ber (17.9%), wood ash (17.6%), and wood husk (16.3%); but very low in sheep dung (0.13%), cow dung (0.16%), millet husk (0.20%), goat dung (0.21%), and donkey dung (0.29%). Also, calcium is high in ani-cro-ber (5.39%), wood husk (4.11%), wood-ash (3.23%), and millet husk (2.88%). In addition, the result of physico-chemical assessment related to soil quality and soil fertility functions is given in Table 3. Also, a preliminary cluster analysis of all the organic samples given in last column of Table 2 has provided a better understanding of the close relationship of each individual organic material with another in term of their chemical composition.

Table 3: Physico-chemical properties of twelve organic materials after three weeks of test

Organic materials	Colour		Gaseous compound	Sulphurous compound
	Sample	Water		
Cow	Dark-black	Darker-creamy	High bubble of O_2	H_2S
Sheep	Dark-black	Black	Low bubble of O_2	H_2S
Goat	Dark-black	Black	-	H_2S
Donkey	Dark-black	Dark-black	High bubble of O_2	H_2S
Rice husks	Dark-brown	Brown	-	-
Millet husks	Light-black	Light-black	Bubble of O_2	-
Acacia albida	Black-grey	Grey-brown	-	-
Acacia nilotica	Dark-green	Army-green	-	-
Wood ash	Lighter	-	-	-
Wood husk	Dark-brown	-	-	H_2S
House refused	Dark-black	-	Bubble of O_2	-
Ani-cro-ber	Darker, blacker	-	Bubble of O_2	H_2S

DISCUSSION

The physical, chemical and physico-chemical properties of different organic materials are reported in Tables 1, 2 and 3. These organic materials were tested for soil quality and soil fertility managements use. Physically, important organic properties: texture, structure, consistency and colour are vital in soil quality development in the soil medium, whereas chemically, significant amount of essential nutrients would provide a wellbeing soil condition under soil fertility function (FAO, 2005, Usman, 2013). This vital role of the properties of different organic materials examined in this study, are believed to have created a healthy and functional soil condition for proper plant growth (Basu *et al.*, 2007; Uzoma *et al.*, 2011). It is also reported that increased addition of organic materials under soil fertility management, has led to increased nutrient concentration and transformation into soil solution (Muriwira *et al.*, 2001; Powlson *et al.*, 2011). This increased nutrient concentration is transferred into the soil as a result of the different concentration of chemical compounds available in the organic materials (Table 2; Powlson *et al.,* 2011). Similarly, the improvement of soil texture, soil structure and soil bulk density as reported in different soil organic matter related studies (e.g. Ascota *et al.*, 1999; Spaccini *et al.*, 2002; Francisco and Lowery, 2003; Maris and Ryan, 2006; Nagaya and Lal, 2008; Wiesmeier *et al.*, 2012) is likely associated with the physical properties of different organic materials reported in Table 1. Also, colour is an important physical property that serves as indication of soil quality and soil health (Foth, 1990; FAO, 2005; Usman, 2013). Most of the organic materials are characterised as black and darker, still some are grey and light-green (Table 3). These various colours could reflected the soil and soil properties by transforming the surface soil into more fertile appearance, a condition related to soil ability to attract and accommodate varieties of soil organisms for wide range of soil biodiversity (FAO, 2005).

The cluster analysis shown in Figure 2 above, has grouped the available chemical data of twelve different organic materials into three clusters – 1, 2 and 3. This grouping of the organic materials into three cluster-codes was performed according to the order of their chemical content of individual compound tested as presented in Table 2. The cow-dung, sheep-dung, goat-dung, donky-dung, rice-husk and house-refuse are grouped under class 1, whereas millet-husk, Acacia albida and Acacia nilotica are grouped under class 2 while wood-ash, wood-husk and ani-cro-ba are grouped under class 3 (Figure 2). This grouping has further suggested that all the organic materials under each respective class have the same chemical characteristics and are likely to have the same function under soil management point of view.

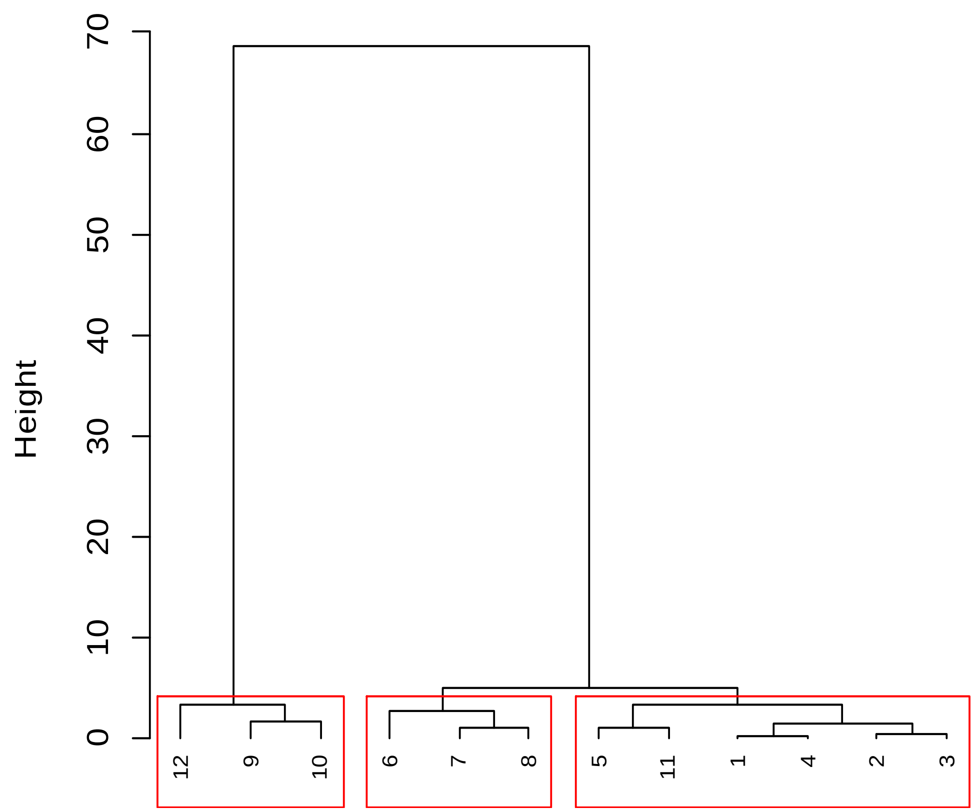

Figure 2: Cluster dendrogram of the organic material samples tested

On the other hand, a representative of organic material (e.g. cluster-code 1) from each group can be used in combination with another organic material from other group (e.g. cluster-code 3) as a formulation under best sustainable management practice for high crop yield. It appeared that some of these organic materials have gaseous and sulphurous compounds and some does not have. These gaseous and sulphurous compounds are found presence in all animal samples, ani-cro-ber and house-refuse. However, high reactions in term of these physic-chemical properties were noted strongly in cow dung, donkey dung and ani-cro-ber, but the reaction is very low in sheep and goat dung.

CONCLUSION

Based on the fact that, the present study has shown that organic materials are important source of essential soil physical and chemical components (Tables 1, 2, 3), it is concluded that the transformation and development of soil quality and soil fertility when organic materials is been added to the soil, is likely depend on the availability of chemical physical characteristics of the individual organic material involved (Figure 1). This is because as organic materials slowly decomposed in soil, they colour the surface soil, maintain the soil strength, increase soil resilience (ability of soil to return to its initial state after disturbances), soil aggregation and aggregate stability (Tisdall and Oades, 1982; Wiesmeier *et al.*, 2012), thereby transforming soil texture into stable, suitable and good textural quality classes for wide range of crop production (Hartemink, 2006; Viaud *et al.*, 2011). The finding of this study, suggests that organic materials should be widely use as good sources of essential soil nutrients for soil quality and soil fertility rehabilitations particularly under poor soil condition.

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REFERENCES

1. Addisnsoft, New version of statistical software ‘14.3.1.0’. Addisnsoft company, 2012.
2. Basu, M. Bhanu, P. Bhadoria, S. and Chandra, SC. Comparative effectiveness of different organic and industrial wastes on peanut: Plant growth, yield, oil content, protein content, mineral composition & hydration coefficient of kernels. Achives of Agronomy & Soil Science,2007, 53(6):645–658.
3. Brady, NC. and Weil, RR. Elements of the nature and properties of soil. 2nd ed. Person Education Ltd. 2004, pp. 9-24.
4. Bray, RH and Kurtz LT. Determination of total, organic, and available forms of phosphorus in soils. [Jillinois Agricultural Experiment Station, Urbana, Ill] Soil Sci. 1945, 59:39-45.
5. Brian AS. Methods for the determination of total organic carbon (TOC) in soils and sedments. United States Environmental Protection Agency Environmental Sciences Division National Exposure Research Laboratory NCEA-C- 1282 EMASC-001. 2002 Las Vegas,NV.

6. Evelyn, SK. Jan, OS. and Jeffrey AB. Functions of soil organic matter and the effect on soil properties. CSIRO Land & Water Report, GRDC: CSO00029. 2004, CSIRO Glen Osmond SA.
7. FAO The importance of soil organic matter: key to drought-resistant soil and sustained food production. FAO Soils Bulletin, No. 80. Food and Agricultural Organization of United Nation, Rome, Italy. 2005, 11-47 & 65pp.
8. Foth, HD. Fundamental of Soil Science. John Wileyas and Sons. New York, USA. 1990, 36-39pp.
9. Francisco, JA. and Lowery, B. Soil Physical Properties and Crop Production of an Eroded Soil amended with Cattle Manure. Soil Sci. 2003, 168: 2.
10. Hartemink, AE. Assessing soil fertility decline in the tropics using soil chemical data. Advances in Agronomy, 2006, 89, 89.
11. Hood, R. Evaluation of a new approach to the nitrogen 15Isotope dilution technique to estimate crop N uptake from organic recidues in the field. Biofertile Soils, 2001, 34:156 – 161.
12. Lal, R. Soil Management in the developing World. Soil Sci. 2000, 165: pp 57- 72.
13. Maris, Z. and Ryan, J. Soil organic matter and related physical properties in a Mediterranean wheat-based rotation trial. Soil and Tillage Research, 2006, 87, (2), 146-154.
14. McDonald, D. Soil organic matter. The Department of Primary Industries, Parks, Water and Environment. 2010, Hobart, Tasmania, Australia.
15. Mitchell, CC. and Everest, JW. (1995) Soil testing and plant analysis: Interpreting Soil Organic Matter Tests. 1995, Southern Regional Fact Sheet SERA-IEG-6*1 Dept. Agronomy & Soils, Auburn University.
16. Muriwira, HK. Mutiro, K. Nhamo, N. and Nzuma, JK. Research Results on improving cattle manure in Tsholotsho and Shurugwi in Zimbabwe. In: Improving soil management options for women farmers in Malawi and Zimbabwe. Proceeding of a collaborator's workshop on the DFID-supported project 13 – 15 September 2001. ICRISAT-Bulawayo, Zimbabwe.
17. Nagaya, L. M. and Lal, R. Mulching effects on selected soil physical properties. Soil and Tillage Research, 2008, 98, 1, 106-111.
18. Nelson, DW. Sommers, LE. Total carbon, organic carbon and organic. In Methods of soil analysis, Page, A.L.; Miller, R.H.; Keeney, D.R., (Eds.), American Soc. of Agronomy, Madison, Wisconsin, USA. 1982, Pp. 539-549.
19. NRCS Managing soil organic matter: the key to air and water quality. Soil quality technical note No. 5. Natural Resource Conservation Services (NRCS), USDA, 2003.
20. Omotayo O. and Chukwuka, C. Soil fertility restoration techniques in sub-Saharan Africa using organic resources. African Journal of Agricultural Research 2009, 4 (3) 144 – 150.
21. Powlson, DS. Whitmore, AP. and Goulding, KWT. Soil carbon sequestration to mitigate climate change: a critical re-examination to identify the true and false. European Journal of Soil Science, 2011, 62, 42–55.
22. Put, M. Verhagen, J. Veldhuizen, E. and Jellema, P. Climate Change in Dryland West Africa?: The empirical evidence of rainfall variability and trends. Environment and Policy, 2004, 39, 27-32.
23. Reeves, DW. The role of soil organic matter in maintaining soil quality in continuous cropping systems. Soil & Tillage Research, 1997, 43, 131-167.
24. Spaccini, R. Piccola, A. Mbagwu, JSC Zena, TA. and Igwe, CA. Infl uence of the addition of organic residues on carbohydrate content and structural stability of some highland

soils in Ethiopia. Soil Use and Management, 2002, 18: 404-411.

25. Tisdall, J. M. and Oades, J.M. Organic matter and water stable aggregates in soils. Journal of Soil Science, 1982, 33: 141-163.
26. USDA-NRCS Field Book for Describing and Sampling Soils, Version 2.0. National Natural Resource Conservation Service and USDA. Soil Survey Centre, 2002.
27. Usman, S. Sustainable soil management of the dryland soils of northern Nigeria. GRIN Publishing GmbH, Germany, 2007, ISBN (Book): 978-3-640-92136-2.
28. Usman, S. Understanding Soil: properties and environment under agricultural condition. PublishAmerica, USA, 2013.
29. Uzoma, KC. Inoue, M. Andry, H. Fujimaki, H, Zahoor, A. and Nishihara, E. Effect of cow manure biochar on maize productivity under sandy soil condition. Soil Use and Management, 2011, 27, 205–212.
30. Viaud, V. Angers, DA. Parnaudeau, V. Morvan, T. and Menasseri Aubry, S. Response of organic matter to reduced tillage and animal manure in a temperature loamy soil. Soil Use and Management, 2011, 27, 84–93.
31. Wiesmeier, M. Stefens, M. Mueller, CW. Kolbl, A. Reszkowska, A. Peth, S. Horn, R. and Kogel-Knabner, I. Aggregate stability and physical protection of soil organic carbon in semi-arid steppe soils. European Journal of Soil Science, 2012, 63, 22–31.