DOI: https://doi.org/10.67042/njss.2011.jlyprr3y

Nigerian Journal of Soil Science

Journal homepage:www.soilsjournalnigeria.com

MICROAGGREGATE STABILITY AND ORGANIC CARBON FRACTIONS OF A TROPICAL LOAMY SAND AMENDED WITH PIG-COMPOSTED MANURE

J. K. Adesodun[1] and O. S. Adekonojo

Department of Soil Science and Land Management, University of Agriculture, P. M. B. 2240, Abeokuta 110001, Ogun-State, Nigeria.

ABSTRACT

Soil organic carbon (SOC) is important in restoration of microaggregate stability of tropical soils. This study evaluated effect of pig-composted manure applied at 0, 5, 10 and 15 Mg ha^{-1} to cultivated land and forest re-growth land on distribution of organic carbon (OC) fractions and microaggregate stability using principal component analysis (PCA). The cultivated land was planted with two varieties of maize (*Zea mays*): TZESR-W (improved variety) and OHORI (local variety). Soil samples were collected from 0-20 cm depth and analyzed for total organic carbon (TOC) within 2000-200 µm, 200-63 µm and < 63 µm aggregate fractions and free particulate organic carbon (fPOC), occluded particulate organic carbon (oPOC), acid-hydrolyzable organic carbon (HOC) and non-acid hydrolyzable organic carbon (nHOC) in whole soil. The microaggregate stability was estimated by dispersion ratio (DR), clay dispersion ratio (CDR), clay flocculation index (CFI) and aggregated silt + clay (ASC). Results showed that TOC, oPOC and aHOC were significantly ($p \leq 0.05$) higher in forest re-growth land than the cultivated land. However, fPOC and nHOC were higher in cultivated land than forestland. The trend followed TOC > nHOC > fPOC > oPOC > aHOC. Distribution of TOC within aggregates was similar to OC fractions in whole soil. The result showed that < 63 µm associated-OC was highest followed by 200-63 µm-OC while OC was least in 2000-200 µm aggregates. Correlations were highly significant between ASC and TOC (r = 0.84***) and ASC and < 63 µm associated-OC (r = 0.85***); while correlation between CFI and 2000-200 µm associated-OC was high (r = 0.70*). To remove multicollinearity, principal component analysis grouped the six correlated OC fractions (fPOC, aHOC, TOC, 2000-200 µmOC, 200-63 µmOC and < 63 µmOC) to two component defining variables (CDVs), i.e. fPOC and TOC. Multiple regression was used to show the relationship between the retained variables (fPOC and TOC) and the two indices of better microaggregation (ASC and CFI); and the results showed fPOC and TOC only correlated significantly ($r = 0.73^{*}$) with ASC.

Keywords: Microaggregate stability, organic carbon fractions, forest re-growth, cultivated land, principal component analysis, compost**.**

INTRODUCTION

Organic matter (OM) has been conveniently partition to the total carbon (C) and different pools which are generally grouped into persistence or stable pools as well as labile or easily degradable fractions (Christensen, 2001; von Lutzow *et al.*, 2007). Chemical characterization of soil organic pools (humic and non-humic substances such as humic and

fulvic acids, humin, carbohydrates, peptides, resin and waxes) and the implication of these pools on soil aggregation and stability are the most common studies. However, physical fractionation techniques, (particle size fractionation, aggregate fractionation and density fractionation) which enable OM to be partition into dissolved organic matter and particulate organic matter relate more directly to the structure of soil organic matter (SOM) in-situ instead of chemical methods. These forms of organic matter have different effects on soil quality, hence might respond differently to management practices or land use. One of the pronounced and widespread changes that occur when forest is converted to cropland is the decrease in soil C, and this is attributable to a number of factors (Lal, 2004). First, the C-inputs in agricultural systems are usually lower than those in native system; and second is agricultural management practices which may help to enhance decomposition. For example, no-tillage practice can permit sequestration of atmospheric C, while conventional tillage system though does enhance SOM mineralization, could also disrupt soil aggregates and expose physically protected-C to microbial decomposition thereby reducing soil structural stability.

Soil aggregates are dynamic properties that respond rapidly to environmental changes (Coote *et al.*, 1998; Opara, 2009). The low structural stability of tropical soils (Opara, 2009), coupled with high rainfall erosivity leading to high rate of erosion (Lal, 1979; Madubuike, 1999) are major physical constraints to increase crop production. Opara (2009), further noted that knowledge of the impact of different land use types on the stability of various soil aggregates especially at microaggregate level is very imperative. This is because microaggregates when dispersed in water by raindrops action or by other management practice such as tillage operation often leads to clogging of soil pore (surface sealing). Besides, Igwe and Nwokocha (2006), reported that land use changes affect the SOM-associated particle size fractions; whereas total SOM under conservation tillage affects macroaggregate stability while the microaggregate stability is mainly controlled by stable organic matter and soil texture.

The major reason for the high degradation observed in most tropical soils is decline in their organic matter contents (Adesodun *et al.* 2007), therefore investigation of OM dynamics by approaches which describe in-situ condition of the different agricultural systems in terms of understanding OM fractions which correlate better with soil aggregation and stability are necessary in developing framework that would guide the management of these soils. Hence, evaluation of the role of different soil organic carbon (SOC) fractions in restoration of stability of soil at microaggregates level is important for tropical soils that degrade rapidly. The objectives of this study were to (i) evaluate the effect of different land uses, i.e. cultivated land amended with pig-composted manure and uncultivated land (forest re-growth) on the distribution of OC fractions within whole soil and soil aggregates; and (ii) identify the most sensitive OC fractions influencing microaggregate stability of this fragile tropical soil using principal component analysis.

MATERIALS AND METHODS

Experimental site and sampling

Soil samples for this study were collected at 0-20 cm depth from organic agriculture farm located within the University of Agriculture, Abeokuta, Ogun State (Lat. 7.12^0 N and Long. 3.23^0 E) with the aid of cutlass to maintain the soil relatively in its natural aggregates. The total land area of the site is 2940 m^2 with 24 experimental plots (6 m x 10 m). The treatments on these plots were pig-composted manure applied at 0, 5, 10, 15 Mg ha^{-1}, and planted with two varieties of maize "*Zea mays"* i.e. TZESR-W (improved variety) and OHORI (local variety). These were arranged in Randomized Complete Block Design (RCBD) and replicated four times. The

treatments were applied in the year 2005 and repeated in 2006, while residual effect of these treatments was monitored in 2007 and 2008. Soil samples were also collected from adjacent forest re-growth land. Data presented in this article were for the year 2008. Some soil properties of the study site are presented in Table 1.

Table 1: Selected properties of the study site

Parameter	Units	Cultivated	Adjacent forestland
Sand (2000-50µm)	g/kg	752	772
Silt (50-2µm)	g/kg	80	40
Clay (<2µm)	g/kg	168	188
Texture	-	Loamy sand	Loamy sand
pH (H_2O)		6.43	6.44
OC	g/kg	42	50
Total N	g/kg	7.0	8.8
CN	-	6.0	5.7
Ca	cmol/kg	0.52	0.46
Mg	cmol/kg	0.73	0.15
K	cmol/kg	0.60	0.73
Na	cmol/kg	1.17	1.11

OC = Organic carbon

Laboratory studies

Separation of particle size fractions

Particle size distribution of the < 2 mm soil from the cultivated and forest re-growth sites was determined by the hydrometer method as described by Gee and Bauder (1986). The clay and silt obtained from particle size analysis with sodium hexa-metaphosphate (calgon solution) was regarded as total clay (TC) and total silt (TSilt), while clay and silt obtained after particle analysis using distilled water only were water-dispersible clay (WDC) and water-dispersible silt (WDSi).

The 2000-200, 200-63 and < 63 µm aggregate size fractions were separated from soil pre-sieved with 2 mm sieve by wet-sieving technique described by Kemper and Rosenau (1986). In this procedure, 50 g of the < 2 mm aggregates were placed on the topmost of a nest of sieve of diameters 2, 0.2 and 0.063 mm. The samples were pre-soaked in distilled water for 10 minutes before oscillating vertically in water for 20 times (along 5 cm amplitude) at the rate of 10 stokes min^{-1} for 2 minutes. The resultant aggregates on each sieve were dried at 105 ^{0}C for 24 hrs.

Microaggregate stability

Soil microaggregate stability indices were calculated as:

Dispersion ratio (DR) = [(WDS + WDC)/ (TSilt + TC)] (1)

Clay dispersion ratio (CDR) = WDC/TC (2)

Clay flocculation index (CFI) = [(TC-DC)/ TC] (3)

Aggregated silt + clay (ASC) = (TC + TSilt) – (WDC + WDSi) (4)

The higher the value of DR and CDR the greater is the ability of the soil to disperse, i.e. the lower the aggregate stability. The higher the value of CFI and ASC (%) the better the soil aggregation, i.e. the higher aggregate stability at microaggregate level; Igwe and Nwokocha, 2006).

Soil organic carbon fractions

Air-dried whole-soil samples pre-sieved with 2 mm sieve were used for the determination of free particulate organic carbon (fPOC), occluded particulate organic carbon (oPOC) fractions, and acid-hydrolyzable organic carbon (aHOC) and non-acid hydrolyzable organic carbon (nHOC) concentrations. Whereas, total organic carbon (TOC) was determined in the 2000-200, 200-63 and < 63 µm aggregate sizes and whole soil.

Aggregate-associated OC and TOC for whole soil were determined by acid-dichromate wet

oxidation procedure as presented by Nelson and Sommers (1996). The particulate organic carbon separated into oPOC and fPOC fractions were determined. The oPOC is the fraction retained on 53 μm sieve, while fPOC is the fraction that passes through the 53 μm sieve. In this procedure, 20 g of air-dried soil was weighed into a beaker and then shaken with 10 ml sodium hexa-meta phosphate solution. The suspension was passed through a 53 μm sieve to separate out > 53 μm and < 53 μm fractions. Both the > 53 μm and < 53 μm were oven-dried and then ground to < 0.05 mm. One gramme each of > 53 μm and < 53 μm was used for OC determination by acid-dichromate wet oxidation procedure as presented by Nelson and Sommers (1996).

Non-hydrolyzable OC concentration was determined. In the procedure, 2 g of soil (< 2.00 mm) was mixed with 6N HCl and allowed to react for 2 hours. The samples were later heated at 105^0C for 3 hours, washed three times with distilled water and then centrifuged to remove the HCl. The residue was dried and the non-hydrolyzable OC concentration was determined by acid-dichromate wet oxidation procedure of Nelson and Sommers (1996). The hydrolyzable OC concentration was calculated as the difference between total OC and non-hydrolyzable OC concentration.

DATA ANALYSIS

Data was analyzed using the general analysis of variance procedure of GenStat Release 7.2 DE (2007), and significance was reported at 5% probability level. Only 11 soil properties that showed significant difference ($P \leq 0.05$), i.e. fPOC; aHOC; TOC; 2000-200 μm, 200-63 μm, < 63 μm aggregate-associated OC; DR; CDR; CFI; ASC; and WDSi were retained for further analysis. The retained properties were subjected to correlation analysis in order to identify relationship between soil properties and microaggregate stability indices and correlations among soil properties. Water-dispersible clay (WDC) was retained in the correlation analysis because of the importance of clay fraction on stability of soil at microscale level. To avoid the problem of multicollinearity, principal component analysis (PCA) was used to determine the SOC fractions that most influence the microaggregate stability of this soil. Total variance of each factor was defined as eigenvalue and factors with eigenvalue ≥ 1 were retained. Also, soil properties with factor loadings or loading coefficients > 0.40 were selected as the factor having the highest coefficient value. Lastly, the relationship between the selected soil properties and the microaggregate stability indices were done by multiple regression analysis using the PCA derived soil properties as independent variables and microaggregate stability indices values as dependent variables

RESULTS AND DISCUSSION

Distribution of organic carbon fractions in whole soil

Organic carbon (OC) fractions in whole soil under the different land use types, i.e. uncultivated forestland and cultivated land are presented in Table 2. The results showed that total OC, occluded particulate OC (oPOC) and acid-hydrolyzable OC (aHOC) were significantly ($p \leq 0.05$) higher in forestland than amended cultivated land planted with local (OHORI) and improved (TZESR-W) varieties of maize. Whereas, free-particulate OC (fPOC) and non-acid hydrolyzable OC (nHOC) were higher in the cultivated land than in forestland. Carbon fractions distribution in the cultivated land, relative to different rates of compost applied, revealed significant ($p \leq 0.05$) accumulation of OC in the whole soil in plots amended with 10 Mg ha^{-1} pig-composted manure over plots amended with 15 Mg ha^{-1}. The overall trend followed the order TOC > nHOC > fPOC > oPOC > aHOC irrespective of land use type. While the particulate organic matter (OM) fractions (fPOC and oPOC) represented the active fraction of OM which are very sensitive to management practices, the non-hydrolyzable OC is the recalcitrant physical fraction of OM (Rovira and Vallejo, 2003).

These authors also noted that while the capacity of soil to accumulate and stabilize OC could be compensated by policies such as afforestation, the need to feed the world increasing population at times necessitated conversion of forestland to arable crop production. Therefore, observations from this study revealed that some agricultural management practices such as the use of compost could compensate the role of forests as sink of OC in cultivated land.

Aggregates-associated organic carbon relative to land use types

The distribution of total organic carbon (TOC) associated with aggregate size fractions is presented in Table 3. In cultivated land planted with improved (TZESR-W) and local (OHORI) varieties of maize, OC was significantly occluded in 2000-200 μm aggregate size fraction in plots amended with 10 Mg ha^{-1} compost followed by 15 Mg ha^{-1} over other compost rates and the control. The TOC associated with 200-63 μm size fraction followed this trend in plots planted with OHORI local maize variety. However, mean distribution indicated significant ($p \leq 0.05$) higher accumulation of OC within the aggregate size fractions of uncultivated forestland (Table 3) than the cultivated land amended with compost. The overall trend showed that 2000-200 μm associated OC

Table 2: Organic carbon (%) fractions from whole soil of cultivated and forestland

Land use	Compost rate (t/ha)	fPOC	oPOC	nHOC	aHOC	TOC
C1 (TZESR-W[a])	0	1.27	0.78	2.05	0.14	2.19
	5	1.14	0.76	1.89	0.68	2.57
	10	1.71	0.42	0.30	0.33	2.63
	15	1.00	0.59	1.68	0.57	2.25
	Mean	1.35	0.65	1.98	0.43	2.41
C2 (OHORI[b])	0	2.23	0.63	2.05	0.50	2.55
	5	1.04	0.77	1.75	0.54	2.28
	10	1.39	0.64	2.10	0.46	2.57
	15	1.03	0.81	1.65	0.84	2.49
	Mean	1.42	0.71	1.88	0.59	2.47
Forestland	NA	1.31	0.89	1.71	1.48	3.18
LSD (P<0.05)		0.39	NS	NA	0.73	0.52

C1 & C2 = Cultivated land amended with pig-composted manure; NA = Not applicable; NS = Not significant ($p < 0.05$)

[a]: Improved maize variety

[b]: Local maize variety

fPOC = Free particulate organic carbon

oPOC = Occluded particulate organic carbon

nHOC = Non-acid hydrolyzable organic carbon

aHOC = Acid hydrolyzable organic carbon

TOC = Total organic carbon

Table 3: Aggregate-associated organic carbon (%) of soil amended with compost compared with uncultivated forestland

Land Use	Compost rate (t/ha)	Aggregate size (mm)		
		2000-200 µm	200-63 µm	< 63 µm
C1 (TZESR-W[a])	0	1.10	2.55	2.91
	5	1.71	2.46	3.53
	10	2.36	2.23	3.29
	15	1.73	2.14	2.88
	Mean	1.73	2.35	3.15
C2 (OHORI[b])	0	0.89	1.81	3.26
	5	1.12	2.54	3.43
	10	2.58	3.35	3.23
	15	1.22	3.06	3.18
	Mean	1.48	2.69	3.28
Forestland	NA	2.55	30.9	4.05
LSD (P < 0.05)		1.37	0.86	1.06

C1 & C2 = Cultivated land amended with pig-composted manure; NA = Not applicable; NS = Not significant ($p < 0.05$)
[a]: Improved maize variety [b]: Local maize variety

was least followed by 200-63 associated OC, whereas the highest content of OC associated with < 63 µm aggregate fraction. This trend was similar to that reported by Igwe and Nwakocha (2006), for an Ultisol under cultivation and secondary forest in South eastern, Nigeria. They further noted that most of the 2000-200 µm associated SOC seems to be generated from recently deposited materials.

Effect of land use types on microaggregate stability

The stability of this soil relative to land use types was assessed through its tendencies to slake in water. Since tropical soils degrade rapidly, restoration of the stability of these soils at microaggregate level is very important. Clay and silt are major soil parameters involved in stability at colloidal scale, hence the microstability of this soil was measured by dispersion ratio (DR), clay dispersion ratio (CDR), clay flocculation index (CFI), aggregated silt +clay (ASC), water-dispersible clay (WDC) and water-dispersible silt (WDSi), and are presented in Table 4. The DR was 0.47 for uncultivated forestland, while it ranged from 0.58 to 0.69 for uncultivated land amended with different rates of compost. Clay dispersion ratio (CDR) values were low for forestland (0.56) compared to the cultivated land which was 0.52 in plots amended with 15 Mg ha^{-1} compost, and 0.96 in plots planted with local (OHORI) maize variety and amended with 10 Mg ha^{-1} compost. The WDC was 9.4% for forestland and control plots of land planted with OHORI maize; while values for other cultivated plots were similar. However, this observed trend were not significantly ($p \leq 0.05$) different. Water-dispersible silt (WDSi) was significantly ($p \leq 0.05$) higher (4.93%) in cultivated plots amended with 15 Mg ha^{-1} and 5 Mg ha^{-1} compost for TZSER-W (improved) and OHORI (local) maize variety plots respectively than in uncultivated forestland (2.13%). The values for ASC were statistically similar ($p \leq 0.05$) for plots amended with compost, whereas ASC was significantly higher for forestland (14.6%). The trend with CFI which is also an index of better

Table 4: Microaggregate stability indices

Land Use	Compost rate (t/ha)	DR	CDR	CFI	ASC (%)	WDC (%)	WSI (%)
C1 (TZESR-W[o])	0	0.58	0.57	0.20	8.0	8.73	2.13
	5	0.61	0.71	0.29	8.0	8.73	3.47
	10	0.58	0.70	0.52	8.7	8.73	2.80
	15	0.69	0.52	0.46	6.0	8.60	4.96
C2 (OHORI[b])	0	0.59	0.81	0.19	8.7	9.40	2.80
	5	0.62	0.77	0.43	8.7	8.73	4.93
	10	0.62	0.96	0.40	7.3	8.73	2.80
	15	0.55	0.74	0.26	9.3	8.73	2.13
Forestland	NA	0.47	0.56	0.44	14.6	9.40	2.13
LSD (P < 0.05)		0.17	0.43	0.21	4.8	NS	2.22

C1 & C2 = Cultivated land amended with pig-composted manure; NA = Not applicable;
NS = Not significant ($p < 0.05$)

[a]: Improved maize variety

[b]: Local maize variety

DR = Dispersion ratio; CDR = Clay dispersion ratio; CFI = Clay flocculation index;
ASC = Associated silt + clay;

WDC = Water dispersible clay; WSi = Water dispersible silt

aggregation like ASC showed that plots amended with 10 Mg ha^{-1} compost and planted with TZESR-W maize variety was higher (0.52) than uncultivated forestland. The trend with cultivated plots planted with improved maize variety was 10 Mg ha^{-1} > 15 Mg ha^{-1} and least in control (0.20); while it was 5 Mg ha^{-1} > 10 Mg ha^{-1} >15 Mg ha^{-1} > 0 Mg ha^{-1} for OHORI (local) maize variety. Since higher DR and CDR indicates greater ability of soil to disperse, while higher CFI and ASC indicate better aggregation (Igwe and Nwakocha, 2006), this study revealed significant ($p \leq 0.05$) improvement in soil microaggregate stability with addition of pig-composted manure to the cultivated land to about the same level observed in uncultivated forestland. Generally, this study confirmed improvements in soil aggregation which usually follow addition of organic amendments; however controversy exists as per the actual fractions of the organic matter that are responsible for soil aggregation and stability (Adesodun *et al.*, 2007).

Relationship between microaggregate stability and soil organic carbon fractions

The correlation coefficients which show the relationship between the microaggregate stability indices of this fragile tropical soil and the SOC are shown in Table 5. Irrespective of land use types, there were higher and positive correlations between WDC, fPOC and < 63μm aggregate associated OC; whereas, the relationship between WDC and total organic carbon (TOC) fraction was significant ($r = 0.68^{*}$). The DR negatively correlated with TOC ($r = -0.77^{*}$) and < 63 μm aggregate associated OC (0.70^{*}), while the correlation between DR and aHOC was high (-0.637). The relationship between the CDR and OC fractions was low for this soil. Associated silt + clay (ASC) and CFI which are indices of better aggregation showed positive and very high significant correlation between ASC and TOC ($r = 0.84^{***}$) and < 63 μm aggregate associated OC ($r = 0.85^{***}$); however, CFI correlated significantly with 2000-200 μm aggregate associated OC ($r = 0.70^{*}$).

Table 5: Correlations between microaggregate stability indices and organic carbon fractions

	fPOC	nHOC	TOC	2000-200 µm OC	200-63 µm OC	< 63 µm OC
nHOC	-2.208					
	0.591					
TOC	0.251	**0.795**				
	0.515	0.010				
2000-200 µm OC	-0.050	0.359	0.639			
	0.899	0.342	0.064			
200-63 µm OC	-0.634	0.367	0.273	0.528		
	0.067	0.331	0.478	0.144		
< 63 µm OC	0.051	**0.798**	**0.866**	0.435	0.276	
	0.897	0.010	0.003	0.242	0.473	
WDC	0.624	0.545	**0.683**	0.017	-0.288	0.608
	0.072	0.129	0.043	0.965	0.453	0.082
WSi	-0.349	-0.185	-0.482	-0.169	-0.269	-0.206
	0.358	0.634	0.189	0.664	0.485	0.594
DR	-0.171	-0.637	**-0.766**	-0.225	-0.329	**-0.700**
	0.661	0.065	0.016	0.560	0.388	0.036
ASC	0.083	**0.813**	**0.844**	0.306	0.299	**0.853**
	0.932	0.008	0.004	0.423	0.435	0.003
CDR	0.328	-0.244	-0.024	0.048	0.097	-0.009
	0.388	0.528	0.951	0.903	0.803	0.981
CF1	-0.235	0.207	0.266	**0.703**	0.269	0.259
	0.544	0.594	0.489	0.035	0.484	0.500

Cell Contents: Pearson correlation P-Value

fPOC = free particulate organic carbon; aHOC = acid hydrolyzable organic carbon; TOC = Total organic carbon; DR = Dispersion ratio; CDR = Clay dispersion ratio; CFI = Clay flocculation index; ASC = Associated silt + clay; WDC = Water dispersible clay; WSi = Water dispersible silt

The general positive correlation between WDC and the SOC fractions showed increase in the tendency of clay particles to disperse in water with higher level of SOC resulting from increased negative charge at the edges of this colloidal soil fraction. Igwe and Nwokocha (2006), reported similar trend between WDC and OC fractions for some soils in South eastern Nigeria. However, positive and highly significant ($p \leq 0.01$) correlation obtained between ASC and aHOC, TOC and 63 µm aggregate associated OC indicated increase in ASC with increase in OC fractions suggesting better aggregation and stability.

Multivariate analysis

Results presented in Table 5 generally showed strong intercorrelations between the OC fractions and microaggregate stability indices. To remove the disturbances due to these interrelationships and determine the underlying structure of the interrelations among these parameters, they were subjected to principal component analysis (PCA). The PCA grouped the six correlated soil properties to orthogonal components with the first two groups or factors having eigenvalues greater than unity and together accounting for 80.5% of the total variability (Table 6). Component 1 (PC1), which is the most important, explained 53.6% of the variation and had high factor loading (> -.40) for properties such as aHOC, TOC and < 63 µm aggregate associated OC. Component 2 (PC2) explained 26.9% of the total variance from fPOC and 200-63 µm aggregate-associated OC. The component defining variables (CDVs) are those which loaded highest in each component (Igwe and Nwokocha, 2006). Therefore, the CDVs in this study are TOC from PC1 (51%) and fPOC with 72.9% loading in PC2. Relationship between these two properties (TOC and fPOC) and microaggregate stability indices (ASC and CFI) were further subjected to multiple regression analysis.

Table 6: Principal component analysis of microaggregate stability factors

Variable	PC1	PC2	PC3	PC4
fPOC	0.077	0.729	-0.314	-0.388
aHOC	-0.483	0.028	0.483	0.327
toc	-0.510	0.300	-0.057	-0.049
2000-200	-0.399	-0.074	-0.739	0.468
200-63?m	-0.320	-0.573	-0.209	-0.666
<63?mOC	-0.489	0.210	0.273	-0.278
Eigenvalue	3.2185	1.6132	0.7828	0.2148
Proportion	0.536	0.269	0.130	0.036
Cumulative	0.536	0.805	0.936	0.972

Multiple regression analysis

Multiple regression was performed to show the relationship between the retained PCA soil properties (TOC and fPOC) and ASC and CFI. The regression equation of TOC, fPOC and ASC was significant ($r = 0.73^{*}$), while that of these soil properties with CFI was not significant:

$$ASC = -8.00 - 0.82(fPOC) + 7.10(TOC) \quad (5)$$

$$CFI = 0.13 - 0.097(fPOC) + 0.143(TOC) \quad (6)$$

These relationships show that total organic carbon (TOC) influenced best the stability of this fragile tropical soil at colloidal (micro) scale, while fPOC fraction which response more to soil management practices influence the soil more at macroaggregates level. This confirmed the observation of Chan *et al.* (2002) that different forms of organic matter (OM) have different effects on soil quality.

CONCLUSION

This study revealed that application of compost at 10 Mg ha^{-1} is adequate to enhance better carbon storage and improve microaggregate stability of this fragile tropical soil. Principal component analysis also showed that TOC and fPOC were SOC fractions that best explained the variability in ASC and CFI. However, multiple regression analysis further indicated that TOC contributes best to microstability of this soil than fPOC.

REFERENCES

Adesodun, J. K., Adeyemi, E. F. and Oyegoke, C. O. (2007). Distribution of nutrient elements within water-stable aggregates of two tropical agro-ecological soils under different land uses. *Soil & Tillage Research* 92: 190-197.

Brejda, J. I., Moorman, T. B., Karen, D. L. and Dao, T. H. (2000). Identification of regional soil quality factors and indicators. I. Central and Southern high plains. *Soil Science Society of America Journal* 64: 2115-2124.

Chan, K. Y., Heenan, D. P. and Oates, A. (2002). Soil carbon fractions and relationship to soil quality under different tillage and stubble management. *Soil & Tillage Research* 63: 133-139.

Christensen, B.T. (2001). Physical fractionation of soil and structural and functional complexity in organic matter turnover. European Journal of Soil Science 52: 345-353.

Coote, D. R., Malcolm-Mcgovern, C. A., Wall, G. J., Dickinson, W. T. and Rudra, R. P. (1988). Seasonal variation of erodibility indice based on shear strength and aggregate stability in

some Ontario soils. *Canadian Journal of Soil Science* 68: 405-416.

Gee, G. W. and Bauder, J. W. (1986). Particle size analysis. In: Klute A., (Ed.), *Methods of Soil Analysis*. Part I, Part 1 *Physical and Mineralogical Methods*, 2nd Edition. ASA and SSA, Madison, WI USA, pp. 91-100.

Igwe, C. A. and Nwokocha, D. (2006). Soil organic fractions and microaggregation in a Ultisol under cultivation and secondary forest in South-eastern Nigeria. *Australian Journal of Soil Research* 44: 627-635.

Kemper, W. D. and Rosenau, R. C. (1986). Aggregate stability and size distribution. In: Klute A., (ed.), *Methods of Soil Analysis*. Part I. Am. Soc. Agron. Monograph 9, pp. 425-442.

Lal, R. (1979). Physical characteristics of soils in the tropics: determination and management. In: Lal, R.., Greenland, D. J., (eds.). *Soil Physical Properties and Crop in the Tropics*. John Wiley and Sons, New York, pp. 7-44.

Lal, R. (2004). Soil carbon sequestration impacts of global climate change and food security. *Science* 304: 1623-1627.

Madubuike, C. N. (1999). Comparative analysis of soil loss in southeastern and southwestern Nigeria. *Journal of Erosion and Environmental Degradation.* Published by Institute of Erosion Studies, Federal University of Technology, Owerri, Nigeria 1(1): 43-52.

Nelson, D. W. and Sommers, L. E. (1996). Total carbon, organic carbon and organic matter. In: Sparks, D. L. (Ed.), *Methods of Soil Analysis. Part 3. Chemical Methods*. No. 5, ASA and SSSA, Madison, WI, pp 961-1010.

Opara, C. C. (2009). Soil microaggregates stability under different land use types in South eastern Nigeria. *Catena* 79: 103-112.

Rovira, P. and Vallejo, R. V. (2003). Physical protection and biochemical quality of organic matter in Mediterranean calcareous forest soils: a density fractionation approach. *Soil Biology & Biochemistry* 35: 245-261.

Swan, A. R. H. and Sandilands, M. (1995). *Introduction to Geological Data Analysis*. Blackwell, London, pp. 1-446.

Von Lützow, M., Kögel-Knabner, I., Ekschmitt, K., Flessa, H., Guggenberger, G., Matzner, E and Marschner, B (2007). SOM fractionation methods: Relevance to functional pools and to stabilization mechanisms. *Soil Biology & Biochemistry* 39: 2183-2207.