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Aggregate Stability and Dispersibility Index of Soil in Relation to Land Use Management in Humid Tropics of Southeast Nigeria

Nwosu T. V.*
Department of Soil Science and Land Resources Management, Nnamdi Azikiwe University, Awka, Nigeria
Onunwa A.O.
Department of Soil Science and Land Resources Management, Nnamdi Azikiwe University, Awka, Nigeria
Nnabuihe E.C.
Department of Soil Science and Land Resources Management, Nnamdi Azikiwe University, Awka, Nigeria
Okafor M.J.
Department of Soil Science and Land Resources Management, Nnamdi Azikiwe University, Awka, Nigeria
Madueke C.O.
Department of Soil Science and Land Resources Management, Nnamdi Azikiwe University, Awka, Nigeria
Nwaiwu C.J.
Department of Soil Science and Land Resources Management, Nnamdi Azikiwe University, Awka, Nigeria
Ibigweh M.N.
Department of Soil Science and Land Resources Management, Nnamdi Azikiwe University, Awka, Nigeria
Chukwuma T.R.
Department of Soil Science and Land Resources Management, Nnamdi Azikiwe University, Awka, Nigeria
Ikot I.E.
Department of Soil Science and Land Resources Management, Nnamdi Azikiwe University, Awka, Nigeria
Igboka C.R.
Department of Soil Science and Land Resources Management, Nnamdi Azikiwe University, Awka, Nigeria
Obasi S.N.
Department of Crop and Soil Sciences, Faculty of Agricultural sciences, NOUN Kaduna Campus

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ABSTRACT: Soil aggregate stability and dispersibility are among the key indicators of soil health and productivity hence the aggregate stability and dispersibility of soil was evaluated in relation to land use management practices in Awka and Ifite Ogwari areas of Anambra State, Nigeria. The study made use of three land use practices namely arable land for cassava farming, rice farm and grassland. Auger and core soil samples were collected from each of the land use types in three replicates at 0-20 cm depth. Collected soil samples were subjected to laboratory analysis after which the results obtained were subjected to statistical analysis. From the results obtained, the soils at Awka site had a sandy loam textural class while that of Ifite Ogwari had a clay textural class. Aggregate stability index (ASI) was generally low and ranged from 0.003-0.008 Jkg^{-1}. Organic carbon ranged from 0.36-1.12% while dispersion ratio (DR) ranged from 56.67-83.14% of which cassava farm recorded the highest DR value at Ifite Ogwari site. The higher the DR the more the ability of soil to disperse and the more soil loss. Soil dispersibility increased as time intervals increased of which significant differences were obtained at 4hrs, 12hrs, 16hrs and 20hrs intervals except at 8hrs. Continuous land use without replenishing the organic carbon content of soils was observed to have led to the structural imbalance hence to improve the stability of the soils and ensure aggregate formation practices like residue management and organic matter incorporation must be adopted.

KEYWORDS: aggregates, agriculture, dispersion, soaking, tillage

INTRODUCTION

Soil aggregate stability is the ability of the soil particles to bind together into aggregates which plays a crucial role in regulating water infiltration, nutrient cycling and erosion control. It is an important factor in determining the overall health and productivity of the soil. According to Spaccini *et al.* (2004) soil aggregates are dynamic and under tropical conditions, the size distribution of aggregates is affected by change in land use and management practices. The aggregation of soil is an essential mechanism for the stabilization of soil organic matter, especially in organic soils

(Lutzow *et al*., 2006) which affects the soil's physical, chemical and biological activities. Since the stability of soil can provide information about the capacity of a soil to function which also affect other soil properties it means that maintaining high stability of soil aggregate is essential for preserving soil productivity, minimizing soil erosion and degradation and thus minimizing environmental pollution (Six *et al.,* 2000).
Understanding the factors that influences aggregate stability is essential for sustainable soil management practices. One such factor is the soaking period, which refers to the duration of contact between soil aggregate and water and this can have both short-term and long-term effects on soil aggregation. Extended periods of soaking can lead to the disintegration of soil aggregates. When soil is continuously saturated with water, the soil particles are more prone to detachment and dispersion and can break down the existing aggregates, reducing their stability and causing a decrease in soil aggregation and as a result lead to soil water erosion. Different land use types can lead to variations in soil properties and processes (Lal, 2008) and can have direct consequences on soil aggregate stability. For instance, in agricultural fields, intensive tillage practices, the use of heavy machinery and the removal of crop residues can result in reduced soil organic matter content and decreased aggregate stability (Han *et al.,* 2010). Conversely, natural ecosystems such as forests, often promote the accumulation of organic matter and the formation of stable aggregates through the inputs of plant residues and the activity of soil organisms (Paustian *et al.,* 2000). These studies have demonstrated the importance of land use in influencing soil aggregate stability hence the need for targeted land management practices within the studied area

MATERIALS AND METHODS

Site Description

This research was conducted in Anambra State, southeast, Nigeria. Two sites (Awka and Ifite Ogwari annex of Nnamdi Azikiwe University served as the study sites. Awka lies within Latitude 06°12 N and 06°25 N and Longitudes 07°7 E and 07°11 E and underlain by Imo shale and Ameki geologic formations. The soils of the area are continuously cultivated with mostly annual crops e.g cassava, yam, maize and rice. The original rainforest vegetations have been lost due to urbanisation. As per 2022 data from Nigeria Meteorological Agency (NiMET), the cumulative annual mean rainfall of Awka was 2590.6mm. It has an average mean temperature of about 28 °C and an average relative humidity of about 84%. Ifite Ogwari is about 40km from Awka and lies within Latitude 06°4' N and 06°60'N, and Longitude 06°57'E and 06°95'E. According to FDALR (1990), the soils of Ifite Ogwari originated from Imo shale geologic formation characterised by derived savanna vegetation with some patches of rainforest. This area experiences two main seasons (dry and wet), average temperature of 35°C, relative humidity of 74% and according to Nigeria Meteorological Agency (NiMET) an average annual rainfall of 2737.4 mm was recorded in the year 2022. Majority of the land in this area is used for farming of cassava, yam, plantain, rice and okro.

Land Use Practices: Arable land **(**Cassava farming), Rice farm and Grassland

Soil sampling and Collection

Soil samples were collected in three replicates from each of the land use practices at 0 -20 cm depth using core and auger samplers. The collected soil samples were bagged, labelled accordingly in preparation for laboratory analysis.

Laboratory analysis

i. Particle size Distribution: The hydrometer method as described by Gee and Or (2002) was used to determine the particle size distribution of the samples, while the soil texture was determined using the USDA Textural triangle.

ii. An aggregate stability index was determined using single water drop technique method as modified from Idowu (2003). ASI was computed as the total raindrop dispersion energy required to shatter a given mass of soil as shown in the equation:

$$ASI = \frac{n \times Ke}{m}$$

where ASI is the aggregate stability index (J kg–1); n is the mean number of drops to shatter an aggregate; Ke is the kinetic energy per drop which corresponds to the energy of the water drop at rest, approximated as the product of its mass, acceleration due to gravity and height of fall (7.4 × 10–4 J); and m is the mean mass of aggregates (g).

iii. Soil Dispersibility: Dispersibility at 4hrs, 8hrs, 12hrs, 16hrs and 20hrs was determined by placing 20g of soil in 350ml plastic shaker container with 200ml deionized water and shaken end over end in a mechanical shaker for the time in view. A 2ml sample was pipetted from a depth of 2cm after allowing coarser particle (sand) to settle for about 1min, for silt+clay and after 2hrs for clay alone. The percentage of total clay per total silt+clay dispersed at each period was calculated using the formula:

$$SD = \frac{Clay}{Clay + silt} \times 100$$

Where SD = Soil dispersibility

iv. Dispersion Ratio (DR) was computed as follows: $\frac{\%\ Silt + \%\ clay\ (water)}{\%\ Silt + \%\ clay\ (calgon)}$

v. Soil organic carbon was determined using the wet dichromate oxidation method of Walkley and Black (1934).

Statistical analysis

Data collected was subjected to analysis of variance using SPSS 13.0 (SPSS Inc., Chicago, IL, USA). Significant difference between the means was separated using F-LSD at 5% probability level.

PHYSICAL PROPERTIES OF SOIL UNDER LAND USE TYPES AND DEPTH

Particle size distribution

The result of the particle size distribution of soil under land use types in both Awka and Ifite Ogwari sites are shown in Table 1. From the results obtained, soils from the arable land used for cassava farming had the highest sand content of 664g/kg while rice farm had the lowest sand content of 554g/kg. The sand content under land use types in Awka were higher compared to those of Ifite Ogwari. Highest clay content of 466 g/kg was obtained under rice farm at Ifite Ogwari site while the lowest clay content of 422 g/kg was obtained under grassland at Ifite Ogwari site. In comparing the clay content based on the location, Ifite Ogwari site recorded the highest clay content compared to Awka site. Silt content was highest with a value of 273 g/kg under rice farm and lowest under cassava farm with a value of 240 g/kg at Awka site while at Ifite Ogwari site the soil under cassava farm had the highest silt content of 235 g/kg and lowest silt content of 229 g/kg under grassland. There was a significant difference in particle size distribution across the land use practices in both sites which probably may be as a result of the geological positions of the studied sites. Awka site had a sandy loam textural class while Ifite Ogwari had a clay textural class based on the land use types studied. The dominance of sand fraction under land use practices at Awka site may indicate well aerated soils (Nweke and Nsoanya, 2012) however Osujieke *et al.* (2020) suggested that soils high in sand content are prone to erosion due to a low binding agent.

Table 1: Particle size distribution in relation to land use practices in the studied sites

Land Use	Sand (g/kg)		Silt (g/kg)		Clay (g/kg)		Textural Class	
	Awka	Ifite-Ogwari	Awka	Ifite-Ogwari	Awka	Ifite-Ogwari	Awka	Ifite-Ogwari
Arable land(Cassava farm)	664	308	240	235	96	457	SL	Clay
Grassland	591	349	267	229	142	422	SL	Clay
Rice farm	554	300	273	234	173	466	SL	Clay
LSD (P<0.05)	*	*	*	*	*	*		

Note: *- significant

Aggregate Stability Index (ASI)

The result of ASI obtained showed that arable land used for cassava farming had a value of 0.007 Jkg^{-1} while rice farm had a value of 0.004 Jkg^{-1} at Awka site while at Ifite Ogwari site, rice farm and grassland recorded ASI values of 0.008 Jkg^{-1} and 0.003 Jkg^{-1} respectively. The ASI values obtained in this study were low and probably may indicate rapid soil disaggregation in contact with water hence poor structural stability. Again, continuous cultivation and lack of adequate organic matter content could have contributed to the poor stability of soils within the studied area. Lioyd *et al*., (2006) reported tillage to cause poor structure, smoothing of the surface and loss of organic matter and an increase in dispersed clay. Generally, the aggregate stability index across the land use practices in both sites were statistically similar and may be due to the similar geologic characteristics of the sites.

Soil organic Carbon

From the result obtained, cassava farm, grassland and rice farm respectively had organic carbon content values of 0.42%, 0.50% and 0.51% at Awka site. However, at Ifite Ogwari site cassava farm had a value of 1.12%, grassland had 1.00% while rice farm had 0.36%. The highest (0.51%) and lowest (0.42%) organic carbon content was obtained under rice and cassava farms respectively at Awka site while the highest organic carbon content of 1.12% and the lowest with a value of 0.36% was obtained respectively under cassava farm and rice farm at Ifite ogwari. At Awka site, there was 17.6% decrease of organic carbon in cassava farm when compared with rice farm. Cassava farm had 12% more of organic carbon when compared with grassland at Ifite Ogwari site. There was a significant difference in organic carbon content under land use types at Ifite Ogwari site compared to Awka site probably due to variation in residue management, tillage methods, continuous cropping and cultivation with different tillage implements (Nweke and Ilo 2019) as well as textural nature of the area. Though organic carbon has the ability to disperse or aggregate the soil however it is dependent on the threshold level of the organic carbon in the soil as well as the ratio at which it occurs with other aggregating agents thus the low organic carbon values as obtained in this study could suggests higher ability of the soil to disperse. Nwosu and Nweke (2024) in their research recognised soil texture and organic carbon as important variables in aggregate formation.

Dispersion Ratio (DR)

Based on the results obtained, the soils under cassava farm recorded DR value of 56.67%, grassland recorded 65.78%, and rice farm recorded 68.69% at Awka site. At Ifite Ogwari site cassava farm recorded DR value of 83.14%, grassland recorded 74.77%, and rice farm recorded 81.52%. Rice farm and cassava farm recorded the highest (68.69%) and lowest (56.67%) DR values respectively at Awka site while at Ifite Ogwari site cassava farm and grassland respectively recorded the highest (83.14%) and lowest (74.77%) DR values. The highest DR value of 83.14% observed under cassava farm at Ifite Ogwari site could be attributed to the colloidal nature of clay which usually aid poor aggregation in soils as reported by Ghezzi (2010). The higher the DR the more the ability of soil to disperse and the more soil loss. Igwe (2003) stated that soils with high DR value have the potential to erode more easily than those with lower DR values while Elges (1985) rated soils with DR >50% to be extremely dispersive, 30-50% to be moderate, 15-30 to be little dispersive, and <15% to be non-dispersive and based on this rating the soils across the land use practices could be said to be extremely dispersive having recorded more than 50%.

Table 2: **Aggregate stability index, organic carbon and Dispersion ratio under land use practices in the studied sites**

Land Use	ASI Jkg^{-1}		Organic carbon (%)		DR (%)	
	Awka	Ifite	Awk	Ifite	Awk	Ifite
Arable land(Cassava farm)	0.007	-	0.42	1.12	56.67	83.14
Grassland	-	0.003	0.50	1.00	65.78	74.77
Rice farm	0.004	0.008	0.51	0.36	68.69	81.52
LSD (P<0.05)	ns	ns	ns	*	*	*

Note: *- significant, ns- not significant. ASI- Aggregate stability index, DR-Dispersion ratio

Soil Dispersibility

The result of soil dispersibility across land use practices at various time intervals in the studied sites are shown in Table 3. At 4hrs soil dispersibility was highest under rice farm with a value of 21.00% and was lowest under cassava farm with a value of 11.00% at Awka site while grassland recorded the highest soil dispersibility with a value of 22.89% and rice farm the lowest with a value of 8.44% at Ifite Ogwari site. At 8hrs soil dispersibility, rice farm recorded the highest value of 24.56% while grassland recorded the lowest with a value of 12.89% at Awka site whereas at Ifite Ogwari site, grassland had the highest value of 26.78% while rice farm had the lowest value of 10.56. At 12hrs, rice farm recorded the highest dispersibility with a value of 23.44% while cassava farm recorded the lowest with a value of 14.67% in Awka site; in Ifite Ogwari site grassland recorded the highest the highest value of 27.00% while rice farm recorded the lowest with a value of 11.56%. At 16 hrs, rice farm recorded the highest value of 26.67% while cassava farm recorded the lowest with a value of 15.11% whereas at Ifite Ogwari, cassava farm recorded the highest value of 28.11% while rice farm recorded the lowest with a value of 13.11%. At 20 hrs, rice farm recorded the highest value of 31.33 while cassava farm recorded the lowest with a value of 16.78% at Awka site. At Ifite Ogwari site, grassland had the highest value of 32.56% while rice farm recorded the lowest value of 13.44%. Soil dispersibility at Awka site at various time intervals showed that rice farm recorded the highest values while cassava farm predominantly recorded the lowest except at 8hrs where grassland recorded the lowest value. Significant differences in soil dispersibility across land use practices were observed at 4hrs, 12hrs, 16hrs and 20hrs intervals at both studied sites. Generally, grassland recorded the highest dispersibility value at 20hrs interval (fig 1) while Ifite Ogwari site recorded higher soil dispersibility compared to Awka site (fig 2) and could be attributed to the textural features of the studied soil

Table 3: **Soil dispersibility under land use practices at various time intervals in the studied sites**

Land Use	DISPERSIBILITY %									
	At 4hrs		At 8hrs		At 12hrs		At 16hrs		At 20hrs	
	Awka	Ifite	Awka	Ifite	Awka	Ifite	Awka	Ifite	Awka	Ifite
Arable land (cassava farm)	11.00	16.44	13.33	16.00	14.67	21.33	15.11	28.11	16.78	30.56
Grassland	13.33	22.89	12.89	26.78	23.11	27.00	23.44	27.44	23.22	32.56
Rice farm	21.00	8.44	24.56	10.56	23.44	11.56	26.67	13.11	31.33	13.44
$LSD_{(P<0.05)}$	*	*	ns	ns	*	*	*	*	*	*

Note: *- significant, ns- not significant

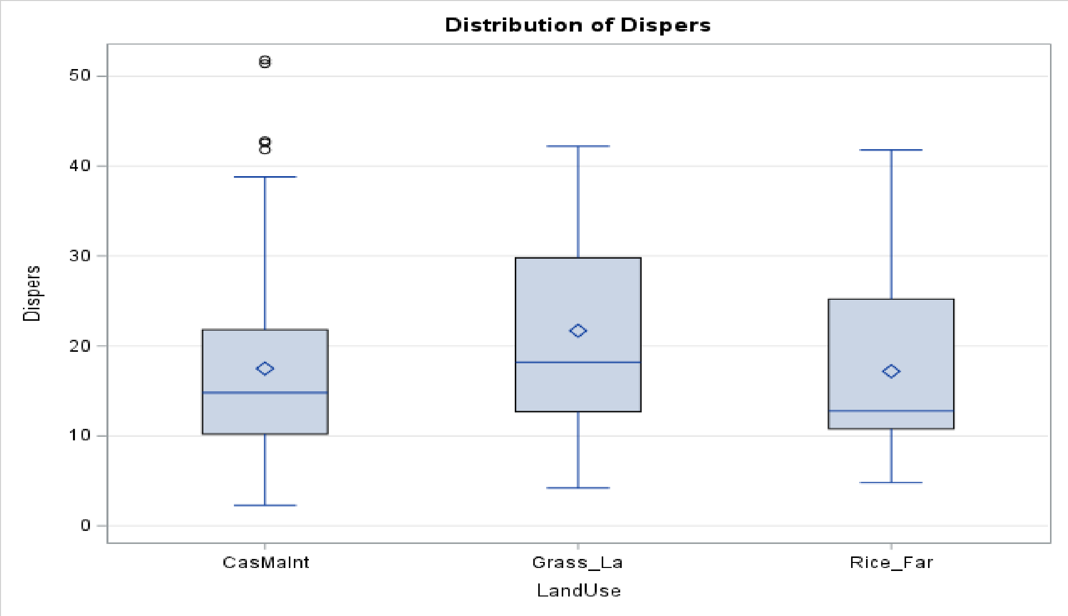

Fig 1.Soil dispersibility in relation to land use management

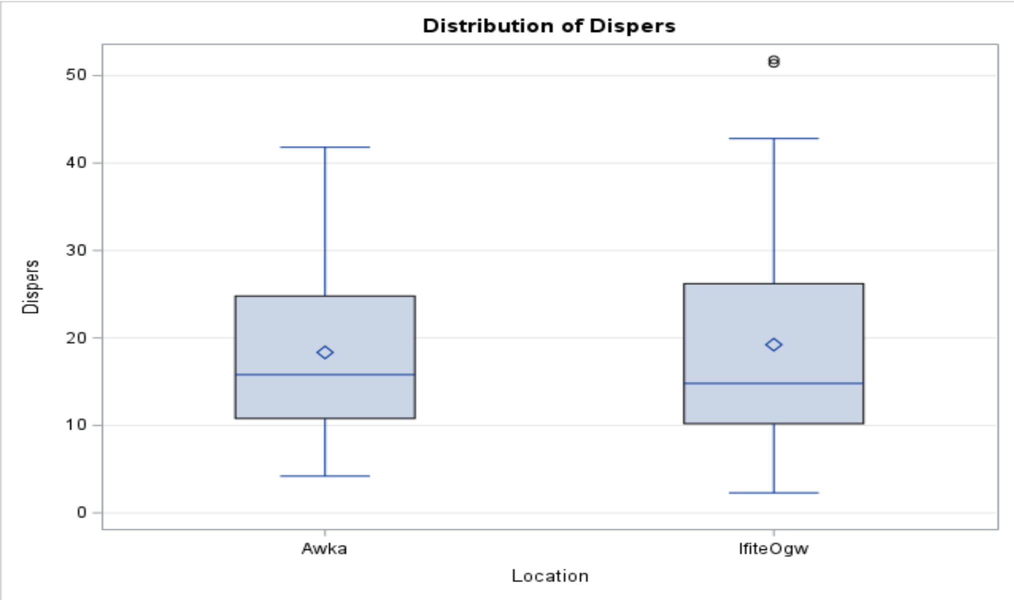

Fig 2 .Soil dispersibility in relation to studied location

CONCLUSION

The study observed that continuous land cultivation contributed to the instability of soils under the studied land use practices. Higher soil dispersion ratio was noticed at Ifite Ogwari site compared to Awka site. This study underscores the need to incorporate farm residues into the soil for improved organic matter content so as to help in aggregate formation and soil stability.

REFERENCES

1) Elges, H.F.W.K., (1985). "Problem Soils in South Africa -State of the Art," The Civil Engineer in South Africa, 27(7) : pp. 347-349 and 351-353.
2) Federal Department of Agricultural land resources- FDALR (1990). The reconnaissance soil survey of Nigeria. Soils Report Vol. 5 FDALR Kaduna, p. 377.
3) Gee, G. W., and Or, D. (2002). Particle Size Analysis. In: Dane, J.H. and Topp, G.C. (eds). Methods of Soil Analysis. Part 4, Physical methods, Soil Sci. Soc. Am. **5**: 255-293
4) Ghezzi, J. L (2010). Influence of clay mineralogy on soil dispersion behavior and water quality. California Polytechnic State University, USA pp.46-57

5) Han, K. H., Ha, S. G., and Jang, B. C. (2010). Aggregate stability and soil carbon storage as affected by different land use practices. In Proc. Int. Workshop on Evaluation and Sustainable Management of Soil Carbon Sequestration in Asian Countries. Bogor, Indonesia Sept (pp. 28-29).
6) Idowu, O. J. (2003). Relationships between aggregate stability and selected soil properties in humid tropical environment. Communications in Soil Science and Plant Analysis; 34 695-708
7) Igwe, C. A (2003). Erodibility of soils of the upper rainforest zone, southeastern Nigeria. Land degradation and development. 14(3): pgs 323-334.
8) Lal, R., Girmany, G., Singh, B. R., Mitiku, H., and Borresen, T. (2008). Carbon stocks in Ethiopian soils in relation to land use and soil management. Land Degradation and Development, 19(4), 351-367.
9) Lioyd, D; Norhton Amrakh, I; Mamedov Chi – Lava Huang, and Guy J Levy (2006). Soil aggregate stability as affected by long – term tillage and clay mineralogy, Advances in Geology 38:422-429
10) Lützow, M. V., Kögel-Knabner, I., Ekschmitt, K., Matzner, E., Guggenberger, G., Marschner, B., and Flessa, H. (2006). Stabilization of organic matter in temperate soils: mechanisms and their relevance under different soil conditions–a review. European journal of soil science, 57(4), 426-445
11) Nigeria Meteorological Agency –NIMET (2022). Annual field data collection and computation Nigerian Meteorological Agency-NIMET (2014). Seasonal Rainfall Prediction (SRP). S & E Consulting, Scottsdale, 9-15.
12) Nweke, I. A. and Nsoanya L.N (2012). Inventory of Physicochemical characteristics of soils of the the Teaching and Research Farm Faculty of Agriculture. Anambra State University- Igbaraiam Campus: In: A.O. Aniebo C.O.A Ugwumba(eds): Environmental concerns and agricultural productivity: Addressing the challenges of food security, proceedings of international Agricultural conference 6-9th may held at Anambra State University pp 488-493.
13) Nweke, I. A. and Ilo, G. E. (2019). Cultivation and Land use changes their implications in soil productivity management and crop yield. InT'L Journal of Agriclture and Agribusiness, 4 (1): 35-62
14) Nwosu, T. V., and Nweke, I. A. (2024). Erosion potentials of soils under different land utilization types in Anambra State, Nigeria. Agriculture, Food and Natural Resources Journal, 3(1), 101–106.
15) Osujieke, D. N, Bernardine, N. A. and Ahukaemere, C. M. (2020). Evaluation of erodibility indices and soil properties affected by land use-types in Mbano, southeast, Nigeria. Journal of Agricultural Sciences (Belgrade) 65(4): Pages 361-373
16) Paustian, K., Six, J., Elliott, E. T., and Hunt, H. W. (2000). Management options for reducing CO2 emissions from agricultural soils. Biogeochemistry, 48, 147-163.
17) Six, J., Elliott, E. T., and Paustian, K. (2000). Soil macroaggregate turnover and microaggregate formation: A mechanism for C sequestration under no-tillage agriculture. Soil Biol. Biochem., 32, 2099–2103.
18) Spaccini, R., Mbagwu, J. S. C., Igwe, C. A., Conte, P., and Piccolo, A. (2004). Carbohydrates and aggregation in lowland soils of Nigeria as influenced by organic inputs. Soil and Tillage Research, 75(2), 161-172.
19) Walkley, A., and Black, J. A. (1934). An examination of wet oxidation method for determining soil organic matter and a proposed modification. Sci. 37, 29-38.

Corresponding Author: Nwosu T. V.