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Effect of Soil Physical Properties on the Efficiency of Soil Organic Carbon Sequestration in Selected Farming Systems in South-western Nigeria.

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ABSTRACT

The study was aimed at determining the effect of soil bulk density, particle size, pH and electrical conductivity on the efficiency of soil organic carbon sequestration in four study sites of Lagos State, south western Nigeria. Samples were collected at the end of harvesting season in August2010, bulked and analyzed. The study sites were conservation/organic farm plots) (A), Manual and continuous cropping plot (B) Agro-forest plot (C) and conventional farmers plot (D). Bulk density and Conductivity of the conservation tilled/organic farm plots were not significantly ($p<0.05$) different from agro-forestry, whereas bulk density and conductivity of the soil samples of the conservation tilled/organic farm plots were found significantly ($p<0.05$) different from the adjacent conventionally tilled/ continuously cropped farm plot. Bulk density, pH and Particle size of the study sites were found to influence the quantity of soil organic carbon (SOC) stock at each study site.

INTRODUCTION

Understanding the factors that affect the stocks of carbon in the soil is one of the most important short-term sinks for atmospheric carbon dioxide (CO_2) fluxes on earth, and an avenue to increase the amount of carbon in the soil. Though, Carbon exists as an inseparable component of vegetation, litter and soil organic matter, and it is primarily lost as an invisible gas [1]. A variety of factors has been identified in the literature to affect the stock or proportion of soil organic carbon (SOC); these include climate, precipitation and temperature [2], soil and landscape such as cation exchange capacity, total nitrogen, clay, available phosphorus [3, 4].

Hoover [5] noted that harvesting and site preparation, soil drainage and planting of adapted species with high Nitrogen, Phosphorus and Potassium and more below-ground biomass production, fertilization and liming are some of the management activities that may impact the soil organic carbon (SOC) stock. There are no known researches that studied the effect of soil physical properties on carbon sequestration in Lagos south western Nigeria where this experiment was conducted.. Hence, the objective of this study was to determine the effect of bulk density, particle size, pH and electrical conductivity) on the efficiency of soil organic carbon sequestration in four study sites in Lagos.

MATERIALS AND METHODS

The Study Area

Four study sites were used for the study. These were (i) The Organic/conservation Farm plots at Ikorodu farm settlement. (ii) Manual and continuously crop farmers plot adjacent to the farm settlement. (iii) Majek Agroforestry situated at Lekki Peninsula. (iv) Conventional tilled farmer plot adjacent to Majek Agroforest, Lekki Peninsula. The four sites were located in Lagos. Lagos is situated in the southwestern corner of Nigeria; this elongated state spans the Guinea coast of west to its boundary with Ogun state in the east. It extends approximately from latitude 6°27′11″N 3°23′45″E/ 6.45306°N. Of its total area of 3, 577sq.km, about 787sq km or 22 percent is water.

Samples Collection

An initial survey was carried out at the 4 sites selected for the study to establish sampling points. Five representative sampling points were chosen in each selected site using the free survey approach. Three sampling depths (0-5, 5.1-15 and 15.1- 30 cm) were used for the study. At each depth, samples were collected for laboratory analysis.

The samples were collected at the end of the first harvesting season. The samples was air-dried at ambient temperature for 72 hours and subsequently sieved.

Samples Analysis

Samples were analyzed in the Environmental Laboratory (EMT Lab) of the College of Environmental Resource Management, Federal University of Agriculture-Abeokuta, and organic carbon content, soil conductivity, bulk density, particle sizes and soil pH were determined. Organic carbon was determined by the Walkley-Black procedure. Soil pH on a saturated sample was determined in soil electrolyte (0.01 M $CaCl_2$) suspension using a glass electrode pH meter, particle size by hydrometer method and bulk density through the core method. The determination of electrical conductivity (EC) was made with a conductivity cell by measuring the electrical resistance of a 1:5 soil: water suspension [6].

Data Analysis

The data obtained from the laboratory analysis was analysed using Statistical Package using Analysis of variance (ANOVA) procedure to determine the effects of various factors on the treatments being evaluated. Further analysis of Tukey HSD was employed to determine significant (P<0.05) difference between and among treatments means. The hypotheses set were tested using ANOVA as a statistical tool.

RESULTS AND DISCUSSION

The results showed that there were differences in total quantity of carbon sequestered in the different land utilization types in the study area. Site C (Agro-forest farm plot) had the highest percentage of organic carbon per soil sample followed by Site A (conservation/organic farm plot) as 5.59% and 4.89% in the 0-5.0 cm soil layers, respectively as against 2.25% and 2.79% that were found in Sites B and D respectively (the continuously cropped and conventionally tilled farm plots). At 5.1-15.0 cm layer of the soil, the highest percentage of the organic carbon sequestered was found in site C with 5.39% soil organic carbon stock followed by site A which had 4.59% soil organic carbon stock while sites B and D have very low percentage organic carbon stock at their 5.1-15.0cm of their soil layers. For 15.1-30.0 cm depth, Site B had 2.56% and site D had 2.79% soil organic carbon stored, highest SOC was also found in site C followed by site A. Lowest SOC were found in site B and D

The pH of the soil in the study sites was good enough for the uptake of soil nutrients. At the first layer of the soil the pH value of the soil were found to be 6.92, 6.24, 6.34 and 6.48 at sites A, B, C and D respectively. At the second layer (5.1-15.0 cm) the pH values were found to be 8.34, 7.83, 7.94 and 7.34 at sites A, B, C and D respectively. The pH values at the study sites at soil layer 15.1-30.0cm were found higher compared with the first and second layers. The values of the pH at this depth are 8.34, 7.83, 7.94 and 7.34 for sites A, B, C and D respectively.

Results show slight differences in pH values for the different sites studied. The four sites have a pH value ranged from 6.24-8.34. The pH value increases from 6.24-8.34 down the depth. The pH values of the first depth at the four sites were not significantly (p<0.05) different. The first depth (0-5 cm) were slightly acidic, depth (5.1-15cm) and (15.1-30cm) were slightly alkaline. However, sites A and C had the highest pH compared to other sites at 5.1-15.0 cm and 15.1-30.0 respectively.

Bulk density increased down the depth at the four sites studied. The four studied sites were significantly (P<0.05) different in terms of the bulk density. The highest bulk density was found in sites C which corresponded with the agro-forestry followed by the organic/conservation tilled farm plot, site A. Sites were the bulk density was found low were sites B and D which corresponded with the conventionally tilled and continuously cropped farm plots. This agreed with the findings of Anikwe [7] (2010. Alan [8], and Alan et al. [9],. The bulk density rate was found to be related with the quantity of the organic matter and consequently the quantity of organic carbon sequestered at each of the study site.

Conductivity of the soil at the study sites increased down the depth. Conductivity was significantly (P<0.05) different at the four study sites. There was no significant difference between the conductivity of soil in sites A and C. These were the conservational tilled/organic farm plot and Agro-forestry respectively. This is in support of the findings of Wilcox et al., Attua and Anikwe.

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Bulk density increased down the depth at the four sites studied. The four studied sites were significantly (P<0.05) different in terms of the bulk density. In agreement with the findings of Attua and Anikwe, the highest bulk density was found in sites C which corresponded with the agro-forestry followed by the organic/conservation tilled farm plot, site A. Sites where the bulk density was found low were sites B and D which corresponded with the conventionally tilled and continuously cropped farm plots.

Conductivity of the soil at the study sites increased down the depth except site B (conventionally tilled soil). Conductivity was significantly (P<0.05) different at the four study sites. There was no significant difference between the conductivity of soil in sites A and C. These were the conservational tilled/organic farm plot and Agro-forestry respectively.

Sand particles decreased down with depths at each study site. However clay and silt particles increased down with the depths. In agreement with findings of Anikwe, the pH value, particle sizes distributions and the soil conductivity at study sites may influence the growth and productivity of plants at the study sites. The rate of growth of the plants in turn determines the rates at which C is fixed in the soil at the study sites.

The high quantity of the soil organic carbon sequestered at study sites A and B could have been as a result of the high bulk density of the soil (Anikwe 2010). Low soil organic carbon stock found at sites B and D might be due to the low bulk density found at this two sites (B and D) [10,11,12,13].

Table 1: Physical parameters of the soil at 0.0-5.0 cm of the study sites

SITE	ORGANIC CARBON (mg kg-1)	pH (pH)	Particle size			Bulk Density (g m-3)	Conductivity (nscm-1)
			Sand	Clay	Silt		
A	4.89ab	6.92a	89.2c	7.20a	3.6a	1.25b	101c
B	2.57d	6.24d	92.8b	5.4a	1.8b	1.03bc	245a
C	5.59a	6.34d	94a	4.6ab	1.4b	1.50a	101c
D	2.79c	6.48cd	96.0a	2b	2.0b	1.46a	120b
SE±	0.04	0.01	0.65	0.02	0.03	0.007	0.92

Means having the same letter(s) in the same column are not significant different at 5%

A= Ikorodu Farm Settlement under (conservation/organic farm plots) .
B= Adjacent land near Ikorodu Farm Settlement Manual and continuous cropping.
C= MAJEK Agro-forest.
D= Adjacent conventional farmers plot near the agro-forestry.

Table 2: Physical Parameters of the Soil at 5.1-15.0 cm of the Study Sites

SITE	ORGANIC CARBON (mgkg-1)	pH	Particle size			Bulk Density (gm-3)	Conductivity (nscm-1)
			sand	clay	Silt		
A	4.59ab	8.34a	87.4b	3.6a	9a	1.27b	128a
B	2.56d	7.83bc	91.0a	1.8b	7.2a	1.09c	104c
C	5.39a	7.94b	96.4a	1.2b	2.4b	1.53a	128a
D	2.79c	7.34d	91.0a	1.8b	7.2a	1.50a	122b
SE±	0.004	0.07	0.35	0.03	0.16	0.005	0.74

Means having the same letter(s) in the same column are not significant different at 5%

A= Ikorodu Farm Settlement under (conservation/organic farm plots) .
B= Adjacent land near Ikorodu Farm Settlement Manual and continuous cropping
C= MAJEK Agro-forest.
D= Adjacent conventional farmers plot near the agro-forestry.

Table 3: Physical and chemical parameters of the soil at 15.1-30.0 cm of the study sites

SITE	ORGANIC CARBON (mgkg-1)	pH (pH)	Particle size			Bulk Density (mgm-3)	Conductivity (nscm-1)
			Sand	Clay	Silt		
A	3.39ab	8.34a	78.4a	9.0a	12.6a	1.29b	223a
B	2.09d	7.83c	85.6a	7.2a	7.2b	1.12c	69c
C	3.59a	7.94b	89.2a	3.6b	7.2b	1.57a	223a
D	2.79c	7.34d	87.4a	7.2a	5.4c	1.56a	134b
SE±	0.05	0.07	0.28	0.2	0.15	0.06	0.96

Means having the same letter(s) in the same column are not significant different at 5%

A= Ikorodu Farm Settlement under (conservation/organic farm plots) .
B= B= Adjacent land near Ikorodu Farm Settlement Manual and continuous cropping
C= MAJEK Agro-forest.
D= Adjacent conventional farmers plot near the agro-forestry.

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