DETERMINATION OF THE CONCENTRATION OF ORGANIC CARBON IN SOIL AND PLANTS AT OTTA FARM, AGBOWA-IKOSI, LAGOS STATE

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ABSTRACT
Organic carbon in soil and plants are both vital for soil health and ecosystem productivity. However, the unexplored impact of agricultural practices and seasonal variations on soil organic carbon levels, hinders the development of sustainable land management strategies. Thus, this study aimed to determine SOC concentrations in plants and soil across various plots at Otta Farm, Lagos state. Stratified random sampling was employed to select soil and vegetation samples from different farm sections. Otta Farm was divided into 50m x 50m grids across its 200 acres. From these grids, 20 plots were randomly selected, and 200 soil samples were collected at random for laboratory analysis. The Organic carbon in soil samples was determined using the Walkley-Black chromic acid wet oxidation method and plant samples were determined using the oxidation technique. Student t-test compared carbon concentrations across different strata. The findings revealed that soil organic carbon (SOC) are increased by heterotrophic microbes converting substrates into stable microbial residues. Root crops and perennial crops had higher SOC. SOC increased in maize sites but lower in palm tree sites due to decomposed stalks, limited carbon capture, elevated atmospheric CO2 levels, and high carbon storage in roots. The t-test results show a significant difference in organic carbon concentrations between plants and soil in both dry and wet seasons, with lower levels in soil compared to plants ($p < 0.001$). The study concluded that vegetation type and management practices significantly influence SOC levels. It suggests utilizing crop residues to improve soil organic carbon and health.

Keywords: Soil Organic Carbon, Organic Carbon in Plant, Seasonal Variations, Otta Farm

INTRODUCTION

Soil is a principal part of the ecological system that gives rise to food and fiber for the consumption of humans, but they are a limited resource. Soils are important enabling resource and fundamental to ecosystems and the well-being of humans. Soil organic carbon (SOC) is a critical component of soil health and fertility, playing a crucial role in supporting plant growth and influencing nutrient availability (Lal, 2004). It is essential to understand the levels and distribution of SOC in agricultural settings in order to develop sustainable farming practices that enhance soil quality and productivity (Friedrich et al., 2012).

Studies have shown that agricultural practices, such as continuous cultivation and the application of fertilizers, significantly impact soil organic carbon levels(Hamid et al., 2020). In Nigeria, agricultural activities are a major economic driver(Nwogwugwu et al., 2023). Otta Farm in Agbowa- Ikosi represents a typical agricultural setting in Lagos, Nigeria, where diverse crops are cultivated. The study of SOC concentration in this area can provide insights into the effectiveness of different agricultural practices and their impact on soil health. Given the significance of SOC in soil management and its implications for crop productivity, this study aims to determine the concentration of organic carbon in both soil and plant samples at Otta Farm. By analyzing SOC levels and exploring their relationships with various crops and management practices.

LITERATURE REVIEW

Conceptual Review

Organic carbon refers to the carbon component of organic compounds, which are derived from living or once-living organisms. It plays a vital role in soil fertility, structure, and overall ecosystem functioning, as it affects water retention, nutrient availability, and soil microbial activity (Lal, 2004).Organic carbon in soil exists in two primary forms: aboveground (e.g., plant biomass and crop residues) and belowground (e.g., roots and soil organic matter)..

Organic Carbon Above ground

Aboveground organic carbon primarily consists of plant biomass, including living plants, crop residues, and litter. Crop residues left on the soil surface can decompose, contributing to soil organic carbon (SOC) through the incorporation of organic matter (Lal, 2004). The role of crop residues in enhancing SOC is well-documented, with studies indicating that residues can significantly improve soil structure and microbial activity (Blanco-Canqui&Lal, 2009).

Organic Carbon Below ground

Belowground organic carbon is found in roots and soil organic matter. Roots contribute directly to SOC through root exudates, dead root material, and interactions with soil microorganisms (Rasse et al., 2005). The decomposition of root biomass and the subsequent formation of stable organic compounds play a critical role in SOC dynamics.

Measurement and Quantification

Accurate measurement of organic carbon concentration requires robust methodologies. Aboveground biomass can be quantified through direct sampling and weighing of plant material, followed by laboratory analysis for carbon content (Walkley & Black, 1934). Belowground carbon is typically measured by soil sampling at various depths, followed by chemical analysis to determine SOC concentration. Techniques such as dry combustion using a CHN analyzer or wet oxidation methods are commonly employed (Nelson & Sommers, 1996).

Empirical Review

The empirical review examines recent studies on organic carbon concentration above and below ground, on a global scale and in Nigeria. The review highlights methodologies, findings, and implications for soil health, agricultural productivity, and climate change mitigation.

Haija et al., (2024) examined Photocatalytic approach of on-Site Determination of Soil Organic Carbon Content. Soil samples from various

Canadian sites were analyzed using sieve analysis and three SOC evaluation techniques: loss on ignition (LOI), Walkley-Black, and PeCOD. The PeCOD system, which uses photochemical oxidation, proved reliable for SOC assessment. Results indicated higher SOC in finer soils (clayey, <50 µm) and decreased SOC with depth (below 30 cm). Factors like land management, precipitation, and temperature affected SOC formation. GIS mapping identified SOC hotspots, aiding sustainable farming and climate change mitigation. This study's results support sustainable farming, climate change mitigation, and soil health by offering farmers strategies to enhance carbon sequestration and improve soil health.

Reyna-Bowen et al., (2018) conducted a study on soil-organic-carbon concentration and storage under different land uses in the Carrizal-Chone Valley in Ecuador. This study examined soil organic carbon (SOC) levels at various depths and its accumulation across different soil profiles in the Carrizal-Chone system. Sixty-three soil samples were analyzed, revealing 21 distinct soil management types. Livestock grazing areas had the highest SOC concentration, while silty clay loam soil showed the greatest sequestration capacity. SOC levels decreased with depth, with the top 40 cm having the highest concentration.

John et al., (2020) used machine learning algorithms to estimate soil organic carbon variability with environmental variables and soil nutrient indicators in an alluvial soil. Various machine learning algorithms (ANN, SVM, cubist regression, RF, and MLR) were employed to predict soil organic carbon (SOC). Sixty soil samples were collected at 30 cm depth and analyzed using the Walkley–Black method. Eighty percent of the samples were used for model training with 21 predictors, including soil nutrient indicators and environmental variables. Model performance was evaluated using MAE, RMSE, and R^2. The RF model performed best ($R^2 = 0.68$), followed by cubist regression, SVM, ANN, and MLR. Key predictors for SOC were soil nutrient indicators, topographic wetness index, and total catchment area.

MATERIALS AND METHODS

Description of Study Area

The study area, Otta farm, is a government owned farm, located in Agbowa- Ikosi under Ikosi-Ejirin LCDA, Epe Division, Lagos State. .Palm trees, cassava, maize, tomatoes and pepper are the major crops grown in Otta farm. The farm covers an area of about 200 acres of land and lies at latitude 6.390^{0}N and longitude 3.430^{0}E. The uniqueness of the study area is due to its accessibility, has a history of leaching and also has an agricultural event which can be traced for many years. The area experiences a tropical savanna climate with dry winters, based on climatological records spanning from 1991 to 2021. June temperatures gradually decrease with daily highs averaging around 29°C, rarely dropping below 27°C or exceeding 32°C. Vegetation comprises swamp forests along the coastal belt, consisting of mangroves and coastal vegetation, and dry lowland rainforests with economically valuable trees. Soil types in the area include juvenile soils, fluviomarine alluvium, red ferritic soils, and coastal plain sands.

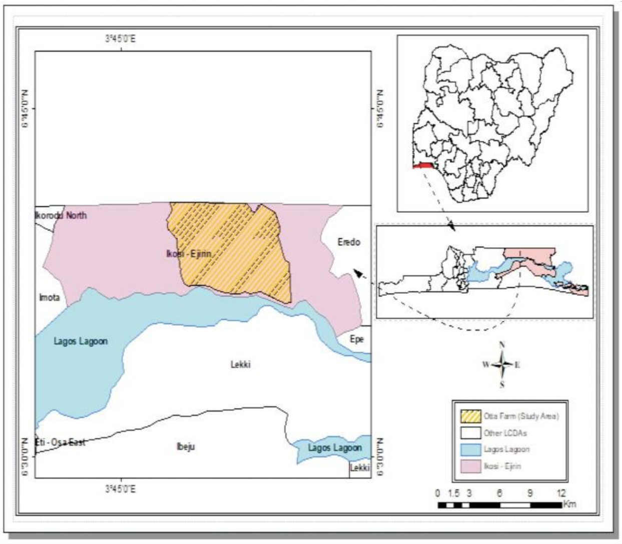

Figure 1: Map of Lagos State Showing the Study Area

Data Sources and Sampling

In this study, primary data of 200 soil and 200 plant samples were collected from the farm during each of the dry and wet seasons. Twenty sites within the farmland where crops were found were randomly selected after being divided into grids of 50cm by 50cm. Ten soil samples and ten plant samples were collected in each of the twenty sites to make a total collection of 200 soil samples and 200 plant samples in each of the season within the farmland. The soil auger was used to collect the soil samples at a depth of 15cm with their corresponding geographical coordinates in each of the sites which include the cassava sites (1, 3, 5, 16, 19), maize sites (4, 8), palm tree sites (2, 6, 15), an okra site (7), an orange and palm tree site (9), tomato and pepper sites (10, 20), bare land with few grasses (11), mixed cropping (12), water leaf (13), beans and vegetables (14), and grass sites (17, 18). This approach aimed to evaluate SOC variations linked to different agricultural practices.These samples were taken to the laboratory within 24 hours for analysis of soil and plant organic carbon.

Laboratory Analysis

The laboratory analysis for determining organic carbon in soil and plant samples involves specific procedures. For below-ground soil analysis, the Walkley-Black method was used due to its simplicity and rapidity in measuring SOC. Here, 1 gram of air-dried soil is transferred into a 500 ml conical flask, followed by the addition of 10 ml of 1N $K_2Cr_2O_7$ solution and 20 ml of concentrated H_2SO_4. The flask's contents are swirled a few times and left to stand for 30 minutes to allow the reaction to complete. Subsequently, 200 ml of distilled water is added to dilute the suspension. Then, 10 ml of orthophosphoric acid or 0.5 grams of NaF is introduced, along with 1 ml of diphenylamine indicator, resulting in a deep violet color. The mixture is titrated with 0.5N ferrous ammonium sulfate until the color shifts from violet to blue and finally bright green. The volume of ferrous ammonium sulfate used in the titration is recorded. A blank titration, conducted without soil, follows the same procedure to ensure accuracy. Bahadori & Tofighi (2017) used the Walkley-Black method to determine the OC of soil under four diverse vegetation systems, results indicated that there was a significant difference among the SOC under the diverse vegetation system.

For organic matter in plants, a wet-oxidation technique for determining organic carbon in plant material and aqueous plant extracts was used. The oxidation was carried out by heating the plant sample (containing 50–100 mg. carbon) with a mixture of potassium dichromate, sulphuric, and phosphoric acids for 10–15 min., and the carbon dioxide liberated was determined gravimetrically after absorption in soda-lime with slight modifications, the method had proved useful for the determination of carbon in plant extracts as indicated by Snyder &Trofymow (2008) that used the wet-oxidation diffusion procedure to determine the organic carbon in extract of plant tissues in modified culture tubes; describing that the method is precise and accurate.. This technique of determining carbon is convenient for the fairly rapid analysis of soils and plant materials where an accurate total carbon value is required.

Calculations:

Organic carbon% in soil=(X-Y) ml× 0.003 × 100 ÷ 2×W=Z Organic carbon% in soil= Z×1.3= R

Where,

X= blank titration reading

Y= sample reading

W= Weight of soil used

Assume that organic matter contains 58% carbon, thus the organic matter content of the soil will be calculated as: organic matter in soil (%) = R × 1.724

Method of Analysis

Descriptive statistical tools including mean and standard deviation were used to compare carbon concentrations across different strata. A paired sample t-test was also employed to determine if there were differences in between organic carbon levels in soil and plants within the study area, providing insights into carbon distribution and storage at the farm As Alessandra et al. (2024) used the t-test to determine the variation in mean of soil organic carbon in samples collected at three locations.

RESULTS AND DISCUSSION

A. Cassava sites 1,3, 5,16,19

During the dry season in table 1, the values of SOC in sites 1,3,5,16 and 19 were 3.38gkg^{-1}, 3.21gkg^{-1}, 2.98gkg^{-1},4.01gkg-^{1}, and 4.25gkg^{-1}, respectively and for the wet season, values of SOC were 5.47gkg^{-1}, 4.55gkg^{-1}, 6.01gkg^{-1}, 6.53gkg^{-1} and 5.34gkg^{-1}, respectively. During the dry season, values for OC in plants for the above sites were 29.46gkg^{-1}, 27.43gkg^{-1}, 29.43gkg^{-1}, 26.59gkg^{-1} and 30.62gkg^{-1} respectively. For the wet season, values of OC in plants were 58.27gkg^{-1}, 59.09gkg^{-1}, 56.06gkg^{-1}, 58.89gkg^{-1} and 57.04gkg^{-1} respectively. It can be observed that SOC in these sites were lower than the expected quantity of SOC for a productive soil which ranges between 5-12gkg^{-1}.This aligns with the opinion of Musinguzi et al. (2016) who opined that for high yield of crops, SOC should be between the range of 9-11gkg^{-1}. However, OC in plants were high according to the WHO standard as seen in table 2, this could be due to the high rate of the manufacturing of organic matter by plants during photosynthesis(Chan, 2008).Production of cassava leads to soil degradation and long term cassava cultivation results into low level of Organic Carbon (FAO, 1999).

B. Maize site 4 & 8

It was observed that SOC in site 4 for both the dry and wet season were 3.14gkg^{-1} and 4.34gkg^{-1} respectively, OC in plants for both dry and wet season for site 4 were 30.54gkg^{-1} and 57.11gkg^{-1} respectively. SOC in site 8 for both dry and wet season were 3.38gkg^{-1} and 6.41gkg^{-1} respectively

OC in plants for site 8 for both dry and wet season were 32.39gkg^{-1} and

D. Okra site 7

57.68gkg^{-1} respectively. It was observed that organic carbon values were The values of SOC and OC in plants during the dry season according to

lower than the expected quantity of OC for a productive soil which table 1 in site 7 were 4.16gkg^{-1}and 31.47gkg^{-1}respectively. For the wet

ranges between 5-12gkg^{-1} but the OC in plants were high according to the season, SOC and OC in plants values were 7.47gkg^{-1}and 67.24gkg^{-}

WHO standard which ranges between 25-40gkg^{-1} as seen in table 2. The presence of organic carbon in these sites could be attributed to the decomposed maize stalks found on the sites This aligns with opinion of (Pei et al. 2015) which explained that after maize derived organic carbon was incorporated into the soil, there was an increase in soil-derived organic carbon after two months.

C. Palm tree sites 2,6,15

During the dry season in table 1, the values of SOC in sites 2, 6 and 15 were 1.24gkg^{-1}, 1.26gkg^{-1}, and 1.28gkg^{-1}, respectively and for the wet season, values of SOC were 1.98gkg^{-1}, 1.75gkg^{-1}, and 6.53gkg^{-1}, respectively. During the dry season, values for OC in plants for the above sites were 10,16gkg^{-1}, 12.45gkg^{-1}, and 13.35gkg^{-1} respectively. For the wet season, values of OC in plants were 17.85gkg^{-1}, 15.79gkg^{-1}, and 35.0gkg^{-1} respectively. It can be observed that SOC and OC in plants in these sites were lower than the expected quantity of SOC for a productive soil and plant which ranges between 5-12gkg^{-1}and 25-40gkg^{-1} respectively according to the WHO standard as seen in table 2, this could be because of low organic materials in the soil and palm trees capture very little amount of Carbon from the atmosphere (Miller, 2019) but Organic Carbon found its way into the soil as SOC through the roots. This aligns with the work of (Johanna et, al., 2019), in an attempt to identify main drivers of soil organic input in palm plantations, an experiment of litter application, fertilization and frond stacking resulting from management scheme was devised, to influence the decomposition of savanna-derived SOC, it was concluded that soil organic carbon stabilization was derived by carbon input from fine roots.

^{1}respectively. It was observed that organic carbon values were adequate as expected quantity of OC for a productive soil and plant which ranges between 5-12gkg^{-1} and 25-40gkg^{-1} respectively according to the WHO standard as seen in table 2, The increase of OC in the okra site could be attributed to application of cow dung and poultry manure which has the ability to improve the organic matter of the okra plant and the soil physical condition particularly its structure and drainage. This aligns with the work of Tiamiyu et al. (2012) that okra crop yielded by increase of 39.4 % by the addition of organic manure due to the increase of OC in the soil.

E. Orange and palm tree site 9

It was observed that the values of SOC and OC in plants during the dry season according to table 1 in site 9 were 1.16gkg^{-1}and 13.33gkg^{-1}respectively. For the wet season, SOC and OC in plants values were 1.54gkg^{-1} and 17.05gkg^{-1}respectively. It was observed that organic carbon values were lower than the expected quantity of OC for a productive soil and plant which ranges between 5-12gkg^{-1} and 25-40gkg^{-1} respectively according to the WHO standard as seen in table 2, The significant relationship between OC in plants (orange and palm) and SOC explains that though OC in the plants were low probably due to the loss of atmospheric CO2 during photosynthesis when respiration process of green and non-green organs in plants took place (Scandellari et al. 2016), Organic Compounds found their way their way into the soil through fine roots. However, the reason for the loss of SOC in this site could be as a result of the release of CO2 which occur during the process of respiration of the heterotrophic organisms that are present in the soil.

F. Tomato and pepper site 10, 20

It was observed that SOC in site 10 for both the dry and wet season were $3.29gkg^{-1}$ and $4.71gkg^{-1}$ respectively, OC in plants (tomatoes and pepper) for both dry and wet season for site 10 were $28.12gkg^{-1}$ and $57.74gkg^{-1}$ respectively. SOC in site 20 for both dry and wet season were $0.82gkg^{-1}$ and $5.34gkg^{-1}$ respectively. OC in plants for site 20 for both dry and wet season were $10.45gkg^{-1}$ and $12.11gkg^{-1}$ respectively. It was observed that organic carbon values were lower than the expected quantity of OC for a productive soil and plant which ranges between $5\text{-}12gkg^{-1}$ and $25\text{-}40gkg^{-1}$ respectively according to the WHO standard as seen in table 2, The increase of OC in plants for site 10 could be attributed to increased concentration of CO_2 in the atmosphere which increased the Organic Carbon in tomato plants through the process of photosynthesis. This aligns with an experiment that took place in Murphy fresh farms in Australia, where a technological advantage of directly injecting the precise volume of CO_2 required for the cultivation of Tomatoes into the greenhouse environment. An increase in tomato yield from $60kg/m^2$ in the previous seasons to $70kg/m^2$ in the following season took place. The same was experienced when tomatoes yield increased when cultivated under CO_2 enriched environment in the work of (Tara et al. 2012). This implies that an increased quantity of CO_2 in the atmosphere favors an increase in Tomato plants and a low OC in tomato plants could be

G. Site 11(Bare land with few grasses)

It was observed that the values of SOC and OC in plantsduring the dry season according to table 1 in site 11 were 0.97gkg^{-1}and 8.75gkg^{-1}respectively. For the wet season, SOC and OC in plants values were 1.24gkg^{-1} and 11.15gkg^{-1}respectively. It was observed that organic carbon values were lower than the expected quantity of OC for a productive soil and plant which ranges between 5-12gkg^{-1} and 25-40gkg^{-1} respectively attributed to the plants' inability to capture adequate CO_2 in the according to the WHO standard as seen in table 2, this could be due to the atmosphere as a result of reduced carbon dioxide in the particular environment of cultivation. Furthermore, the low concentration of SOC could be attributed to misuse of land and soil mismanagement (Okebalama et al. 2017).removal of crop residue and overgrazing which leads to carbon loss to the atmosphere as a result of exposing carbon to oxygen (Cho, 2018). Although the soil in this site is clayey, organic carbon from plant materials could find its way in clay soil by adsorption at the external and internal surfaces of the soil as well as by exchange of exchangeable ions at the external and internal surfaces of the soil molecules (Lagaly et al. 2013).

Table 1: Average values for soil and plant samples of laboratory result

Site	Dry Season OCsoil(gkg^{-1})	Dry Season OCplant (gkg^{-1})	Wet Season OCsoil (gkg^{-1})	Wet Season OCplant (gkg^{-1})
1	3.38	29.46	5.47	58.27
2	1.24	10.16	1.98	17.85
3	3.21	27.43	4.55	59.09
4	3.14	30.54	4.34	57.11
5	2.98	29.43	6.01	56.06
6	1.26	12.45	1.75	15.79
7	4.16	31.47	7.47	67.24
8	3.38	32.39	6.41	57.68
9	1.16	13.33	1.54	17.05
10	3.29	28.12	4.71	57.74
11	0.97	8.75	1.24	11.15
12	3.29	31.75	3.35	57.19
13	1.20	11.81	2.09	11.21
14	1.32	12.23	3.41	30.68
15	1.28	13.35	2.91	35.00
16	4.01	26.59	6.53	58.89
17	1.45	11.19	1.95	17.56
18	1.73	12.28	1.89	17.09
19	4.25	30.62	5.34	57.04
20	0.84	10.45	1.47	12.11

Source: Author's Field Work, 2023

Table 2: Permissible Limit of organic carbon in of soil and plants

S/N	Soil Property	Very high	Medium	Moderately low	Very low
1	OCs gkg^{-1}	>18-12	12-5	5-2	<1.9-0.5
2	OCp gkg^{-1}	75-40	40-22.5	22.5-12.5	<12.5

Source: World Health Organization (WHO), 2021

H. Site 12 (Mixed cropping)

It was observed that the values of SOC and OC in plants during the dry

according to the WHO standard as seen in table 2, The reason for low OC in both soil and plants could be as a result of low application of manure and fertilizer on the site(Ukpong& Moses, 2001), also the low concentration of SOC in this site could be caused by excessive tillage practices where the soil structure is disturbed and microorganisms are displaced; exposing the soil to erosion (the washing away of Organic materials on the surface of the soil) (Upendra etal. 2014) .

J. Site 14 (Beans and Vegetables)

The values of SOC and OC in plantsduring the dry season according to table 1 in site 13 were 1.32$gkg^{-1}$and 12.23kg^{-1}respectively. For the wet

season according to table 1 in site 12 were 3.29$gkg^{-1}$and 31.75gkg^{-}season, SOC and OC in plants values were 3.41$gkg^{-1}$and 30.68gkg^{-}

^{1}respectively. For the wet season, SOC and OC in plants values were 3.35gkg^{-1} and 57.19gkg^{-1}respectively. It was observed that organic carbon values were lower than the expected quantity of OC for a productive soil according to WHO which is within the range of 5-12gkg^{-1}, whereas, the organic carbon in plants were higher than that of the standard of WHO which ranges between 25-40gkg^{-1} as seen in table 2, the reason for a low SOC could be as a result of tillage practices which compact the soil, thereby affecting the rooting system which is a rich source of organic compound to soil (Upendra et al. 2014) while a high value of OC in plants indicated that many crops cultivated on this site were rich in Organic compounds such crops include maize, plantain and cocoyam.. In addition, an increase in SOC could be attributed to the application of fertilizers (Marcelo et al. 2021).

I.Site 13 (Water leaf)

It was observed that the values of SOC and OC in plants during the dry season according to table 1 in site 13 were 1.2$gkg^{-1}$and 11.81kg^{-} ^{1}respectively. For the wet season, SOC and OC in plants values were

^{1}respectively. It was observed that organic carbon values were lower than the expected quantity of OC for a productive soil and plant which ranges between 5-12gkg^{-1} and 25-40gkg^{-1} respectively according to the WHO standard as seen in table 2, The reason for low OC could happen when organic matter held within soil aggregates becomes available to organisms in soil when aggregates are broken down when tillage takes place and plants on this site were low in OC, this could be as a result of the poor health of the plants, as certain elements for capturing CO2 in the plants could be missing (Hapsoh et al. 2019) also, low level of organic carbon in plants will also affect the level SOC. More also, the decline of SOC could be as a result of excessive practice of tillage. However, it was observed that SOC increased in the wet season. This is attributed to the application of fertilizer; this increases the OC in the soil and promotes plant health (Yuliana et al. 2019).

K. Site 17 and 18 (Grasses)

It was observed that SOC in site 17 for both the dry and wet season were

1.45gkg^{-1} and 1.95gkg^{-1} respectively, OC in plants for both dry and wet season for site 17 were 11.19gkg^{-1} and 17.09gkg^{-1} respectively. SOC in

2.09gkg^{-1} and 11.21gkg^{-1}respectively. It was observed that organic carbon site 18 for both dry and wet season were 1.73gkg^{-1} and 1.89gkg^{-1}

values were lower than the expected quantity of OC for a productive soil and plant which ranges between 5-12gkg^{-1} and 25-40gkg^{-1} respectively respectively. OC in plants for site 18 for both dry and wet season were

12.28gkg^{-1} and 17.07gkg^{-1} respectively. It can be seen that organic carbon

values were lower than the expected quantity of OC for a productive soil and plant which ranges between 5-12gkg^{-1} and 25-40gkg^{-1} respectively according to the WHO standard as seen in table 2, however, there was a significant relationship between OC plant and OC soil in both sites. The reason for this could be because grasses are rich sources of SOC. Recent studies stated that land with grasses constitute more than half of total SOC to the depth of one meter in soil directly under trees. The largest SOC concentration was associated with the largest grass contributions (Youg et al. 2023). Grass litter could decompose and return to the soil as manure or return to the atmosphere through enteric fermentation. Furthermore, presence of OC in grasses is by its absorption of CO_2 during growth, as it stores it in different tissues. Recent studies explained that in the United States of America alone, grasses alone can sequester between 12.5 million and 95million tons of atmospheric CO_2per year. However, grasses mostly store carbon in its roots, thereby increasing the SOC (Chang et al., 2021).

Examination of Difference in Organic Carbon Concentration in Plants and Soil

The t-test results in Table 2 indicate significant differences in organic carbon concentrations between above-ground (plants) and below-ground (soil) during both dry and wet seasons. In the dry season, the mean difference is -18.31300 with a t-value of -9.832 and a p-value of 0.000, indicating a highly significant difference. Similarly, in the wet season, the mean difference is -34.8695 with a t-value of -7.959 and a p-value of 0.000, also showing a significant difference. These results suggest that organic carbon concentrations are consistently higher below ground compared to above ground in both seasons. Thus, we can conclude that there is a significant relationship between the concentration of organic carbon in plants and in soil during the dry and wet season as seen in table 2.

Table 3:Student t-test of Organic Carbon Plants and Organic Carbon Soil (Dry and Wet Season)

Season	Variable	Mean	SD	T	df	Sig. (2 - tailed)
Dry season	Organic carbon above ground (plants) and Organic carbon below ground (soil)	-18.31300	8.3294	-9.832	19	0.000
Wet season	Organic carbon above ground (plants) and Organic carbon below ground (soil)	-34.8695	19.592	-7.959	19	0.000

Source: Author's Computation, 2024

The rise in soil organic carbon (SOC) can be attributed to the presence of heterotrophic microbes that consume plant or soil-derived organic matter, converting labile substrates into stable microbial residues and byproducts (Cotrufo et al,2019). Kaiser&Kalbitz (2012) explained that most crucial source of OC is from root exudates which are substances released from the plant root into the soil in form of sugars, amino acids, protein hormones and enzymes.

Vegetation types determine SOC (Freschet*et al*. 2013). The chemical composition of plant derived organic matter is greatly modified and varies from plant to plant; this plays a role in the fate of plant carbon (Barre et al, 2018). Sites with woody species (Palm Tree) could have lesser OC in soil (Sun et al. 2018). OC varies in plants due to their growth rate of cells, physiological stage of plant growth, mass of chlorenchyma tissues and environmental factors. Trees have the ability to absorb CO_2 higher than shrubs. A tree with a large diameter will increase the capacity of carbon absorption (David et al. 2021). Half of the plant assimilates is calculated to enter yearly into the soil. Therefore, plant inputs are important drivers for soil organic carbon accumulation, most especially during the initial stages when soil is formed (Khedim et al. 2021).

CONCLUSION AND RECOMMENDATIONS

The study concluded that organic carbon (OC) concentrations vary significantly across different crop sites and seasons at Otta Farm, with notable implications for soil health and agricultural practices as a decline in SOC lead to the degradation of agricultural ecosystem degradation and food insecurity. Vegetation type and management practices also influence soil organic carbon levels. The study suggests crop rotation and diversified planting to increase soil organic carbon (SOC) through diverse plant residues. This supports sustainable farming, increases SOC, and improves soil health.

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