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ANALYSIS OF SOIL PROPERTIES AT OTTA FARM, AGBOWA-IKOSI, LAGOS STATE: IMPLICATIONS FOR AGRICULTURAL PRODUCTIVITY

***OLUWABIYI, T.G.,[1] ONAFESO, D.O.,[2] BADEJO, A.B.[3] AND KUWANDE, S.B.[4]**
Department of Geography, Olabisi Onabanjo University, Ago-Iwoye, Ogun State, Nigeria
*Corresponding author: glorytomi@gmail.com

Abstract
This study analysed soil properties in Otta Farm, Agbowa-Ikosi, Lagos state and their implications for agricultural productivity. Otta Farm covers 200 acres of farmland. After dividing the area into 50m x 50m grids, 20 farmlands were chosen randomly. From these selected farmlands, 200 soil samples were randomly collected and then taken to the laboratory for analysis. Findings revealed negative correlations between soil pH and various parameters like electrical conductivity (EC), organic carbon (OC), total nitrogen (TN), organic matter (OM), and cation exchange capacity (CEC), highlighting the impact of soil acidity on nutrient availability. The study identified slightly acidic to neutral pH values across most sites, posing challenges for maintaining optimal soil conditions. Additionally, positive relationships were observed between EC and critical soil properties (OC, TN, OM, CEC). Agricultural practices, including organic compound additions and nutrient cycling, significantly influenced these relationships. Furthermore, the study highlighted nitrogen's role in enhancing soil productivity through positive correlations with OC soil, OM, and CEC, indicating the importance of nitrogen inputs for carbon sequestration processes. The positive correlation between OM and CEC emphasized organic matter's role in determining cation exchange capacity and nutrient availability. Furthermore, a negative correlation was observed between temperature and CEC during the wet season, indicating complex environmental influences on soil dynamics. Similarly, soil moisture showed negative correlations with key soil properties during the wet season, suggesting impacts on nutrient availability and soil structure. The study recommends long-term soil monitoring to track pH, EC, OC, TN, OM, and CEC fluctuations over time. Integrated practices like cover cropping and crop rotation can enhance soil health and fertility by mitigating degradation. Outreach programs are also vital for educating farmers and stakeholders on soil health and nutrient cycling in sustaining crop yield. By implementing these strategies, stakeholders can work towards enhancing soil quality and promoting sustainable land management practices that support long-term agricultural productivity.

Key Words: *Soil Properties, Soil Health, Agricultural Productivity, Otta Farm*

Introduction

Soils are principal part of the ecological system that give rise to food for the consumption of humans, and they are important enabling resource for the production of a wide range of goods and services fundamental to the ecosystem (Abdul *et al*., 2023). Globally, the continuous effect of climate change on soils alters soil-forming processes by modifying the soil water regime and the rate of organic matter formation (Gelybó *et al*. 2018). In Nigeria, high temperature caused by climate change increases soil temperature which influence soil respiration and microbial respiration rate (Onwuka, 2018). Also, changes in precipitation affect vegetation which has impacts on soil organic matter cycle. This can influence the runoff rate and formation of surface crusts, which causes erosion and deterioration (Zhang *et al*., 2015). This study therefore examined various soil properties in Ota farm, including, pH levels, nutrient composition, and organic matter content, providing valuable insights into the soil's fertility and suitability for different crops. It also delves into the interrelationship between these soil properties and their implications for agricultural productivity. Located in Agbowa-Ikosi, Lagos State, Nigeria, Ota Farm sits within an area undergoing rapid urbanization, posing significant implications for its soil health and agricultural productivity. Additionally, the research explored the impact of anthropogenic activities, such as agricultural practices on soil quality and sustainability.

The agricultural significance of Otta farm plays a vital role in supplying fresh produce to local markets and supporting the livelihoods of many in the region. However, the increasing pressure of urbanization poses adverse effects on soil health, potentially leading to reduced productivity. By conducting a comprehensive analysis of soil properties, this study aims to identify any existing soil deficiencies that may hinder crop growth while also proffering potential soil management strategies to promote sustainable agricultural practices in the area.

Furthermore, understanding the soil properties at Otta Farm is essential for informing land-use planning and agricultural decision-making processes in Lagos State. With the ever-growing demand for food in urban centers like Lagos, ensuring the sustainability of agricultural land is paramount for food security and environmental conservation. By examining soil characteristics and their spatial distribution, agricultural stakeholders can develop targeted interventions to improve soil quality, enhance crop yields of Ota Farm and similar agricultural areas in Lagos State.

Literature Review

The relationship between soil chemical properties and agricultural practices is intricately interwoven, with agricultural activities exerting profound effects on soil chemistry, and soil chemical properties in turn influencing agricultural productivity. For instance, fertilization practices significantly impact soil nutrient content and availability, with excessive use of synthetic fertilizers leading to imbalances and nutrient leaching. Conversely, soil pH, a key chemical property, directly affects nutrient availability and microbial activity, thus influencing crop growth (Guo *et al*., 2019). Sustainable management practices such as balanced fertilization, pH regulation, and organic matter management are essential for supporting agricultural productivity (Lal, 2018).

Soil pH is the measure of the soil acidity or alkalinity. The total range of the pH scale is from 0 to 14. Values below the mid-point (pH 7.0) are acidic and that above pH 7.0 are alkaline. Acidic soils are better for certain plants, while slightly alkaline soils are better for others. Soil pH also affects the availability of metals, such as Cd and Zn in plants (Chibuike and Obiara, 2014).

Cation exchange capacity (CEC) is a soil test that estimates its ability to attract, retain, and exchange cation elements. The soil's CEC is determined by organic matter and texture, which work together to determine the soil's overall Cation Exchange Capacity (Keshavarzi *et al*., 2012). Soil organic matter, primarily composed of carbon, provides nutrients to plants and alters soil's physical properties by binding soil particles into aggregates. Keramati *et al*. (2010) found that organic matter provides essential mineral nutrients to plants.

Electrical conductivity is the capacity of a material to be able to transmit an electrical current. The conductivity of sandy soil is low, that of silts is medium and that of clay is high. Soil conductivity is affected by both the texture and particle size of soil (Grisso *et al*., 2009).

Agricultural practices significantly influence soil properties and overall soil health in the following ways:

Tillage and Soil Structure: Tillage operations play a crucial role in soil management but can also increase erosion risks. According to (Peng *et al*., 2023), conventional tillage practices often lead to soil compaction. Conservation tillage methods preserve soil structure and promote soil organic matter accumulation (Ogieriakhi and Woodward, 2022).

Fertilization and Nutrient Dynamics: Fertilization practices significantly impact soil nutrient content. Chen *et al*. (2020) showed that excessive fertilizer application can lead to nutrient imbalances and groundwater contamination. Balanced nutrient management strategies are essential for maintaining optimal soil fertility while minimizing environmental risks (Guo *et al*., 2019).

Crop Rotation and Soil Health: Crop rotation is a widely adopted practice for improving soil health and reducing pest and disease pressures. Bender *et al*. (2016) highlighted the benefits of crop rotation in enhancing soil organic matter content and nutrient availability. Diverse crop rotations help to break pest cycles and improve overall agro-ecosystem resilience.

Soil provides essential ecosystem functions that are endangered by climate change (Sunnemann *et al*., 2023) such that higher air temperatures elevate soil temperatures and accelerating chemical reactions (Atish and Mutum, 2018). Climate change affects biological soil crusts and alters species composition (Anthony *et al*., 2018). The effects on soils are mainly in alteration of soil moisture conditions and an increase in soil temperature (Pareek, 2017).

Empirical studies on soil properties and their implications for agricultural productivity review findings related to soil characteristics in Nigeria and other regions, analyzing how these properties influence crop yield. Sainju and Liptzin, (2022) carried out a study on relating soil chemical properties to other soil properties and dry land crop production. They investigated six soil chemical properties, including pH, electrical conductivity (EC), cation exchange capacity (CEC), inorganic P (IP), K, and Al concentrations, across two long-term dryland farming sites in the northern Great Plains, USA. Analyzing sixty-two soil physical, chemical, biological, and biochemical properties alongside crop yields, they found that CEC, IP, and K concentrations were linked to average crop yields over time at individual or combined sites. However, other chemical properties showed no significant correlation with yields. The researchers inferred that CEC, IP, and K concentrations could serve as potential chemical indicators of soil health, given their association with numerous soil properties and crop yields in semiarid regions under dryland cropping systems. Olowookere and Oyerinde (2018) conducted research on the correlation between soil and plant nutrients in various maize varieties in the Guinea Savannah during the rainy seasons of 2008 and 2009 using the Institute for Agricultural Research farm in Samaru as a case study. Results revealed that soil pH increased with exchangeable acidity, available phosphorus, and boron, while showing a negative correlation with organic carbon and exchangeable cation capacity.

Study Area

The study area, Otta farm is located in Agowa-Ikosi in Lagos State. The area experiences a tropical savanna climate with dry winters. 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. Soil types include juvenile soils, fluviomarine alluvium, red ferritic soils, and coastal plain sands.

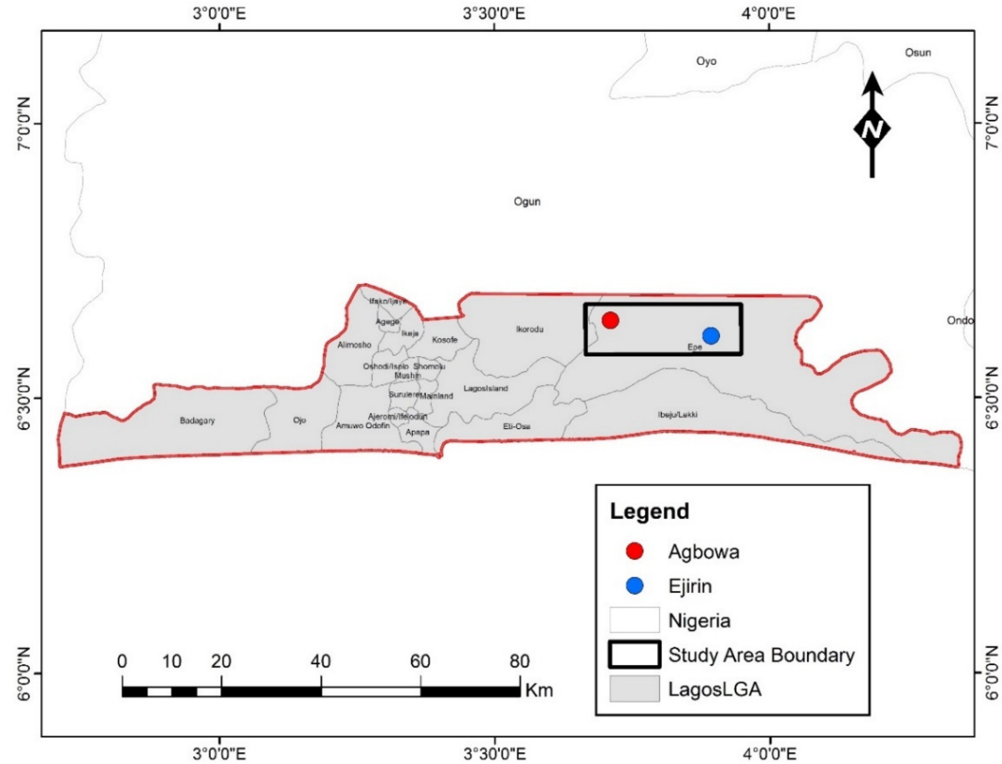

Fig. 1: Map of Lagos State showing the location of the Study Area

Materials and Methods

Otta Farm, spanning 200 acres, was segmented into 50m x 50m grids, and 20 farmlands were randomly chosen for sampling. From these plots, 200 soil samples at 0-30cm depth were randomly collected and transported to the laboratory for comprehensive analysis. This method ensured a representative sampling of the farm's soil, enabling a robust evaluation of soil properties across the study area. Descriptive statistical tools were employed in data analysis and Pearson correlation in SPSS was employed to analyse the relationship between the soil parameters.

Result and Discussion

From the analysis of the soil properties in Ota farm, the following results were derived.

Table 1: WHO Permissible Limit

S/N	Soil Property	Very high	Medium	Moderately low	Very low
1	pH	Akaline>8.0	Neutral 7.0-8.0	Moderately acidic 5.0-6.8	Highly acidic <5.0
2	EC $mScm^{-1}$	600-400	399-299	298-200	<200
7	OM %	>6	6-3	3-2	<2
8	CEC $molkg^{-1}$	>10	10-9	8	<8

Table 2: Correlations among Soil Properties in Dry Season

	pH(H20)	Electrical Conductivity	% Organic Matter	Cation Exchange Capacity (cmol/kg)
pH(H20)		-.565(**) .008	-.491(*) .024	
Electrical Conductivity	-.565(**) .008		.846(**) .000	.805(**) .000
% Organic Matter	-.491(*) .024	.846(**) .000		.809(**) .000
Cation Exchange Capacity (cmol/kg)		.805(**) .000	.809(**) .000	

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

Table 3: Correlations among Soil Properties in Wet Season

	pH(H20)	Electrical Conductivity	% Organic Matter	Cation Exchange Capacity (cmol/kg)
pH(H20)		-.441(*) .045	-.716(**) .000	-.614(**) .003
Electrical Conductivity	-.441(*) .045		.585(**) .005	.696(**) .000
% Organic Matter	-.716(**) .000	.585(**) .005		.702(**) .000
Cation Exchange Capacity (cmol/kg)	-.614(**) .003	.696(**) .000	.702(**) .000	

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

pH and Other Soil Properties

From table 2 dry seasons, the correlation co-efficient of pH and EC is negative and significant at a 1% significance level while the correlation co-efficient of pH and OM is negative but significant at a 5% significance level. In the wet season, in table 3 the correlation co-efficient of pH and EC is negative and significant at a 5% level of significance. Meanwhile, correlation co-efficient of pH, OM and CEC is negative but significant at a 1% level of significance.

pH and EC

In the dry season, a negative correlation was observed between pH and EC as seen in figure 2. This is because conductivity is related to ionic mobility, which is higher if the ion is smaller so the lower the soil pH, the higher the Electrical Conductivity. Lauchli and Grattan (2012) explained that most soils cultivated for crop production fall within the pH range of pH 6-7.7, where nutrient availability to the plant is optimal. Soil with pH 8.3 – 8.8 and 4.2-5.3 would be deficient of some mineral elements such as Ca, Fe, Cu among others, which promotes the potential yield cropping system of an area.

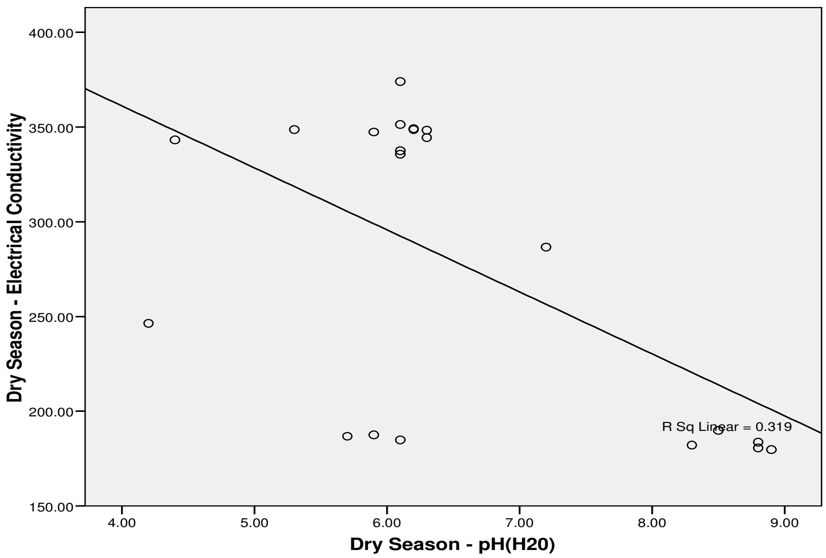

Fig. 2: The negative correlation between pH and EC (dry season)

Also, the variation of soil EC indicates that more sites have moderate than very low EC within the study area. As the soil with < 200mScm^{-1} is regarded to be very low, 200-600mScm^{-1} is high while that which is above 600mScm^{-1} is very high, according to WHO permissive limit as seen in table 1. High EC could be attributed to the microtopo graphic depressions in agricultural soils which accumulate nutrients and therefore have a higher EC than surrounding the drained areas (Corwin and Lesch, 2005). Thus, EC within the study area enhances productivity, influenced by agricultural activities.

In the wet season, there was a negative correlation of pH and EC as seen figure 4. It can be observed that there was an increase in soil pH in most of the sites within the study. This could occur as a result of the release of positive ions from compounds like carbon and sulphur (Huang *et al*., 2023). The alkalinity of some sites could be attributed to the application of Calcium Carbonate also known as garden lime to the soil to improve soil fertility. High EC values could be due to the rainfall in the season because soil EC generally increases with precipitation and high organic matter content. Organic Matter increases EC by adding cations and anions and improving water holding capacity (Adviento-Borbe, 2006).

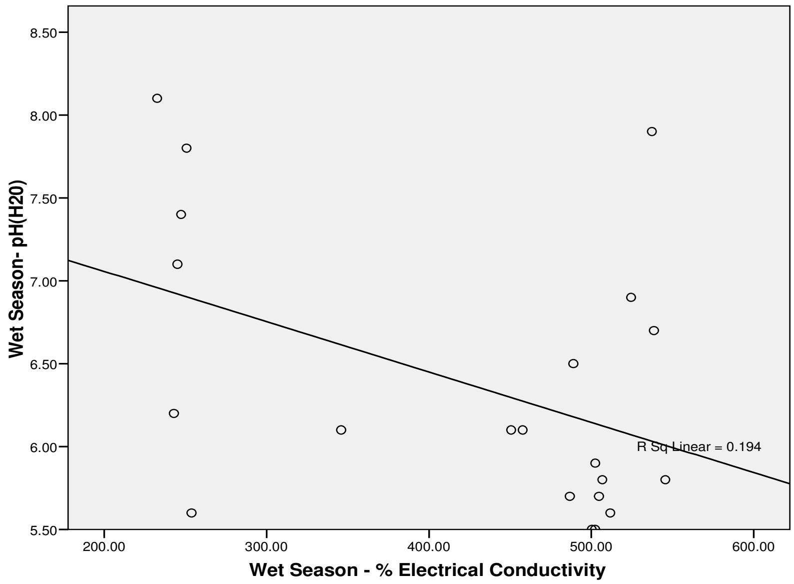

Fig. 3: The negative correlation between Soil pH & Electrical Conductivity (wet season)

pH and OM

During the dry season, the negative correlation co-efficient of pH and OM can be seen in figure 4. High OM in some sites can be from the application of manure from animal dung which are mixed with soil to provide nutrients to plants. Ashokkumar (2019) stated that major input of OM in soil is from plant in form of above ground litter, or below ground material which involves both and biotic and abiotic processes of decomposition. The decline in OM in some sites could result from intensive cultivation. Merga *et al*. (2023) explained that low organic matter in soil could be attributed to rapid rate of decomposition or inadequate OM from animal dung.

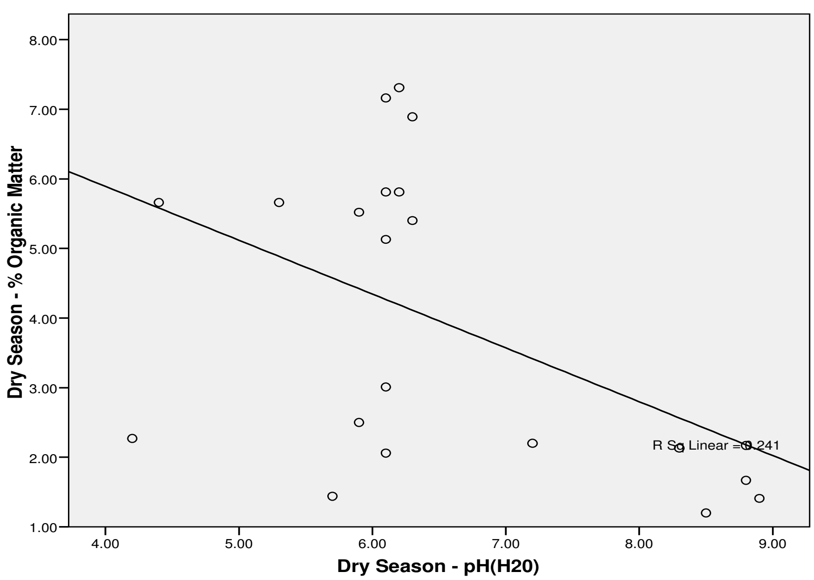

Fig. 4: The negative correlation between pH and OM (dry season)

During the wet season, the negative correlation of pH and OM can be seen in figure 5. The increase in organic matter (OM) within the study area could be attributed to rainfall which causes decomposition of soil OM, with more plant residues returning to the soil from grasses or trees, enhancing OM levels (Magdoff and Vans, 2021). The decline of OM in some sites could result from the washing away of humus found on the topsoil by runoffs from the rains (Jakab *et al.,* 2023).

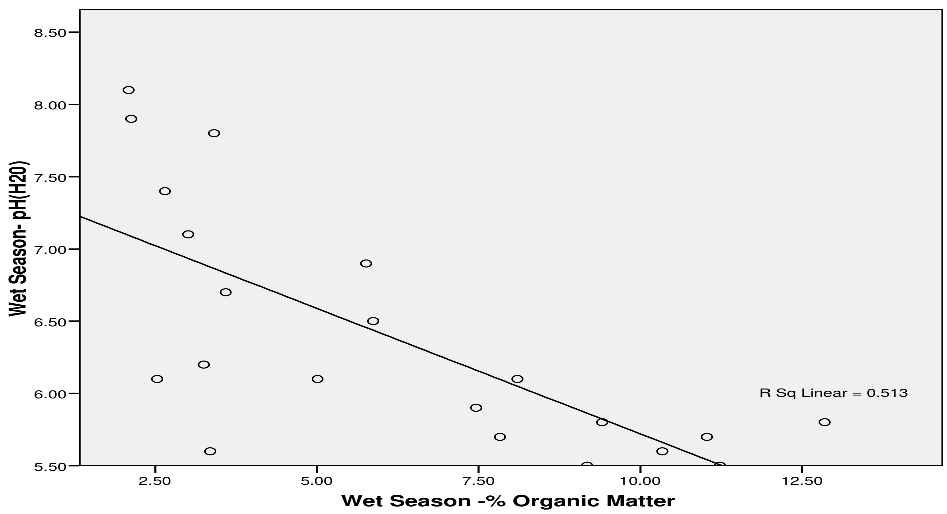

Fig. 5: The negative correlation between pH and OM (Wet Season)

pH and CEC

During the wet season, the negative correlation of pH and CEC can be seen in figure 6. The increase of CEC within the study area can be attributed to the decomposition of OM that occurs during the rainy season (Magdoff andVans, 2021). The low values of CEC in the study area could be attributed to the low OM as a result of its washing away by erosion.

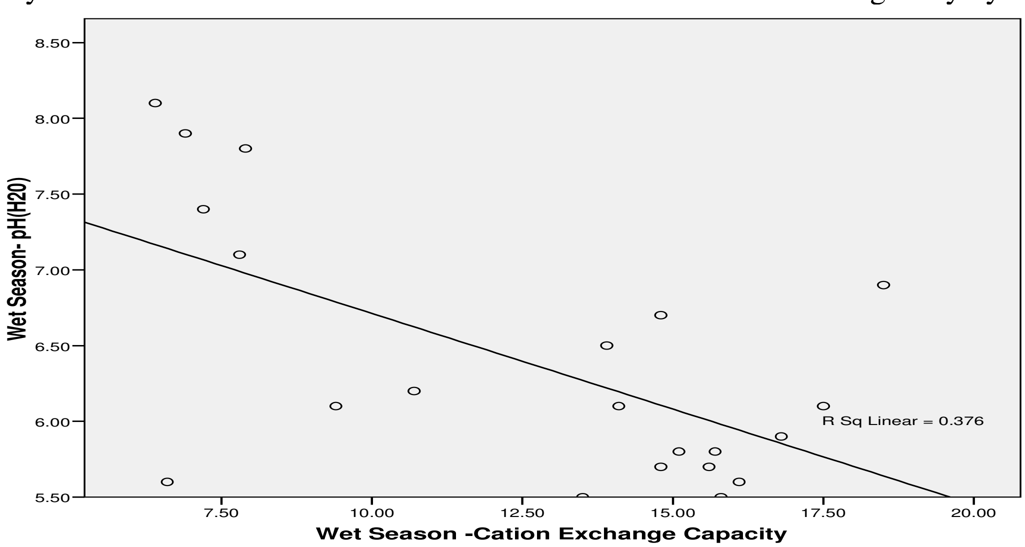

Fig. 6: The negative correlation between pH and CEC (wet season)

EC and Other Soil Properties

In the dry season, the correlation co-efficient of EC, OM and CEC is positive and highly significant at a 1% significant level as seen in table 2. Meanwhile in the wet season, the correlation co-efficient of EC, OM and CEC is positive and highly significant at 1%level of significance as seen in table 3.

EC and OM

During the dry season, the positive correlation of EC and OM is observed in figure 7. Carmo *et al*. (2016) opined that when compost from animal wastes which are rich in nutrients decomposes, ions and salts in the soil affects soil EC.

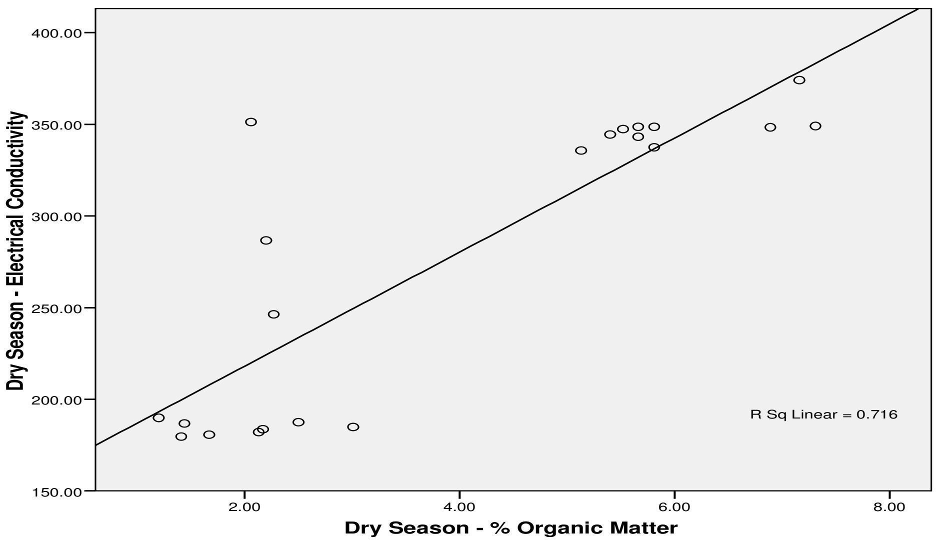

Fig. 7: The positive correlation between EC and OM (dry season)

During the wet season, the positive correlation of EC and OM is observed in figure 8. It can be observed that the EC in the wet season increased than that of the dry season. This could be due to the rainfall in the season because soil EC generally increases with precipitation. However, reduced EC in some sites within the study area could that precipitation flushed soluble salts out of the soil and reduce EC while increased EC in some sites could be attributed to the increased presence of higher Organic Matter. Organic Matter increases EC by adding cations and anions and improving water holding capacity (Adviento-Borbe, 2006). Also, numerous sum of soluble salts accumulates in the soil profiles result into high EC.

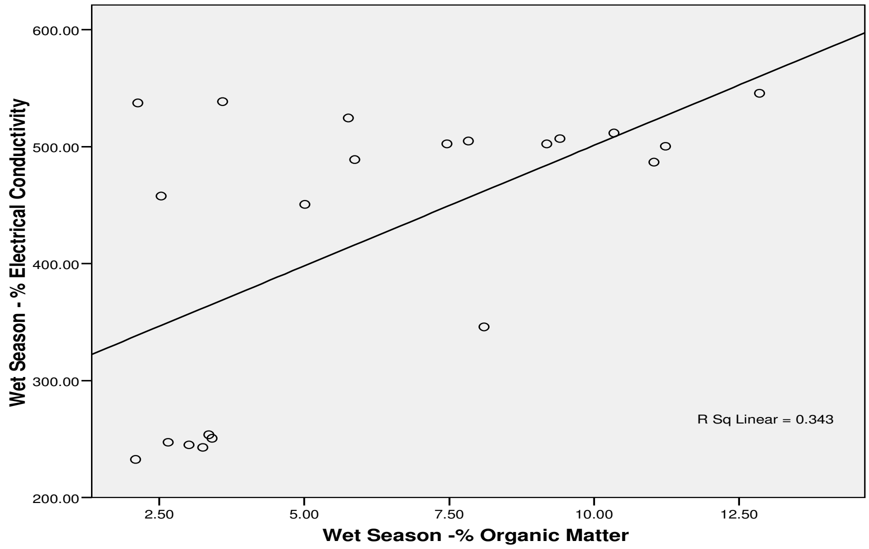

Fig. 8: The positive correlation between EC and OM (wet season)

EC and CEC

During the dry season, the positive correlation of EC and CEC is observed in figure 9 that as the EC values increase, the CEC values increase also. The CEC value within the study area is above the permissive limit of 10cmolkg^{-1} as seen in table. The increase of CEC within the study area can be attributed to Agricultural activities.

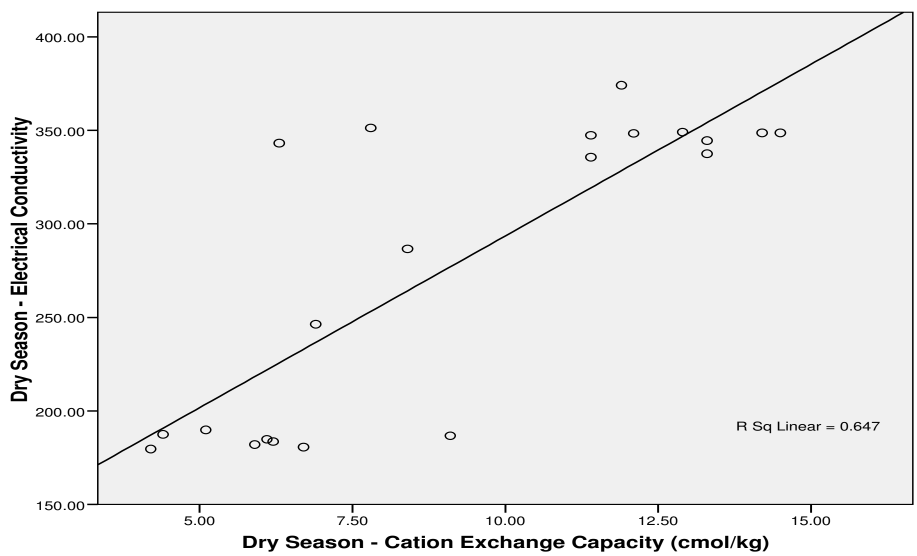

Fig. 9: The positive correlation between EC and CEC (dry season)

During the wet season, the positive correlation co-efficient of EC and CEC is observed in figure 10. This could be because of the high OM content, soil pH and soil type. Soil with little OM will have a very low CEC while a clay soil or soil with a lot of OM will have a high CEC. Soil with higher CEC value indicates higher negative charge and the greater capacity of that particular soil to hold more cations. Sites with lower value of CEC have lesser OM content and low clay particles. Soil with CEC has a low ability to hold nutrients, making the nutrients washed away easily by water (Purnamasari, 2021).

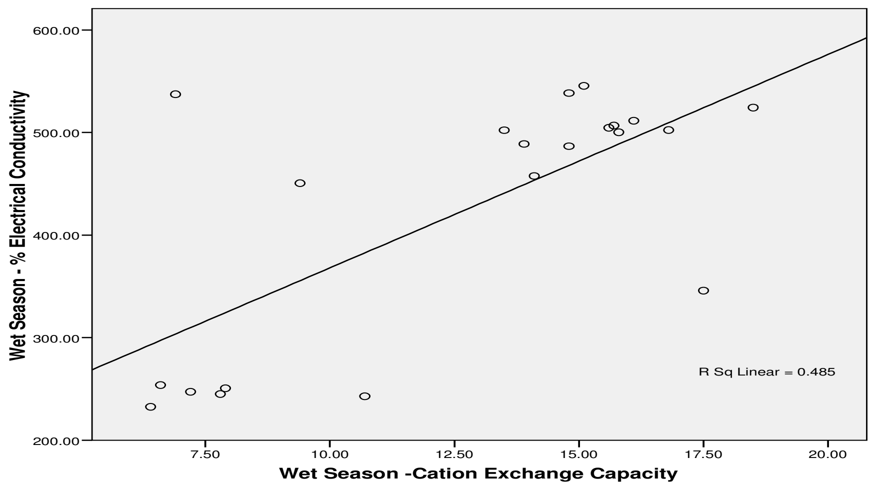

Fig. 10: The positive correlation between EC and CEC Wet Season

OM and CEC

In the dry season, the correlation of Organic Matter and CEC is positive as seen in figure 11. The result implies that as the OM values increase, the CEC values increase also.

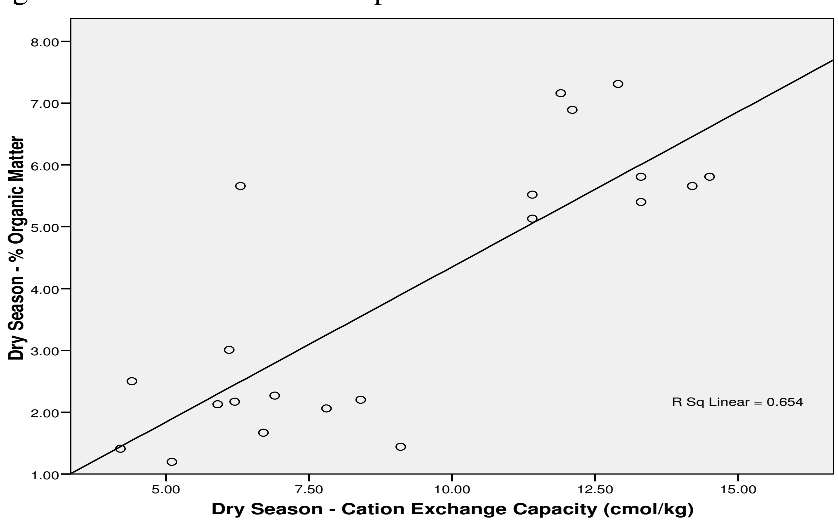

Fig. 11: The positive correlation between OM & CEC (dry season)

In the wet season, there was a positive correlation of OM and CEC as seen in figure 12. The reason for the positive correlation between OM and CEC is because Organic Matter has negative charges which hold cations in the soil. This means that the large amount of organic matter in soil makes it have more negative charges and therefore a high CEC (Sanchez, 2023).

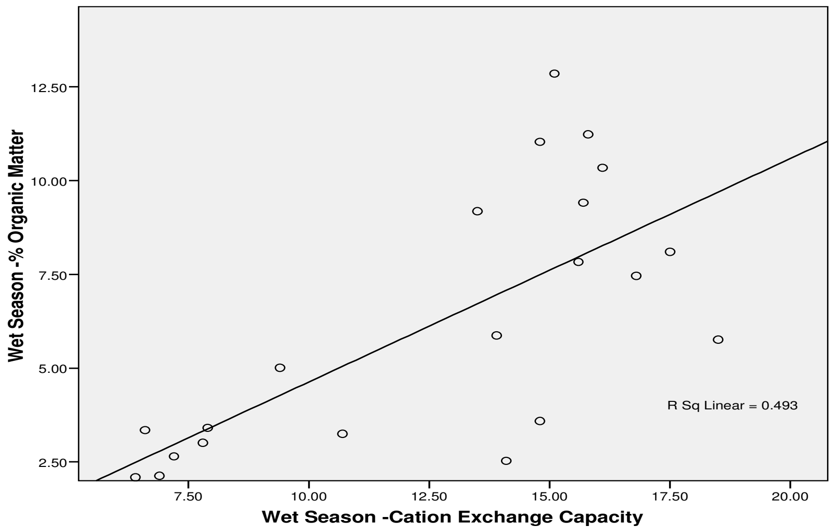

Fig. 12: The positive correlation between OM and CEC Wet Season

Conclusion and Recommendations

This study observed negative correlations between pH and some soil parameters, including EC, OM, and CEC, underscoring the influence of soil acidity on nutrient availability and crop productivity. Furthermore, agricultural activities, such as organic compound additions and nutrient cycling, play pivotal roles in soil functions and processes.

The study recommends implementing long-term soil monitoring programs to track soil properties over time in response to environmental and agricultural factors. Integrated soil management practices are suggested to enhance soil health and fertility. Capacity-building and outreach initiatives are also advised to educate farmers about the importance of soil health.

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