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Fertility investigation of an Acrisol for site-specific soil management for sustainable production of crops in Obehie, southeast Nigeria

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ABSTRACT

A detailed soil survey was carried out to assess the physical and chemical properties of Acrisol soils in Obehie and propose strategies for improving sustainable agricultural productivity. A total number of 36 soil samples were collected on line transect survey method with an auger from surface (0-20 cm) and subsurface (20–40 cm) layers and analyzed for percent sand, silt and clay, pH, organic carbon, total nitrogen, available P, exchangeable cations, cation exchange capacity and base saturation using standard analytical methods. A geo-spatial technique was used to estimate the spatial distribution of the fertility of the soils. Results revealed sandy loam texture at the different depths, well-drained soils, situated on gently to nearly flat terrain. The soils had moderate organic carbon (1.3 gkg-1) in the surface to low content (0.94 gkg-1) in the subsurface layers. The soils were characterized by leaching, high acidity, and low nutrient reserves, especially exchangeable potassium. Generally, the soils were acidic and inherently poor in fertility, but good management practice can support the sustainable production of crop plants. The structure of the soil of the area can be improved by the incorporation of organic manure; the high acidity can be reduced by liming and split application of NPK 15-15-15 fertilizer to boost the nutrient reserves. These suggested practices will enhance good soil health and agricultural sustainability in the area.

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1. Introduction

Conventional agricultural practices are major causes of deterioration in soil fertility especially, decreasing soil organic matter, which negatively influences the productivity and long-term sustainability of the soil (Novara et al., 2021; Carceles Rodriguez et al., 2022). Therefore, expansion and intensification of agricultural land in the tropics puts a big challenge on the sustainability of production systems (Akinbode et al., 2024). Soil fertility is one of the important and essential components of a sustainable agricultural system in the tropical climates. The fertility status of the soil is a subject of soil characteristics especially, physical and chemical properties of the soil (Chikere-Njoku, 2019; Sileshi et al., 2024). The continuous cultivation and indiscriminate deforestation through the use of fuel wood as source of alternative energy are attributed to the main source of declining per capita productivity of soils and fertility status especially in the rain forest zone (Chude et al., 2011, Hassan et al., 2016; Adesemuyi and Nwagbara, 2017; Chavez et al., 2024).

Information on soil properties and distribution is critical for making decisions with regard to sustainable crop production. Sustainable use of soil is necessary for a successful agriculture to meet the increasing demand of food from the decreasing per capita land. This is because soil is an important non-renewable land resource that determines the agricultural potential of a given area (Adjei et al., 2023). The failure of previous efforts to achieve self-sufficiency in food production in Nigeria may have been adduced to the neglect of the soil factors. This therefore underscores the importance of soil within the context of attainment of food and nutritional security. Acrisols are low activity clay soils. They have CEC (by 1 M NH4OAc, pH 7) of < 24 cmolkg-1 clay in some part of the argic horizons (WRB, 2015). Acrisols are the most cultivated and dominant soils in the southeast Nigeria (Chukwu, 2013). The organic matter content of some of these soils tends to decline rapidly under continuous cultivation (Oguike and Nbagwu, 2009). Owing to the low nutrient resources of these soils, most land use systems in the southeastern Nigeria and sub-Sahara Africa can be described as unsustainable. It is therefore important that the land that will be used for agricultural production should be investigated and used according to its capability for optimization and sustainability of soil productivity (Ande et al., 2008). This becomes very vital at this time when precision farming is gaining wider acceptance and the relevance is particularly more now in the developing world where the use to which a land is put is very often not related to its capacity (Ogunkunle, 2004; Adesemuyi and Adekayode, 2018). More importantly, there is paucity of information as regards fertility status of soils for site-specific management in the study area. Keeping these considerations in view, a geospatial investigation was carried out Obehie community, Ukwa West Local Government Area of Abia State, Nigeria to assess the fertility status of the soils and prepare fertility maps for identification of nutrient constraints and their management.

2. Material and methods

2.1 Environmental information of the area

The work was carried out at Obehie community in Ukwa West Local Government Area of Abia State, South-east Nigeria (Fig. 1). The area has a humid tropical climate (Table 1) with wet (April to October) and dry (November to March) seasons. Rainfall ranges from about 1,900 to 2,200 mm and is bimodal with peaks in July and September. Annual air temperature ranges from 23 °C to 29 °C and relative humidity is about 75-80 percent (NOAA/NCEP, 2024). The area is underlain by one main geological formation, the coastal plain sands, comprising largely unconsolidated sands (Lekwa, 2002). It is dominated by low activity clays, low organic matter content and susceptible to accelerated erosion and soil degradation (Ogban and Ibia, 2006). The native vegetation has almost completely been replaced by secondary forest of wild oil palm trees of various densities of coverage as well as woody shrubs and various grasses that form the under growth. Land use comprises mainly cultivation of arable crops with shorter fallow periods due to the current population pressure and increased demand on land for alternative uses.

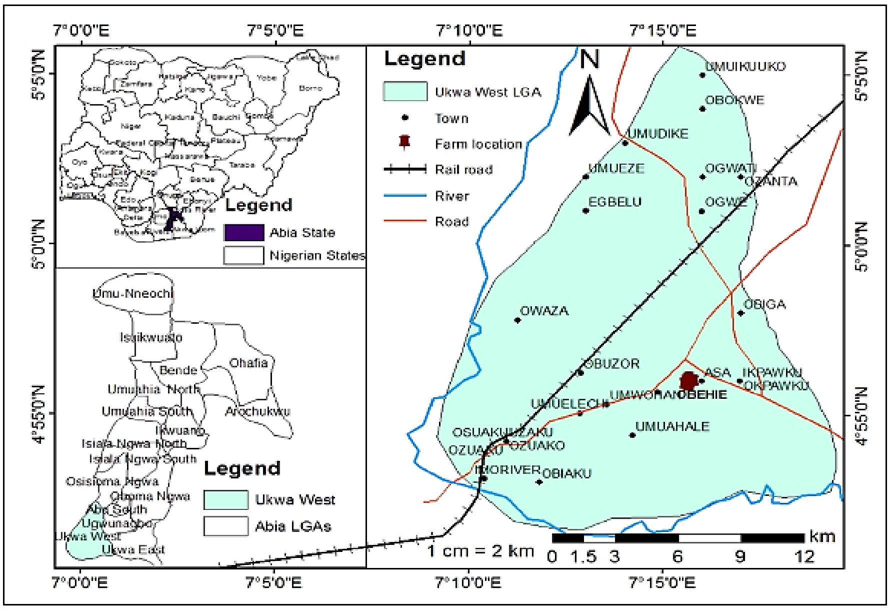

Fig. 1. Map of Ukwa West, Abia State, showing location of (Obehie) study area.

Table 1: Climate data of the study area.

Month	Mean rainfall (mm)	Mean air temperature (ºC)	Mean soil temperature (ºC)	Relative humidity (%)
JAN	84.08	28.27	27.90	76.10
FEB	82.98	28.51	28.57	78.41
MAR	225.49	27.80	28.07	85.74
APR	291.34	28.48	28.30	86.68
MAY	392.33	27.50	27.14	88.61
JUN	480.20	25.71	25.65	91.02
JUL	447.86	25.62	25.70	91.83
AUG	336.16	25.77	25.76	89.61
SEPT	375.64	25.87	26.21	90.95
OCT	366.30	25.65	26.08	90.50
NOV	231.51	27.36	26.85	89.27
DEC	125.52	26.22	27.12	36.78

Source: {NOAA/NCEP, (2024)}

2.2 Field work

The study area, covering about 16.7 ha of land was traversed (east-west) and stratified into transects at 100 m interval. Systematic random sampling was adopted and a total number of 36 soil samples were collected on line transect survey method with an auger from surface (0 - 20 cm) and subsurface (20 – 40 cm) layers. Each soil sample was composited, mixed thoroughly and sub-sampled for uniform representation. The soil samples were appropriately bagged, labeled and transported to laboratory where analyses of some physical and chemical properties were carried out. All sample points and boundary coordinates of the farmland coupled with their altitudes above sea level were recorded, using a hand-held Global Positioning System (GPS) receiver (Garmin-etrex).

2.3 Laboratory procedures for soil analyses

Particle size analysis was carried out by the hydrometer method (Gee and Or, 2002) using sodium hexametaphosphate (calgon) as dispersant. Soil pH was determined in water at a soil: liquid ratio of 1:1 on a combined glass electrode digital pH meter (Thomas, 1996). Exchangeable cations were extracted with neutral normal ammonium acetate. Exchangeable potassium and sodium in the extract were determined using a flame photometer, while, exchangeable calcium and magnesium were determined using atomic absorption spectrophotometer. Organic carbon was determined by the wet oxidation method (Nelson and Sommers, 1996). Total nitrogen was determined by the kjeldahl digestion and distillation method (Bremner, 1996). Available phosphorus was determined by Bray 2 method. Data were interpreted based on Chude, et al. (2011) and Hazelton and Murphy (2016) ratings for soil data interpretation (Table 2).

2.4 Statistical analysis

Descriptive statistics was carried out where the mean, median, standard deviation and coefficient of variation for soil physicochemical properties were determined. The coefficient of variation (CV) was used to estimate the extent of variability in soil properties within the area and calculated as (Eq. 1):

$$CV\ (\%) = \frac{Standard\ Deviation}{Mean} \qquad (1)$$

The CV ranked as low (≤ 15 %), moderate (≥ 15 ≤ 35 %) and high (> 35%) (Wilding, et al., 1994).

2.5 Geo-spatial analysis

The spatial data obtained from the study site were input into the ArcGIS 10.3 software in Geographic Information System (GIS) application to produce the map of the site (Figure 1). Following the Framework for land evaluation, multi-criteria evaluation technique in GIS was used to model fertility indices of the farmland (FAO, 2016). Based on the extent to which the soil properties meet the nutrient rating index, and with respect to the coordinates of the soil samples' locations, the thematic layers were prepared according to the rating scale as very low, low, medium, and high. All the scaled thematic layers were assigned weighted values and integrated using map algebra in GIS to produce soil fertility maps of the site.

Table 2. Nutrient rating for soil data interpretation.

	Very low	Low	Moderate	High	Very high
Organic Carbon (%)	< 0.4	0.4-1.0	1.0-1.5	1.5-2.0	> 2.0
Total N (%)	< 0.05	0.05-0.15	0.15-0.25	0.25-0.30	> 0.30
Available P (mg/kg)	< 3.0	3.0-7.0	7.0-20.0	> 20.0	-
Exch. K (cmol/kg)	< 0.2	0.2-0.3	0.3-0.6	0.6-1.2	> 1.2
Exch. Na (cmol/kg)	< 0.1	0.1-0.3	0.3-0.7	0.7-2.0	> 2.0
Exch. Ca (cmol/kg)	< 2.0	2.0-5.0	5.0-10.0	10.0-20.0	> 20.0
Exch.Mg (cmol/kg)	< 0.3	0.3-1.0	1.0-3.0	3.0-8. 0	> 8.0
CEC (cmol/kg)	<6.0	6.0-12.0	12.0-25.0	25.0-40	> 40
Base Saturation (%)	0-20	20-40	40-60	60-80	90-100
Soil depth (cm)		**Soil reaction (H_2O)**			
		(Acid)		***(Alkaline)***	
Very shallow: < 30		Extremely acid: < 4.5		Neutral (6.6-7.2)	
Shallow: 30-50		Very strongly acid: 4.5-5.0		Slightly alkaline (7.3-7.8)	
Moderate: 50-100		Strongly acid: 5.1-5.5		Moderately alkaline (7.9-8.4)	
Deep: > 100		Moderately acid: 5.6-6.0		Strongly alkaline (8.5-9.0)	
		Slightly acid: 6.1-6.5		Very strongly alkaline (> 9.0)	

Source: (Chude *et al.*, 2011; Hazelton and Murphy 2016).

3. Results and discussion

3.1. Characteristics of the site

The study site (16.7 ha) is located within latitudes 4.93058° and 4.93405° N; and longitudes 7.25971° and 7.6333° E with elevations ranging between 26 and 34 meters above sea level. The soil was well drained and mottle-free, distributed over nearly flat to gently sloping terrains (1–4%) with no significant variation in the altitudes of various sample points on the farmland. The topography of the farmland coupled with well drained conditions makes the soil suitable for crop cultivation (Fig. 2). Field soil texture by feel method had sandy loam texture in both surface and subsurface layers. The soils exhibited weak to moderate crumb-structure. Consistence was friable in moist soil moisture regime and in wet condition, non-sticky and non-plastic. The friable consistence (moist) observed across the entire site will enhance good tillage operation with no restriction to root penetration (Ogban and Ibia, 2006).

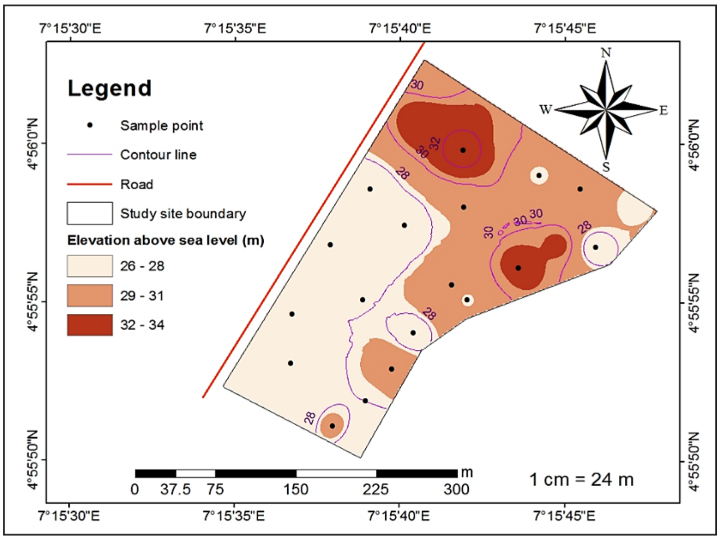

Fig. 2. Map of the study site showing boundary, elevation/topography and sample points.

3.2. Physical properties

Particle size distribution (Tables 3 and 4) showed that sand constituted 73-80% of the mineral fractions compared to clay which varied from 11-17% with slight increase with depth. Silt content was less than 11%. Increased clay content with depth could be attributed to sorting of soil materials, a marked pedogenic process of eluviation-illuviation and pedoturbation facilitated by high and intense rainfall experienced in the area (Malgwi, et al., 2000; Idoga and Azagaku, 2005; Maniyunda et al., 2015). The dominance of sand reflects the underlying parent material (coastal plain sands) (Lekwa, 2002; Idoga and Azagaku, 2005). The sandy nature of this soil suggests its inability to hold much water and nutrients. Sands have a smaller surface area and tend to be less physically and chemically active. Bulk density means values (1.51-1.61 mgm^{-3}) were lower than the critical limit values (1.75-1.80 mgm^{-3}) (Hazelton and Murphy, 2016) for root penetration implying that there is no excessive compaction inhibiting root development for sustainable production of crops in the area. Generally, the topsoil showed a lower bulk density than the subsoil. The higher bulk density in topsoil contrary to subsoil could be attributed to a decrease in organic matter with depth (Oguike and Mbagwu 2009; Sakin et al., 2011; Brown and Adesemuyi, 2019).

3.3. Chemical properties

Some chemical properties of the soils are shown in Tables 3 and 4. Soil reaction indicated strongly (5.00) to moderately (5.80) acidic conditions (Tables 3 and 4). The pH varied minimally (CV<15%) across the site. Low pH is attributed to heavy leaching promoted by the high rainfall in the area. Acidity of the soils may also be due to the effect of cultivation, high sand fraction, erosion and leaching of nutrients due to the porous nature of the soils or a combination of these (Chikezie et al., 2010; Nkwopara et al., 2019). Surface organic carbon ranged from low (0.80%) to high (1.72%) having moderate variation (15<CV<35) and decreased with depth. The low level of organic carbon could be attributed to environment of eastern Nigeria, characterized by high temperature and relative humidity that favour rapid decomposition and mineralization of organic materials. Total nitrogen ranged between low and moderate (0.08-0.19%). Available P was moderate (10.20-15.5 $mgkg^{-1}$). Exchangeable bases were low except exchangeable Mg that was moderate (1.08 $cmolkg^{-1}$). The low level of bases observed could suggest leaching as a marked pedogenic process, resulting from the high sand fraction in the area.

Table 3. Properties of the top soil (0-20 cm) of the study site.

Soil sample	Sand %	Silt %	Clay %	Texture	BD mg/m^3	TP %	pH H_2O	Av. P mg/kg	N %	OC %	Ca ………	Mg ………	K cmol/kg	Na ………	EA ………	ECEC ………	Al^{3+}	BS %
1	78.00	8.20	12.80	SL	1.49	43.70	5.50	12.40	0.13	1.57	3.20	1.50	0.22	0.18	1.35	6.45	0.46	79.01
2	80.00	9.40	10.60	SL	1.50	43.40	5.30	12.30	0.11	1.30	3.20	0.80	0.15	0.17	1.48	5.79	0.49	74.43
3	78.00	9.30	12.70	SL	1.47	44.50	5.40	12.80	0.15	1.38	3.20	1.40	0.14	0.21	1.37	6.32	0.41	78.32
4	78.00	10.40	11.60	SL	1.52	42.60	5.00	12.30	0.11	1.30	3.30	0.90	0.15	0.17	1.56	6.08	0.52	74.34
5	80.00	7.30	12.70	SL	1.58	40.40	5.00	11.80	0.09	1.08	2.80	0.80	0.13	0.14	1.48	5.4	0.49	72.59
6	78.00	9.20	12.80	SL	1.48	44.20	5.30	12.30	0.14	1.45	3.20	1.40	0.21	0.14	1.36	6.31	0.42	78.45
7	80.00	9.40	10.60	SL	1.32	50.20	5.40	15.50	0.14	1.72	3.90	1.60	0.19	0.13	1.48	7.29	0.48	79.69
8	76.00	10.40	13.60	SL	1.45	45.30	5.00	14.10	0.12	1.46	3.40	1.20	0.16	0.19	1.52	6.47	0.51	76.51
9	78.00	10.10	11.90	SL	1.43	46.00	5.10	15.00	0.16	1.62	3.70	1.40	0.23	0.21	1.52	7.00	0.50	78.28
10	77.00	9.70	13.30	SL	1.49	43.80	5.80	13.30	0.16	1.34	2.80	1.20	0.13	0.15	1.43	5.71	0.51	74.96
11	79.00	8.40	12.60	SL	1.47	44.50	5.70	14.20	0.15	1.44	3.10	1.30	0.22	0.20	1.37	6.19	0.39	77.87
12	78.00	10.40	11.60	SL	1.43	46.00	5.50	14.20	0.12	1.50	3.40	1.30	0.17	0.20	1.48	6.54	0.49	77.37
13	80.00	7.50	12.50	SL	1.59	40.00	5.50	11.60	0.09	0.92	2.80	0.60	0.11	0.12	1.48	5.11	0.49	71.03
14	79.00	9.00	12.00	SL	1.56	41.10	5.30	13.30	0.16	1.27	3.10	0.80	0.14	0.17	1.52	5.73	0.51	73.47
15	76.00	10.40	13.60	SL	1.58	40.40	5.60	11.50	0.17	1.03	2.50	1.00	0.14	0.14	1.40	5.18	0.53	72.97
16	78.00	9.40	12.60	SL	1.57	40.80	5.70	11.80	0.10	1.15	2.90	0.80	0.13	0.15	1.56	5.54	0.52	71.84
17	80.00	9.40	10.60	SL	1.60	39.60	5.30	11.10	0.07	0.80	2.80	0.70	0.09	0.11	1.54	5.24	0.51	70.61
18	80.00	8.40	11.60	SL	1.58	40.40	5.30	11.40	0.09	1.08	3.00	0.80	0.12	0.14	1.52	5.58	0.51	72.75
MEAN	**78.50**	**9.24**	**12.21**	**SL**	**1.51**	**43.46**	**5.37**	**12.83**	**0.13**	**1.30**	**3.13**	**1.08**	**0.16**	**0.16**	**1.47**	**6.00**	**0.49**	**75.25**
STDEV	**1.34**	**0.96**	**0.96**		**0.07**	**2.78**	**0.24**	**1.31**	**0.03**	**0.25**	**0.34**	**0.31**	**0.04**	**0.03**	**0.07**	**0.62**	**0.04**	**2.97**
CV (%)	**2.00**	**10.00**	**8.00**		**5.00**	**6.00**	**5.00**	**10.00**	**24.00**	**19.00**	**34.00**	**29.00**	**4.00**	**19.00**	**5.00**	**10.00**	**8.00**	**4.00**

Note: SL = sandy loam, P= available phosphorous, Total N= total nitrogen, OC = organic carbon, Ca= calcium, Mg= magnesium, K= potassium, Na= sodium, EA = exchangeable acidity, ECEC= effective cation exchange capacity, BS= base saturation, SL=sandy loam, TP=total porosity, BD=bulk density.

CV = Coefficient of variation: CV < 15= low variability, CV ≥15≤35=moderate variability, CV>35= high variability (Wilding, *et al.*, 1994).

Table 4. Properties of the sub soil (20-40 cm) of the study site.

Soil sample	Sand %	Silt %	Clay %	Texture	BD mg/m³	TP %	pH H_2O	Av. P mg/kg	N %	OC %	Ca	Mg	K	Na	EA	ECEC	Al^{3+}	BS %
											………………… cmol/kg ………………………							
1	76.00	8.50	14.50	SL	1.51	43.10	5.30	10.6	0.08	1.07	3.40	1.20	0.18	0.13	1.46	6.37	0.41	77.08
2	77.00	10.00	13.00	SL	1.61	39.30	5.40	13.7	0.08	0.91	3.70	0.40	0.13	0.18	1.51	5.56	0.51	72.84
3	75.00	9.60	15.40	SL	1.65	37.80	5.50	14.2	0.11	1.00	2.90	1.10	0.11	0.19	1.26	5.56	0.46	77.34
4	76.00	9.80	14.20	SL	1.60	39.70	5.10	13.3	0.08	1.01	3.10	1.00	0.10	0.18	1.61	5.99	0.51	73.12
5	76.00	8.30	15.70	SL	1.69	36.30	5.30	11.5	0.05	0.70	2.40	0.80	0.10	0.16	1.35	4.81	0.50	71.93
6	73.00	10.20	16.80	SL	1.54	41.90	5.10	10.9	0.09	1.14	2.50	1.00	0.17	0.11	1.43	5.21	0.51	72.55
7	75.00	9.60	15.30	SL	1.51	43.10	5.30	16.1	0.08	1.19	3.20	1.10	0.12	0.11	1.33	5.86	0.51	77.30
8	73.00	10.20	16.80	SL	1.50	43.50	5.30	12.7	0.07	1.16	2.60	0.80	0.17	0.15	1.46	5.18	0.56	71.81
9	76.00	10.20	13.80	SL	1.60	39.70	5.30	13.8	0.08	1.21	3.20	1.20	0.20	0.17	1.51	6.28	0.51	75.96
10	74.00	9.70	16.30	SL	1.58	40.40	5.20	10.3	0.07	1.01	2.30	1.00	0.10	0.14	1.46	5.00	0.49	70.80
11	76.00	8.10	15.90	SL	1.55	41.60	5.20	12.00	0.10	1.02	2.80	1.10	0.18	0.21	1.43	5.72	0.45	75.00
12	76.00	10.50	13.50	SL	1.63	38.50	5.10	12.9	0.06	1.00	3.60	1.10	0.12	0.17	1.52	6.51	0.41	76.65
13	76.00	8.30	15.70	SL	1.61	39.30	5.40	12.2	0.06	0.62	2.40	0.70	0.10	0.14	1.45	4.79	0.44	69.73
14	76.00	10.00	14.00	SL	1.59	40.10	5.40	11.3	0.10	0.92	2.60	0.90	0.10	0.15	1.42	5.17	0.45	72.53
15	75.00	10.10	14.90	SL	1.68	36.70	5.20	11.8	0.09	0.80	2.90	1.10	0.13	0.17	1.45	5.75	0.51	74.78
16	76.00	9.70	14.30	SL	1.72	35.20	5.50	13.5	0.06	0.75	2.70	0.90	0.70	0.12	1.53	5.95	0.50	74.29
17	75.00	9.40	15.60	SL	1.72	35.20	5.00	10.2	0.05	0.60	3.00	0.90	0.10	0.12	1.48	5.60	0.54	73.57
18	75.00	9.40	15.60	SL	1.70	35.90	5.10	14.0	0.06	0.80	2.60	0.70	0.80	0.16	1.47	5.73	0.54	74.35
MEAN	**75.33**	**9.53**	**15.07**	**SL**	**1.61**	**40.09**	**5.26**	**12.50**	**0.08**	**0.94**	**2.88**	**0.94**	**0.20**	**0.15**	**1.45**	**5.61**	**0.49**	**73.98**
STDEV	**1.08**	**0.74**	**1.11**		**0.07**	**2.71**	**0.15**	**1.58**	**0.02**	**0.19**	**0.42**	**0.21**	**0.20**	**0.03**	**0.08**	**0.51**	**0.04**	**2.28**
CV %	**1.00**	**8.00**	**7.00**		**4.00**	**7.00**	**3.00**	**13.00**	**23.00**	**20.00**	**14.00**	**22.00**	**10.00**	**19.00**	**5.00**	**9.00**	**9.00**	**3.00**

Note: SL=sandy loam, P= available phosphorous, Total N= total nitrogen, OC = organic carbon, Ca= calcium, Mg= magnesium, K= potassium, Na= sodium, EA = exchangeable acidity, ECEC= effective cation exchange capacity, BS= base saturation, SL=sandy loam, TP=total porosity, BD=bulk density.

CV = Coefficient of variation: CV < 15= low variability, CV ≥15≤35=moderate variability, CV>35= high variability (Wilding, *et al.*, 1994).

3.4 Spatial distribution of fertility status of the soils

The soil reaction showed that larger percent (78%) of the site was strongly acidic (pH 5.0) while the remaining portion (22%) was moderate (pH 5.8) (Fig. 3). The low pH (strong acidity) of the soil could be attributed to heavy leaching of the soil nutrients promoted by the very high rainfall in the area. Strong acid condition of the soil has serious implication in the fixation of soil nutrients especially phosphorus, which may not be readily made available for absorption by plant roots. Therefore, the sustainable productivity of the area would need adequate liming to reduce the acid effects and ensure adequate availability of soil nutrients to crops.

On the average, organic matter was relatively moderate across the site (Fig. 4). This may be consequent upon litter falls from trees in the area. However, there is need to adopt cultural practices such as minimum tillage operation, mulching, organic manuring, etc. that will encourage the return and incorporation of plant/crop residues into the soil to sustain/increase the level of soil organic matter.

The percentage total nitrogen values range between low and moderate (Fig. 5). The area is relatively nitrogen-deficits which may be attributed to denitrification especially, under high temperature regimes and possibly crop removal without replenishment in the area.

Available phosphorus is relatively moderate across the farmland (Fig. 6). The inadequacy of optimum available phosphorus in the farmland might be consequent upon the acidic nature of the soil as certain portions of the nutrient may have been fixed. Therefore, there is need for liming of the soil and split application of single super phosphate to boost the availability of phosphorus to the crop plants.

Exchangeable bases (Ca^{2+}, Mg^{2+}, Na^{+}, and K^{+}) are generally low especially, the exchangeable potassium (K^{+}) (Fig. 7). This is attributed to the poor colloidal properties of the high sand fraction of the soil, resulting to leaching of the nutrients.

Maintenance of fertility status of the study site is therefore necessary. This can be achieved through liming (to reduce acidity and make nutrients more readily available), application of urea (nitrogen fertilizer), single super phosphate (for phosphorus) and muriate of potash (for potassium) fertilizers and adoption of cultural practices such as minimum tillage operation, mulching and organic manuring that will encourage the return and incorporation of plant/crop residues into the soil to sustain/increase the level of soil organic matter.

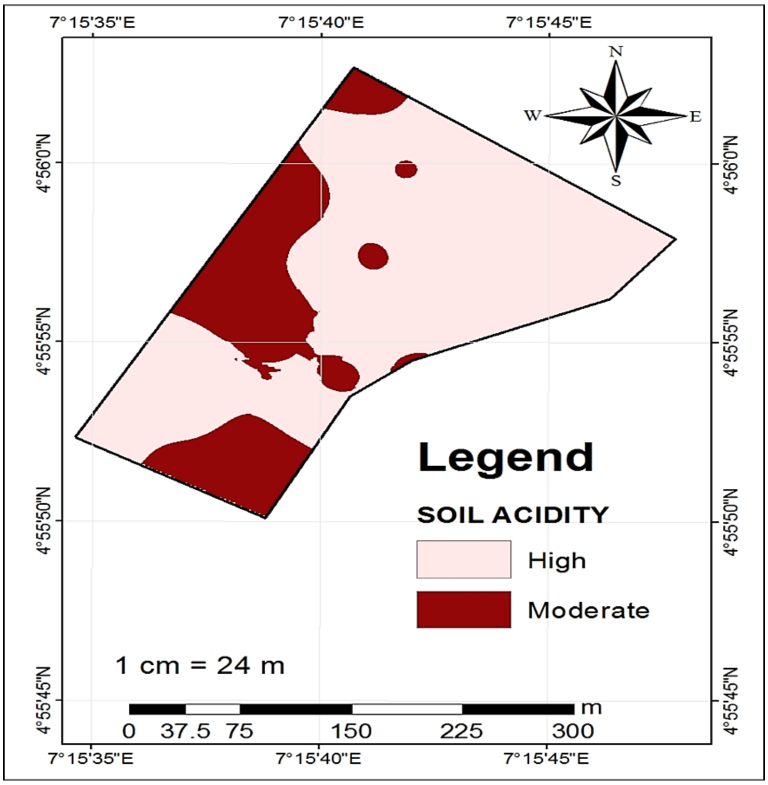

Fig. 3. Spatial distribution of acidity in soil of the study site.

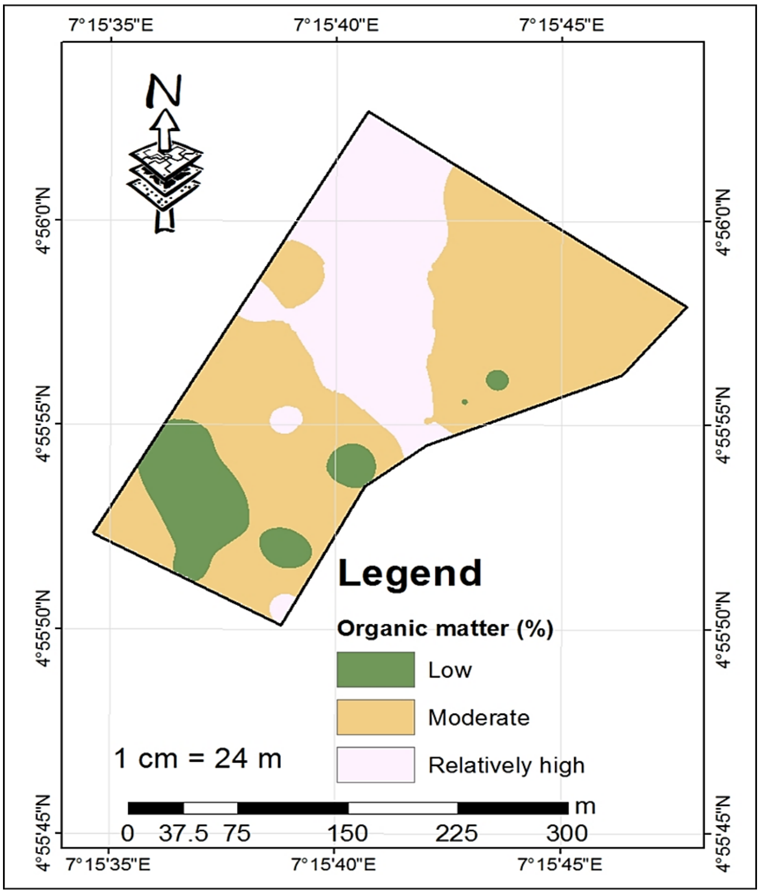

Fig. 4. Organic matter distribution in the soil of the site.

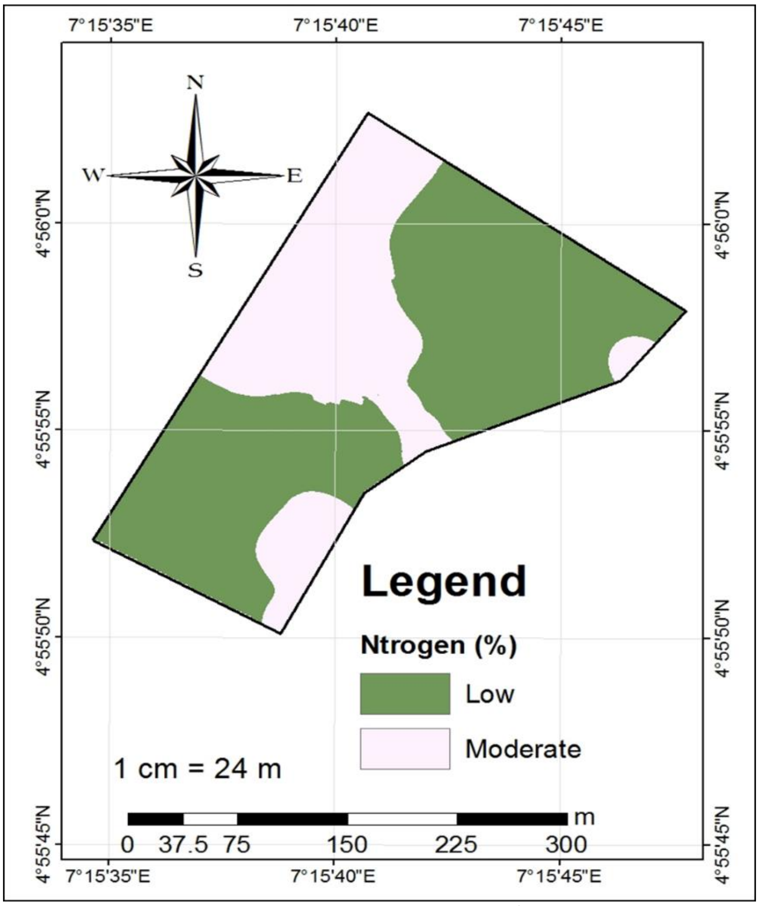

Fig. 5. Nitrogen distribution in the soil of the site.

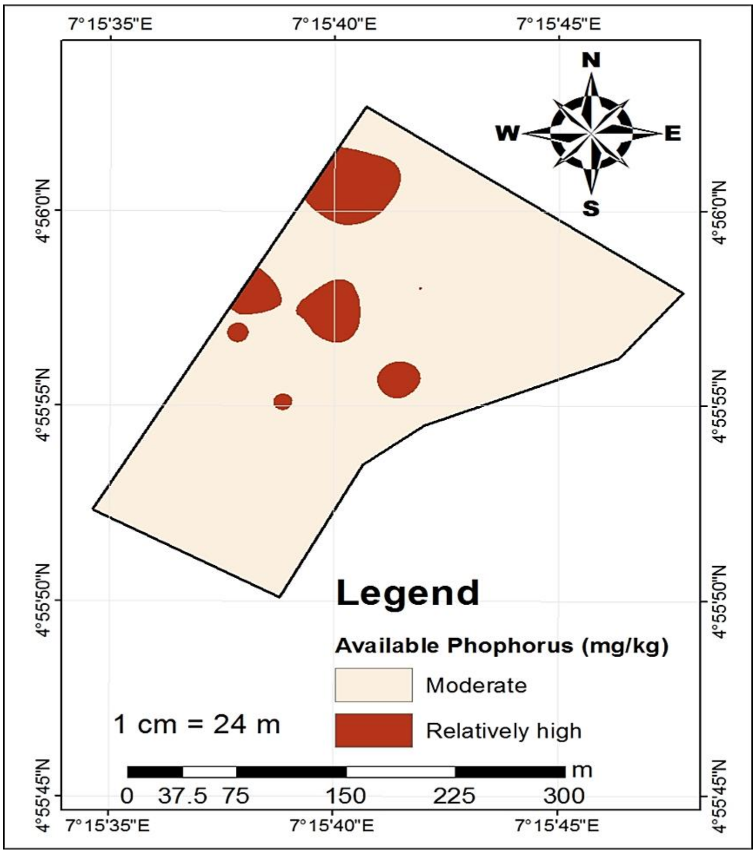

Fig. 6. Spatial distribution of available phosphorus in the soil of the site.

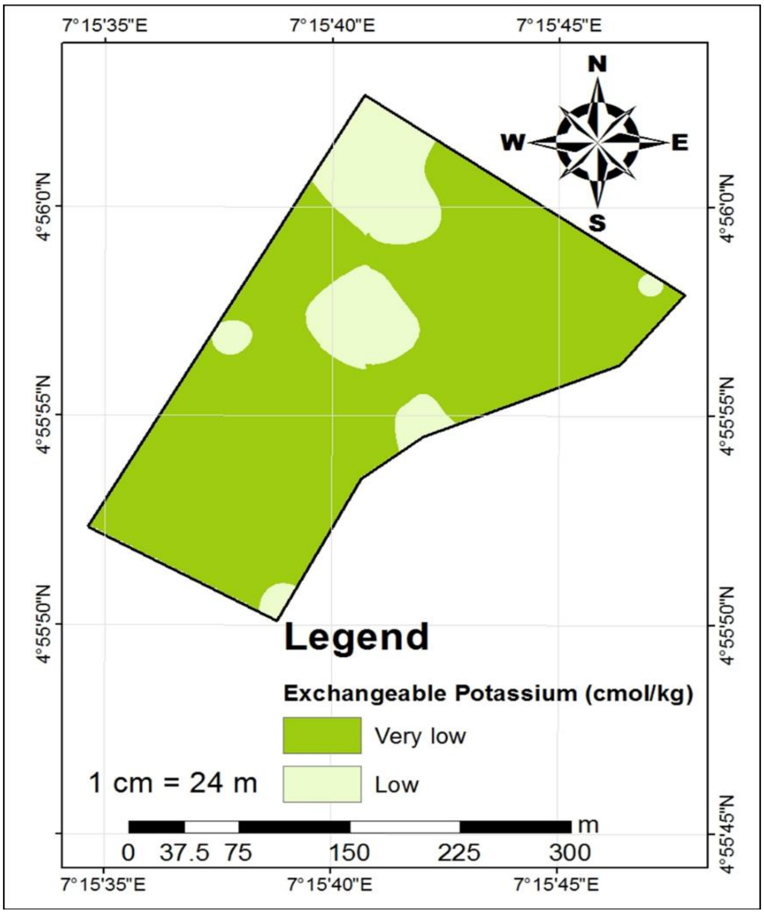

Fig. 7. Spatial distribution of exchangeable potassium in the soil of the site.

4. Conclusion

The soils investigated varied with respect to their properties but showed dominance of the sand fractions. The soils were strongly acidic and predominantly of low activity clay (ECEC < 12 cmolkg^{-1}). Some of the soil chemical properties were below the critical limit (Mg, Na, K, Ca, and N), base was above the critical limit, and organic carbon and available phosphorus were moderate. The results of the high sand fractions suggest that the area was prone to leaching. The overall low fertility status observed in area would require an increased attention to fertilization management. The nutrient holding capacity of the soils can be improved by incorporation of organic manure; the high acidity reduced by liming and split application of NPK 15-15-15 fertilizer to boost the nutrient reserves. These suggested practices will enhance good soil health and agricultural sustainability in the area.

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