African Journal of Social and Behavioural Sciences (AJSBS)
Volume 10, Number 2 (2020) ISSN: 2141-209X

CHARACTERIZATION OF SOIL PROPERTIES IN RELATION TO CASSAVA CROP PRODUCTION IN THREE SELECTED SOIL ZONES IN ABIA STATE, SOUTHEAST NIGERIA

Fidelis Chinazor Okorie

Department of Geography and Environmental Management, Imo State University, Owerri

fidelis.okorie@imsu.edu.ng

ABSTRACT: This study aimed to characterize physicochemical properties of soil of Abia state Nigeria in relation to cassava crop production, with the view to contribute to the crop production improvement in the area. In the research, Cassava crop was identified due to its position among staple crops and relevance to the socio-economic well-being of the people of Abia state and Nigeria in general. Methodology involved free soil survey method after the three zones (Ikwuano, Obuzo and Ovim) in the state were purposely selected for representation of the soil sampling. Auger sampling was conducted at 0-20 and 20-40 cm depths for crop production purposes while soil profile sampling was done for in-depth characterization and scientific classification of soils. Secondary data for the study involved collection of annual crop yield data on cassava for the sate over 30 years ranging from 1988 to 2017. The data were sourced from Agriculture Development Programme (ADP) headquarters in Umuahia. Soil data from auger samples were then subjected to analysis of variance (ANOVA). Thus, variation in properties among soil horizons were obtained using coefficient of variation. Also, the correlation coefficient (r) and the coefficient of determination for simple linear regression (r^2) were calculated to determine the degree of association among some physico-chemical properties of the soils from the selected profiles. Similarly, soil parameters were regressed against crop yield to establish relationship existing among some soil properties and the crop. Results showed that at both 0 – 20 cm and 20 – 40 cm depths, the variations in the soil properties were from low to moderate and high. The results specifically showed that Ikwuano soils are more fertile than Obuzo and Ovim in terms of organic matter, organic carbon content, exchangeable bases and base saturation. It showed that soils properties affects cassava crop production in the area at varying degrees, though it was observed that the soils contain plant nutrient elements that will support crop production. Irrespectively, the chemical properties of the soils are still low therefore, it is recommended to boost more the productivity of soils in the state for maximum crop production.

Keywords: Physico-Chemical Properties, Soils, Correlation, Crop Production, Abia State.

INTRODUCTION

Soil properties are among major physical environmental factors that can hinder or enhance crop production. Plants grown on land completely depend on soil on which they grow. More so, soil indicators which influence crop production are also affected by both natural and human induced factors. soil factors affecting crop production include soil moisture (water),

soil air, soil temperature, soil mineral matter, soil organic matter, soil organisms and soil reaction (pH), which is the pH (hydrogen ion concentration) of the soil.

The global food security crisis jeopardizes the lives of millions of people in vulnerable communities, particularly in Africa where poverty, malnutrition and death from hunger are rife (IPCC, 2007). There are indications and evidences that the agricultural and food system as well as the rural area across the world are experiencing major climatic changes (Apata, Samuel & Adeola, 2009). This change has drastically reduced soil fertility and led to poor agricultural outputs particularly in sub-Saharan Africa.

The recurrent food crisis in Sub-Saharan Africa such as Nigeria is partly due to high rate of population growth over the food production level and erratic amounts of food crops produced from year to year. This, however, can be attributed to high susceptibility of the country to serious environmental hazards, extreme climate events, poor soil quality, deforestation, continuous cropping and unhindered desert encroachment (Ani, 2002). Also Agboola and Ojeleye (2007) noted that the low-available water holding capacity of the soil result to poor crop growth in the tropics. In another study, Uchegbu (2006) believes that rising temperature affects soil moisture, which in turn could affect soil fertility. Supporting the above remark, Lia (1979) observed that the major agro-climatic constraints on agricultural production are related to insufficient, excessive or irregular moisture supply, which in turn will affect the length of growing period (LGP) of crops. From the foregoing, it is clear that there are many factors that affect the growing period of crops, which to a greater extent determine the crop growth cycle and its yield.

In this research, cassava crop has been identified because of its position among staple crops as well as its relevance in the socio-economic well-being of people of Abia Sate and Nigeria in general. This study therefore, aimed to characterize physical and chemical properties of soils of Ovim (Abia north), Ikwuano (Abia central), and Obuzor (Abia south) zones in relation to cassava crop production with the view to contribute to the crop production improvement in the area.

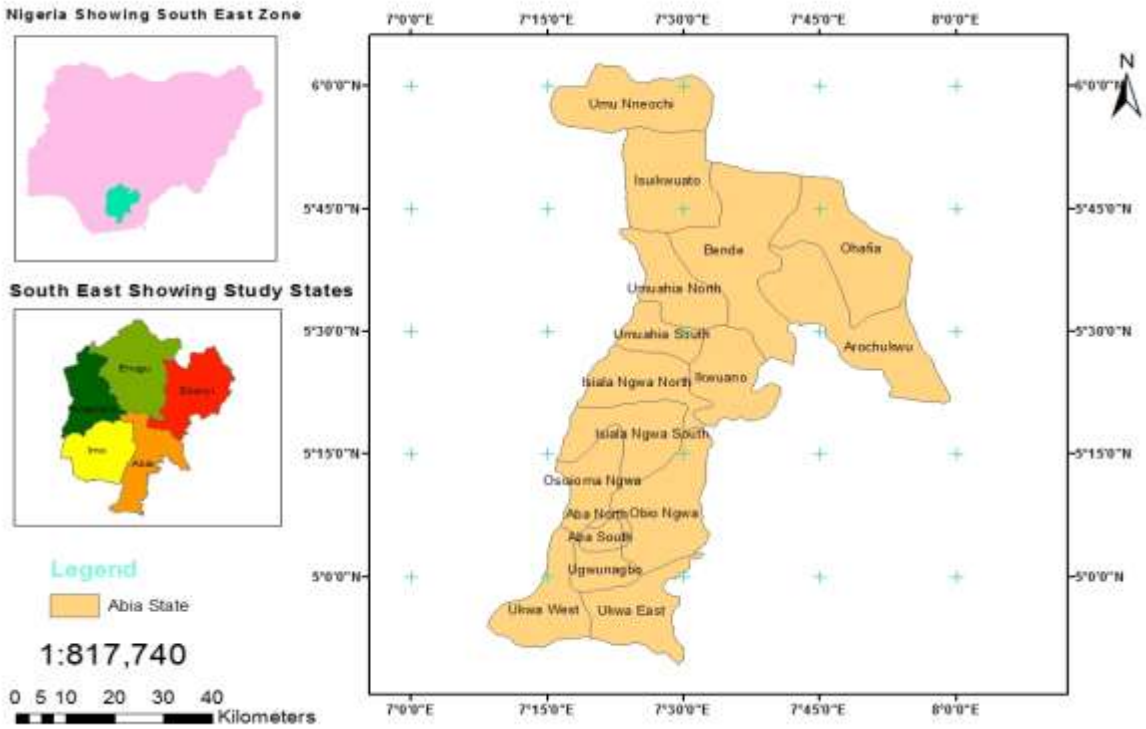
Abia is situated on latitude $05^{0}29^{1}$N and longitude $07^{0}33^{1}$E with altitude of 122 meters above sea level. The state is located in the southeast geographical zone of Nigeria. It was carved out of the old Imo state on August, 1991. The state is made of 17 local government areas (see figure 1), and the capital is at Umuahia while Aba is the commercial centre of the state (Okorie, Njoku, Onweremadu & Iwuji, 2019).

Rainfall is available in the state and evenly distributed all year round. The rainy season usually begins in March as moist Atlantic air mass known as the south-west monsoon invades the country and ends in October or early November. The dry season is from December to February. It witnesses two dry seasons, two wet seasons, if the little dry season "August break" is inclusive (Njoku, 2006). It has a tropical humid climate, with average temperature 32^{o}C during dry season and 28^{o}C in wet season.

The vegetation type is rainforest, (belonging rainforest vegetation zone of southeast Nigeria), being evergreen and luxuriant forest. Forest of the area is displayed in three layers – the ground layer, dominant middle layer and top layer. They are made up of three to six metre high herbs and shrubs, trees of 18 to 24 metres tall possessing robust branches and dark green foliage. Branches of one tree overlaps with those of others to create a continuous canopy of 30 to 60 metres high, some of the trees include iroko, obeche, palm trees, oil-bean trees and tropical cedar. Dependant species such as parasites, saprophytes, climbers and epiphytes are common in vegetation zone.

Since state is in tropical rainforest, the soils are largely a combination of hygromorphic soils, vertisols and ferralsols, and the vegetation plays the double role of supplying humus to the soil and protecting it from erosion. The area is well endowed with fossil fuel and other energy resources especially crude oil, natural gas, coal and biomass. The people of the state engage in subsistence, rural based, small scale farming and produce their own food crops. Therefore, rainfall availability and distribution is very essential in the area. Mineral resources found in the state include petroleum, natural gas, lead and zinc. The major tourist attractions are the National war Museum and Azumiri Blue River. According to 2006 Population and Housing Census, Abia state is made up of 1,430,298 males and 1,451,082 females, but currently, the state total population is estimated at 2,833,999 (oasdom.com, 2019).

Figure 1: Abia State of Nigeria (Study area) with its Local Government Areas



Source: After Okorie et al., 2019

MATERIALS AND METHODS

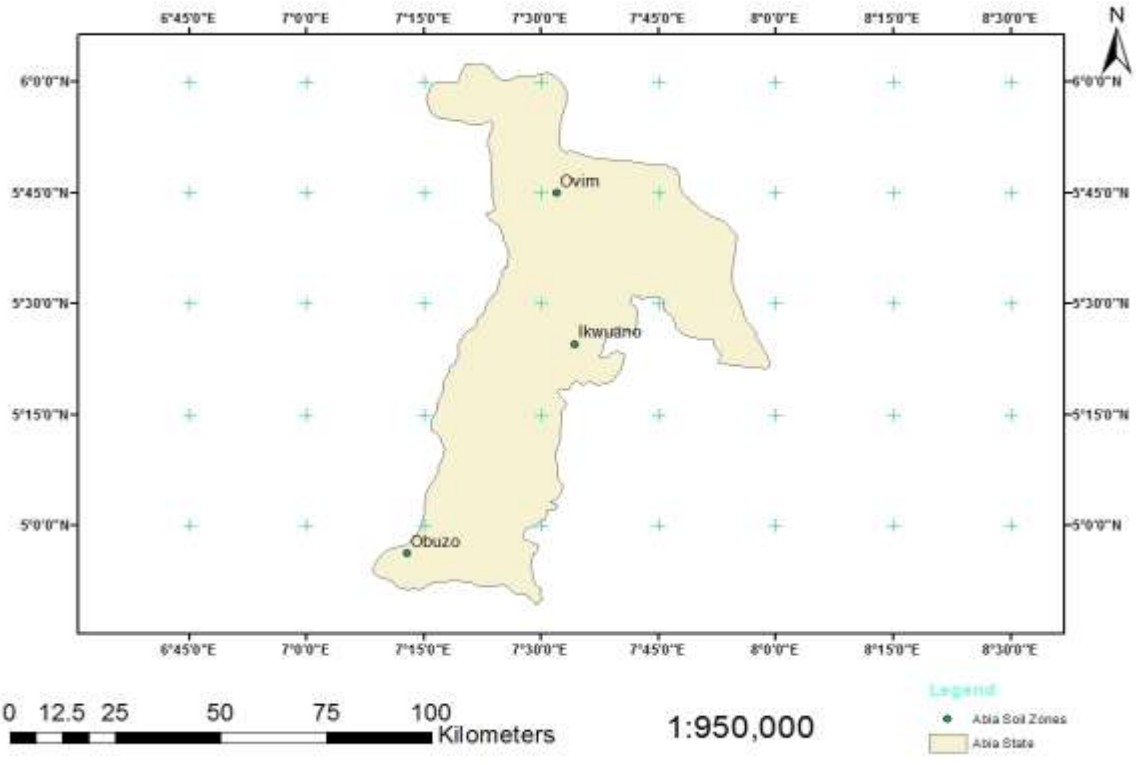
The study involved both primary and secondary data sources and acquisitions.

Primary Data Collection:

A free survey was employed for the study after the three zones in the state was purposely selected for representation of the soil sampling. The zones include Ikwuano in Abia central, Obuzo in Abia south and Ovim in Abia north (see figure 2). The free survey was guided by size and extent of farming activities in each zone. Two types of sampling were conducted; Auger sampling was conducted at 0-20 and 20-40 cm depths for arable crop (cassava) production purposes while soil profile sampling was done for in-depth characterization and scientific classification of soils.

Soil profile was dug, described and sampled using standard procedures as recommended by FAO (2006). Soil samples were collected based on horizon differentiation. Sampling started from the deepest horizon upwards in each soil profile. In each zone, 5 auger samples of the same depth were collected and bulked to form a composite sample for laboratory analyses, and core soil samples were collected for bulk density determinations.

Figure 2: Abia, Southeast Nigeria showing the selected soil zones



Source: Field work, 2020

Secondary Data Collection:

The secondary data involved collection of annual crop yield data on cassava (in kilograms/hectare) for Abia sate over 30 years ranging from 1988 to 2017. The crop yield data were sourced from Agriculture Development Programme (ADP) headquarters in Umuahia. The crop yield data are presented in Tables 1. Also, both soil data and the crop (cassava) yield data were analyzed statistically to determine their relationship.

Table 1.1: Crop (Cassava) yield for Abia State in Metric tons (1988-2017)

S/N	Year	Cassava
1	**Year**	6.90
2	1988	6.40
3	1989	6.55
4	1990	6.75
5	1991	6.80
6	1992	18.17
7	1993	18.05
8	1994	17.92
9	1995	17.80
10	1996	17.67
11	1997	17.55
12	1998	17.55
13	1999	17.50
14	2000	16.47
15	2001	16.47
16	2002	16.45
17	2003	16.76
18	2004	16.84
19	2005	18.68
20	2006	17.89
21	2007	16.01
22	2008	16.09
23	2009	15.94
24	2010	14.11
25	2011	15.91
26	2012	14.71
27	2013	15.08
28	2014	16.66
29	2015	15.00
30	2016	15.75

Total 2017 **450.43**

Source: ADP Umuahia, Abia state

Laboratory Studies

Soil samples were air-dried and sieved using 2-mm sieve. Particle size distribution was determined by hydrometer method (Gee & Or, 2002) while bulk density was measure by core procedure (Grossman & Reinsch, 2002). Results from particle size analysis (sand, silt and clay) values were used to obtained textural class using textural triangle. Bulk density values were used to calculate total porosity of soils given a relationship between bulk density and particle density (Foth, 1984).

Total Porosity (TP) $= \frac{BD}{PD} \times \frac{100}{1}$

Where: BD = determined bulk density

PD = particle density assured to be 2.65 mg m^{-3} (2.65 g/cm^{-3}).

Gravitaional moisture content (ɵm) was measured using the procedure as outlined in Obi (1990).

$\Theta m = \frac{NS-DS}{DS} \times \frac{100\%}{1}$

Where: Θm = gravitmetric moisture content

Ws = weight of wet soil sample

Ds = weight of dry soil sample

AWC = FC – PWP

Soil pH water and pH KCL were determined electronically in 1: 2.5 soil solutions! water-ratio (Hendershot, Laland & Duquette, 1993).

Soil organic Carbon was measured by wet digestion using the procedure outlined in Soil Survey Staff (2010). Soil organic matter was calculated by multiplying organic carbon value by 1.724. Exchangeable basic cations were extracted using ammonium acetate at pH_7. Therefore, exchangeable calcium and magnesium were determined using ethylene diamine-tetraascetic acid (EDTA) titration, and exchangeable potassium and sodium were determined by flame photometry (Soil Survey Staff, 2010).

Exchangeable acidity (exchangeable hydrogen and aluminum) were measured by apparent titration (Soil Survey Staff, 2003).

Cation exchange capacity (ACEC) was measured at pH of 7.0 (neutral) (Soil Survey Staff, 2010).

Total nitrogen (TN) was determined by micro-kjedahl apparatus (Bremner, 1996). Available phosphorous was estimated by Bray 2 method according to procedure of Olson & Sommers (1982). Base saturation was computed as a sum of exchangeable basic cations (Ca,Mg,K,Na) divided by Cation Exchange Capacity, multiplied by 100% (Soil Survey Staff, 2010).

Date Analytical Techniques

Soil data from auger samples were subjected to analysis of variance (ANOVA). Therefore, variation in properties among soil horizons were obtained using coefficient of variation. Also, the correlation coefficient (r) and the coefficient of determination for simple linear regression (r^2) were calculated to determine the degree of association or relationship among some physico-chemical properties of the soils from selected profiles around the study area. Similarly, soil properties (independent variables) were regressed against crop (cassava) yield (dependent variable) to establish relationship existing among some soil properties and the crop.

RESULTS AND DISCUSSION

Physical Properties of Soils of Abia State

Results of soil physical properties in Abia State showed that at the 0 – 20 cm depth Coarse Sand (CS), Fine Sand (FS), Total Sand (TS), Silt (Si) and clay ranged from 350 – 500, 220 – 370, 700 – 720, 10 – 200 and 100 – 270 g/kg, respectively in the three sampled zones (Ikwuano, Obuzo and Ovim). Soil bulk density ranged from 1.22 – 1.25 g/cm^3 while total porosity ranged from 52.83 – 53.96 %. Moisture content ranged from 10.08 – 12.32%. FC, PWP and AWC ranged from 0.198 – 0.217, 0.082 – 0.109, and 0.102 – 0.116 g/kg respectively (Table 2.1). There were low variations in fine sand, bulk density, total porosity, moisture content, field capacity, permanent wilting point and AWC while medium variations were observed on coarse sand and total sand.

At 20 – 40 cm depth, the values of CS, FS, TS, Si and clay ranged from 300 – 500, 280 – 350, 580 – 850, 20 – 160 and 90 – 200 g/kg respectively. Bulk density and total porosity ranged from 1.31 – 1.36g/cm^3 and 47.92 – 50.56%. Filed capacity, PWP and AWC ranged from 0.209 – 0.218, 0.079 – 0.101 and 0.117 – 0.133 g/kg respectively (Table 2.1). There were low variations in bulk density, total porosity, moisture content, FC and PWP while there were moderate variations in FS, Cl, and AWC. High variations were observed in fine sand, bulk density, total porosity, field capacity, permanent wilting point and AWC. Medium variations were observed in coarse sand, total sand and moisture content while high variation were observed in clay fraction. Comparing the two sampling depths, there was low variability in total sand, bulk density, total porosity, moisture content, field capacity, permanent wilting point and AWC. Fine sand and moisture content had medium variability

while silt and clay had high variability. These variations in the physical properties of soils at Ikwuano, Obuzo and Ovim could be attributed to land use system.

Table 2.1: Physical properties of soils of Abia State

Location	CS	FS	TS	Si	Cl	TC	BD	TP	Ǿm	FC	PWP	AWC
	g/kg	g/kg	g/kg	g/kg	g/kg		g/cm^3	%	%	g/kg	g/kg	g/kg
					Sampling depth(0 - 20 cm)							
Ikwuano	500	220	720	10	270	SCL	1.25	52.83	12.32	0.198	0.082	0.116
Obuzo	350	370	720	180	100	SL	1.22	53.96	10.08	0.217	0.109	0.108
Ovim	400	300	700	200	100	SL	1.24	53.2	10.46	0.206	0.104	0.102
Mean	417	297	713	130	157		1.24	53.33	10.95	0.207	0.098	0.109
CV(%)	18.3	1.6	25.3	80.3	62.6		1.2	1.1	10.9	4.6	14.6	6.5
SE	76.4	11.55	75.1	104.4	98.1		0.02	0.58	1.19	0.009	0.01	0.01
					Sampling depth (20 – 40 cm)							
Ikwuano	480	300	780	20	200	SCL	1.36	48.67	12.96	0.212	0.079	0.133
Obuzo	500	350	850	160	90	SL	1.31	50.56	8.7	0.209	0.088	0.121
Ovim	300	280	580	160	160	SL	1.38	47.92	10.2	0.218	0.101	0.117
Mean	427	310	737	113	150		1.35	49.05	10.62	0.213	0.089	0.124
CV(%)	25.8	11.6	19	71.3	37.1		2.7	2.8	20.3	2.2	12.4	6.7
SE	110.2	36.1	140.1	80.3	55.7		0.04	1.36	2.16	0.004	0.11	0.01
Grand mean	422	303	725	122	153		1.29	51.19	10.79	0.210	0.094	0.116
CV(%)	22.5	19.4	13.7	76.7	52		2.1	2	16.2	3.6	13.7	6.6
SE	94.8	58.9	99.4	93.4	79.8		0.03	1.05	1.75	0.01	0.01	0.01

CS = Coarse sand, FS = Fine sand, TS = Total sand, Si = Silt, Cl = Clay, BD = Bulk density, TP = Total porosity, Ǿm = Moisture content, FC = Field capacity, PWP = Permanent wilting point, AWC = Available water capacity, SE = Standard error, CV = Coefficient of variation

Source: Field work (2020)

Chemical properties of soils in Abia State

Soil chemical properties in Abia State are presented in Table 3.1 Results showed that within the 20 cm soil depth, soils of Ikwuano, Obuzo and Ovim are strongly acidic with pH in water ranging from 3.4 to 4.3 and 4.5 – 4.9 in KCl. Organic carbon and organic matter contents were low with the mean value 16.53 and 28.47 g/kg respectively. Total nitrogen according to FAO (2006) rating was also low and ranged from 1.3 – 1.5 g/kg. Exchangeable bases were low with total using Esu (1991) rating. Total exchangeable bases ranged from 0.99 – 1.78 cmol.kg. Ikwuano location had higher total exchangeable bases (3.70 cmol/kg) while effective cation exchange capacity and base saturation had the values at Obuzo location. ACEC ranged from 5.38 – 7.82 cmol/kg, while available phosphorus was low and ranged from 8.80 – 25.20 mg/kg.

At 20 – 40 cm auger depth, soil pH range in water and KCl ranged from 3.2 – 4.1 and 4.1 - 4.6, respectively. Organic carbon and organic matter ranged from 8.6 – 10.0 and 14.8 – 17.2 g/kg. The nitrogen content was low with the range of 0.9 – 1.1 g/kg. Exchangeable cations (Ca, Mg, K and Na) were low in the three locations according to FAO (2006), rating though with the highest values was found at Obuzo village. Total exchangeable acidity ranged from 3.2 – 4.0cmol/kg while effective cation exchange capacity was also low with the highest values found at Ikwuano. Base saturation was low and available phosphorus ranged from 4.8 – 13.6 mg/kg. There were also different levels of variability among the soil chemical properties from 0 – 20 cm and 20 – 40 cm. These results showed that at both 0 – 20 cm and 20 – 40 cm depths, Ikwuano soils are more fertile than Obuzo, and Ovim in terms of organic matter, organic carbon content, exchangeable bases and base saturation. However, the three locations need more external nutrient inputs for maximum crop yield.

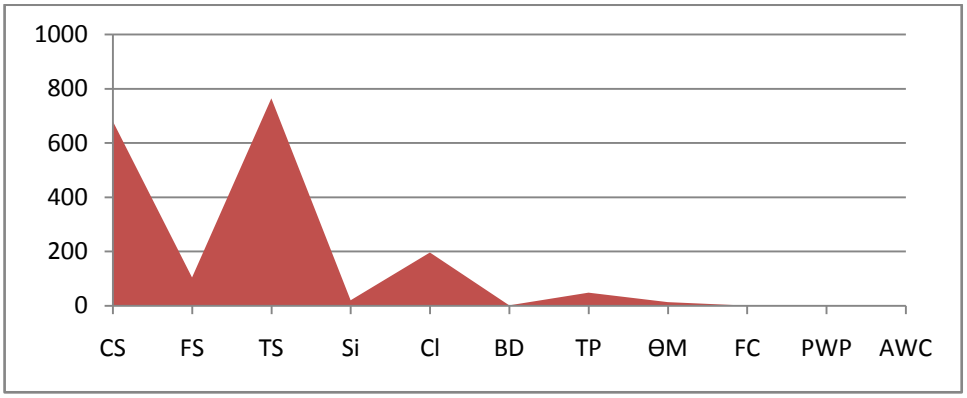
Distribution of soil properties in the three soil zones (Ikwuano, Obuzo & Ovim) of the State

Distribution of soil physical properties in Ikwuano Zone (profile sampling)

The physical properties of Ikwuano in Abia State are presented in Figure 3.1. The textural class of the soil was silt loam and silt clay loam. The mean values of the CS, FS, TS, Si and Cl were 680, 104, 764, 20 and 196g/kg respectively. Average value of bulk density and total porosity were 1.38 g/cm^3 and 47.99% respectively. Moisture content increased down the depth with mean value of 13.18. Field capacity and permanent wilting pointing had the mean values of 0.226 and 0.112 gkg^{-1}, respectively while AWC had mean value of 0.114gkg^{-1}.

Variations occurred among soil physical properties from A to BC horizon. Coarse sand, total sand, bulk density, total porosity, field capacity, PWP and AWC exhibited low variation (figure 3.1). Also clay had low variation while fine sand and silt exhibited high variation using the figure using Wilding (1996) rating.

Figure 3.1 Mean values of soil physical properties in Ikwuano zone, Abia state



Source: Field work 2020

Table 3.1: Chemical Properties of Soils of Abia State

Location	pH(KCl)	pH(H2O)	OC	OM	TN	Ca	Mg	K	Na	TEB	H	Al	TEA	ECEC	ACEC	Bsat	Av.P
			g/kg	g/kg	g/kg	◄				Cmol/kg					►	%	Mg/kg
Sampling depth (0 - 20 cm)																	
Ikwuano	4.3	4.9	14	24.1	1.4	1	0.2	0.06	0.02	1.28	1.3	2.4	3.7	4.98	7.36	25	22.8
Obuzo	3.4	4.5	22	37.9	1.5	1.3	0.3	0.1	0.04	1.74	1.2	2.2	3.4	5.14	7.82	33	25.2
Ovim	4	4.8	13.6	23.4	1.3	0.6	0.2	0.11	0.08	0.99	1.3	1.6	2.9	3.89	5.38	25	8.8
Mean	**3.90**	**4.73**	**16.53**	**28.47**	**1.40**	**0.97**	**0.23**	**0.09**	**0.05**	**1.34**	**1.27**	**2.07**	**3.33**	**4.67**	**6.85**	**27.67**	**18.93**
CV(%)	11.8	4.4	28.7	28.7	7.1	36.3	23.3	29.4	65.5	28.3	4.6	20.1	12.1	14.6	18.3	16.7	46.8
SE	0.46	0.21	4.74	8.18	0.1	0.35	0.06	0.03	0.03	0.38	0.06	0.42	0.4	0.68	1.29	4.62	8.86
Sampling depth (20 - 40 cm)																	
Ikwuano	4.1	4.6	9	15.5	1.1	0.6	0.1	0.03	0.01	0.74	1.5	2.5	4	4.74	7.18	15	13.6
Obuzo	3.2	4.1	10	17.2	0.9	0.8	0.1	0.06	0.01	0.97	1.3	2.4	3.7	4.67	7.03	20	15
Ovim	3.8	4.4	8.6	14.8	1.1	0.4	0.1	0.07	0.03	0.6	1.4	1.8	3.2	3.8	5.12	18	4.8
Mean	**3.70**	**4.37**	**9.20**	**15.83**	**1.03**	**0.60**	**0.10**	**0.05**	**0.02**	**0.77**	**1.40**	**2.23**	**3.63**	**4.40**	**6.44**	**17.67**	**11.13**
CV(%)	12.1	5.8	7.8	7.8	11.2	33.3	0	39	69.3	24.3	7.1	17	11.1	11.9	17.8	14.2	49.7
SE	0.45	0.25	0.75	1.23	0.16	0.2	0	0.02	0.01	0.19	0.1	0.38	0.4	0.52	1.15	2.52	5.53
Grand mean	3.80	4.55	12.87	22.15	1.22	0.78	0.17	0.07	0.03	1.05	1.33	2.15	3.48	4.54	6.65	22.67	15.03
CV(%)	12.1	5.1	26.3	26.4	8.9	36.5	24.5	33.2	72.9	28.3	6.1	18.5	11.6	13.4	18.4	16.4	49.1
SE	0.46	0.23	3.39	5.85	0.11	16.4	0.04	0.02	0.02	0.3	0.08	0.4	0.4	0.61	1.23	3.72	7.38

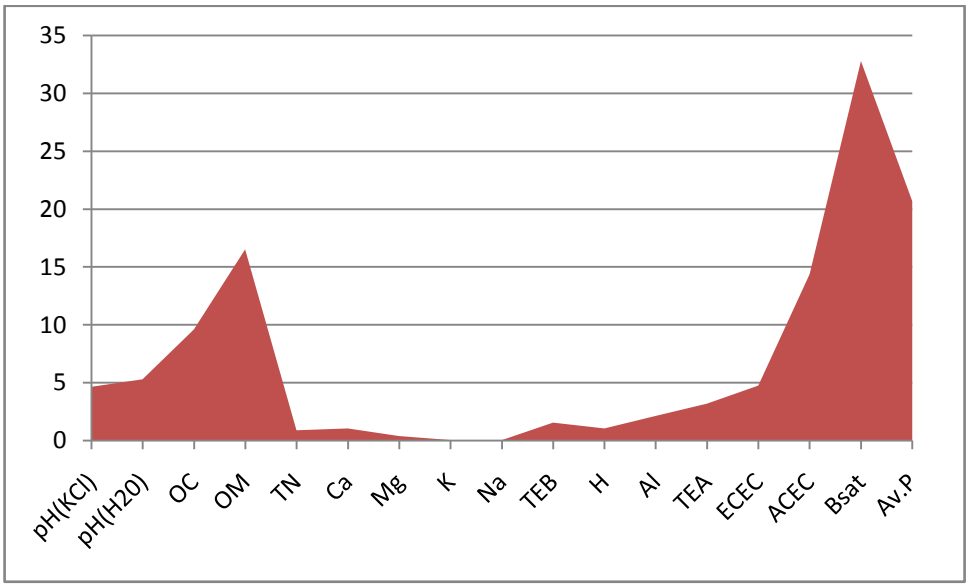
pH(KCl) = Ph Potassium Chloride, pH(H_2O) = pH Water, OC = Organic Carbon, OM = Organic Matter, TN = Total Nitrogen, Ca = Calcium, Mg = Magnesium, K = Potassium, Na = Sodium, TEB = Total Exchangeable Base, H = Hydrogen, Al = Aluminum, TEA = Total Exchangeable Acidity, ECEC = Effective Cation Exchangeable Capacity, ACEC = Apparent Cation Exchangeable Capacity, Bsat = Base saturation, Av.P = Available Phosphorous

Source: field work (2020)

Distribution of soil chemical properties in Ikwuano zone (profile sampling)

Results in Figure 3.2 showed the chemical properties of soil distributed in Ikwuano, Abia State. The soils are strongly acidic with mean pH value of 4.56 in KCl and 5.3 in water. The mean values of organic carbon, organic matter, and total nitrogen were 9.6, 16.52 and 0.9 g.kg respectively. These values were low according to FAO (2006) rating. Exchangeable Ca, Mg, K and Na were low with mean value of total exchangeable bases of 1.56cmol/kg. Effective cation exchange capacity and base saturation were low. Available phosphorus was low with mean value of 20.6mgkg^{-1}. There was low variability in soil pH, exchangeable Ca, total exchangeable bases, exchangeable H, Al, TEA, ECEC and base saturation. Organic matter, total nitrogen, organic carbon and exchangeable K had high variation while exchangeable Mg, Na and available P had medium variation.

Figure 3.2: **Mean values of soil chemical properties in Ikwuano zone, Abia state**

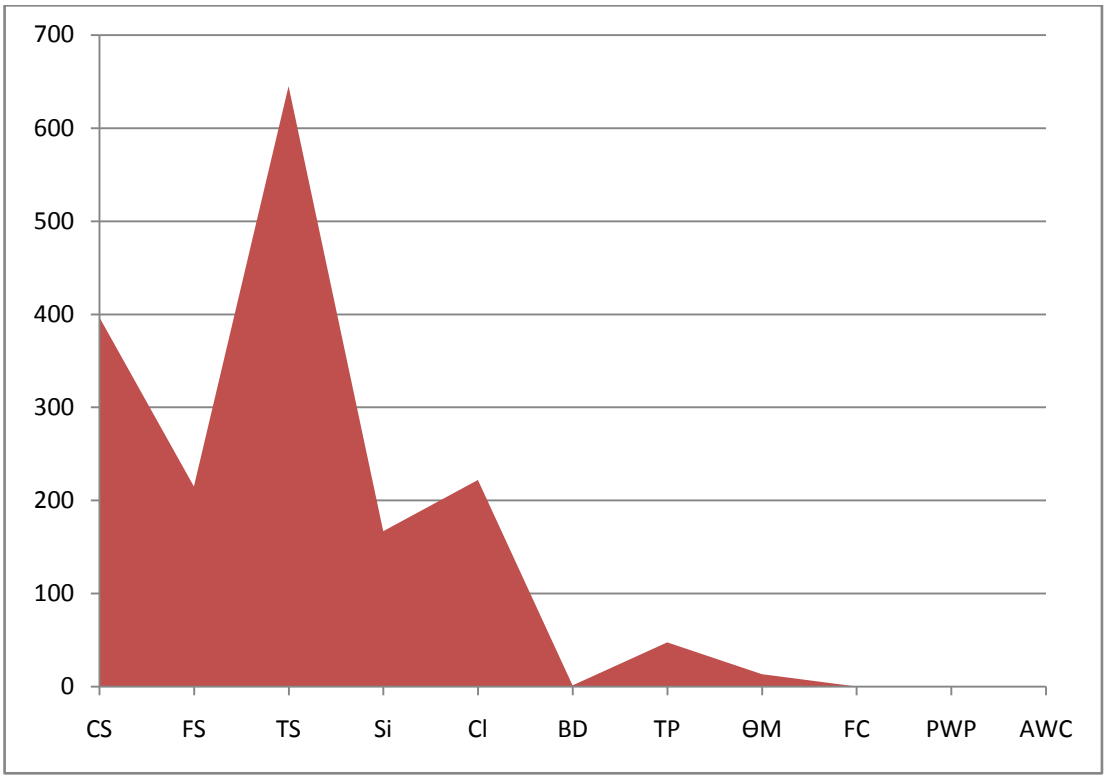


Source: Field work 2020

Distribution of soil physical properties in Obuzo zone (profile sampling)

Figure 3.3 showed the physical properties of Obuzo soil, Abia State. Mean coarse, fine, total sand, silt and clay were 397, 215, 645, 167 and 222gkg$^{-1,}$ respectively. The textural class of the soil from A to AB horizon was silt loam; from Bt_1 to Bt_3 was silt clay loam while at Bt_4 the texture was silt loam. Bulk density increased while total porosity decreased with depth and with mean values of 1.39g/cm^3 and 47.61% respectively. Moisture content increased with depth with mean value of 13.42%. Field capacity and permanent wilting point were 0.212 and 0.103gkg^{-1} respectively. There was downward increase in the AWC down the pit. In all the properties, there are various degrees of variability. Apart from bulk density, total porosity, field capacity, PWP and AWC, other physical properties showed medium to high variation.

Figure 3.3 **Mean values of soil physical properties in Obuzo zone, Abia state**

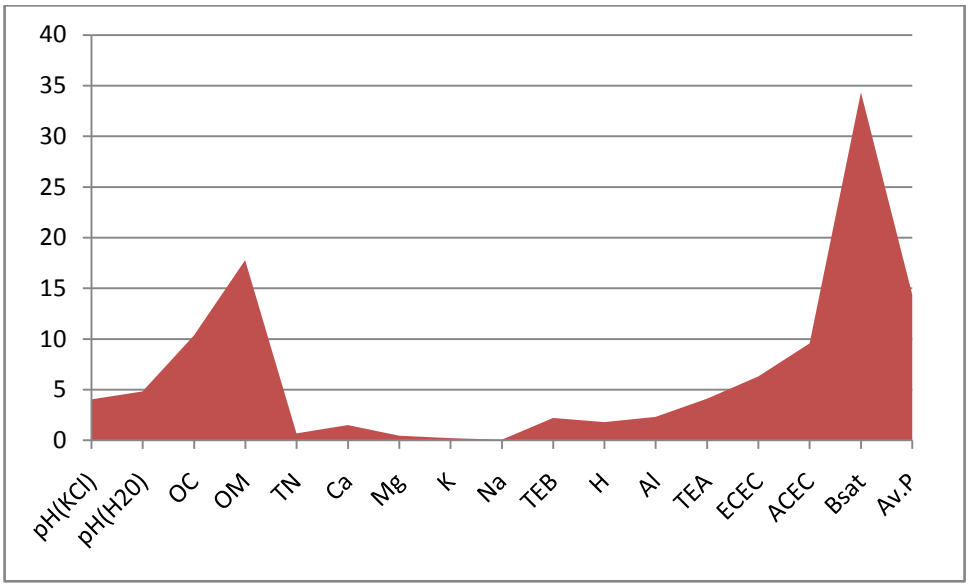


Source: Field work 2020

Distribution of soil chemical properties in Obuzo Zone (profile sampling)

Soil chemical properties at Obuzo, Abia State are presented in Figure 3.4. The pH level of the soil from A to Bt_4 horizon is strongly acidic. Higher organic carbon and organic matter are found at the epipedon layer and this agreed with the results of other locations studied. However, mean organic carbon (10.33g/kg) and organic matter (17.77 g/kg) were low using FAO (2006) rating. Both total nitrogen, exchangeable bases (Ca, Mg, K, Na), were low and attributed to the low organic matter content of the soils. Total exchangeable base were higher at the epipedon attributed to the higher organic matter content at that layer. Mean effective cation exchange capacity (6.30cmol/kg), base saturation and available phosphorus were low (Esu, 2005). Variations also are observed in the properties with organic matter and organic carbon, total nitrogen, exchangeable sodium, and available phosphorus having high variability down the horizons from the top.

Figure 3.4: **Mean values of soil chemical properties in Obuzo zone, Abia state**

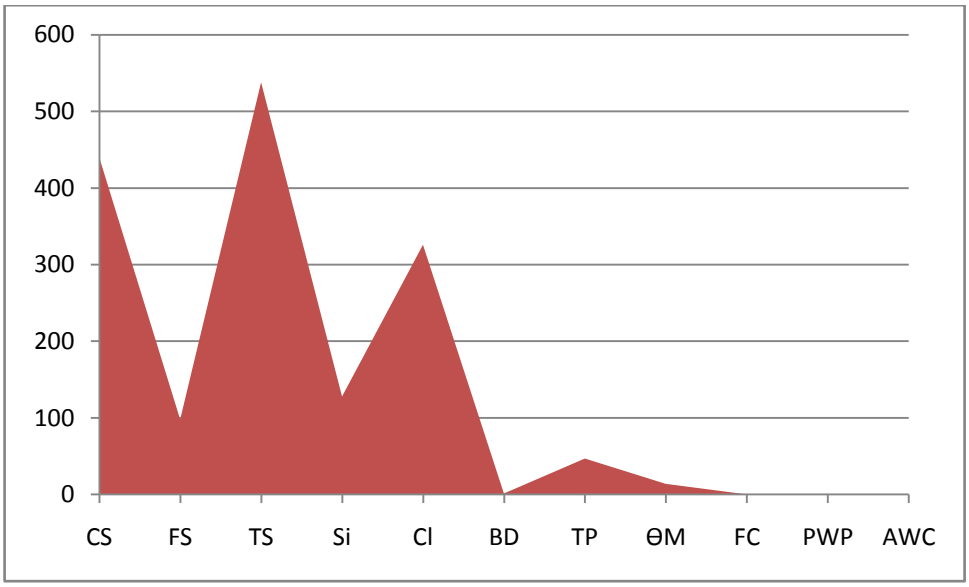


Source: Field work 2020

Distribution of soil physical properties in Ovim Zone (profile sampling)

Physical properties of soil of Ovim Abia State are shown in Figure 3.5. The epidepon is dominated by sand fraction. The mean values of CS, FS, TS, Si and Cl were 440, 98, 538, 128 and 326 g/kg respectively. Their percentage variability between depths were 25.9, 18.3 etc respectively indicating moderate variability exception being clay with high variation. Distribution of TS, Cl, and Si down soil depth was in a decreasing order for sand, increasing for clay and irregular for silt, and with soil texture varying as sandy clay, sandy clay loam and clayey. These variations gave rise to three textural classes. Mean bulk density, total porosity, and moisture contents were 1.40 g/cm^3, 47.01% and 13.95 g/kg respectively. The moisture content was lowest at the epipedon and this could be due to high sand fraction recorded on the top soil. Mean values of field capacity, PWP and AWC were 0.229, 0.11 and 0.117g/kg respectively. Bulk density, total porosity, moisture content, field capacity, PWP and AWC showed low variations.

Figure 3.5: **Mean values of soil physical properties in Ovim zone, Abia state**

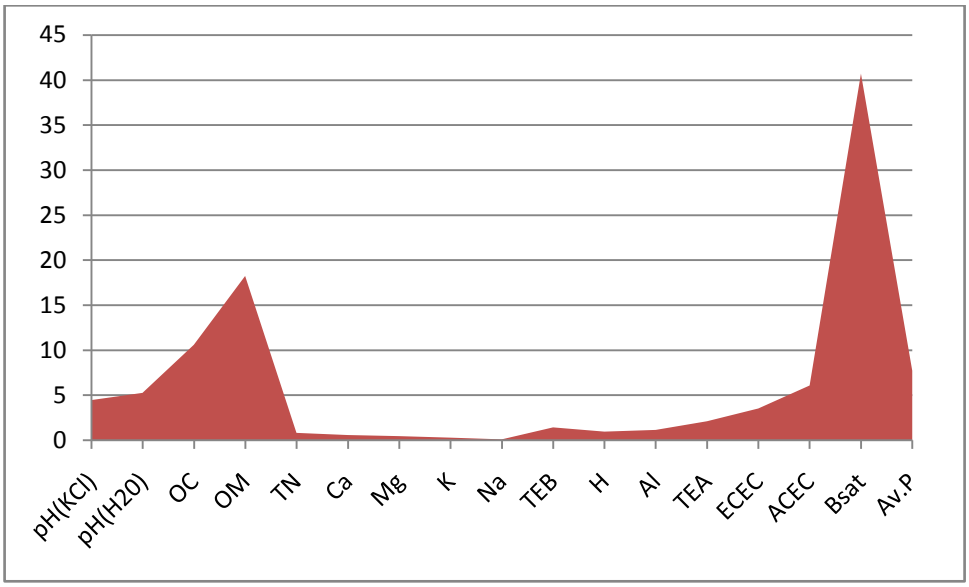


Source: Field work 2020

Distribution of soil chemical properties in Ovim zone (profile sampling)

Chemical properties of Ovim soil in Abia State are presented in Figure 3.6. The soils were moderately acidic with low variability (cv = 0.27). Organic carbon and organic matter are low using FAO (2006) fertility rating. High variations were observed in the organic carbon, organic matter and total nitrogen content within the horizons. This could be due to litter fall influence on soil organic matter on the epipedon which decreased down the soil depth. The mean values of organic carbon, organic matter and total nitrogen were 10.60, 18.24 and 0.82 g/kg respectively. According to FAO, (2006) rating, exchangeable Ca, Mg, K and Na were low with moderate variation. Also effective cation exchange capacity of the soil was low with mean value of 3.53cmol/kg. However, base saturation was moderate and available phosphorus was low with medium variability.

Figure 3.6: Mean values of soil chemical properties in Ovim zone, Abia state



Source: Field work 2020

Comparison of soil Physical and Chemical properties within two sampling depths in Abia State

Results in Tables 4.1 and 4.2 showed the comparison in the physical and chemical properties of soil in Abia State between the two sampling depths respectively. There was significant effect (p=0.05) on soil bulk density and total porosity. There were no significant effects on soil chemical properties except exchangeable H, potassium and base saturation.

Table 4.1 Comparison of soil Physical properties within two sampling depths in Abia State

Location	depth (cm)	CS gkg^{-1}	FS gkg^{-1}	TS gkg^{-1}	Si gkg^{-1}	Cl gkg^{-1}	BD	TP g/cm^3	Ø‌m %	FC %	PWP gkg^{-1}	AWC gkg^{-1}
Abia State	0 – 20	416.7 [a]	296.7 [a]	713.3 [a]	130.0 [a]	156.7 [a]	1.24 [a]	53.3 [a]	10.95 [a]	0.21 [a]	0.10 [a]	0.11 [a]
Abia State	20 – 40	426.7 [a]	310.0 [a]	736.7 [a]	113.3 [a]	150.0 [a]	1.35 [b]	49.05 [b]	10.62 [a]	0.21 [a]	0.09 [a]	0.12 [a]
	$LSD_{(0.05)}$	388.4ns	175.7ns	392.4ns	76.57ns	198ns	0.08	2.88	3.08ns	0.04ns	0.03ns	0.01ns

Means having the same letters are not significant at 0.05 probability level, ns = not significant

CS = Coarse sand, FS = Fine sand, TS = Total sand, Si = Silt, Cl = Clay, BD = Bulk density, TP = Total porosity, Ɵm = Moisture content, FC = Field capacity, PWP = Permanent wilting point, AWC = Available water capacity, SE = Standard error, CV = Coefficient of variation

Source: Field work (2020)

Table 4.2: Comparison of soil chemical properties within two sampling depths in Abia State

Location	depth (cm)	pH(KCl)	pH(H_2O)	OC	OM	TN	Ca	Mg	K	Na	TEB	H	Al	TEA	ECEC	ACEC	Bsat	Av.P
				gkg^{-1}	gkg^{-1}	gkg^{-1}	←				Cmol/kg	→					%	Mg/kg
Abia State	0 – 20	3.90[a]	4.73[a]	16.5[a]	28.47[a]	1.40[a]	0.97[a]	0.23[a]	0.09[a]	0.05[a]	1.34[a]	1.27[a]	2.07[a]	3.33[a]	4.67[a]	6.85[a]	27.67[a]	18.93[a]
Abia State	20 – 40	3.70[a]	4.37[b]	9.20[a]	15.83[a]	1.03[a]	0.60[a]	0.10[a]	0.05[b]	0.02[a]	0.77[a]	1.40[b]	2.23[a]	3.63[a]	4.40[a]	6.44[a]	17.67[b]	11.13[a]
$LSD_{(0.05)}$		1.03ns	0.18	12.3 ns	21.25 ns	0.63 ns	0.46 ns	0.18 ns	0.02	0.06 ns	0.58ns	0.18	0.17 ns	1.05 ns	0.58ns	1.01ns	9.13	10.13 ns

Means having the same letters are not significant at 0.05 probability level, ns = not significant

pH(KCl) = Ph Potassium Chloride, pH(H_2O) = pH Water, OC = Organic Carbon, OM = Organic Matter, TN = Total Nitrogen, Ca = Calcium, Mg = Magnesium, K = Potassium, Na = Sodium, TEB = Total Exchangeable Base, H = Hydrogen, Al = Aluminum, TEA = Total Exchangeable Acidity, ECEC = Effective Cation Exchangeable Capacity, ACEC = Apparent Cation Exchangeable Capacity, Bsat = Base saturation, Av.P = Available Phosphorous

Source: Field work (2020)

Relationship between soil properties and crop yield (cassava) in Abia State

Results of the relationship between edaphic factors and crop yield as shown in Table 5.1 revealed that there is a relationship between soil (edaphic) factors and crop yield. Cassava yield significantly correlated negatively with edaphic factors like anion exchange capacity, available P, CS, and exchangeable Ca, effective cation exchange capacity, total exchangeable bases and TS but significantly correlated positively with bulk density and FC.

Table 5.1 Relationship between soil properties and cassava in the study area

Soil Parameters	Cassava yields
Cassava yield	1
Moisture content	-0.1695
Anion Exchange Capacity	-0.6662*
Available water capacity (AWC)	0.0613
Exchangeable Al	-0.447
Available Phosphorus	-0.6393*
Bulk Density	0.6505*
Base satutation	-0.3800
CS	-0.6742*
Exchangeable Ca	-0.5883*
Cl	0.0714
Effective Cation Exchange Capacity	-0.6382*
FC	0.5020*
FS	-0.2398
Exchangeable H	0.3333
Exchangeable K	-0.0567
Exchangeable Mg	-0.4242
Exchangeable Na	-0.0556
Organic Carbon	-0.4406
Organic Matter	-0.4404
PWP	0.2473
Si	0.1962
Total Exchangeable Acidity	-0.3269
Total Exchangeable bases	-0.5595*
Total N	-0.2746
Total Porosity	-0.6500*
TS	-0.7795**
pH (H_2O)	-0.2537

* = significant at 0.05 and ** = significant at 0.01

Source: Field work 2020

Conclusion

Abia State is agrarian state by nature and its soil is needed to be improved in quality so as to boost agricultural productivity. The study shows that soils of Abia state had a good correlation with arable crops particularly, cassava. Hence, the soil properties significantly correlated differently with the crop in the area. This means that the physical and chemical soils properties affects cassava production in various ways, but other factors such as technology, environmental hazards, and farmers' adaptive skill to climatic variations and change can also account for variations recorded respectively in cassava yields in the state. In the area, total sand (TS) at top soil level is 713kg and 737kg at sub-soil level against silt (Si) with 130kg at top soil level and 113kg at sub soil level.

The study however, indicated that the state is very rich in total sand, and the soils in the state are more porous and had more moisture content and field capacity. Previous research; Akamigbo (1984) reported that soils of Southern Nigeria are low in salt as a result of the high degree and extent of weathering and leaching have undergone. Similar results were also reported by Onweremadu and Anikwe (2007) of very low to moderate silt/clay ratios (0.04 to 0.029) that generally decreased with depth while working on soils at Isienyi Ibeku, which is within Ikwuano soil zone in Abia State. This study however reports high to very high silt/clay ratios (1:9.8) in Ikwuano in general, and the ratios increased with depth. This observation could be attributed to different parent materials in the areas as well as land-use system and climatic conditions. Also for chemical properties, the state is dominated by exchangeable Ca, Mg, K, Na as well as total exchangeable acidity. It also had higher values of ECEC, ACEC, base saturation and available phosphorus.

Furthermore, it was observed that Abia state soils contain good plant nutrient elements that will support crop production. However, the chemical properties of soils in the state are still low according to FAO (2006); Esu (1991) soil fertility rating. Hence, there is therefore need to boost more the productivity of soils in the State for maximum crop production.

Recommendations

1. Proper soil management strategies will be necessary for the farmers in the state to adopt in order to boost soils qualities for optimum food production.
2. Abia state government needs to give incentives like organic fertilizers to the farmers which will support growth and development of food crops for yield maximization.
3. Climate is another physical factor affecting soils quality; therefore, farmers need education and awareness on the climate risks, which reduces soil quality and in turn affects their crops.

REFERENCES

Agbola, T & Ojeleye, D (2007). Climate Change and Food Crop Production in Ibadan Nigeria. *African Crop Science: Conference Proceeding* **8:** 1423–1433.

Akamigbo, F.O.R. (1984). The Accuracy of Field Texture in a Humid Tropical Environment. *Soil Survey and Land Evaluation,* 493, 63-70

Ani, A. O, (2002) Factors inhibiting Agricultural Projection Among Rural Women Farmers in Southern Ebonyi State, Nigeria Ph.D. Thesis, University of Maiduguri, Nigeria.

Apata, T. G, Samuel, K. D & Adeola, A.O (2009). Analysis of Climate Change Perception and Adaptation Among Arable Food Crop Farmers in South Western Nigeria. Contributed Paper prepared for presentation at the International Association of Agricultural Economists' 2009 Conference, Beijing, China, 16–22 August.

Bremner, J. M (1996). Nitrogen Total. *In:* Sparus, D. L (ed) Methods of Soil Analysis part 3. Chemical Methods 5. Soil Sci. Soc. Am. Book series.

Esu, I .E (2005). Characterization, Classification and Management Problems of Major Soil Orders in Nigeria: 26th Inaugural Lecture of the University of Calabar, Nigeria, Pp 66.

Esu, I. E (1991). Detailed Soil Survey of NIHORT Farm at Bunkure, Kano State, Nigeria. Institute for Agricultural Research, Ahmadu Bello University, Zaria.

FAO (Food and Agricultural Organization) (2006) Guidelines for Soil Description (4th ed.) Rome: Food and Agriculture Organization of the United Nations.

Foth, H. D (1984). Fundamentals of Soil Science (7th edition) New York: John Wiley and Sons

Gee, G.W. & Or, D. (2002). Particle Size Analysis In: J. H. Dane, & D. C. Topp, (eds). Methods of Soil Analysis, Part 4. Physical methods, Soil sci. Soc. Am. Book series No.5 ASA and SSSA, Madison, W.I. Pp. 255-293.

Grossman, R. P & Reinschi, T. G. (2002). Bulk Density and Linear Extensibility. In: J. H. Dane & D. C. Topp (eds). Methods of Soil Analysis, Part 4. Physical methods, Soil Sci. Soc. Am. Book series No.5 ASA and SSSA Madison, W. I.

Hendershot, W.H., Laland, H. & Duquette, M (1993). Soil Reaction and Exchangeable acidity. In: M. R. Carter, (ed). Soil Sampling and Methods of Soil Analysis. Canadian Soc. Soil Sci, London: Lewis Publishers.

International Panel on Climate Change (2007a). In Contribution of working groups I, II and III to the fourth assessment report of the intergovernmental panel on climate change, writing Team C, Pa-chauri RK, Reisinger A (eds). IPCC: Geneva; 104.

Lia, R. (1979). Physical Characteristic of Soil in the tropics: Determination and Management in R. Lar & D. Greenland, (eds) Willey and Sons. Uk

National Population Commission (NPC) (2006) Provisional population census report. Abuja: National Bureau of Statistics.

Njoku, J. D. (2006). Analysis of the effect of global warming on forests of Southeastern Nigeria using remotely – sensed data. Unpublished, Ph.D Dissertation, Department of Geography and Environmental Management, Imo State University Owerri.

Obi, M. E. (1990): A compendium of lectures. Department of Soil Science, University of Nigeria, Nsukka.

Okorie, F. C., Njoku, J. D., Onweremadu, E. U & Iwuji, M. C. (2019): Analysis of Physico Chemical properties of Soil in Relation to Arable Crop production in Abia State, Nigeria, *International Journal of Innovative Research & Development, Volume 8 Issue 9, September, 2019.* Pp 179-193.

Olson, R. S & Sommers, L. E (1982). Phosphorous. In A.L Page, R. H. Miller & D. R. Keeney D.R.(eds). Methods of solil analysis. Am. Soc. Agron., Madison, W.I.

Onweremadu, E.U and Anikwe, M. A. N. (2007) Soil wettability characteristics of a forested catena in relation to organic matter fractions. *International journal of soil Science* 2(3): 211-217.

Soil Survey Staff (2003). Keys to Soil Taxonomy (9th ed.). Washington, DC: Natural Resources Conservation Service, United States Department of Agriculture (USDA).

Soil Survey Staff (2010): Keys to Soil Taxonomy. (11th Edition) USDA - NRCS. Washington, DC.

Uchegbu, S. N. (2006). Urban transportation system and management in Nigeria. A Proceeding of an International Workshop on Urban Planning Organized by King Fahd University, February 20-22, Saudi Arabia: King Fahd University.

Wilding, L. P., Bouma, J. & Boss, D. W. (1994) Impact of Spatial Variability on Interpretative Modeling, In: R. B. Bryant & R. W. Arnold: (eds). Quantitative Modeling of Soil Forming Process, SSSA Special Publication, vol. 39, pp. 61-75