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STATUS OF SOME SOIL CHEMICAL PROPERTIES AT BENIN RAINFOREST ZONE, OVIA NORTH EAST LOCAL GOVERNMENT AREA, EDO STATE, NIGERIA

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ABSTRACT

The principal impact of deforestation on chemical and nutritional properties is related to a decrease in organic matter content of the soil and to disruption in nutrient cycling mechanisms owing to removal of deep-rooted trees. This study was carried out to evaluate some soil physical properties at Iguzama community land in Ovia North East local government area of Edo State, Nigeria. Core and routine samples were collected from existing Profiles in 115.5 hectares land that has been mapped which are representatives of the various soil types present in the study area. Standard procedures were used in determining some soil chemical properties. Results showed that Profile 1, covering 19.35 hectares was classified as Loamy Kaolinitic Isohyperthermic Rhodic Kandiudults, Profile 2, covering 18.35 hectares was Sandy Kaolinitic Isohyperthermic Arenic Rhodic Kandiudults, Profile 3, covering 27.5 hectares was Loamy Kaolinitic Isohyperthermic Rhodic Kandiudults while Profile 4, covering 50.34 hectares was Loamy Kaolinitic Isohyperthermic Typic Rhbodudult. Across the four Profiles, Profile 2 (18.35 ha) had the highest mean values for pH, available phosphorus, percentage base saturation, exchangeable calcium,megnesium and sodium while profile 1 (19.35 ha) had the lowest mean values for pH, effective cation exchange capacity (ECCE), percentage base saturation, exchangeable calcium, magnesium and sodium. Conclusively, the fertility status were moderately okay based on the soil characteristics observed and profile 2 had the best soil chemical properties and is suitable for community crops like maize, cassava, okro, vegetables, pepper, tomatoe, yam and oil palm production.

KEYWORDS: *Rhodic, Isohyperthermic, Typic, Arenic, Profile*

INTRODUCTION

Soil chemical properties has a strong influence on the behavior of soil for Agriculture. Rapid population growth in the humid rainforest Zone of Nigeria has led to increasing pressure in land through intensive crop cultivation, resulting in soil degradation (Opara and Onweremadu, 2007), nutrient imbalance (Oti, 2002) and unavailability of plants nutrients (Onweremadu, 2007). These conditions are heightened by bush fires, deforestation, in appropriate tillage techniques and other conflictive land use practices (Lai and Okigbo, 1990). Some of these activities promote leaching of basic cations (Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}) and leaving a preponderance of acidic cations (H^{+} and Al^{3+}) and consequent fixation of available phosphorus (Barzegar and Aoodar, 2003).

Land use induced changes in nutrient availability, which influences biomass production and reduce soil organic carbon, which directly affect soil chemical and biological properties such as soil water retention and availability, nutrient cycling, gas flux, plant root growth and soil conservation (Gregorich *et al.,* 1994).

The conversion of native forests and pasture lands to cultivation is usually accompanied by a decline in soil organic carbon, which changes the distribution and stability of soil aggregates and thereby making the soils more susceptible to erosion. However, when crop land is reconverted to forest land, the amount of carbon sequestered in the soil will be increased, thereby making the soil more fertile (Brady and Weil, 2002).

Looking at the stress on the soil as a natural resource of crop production, emphasis is needed for maintaining soil fertility by adding organic materials such as introduction of legumes in crop rotation, poultry manures etc. These would increase the fertility of the soil and increase in plant growth (Foth, 1990).

MATERIALS AND METHODS

Study Area

This study was carried out at Iguzama Community in Ovia North East Local Government area of Edo State, Nigeria, and covered a total land area of 115.5 hectares of land. The site is located within latitudes 6.42263 and 6.43012 ^{o} N and longitudes 5.47731 and 5.48943^{o} E. The soil is formed from Coastal Plain sand, a derivative of sedimentary rock that has undergone intense weathering process arising from high rainfall and temperatures (NGSA, 2008).

The study area is young oil palm plantation with Cassava and a portion of old fallows land to examine the effect of such land use types on the Soil physical properties. The arable land is a continuous cultivated land with cassava (*Manihot utilissima*) as the dominant crop. This land is used yearly by farmers. Topographic position of the study area is a flat terrain with slight height differentia.

Soil Sampling and Field Work

The methodology involved collecting core and routine samples from existing profiles that were representatives of the various soil types present in the community site. Using a steel core sampler of 6 cm height and 5 cm of diameter, undisturbed soil samples were collected for the determination of some soil chemical properties. This was replicated thrice within layers/horizon depths in each profile pit using a randomized complete block design (RCBD).

Table 1. Profile locations and their coordinates

Profile	Latitude (N)	Longitude (E)	Elevation (m)	Area extent (ha)	Area coverage (%)
	06.42196° N	005.48272° E	91	19.35	16.75
2	06.42532 ° N	005.48017 ° E	96	18.35	15.88
3	06.4300 ° N	005.47970 ° E	99	27.5	23.8
4	06.42791 ° N	005.48844 ° E	102	50.34	43.57

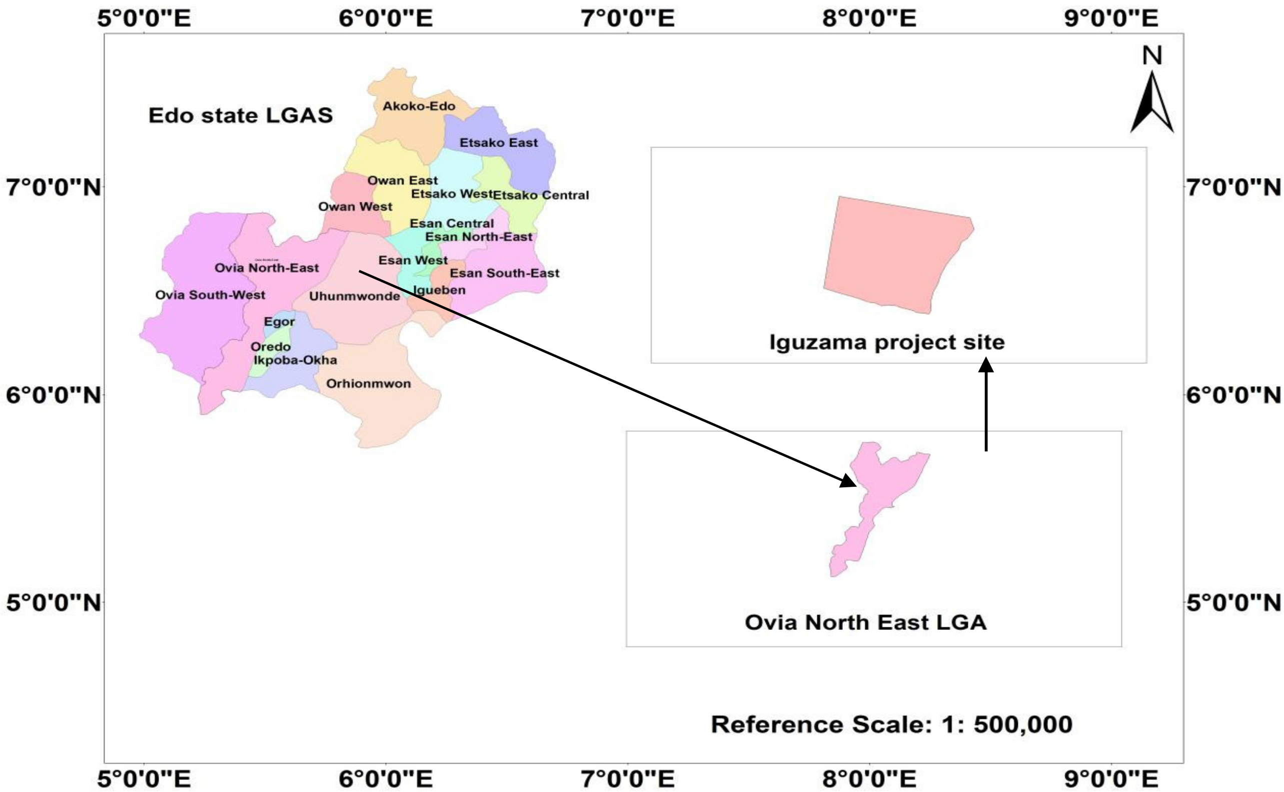


Fig. 1: Iguzama – Site location map

Laboratory Analysis

The soil samples were analyzed at the Soil Science and Land Management Laboratory, Faculty of Agriculture, University of Benin. Soils samples collected from each horizon from the profile pits, were air-dried and passed through a 2 mm sieve. The sieved samples were analyzed for some physical and chemical properties.

Soil Chemical Properties

Available phosphorus was determined by Bray-1 method (Murphy and Riley, 1962). The pH was determined with glass electrode pH meter in soil: Soil and water at ratio 1:1 (Maclean, 1982). Exchangeable bases (Na, K, Ca and Mg) were extracted with neutral 1N ammonium acetate (1 NH4OAC at pH 7.0) (Bache, 1974). Na and K were determined by flame photometer (Bache, 1974). Ca and Mg were determined by atomic absorption Spectro photometer (Thomas, 1982). Total N was determined by macro kjedhal method (Bremner and Mulvaney, 1982). Exchangeable acidity was determined by titration method (Anderson and Ingram, 1993). Organic carbon was determined by Walkley black method (Page *et al.,* 1982). Effective cation exchange capacity (ECEC) was obtained by the summation of exchangeable bases and exchangeable acidity (Tan, 1996). Base saturation was calculated by dividing the sum of exchangeable bases (Na, K, Ca and Mg) by the ECEC and multiplying the quotient by 100 (Bache, 1974). ECEC (Clay) was obtained by dividing ECEC soil by percentage clay and multiplying the quotient by 100 (Bache, 1974).

Particle Size Distribution

Particle size distribution were determined by hydrometer method (Bouyoucos, 1962) after the removal of organic matter content with hydrogen peroxide and dispersion with sodium hexametaphosphate (International Institute for Tropical Agriculture IITA, 1979).

Data Analysis

Data obtained were graphically presented with bar charts.

RESULTS AND DISCUSSION

Tables 2-5 as well as Fig. 1-9 showed the tabular and graphical presentation of the status of chemical properties in the study area. In assessing the status of some soil chemical properties of 115.5 hecatares at Iguzama community in Edo State, continuous cultivation of crops, high rainfall and temperature were major problems affecting crop productivity. High rainfall on the other hand, causes leaching of nutients that move down the soil profiles and not made available to plants. This situation leads to stressed in plants as a result of nutrient uptake which results in reduced crop yields (Lal and Shukla, 2004).

Profile 2 had the highest mean value (5.1) for pH across the four profiles followed by profile 3 (4.8), profile 4 (4.7) and profile 1 (4.2) respectively. This is an indication that these soils were very strongly to strongly acid and likely to be high in exchangeable hydrogen and aluminum ions and deficient in some basic cations especially calcium and megnesium (Chude *et al.,* 2004). These conditions occur due to excessive leaching of exchangeable bases and their replacement with exchangeable acidity especially under the high rainfall condition of the study area.

Profile 3 had the highest mean value (10.38 g/kg) for organic carbon across the four profiles followed by profile 2 (9.43 g/kg), profile 1 (7.83 g/kg) and profile 4 (7.78 g/kg) respectively. Organic carbon content were generally high on the surface soils derived from dead leaves, plants and animal decays. The content of organic carbon is these soils were considered moderate when matched with the critical levels of organic carbon (very low when it is less than 0.4 g/kg, medium when it is 4-10 g/kg and high when it is greater than 10 g/kg as established for organic carbon in tropical soils. This is in conformity with the findings of (Aban and Orji, 2019) on morphological and physico-chemical properties of soils formed from diverse parent materials in Cross River State Nigeria, when the range of values of organic carbon varied widely among the sites. Coastal plain sands ranges from 4.1 to 11.2 g/kg and Sandstone ranges from 4.1 to 10.7 g/kg.

Profile 1 had the highest mean value (2.67 g/kg) for total Nitrogen across the four profiles followed by profile 4 (1.03 g/kg), profile 2 (0.99

g/kg) and profile 3 (0.93 g/kg) respectively. These soils were considered as having low total Nitrogen content. According to Esu (1991) considered 0.3% Nitrogen as certical for New Zealand soils. However going by Enwezor *et al.,* (1990) criterion for soil fertility classification with respect to total Nitrogen, the soil of Cross River State fall between low and medium class having mean total Nitrogen generally less than 0.2 % (2 g/kg) on the surface soils.

Profile 2 had the highest mean value (57.50 mg/kg) for available phosphorus across the four profiles followed by profile 1 (49.69 mg/kg), profile 3 (41.56 mg/kg) and profile 4 (25.63 mg/kg) respectively. According to Esu (1991) available phosphorus is low, when it is <10.0 mg/kg, medium when it is between 10.0 - 20.0 mg/kg and high when it is >20. Generally across the profiles, available phosphorus was high.

Profile 1 and 4 had the highest mean values (1.6 cmol/kg) for exchangeable acidity across the four profiles followed by profile 3 (1.4 cmol/kg), profile 2 (0.6 cmol/kg) respectively. Accroding to Chude *et al.,* (2004) reported that basic cations are deficient or low when the exchangeable hydrogen and aluminium is high. Across the profiles, exchangeable acidity was high.

Profile 1 had the highest mean value (0.14 cmol/kg) for exchangeable potassium across the four profiles followed by profiles 3 and 4 (0.13 cmol/kg) and profile 2 (0.12 cmol/kg) respectively. According to Esu (1991) potassium is very low when it is <0.2 cmol/kg, low when it is between 0.2-0.3 cmol/kg, moderate when it is between 0.3-0.6 cmol/kg, high when it is between 0.6-1.2 cmol/kg and very high when it is between 1.2-2.0 cmol/kg. This indicate that potassium is very low in these soils. The exchangeable potassium status of the present soils could be considered low when been compared with the lower and upper critical values of 0.2-0.4 cmol/kg established by Enwezor *et al.* (1990).

Profile 2 had the highest mean value (1.88 cmol/kg) for exchangeable calcium across the four profiles followed by profile 3 (1.38 cmol/kg), profile 4 (0.95 cmol/kg) and profile 1 (0.50 cmol/kg) respectively. They were below the critical 5.0 cmol/kg (Taylor and Pohlen, 1970) for similar tropical soils of New Zealand. The values of Calcium were very low based on the established critical level of 5.0 cmol/kg (Landon,1991) below which most crops would respond to calcium application in whatever form it is applied.

Profile 2 had the highest mean value (0.15 cmol/kg) for exchangeable megnesium across the four profiles followed by profiles 3 and 4 (0.14 cmol/kg), profile 1 (0.11 cmol/kg) respectively. In tropical soils, critical ranges of megnesium values have been established as low when values are less than 1.5 cmol/kg, moderate when they are 1.5-3.0 cmol/kg and high when it is greater than 3.0 cmol/kg (Landon,1991) elsewhere higher values have been reported as critical for similar group of soils (Taylor and Pohlen,1970) all indicating clearly that these soils are very low in magnesium.

Profiles 2 and 3 had the highest mean values (0.05 cmol/kg) for exchangeable Sodium across the four profiles followed by profiles 1 and 4 (0.04 cmol/kg) respectively and were higher than the critical level of 0.02 cmol/kg sodium in soils as reported by

(Amalu,1998). The above values certainly would not constitute a problem for growth and development of most crops. According to Amalu (2016) most soils contain sufficient sodium for crop growth and responses to sodium fertilizers are confirmed to crops with definite sodium requirements such as Sugar beet and Marigolds.

Profile 3 had the highest mean value (3.11 cmol/kg) for Effective cation exchange capacity (ECEC) across the four profiles followed by profile 4 (2.86 cmol/kg), profile 2 (2.74 cmol/kg) and profile 1(2.38 cmol/kg) respectively. Effective cation exchange capacity was generally low across the profiles. In tropical soils, critical ranges of ECEC values have been established as low when values are less than 10.0 cmol/kg, medium when they are 10-20 cmol/kg and high when they are greater than 20 cmol/kg (Landon,1991). ECEC values were low below 15 cmol/kg reported by Esu (1991) as the critical level of ECEC in tropical soils.

Profile 2 had the highest mean value (81.22%) for percentage base saturation across the four profiles followed by profile 3(49.16%), profile 4(45.31%) and profile 1(32.92%) respectively. According to Edward (1992) percentage base saturation is very low when it is 0-20%, between 20-40 % is low, between 40-60% is moderate, 60-80% is high and very high when it is > 80%. Across the profiles, the percentage base saturation was moderate. The moderate percentage base saturation is an indication of the acidity problems that would be encountered in these soils. Only soils of profile 2, had values above 80%.

Conclusively**,** deforestation on chemical and nutritional properties is related to a decrease in organic matter content of the soil and to disruption in nutrient cycling mechanisms (Lal, 1986). Profile 2 (18.35 ha) had the highest mean values for pH, available phosphorus, percentage base saturation, exchangeable calcium, megnesium and sodium and was considered to have the best soil chemical properties. Profile 2, having the best chemical properties may be attributed to the high litter fall which has the possibility of increasing organic matter content, reducing surface run-off of the top soil, where most of the exchangeable basic cations are present and also due to little or no soil disturbance while profile 1 (19.35 ha) had the lowest mean values for pH, effective cation exchange capacity (ECEC), percentage base saturation, exchangeable calcium, megnesium and sodium and was considered to have the least soil chemical properties. Profile 1, having the least soil chemical properties may be attributed to frequent soil disturbance in form of tillage practices, fertilizer, herbicide, pesticide application and most especially under high rainfall and temperature regimes on a coastal plain sand parent material associated with this location, nutrients move down the profile, usually beyond the reach of most annual crops.

Furthermore, the following recommendations should be considered. Based on the findings in this area of study, Organic farming should be encouraged in Profile 2, in order to maintain and improve the soil fertility while in Profile 1, conservation tillage practices should be encourage in order to reduce surface run-off and leaching of exchangeable basic cations(Mg+2, Ca+2,Na+ and K+) from the top soils. Also in Profile 1, the cultivation of annual crops on a continuous basis is not advisable in this location and any other location with similar soil chaacteristics because nutrients move deep down the profile because of the effect of high rainfall. Therefore the continuous cultivation of tree crops yearly that have been properly evaluated for its suitability for such soils should be planted.

Plate 3 - Profile 1 showing horizons/layers horizons/layers

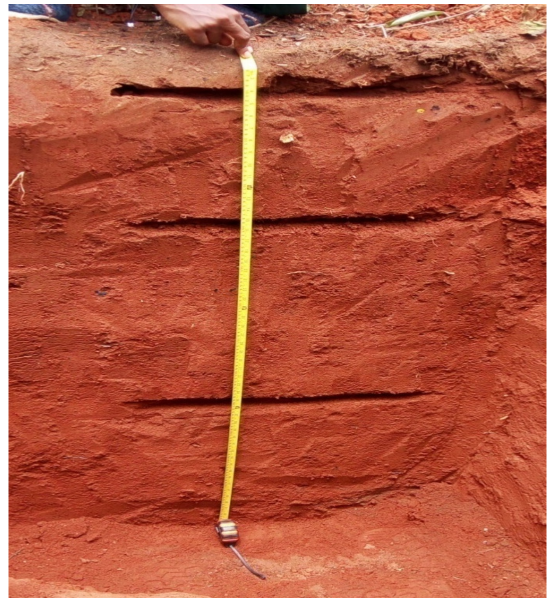


Plate 4 - Profile 2 showing

Plate 5 - Profile 3 showing horizons/layers horizons/layers

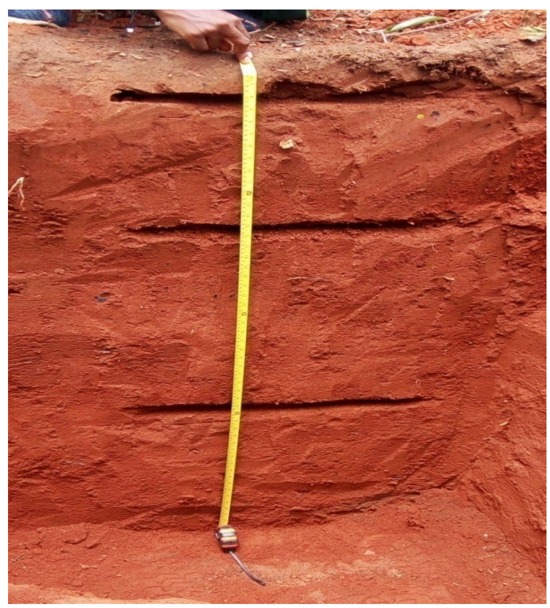
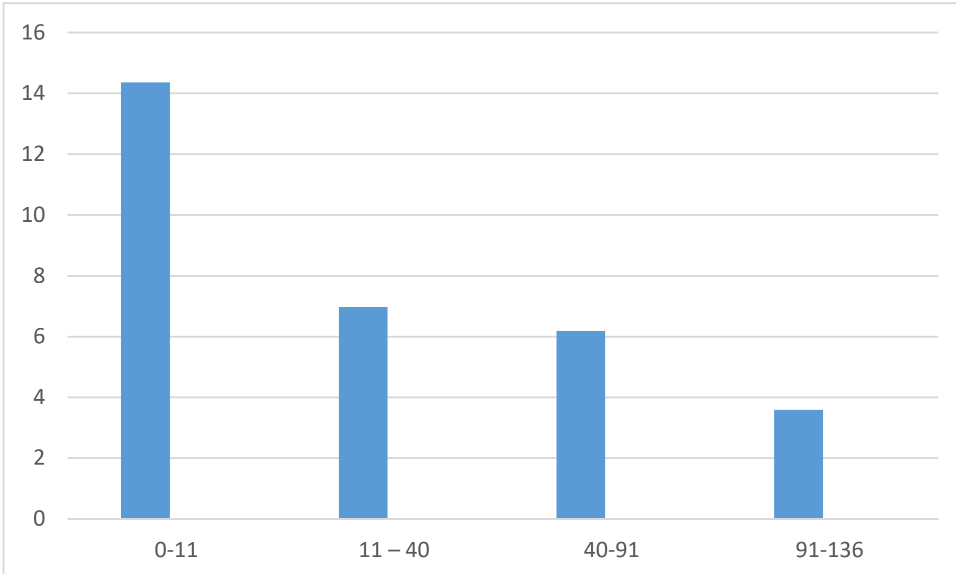


Plate 6 - Profile 4 showing

Table 2: Physical and Chemical Properties of Profile 1

Profile	Depth (cm)	pH(1:1) H_2O	Org. C gkg^{-1}	Tot. N gkg^{-1}	Avail. P $mgkg^{1}$	E.A	K	Ca	Mg	Na	ECEC	BS%	Clay	Sand	Silt	TC
						←		cmolkg^{-1}			→		←	gkg-	→	
1	0-13	4.2	13.17	1.90	122.5	1.2	0.16	0.99	0.17	0.07	2.59	53.65	64.8	895.2	40	S
	13-44	4.4	7.58	1.01	28.75	1.4	0.13	0.3	0.09	0.03	1.94	27.86	154.8	825.2	20	SL
	44-80	3.8	5.59	3.31	13.75	2.4	0.12	0.3	0.1	0.03	2.95	18.57	194.8	785.2	20	SL
	80-149	4.4	4.99	4.45	33.75	1.4	0.13	0.4	0.09	0.03	2.05	31.59	254.8	725.2	20	SCL
	Mean→	4.2	7.83	2.67	49.69	1.6	0.14	0.5	0.11	0.04	2.38	32.92	167.3	807.7	25	
	SE	0.141	1.863	0.76	24.64	0.271	0.009	0.166	0.019	0.01	0.237	7.433	398.7	356.8	05	
	CV	0.067	0.476	0.057	0.992	0.339	0.128	0.667	0.343	0.5	0.199	0.452	04.77	008.8	04	

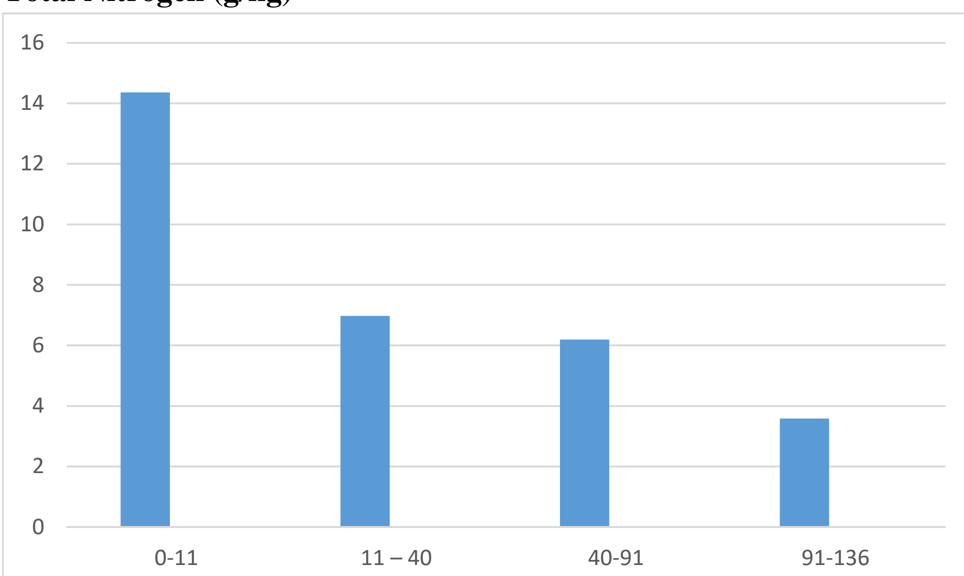
Organic carbon (g/kg)



Soil Depth (cm)

Fig.1: Graphs showing the vertical distribution of organic carbon at different depths

Total Nitrogen (g/kg)



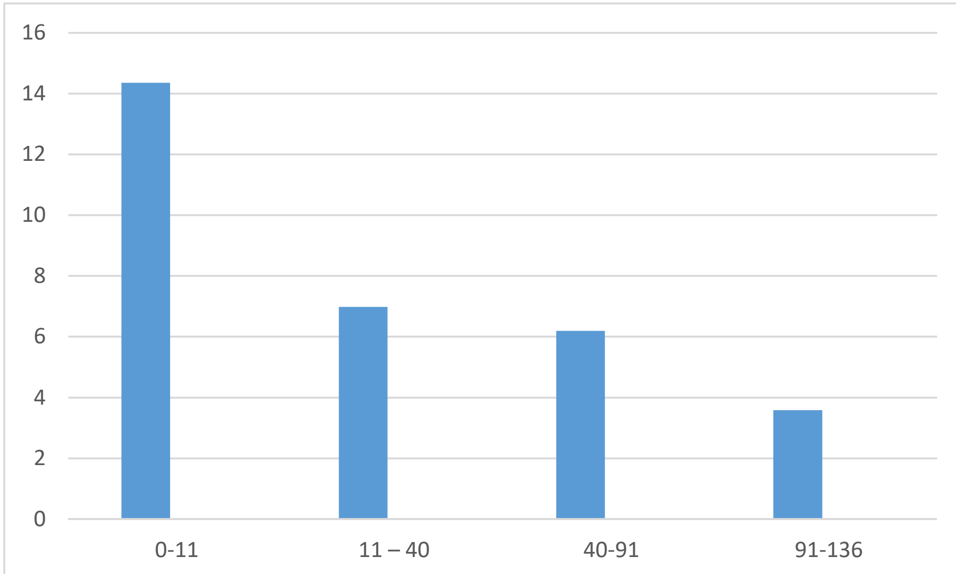
Soil Depth (cm)

Fig.2: Graphs showing the vertical distribution of Total Nitrogen at different depths

Table 3: Chemical and Physical properties of Profile 2

Profile	Depth (cm)	pH (1:1) H_2O	Org. C gkg^{-1}	Tot. N gkg^{-1}	Avail. P $mgkg^{1}$	E.A	K	Ca	Mg	Na	ECEC	B.S%	Clay	Sand	Silt	TC
						←		cmolkg⁻¹			→	←	gkg-		→	
2	0-12	5.3	21.15	1.37	82.5	1.2	0.16	3.37	0.13	0.08	4.93	75.68	44.8	915.2	40	S
	12 – 58	5.2	6.98	1.55	33.75	0.2	0.09	1.39	0.17	0.03	1.87	89.32	84.8	895.2	20	S
	58-125	4.9	5.59	0.89	21.25	0.4	0.14	1.78	0.17	0.04	2.53	84.22	234.8	755.2	10	SCL
	125-174	5.1	3.99	0.18	92.5	0.4	0.1	0.99	0.12	0.03	1.64	75.66	244.8	735.2	20	SCL
	Mean→	5.1	9.43	0.99	57.5	0.6	0.12	1.88	0.15	0.05	2.74	81.22	152.3	825.2	22.5	
	SE	0.085	3.955	0.31	17.626	0.222	0.017	0.521	0.013	0.012	0.753	3.369	512.1	46.55	06.29	
	CV	0.033	0.839	0.061	0.613	0.806	0.27	0.554	0.178	0.529	0.549	0.083	067.3	01.13	0559	

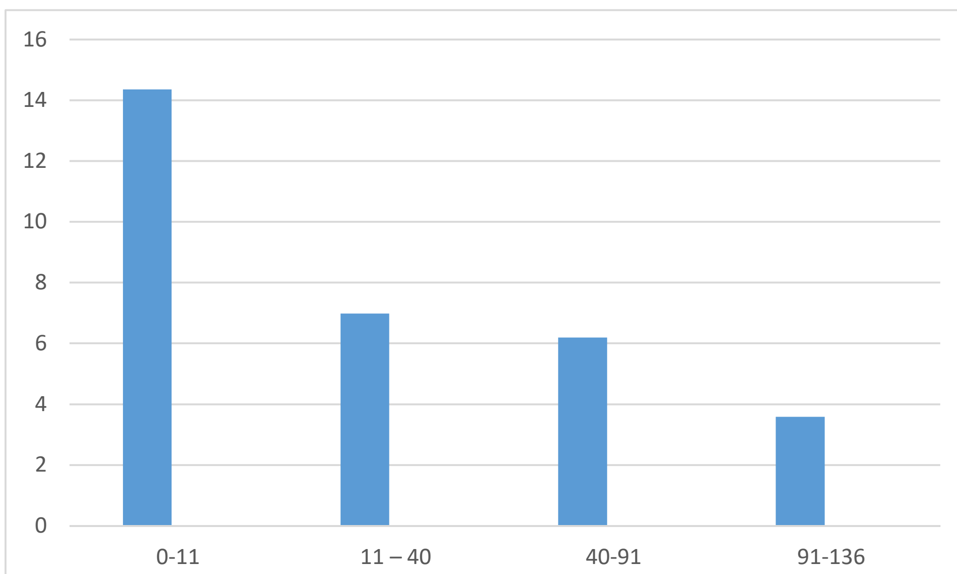
Organic Carbon (g/kg)



Soil Depths (cm)

Fig. 3: Graphs showing the vertical distribution of Organic Carbon at different depths

Total Nitrogen(g/kg)



Soil Depths (cm)

Fig. 4: Graphs showing the vertical distribution of Total Nitrogen at different depths

Table 4: Physical and Chemical Properties of Profile 3

Profile	Depth (cm)	pH (1:1) H_2O	Org. C gkg^{-1}	Tot. N gkg^{-1}	Avail. P $mgkg^{1}$	E.A	K	Ca	Mg	Na	ECEC	B.S%	Clay	Sand	Silt	TC
						←			$cmolkg^{-1}$		→		←	gkg-	→	
3	0-14	5.3	20.35	0.73	45	0.6	0.15	3.66	0.18	0.03	4.62	87.02	44.8	915.2	40	S
	14-41	4.5	11.77	0.89	28.75	1.8	0.13	0.58	0.15	0.08	2.75	34.46	164.8	815.2	20	SL
	41-90	4.7	5.39	0.95	71.25	2	0.11	0.59	0.14	0.03	2.88	30.65	224.8	755.2	20	SCL
	90-176	4.6	3.99	1.13	21.25	1.2	0.13	0.68	0.1	0.05	2.17	44.6	224.8	755.2	20	SCL
	Mean→	4.8	10.38	0.93	41.56	1.4	0.13	1.38	0.14	0.05	3.11	49.16	164.8	810.2	25	
	SE	0.18	3.731	0.08	11.068	0.316	0.008	0.761	0.017	0.012	0.528	12.951	42.43	37.75	05	
	CV	0.075	0.719	0.02	0.533	0.452	0.126	1.105	0.232	0.497	0.34	0.527	05.15	00.93	04	

Organic carbon (g/kg

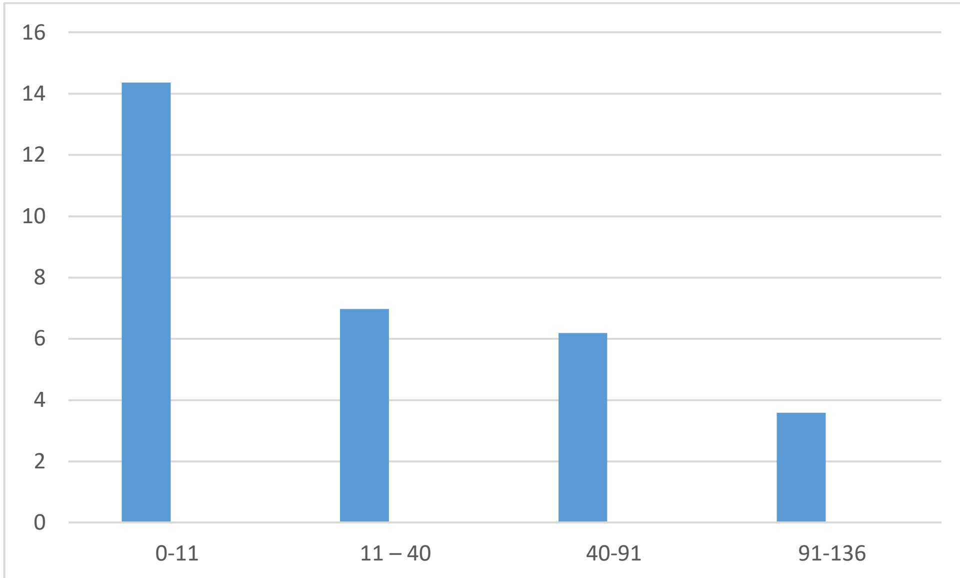
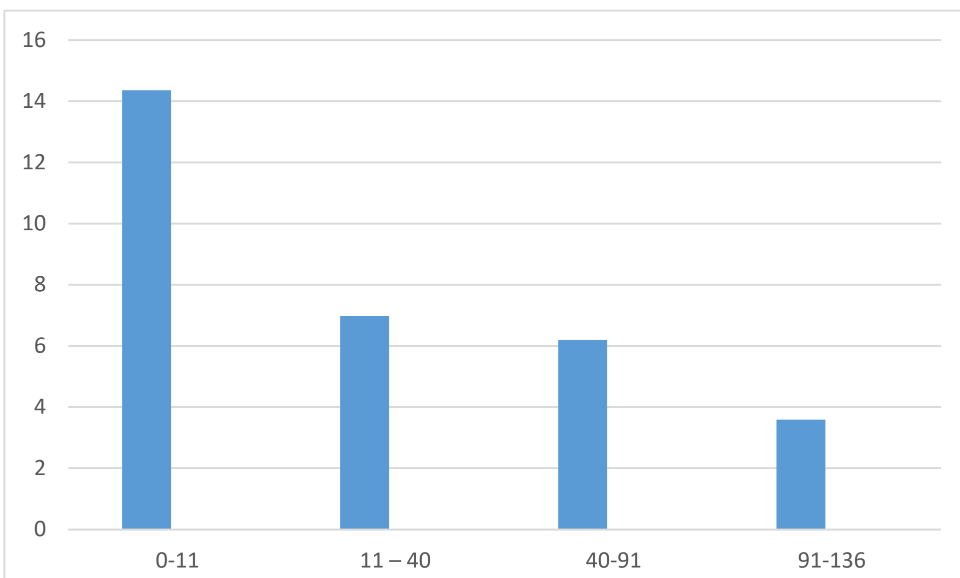


Fig. 5: Graphs showing the vertical distribution of Organic carbon at different depths

Total Nitrogen (g/kg)



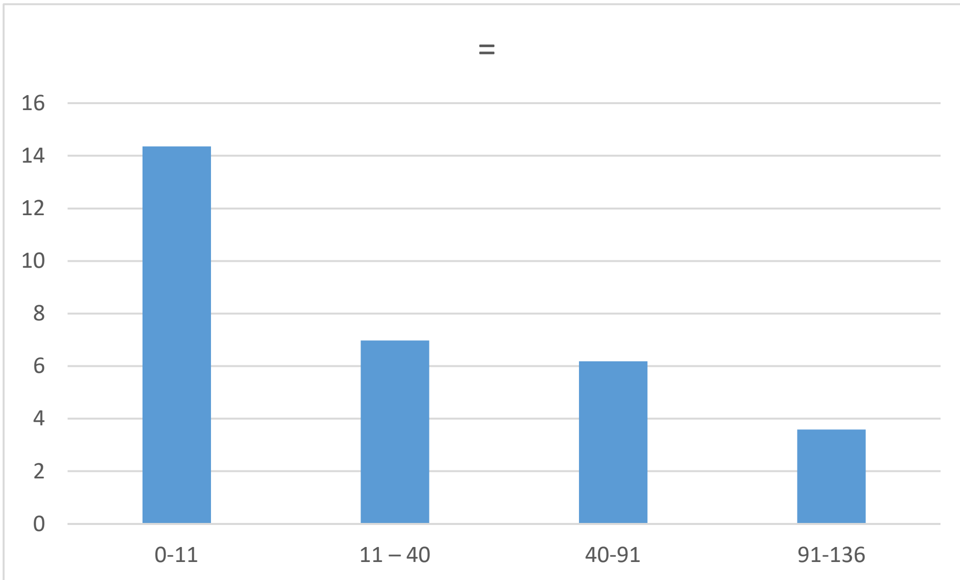
Soil depth (cm)

Fig. 6: Graphs showing the vertical distribution of Total Nitrogen at different depths

Table 5: Physical and Chemical Properties of Profile 4

Profile	Depth (cm)	pH (1:1) H_2O	Org. C gkg^{-1}	Tot. N gkg^{-1}	Avail. P $mgkg^{1}$	E.A	K	Ca	Mg	Na	ECEC	B.S%	Clay	Sand	Silt	TC
						←		cmolkg^{-1}			→	←	gkg-		→	
4	0-11	4.8	14.36	1.19	10	0.6	0.1	1.58	0.18	0.03	2.5	76	74.8	875.2	50	S
	11 – 40	4.5	6.98	1.19	58.75	2	0.14	0.75	0.14	0.04	3.08	34.99	184.8	795.2	20	SL
	40-91	4.7	6.19	0.72	12.5	1.8	0.13	0.74	0.12	0.04	2.84	36.66	254.8	725.2	20	SCL
	91-136	4.7	3.59	1 .01	21.25	2	0.15	0.71	0.12	0.03	3.01	33.6	264.8	705.2	30	SCL
	Mean→	4.7	7.78	1.03	25.63	1.6	0.13	0,95	0.14	0.04	2.86	45.31	194.8	775.2	30	
	SE	0.063	2.311	0.110	11.302	0.337	0.011	0.212	0.014	0.003	0.129	10.248	43.78	38.51	07.07	
	CV	0.027	0.594	0.022	0.882	0.421	0.166	0.448	0.202	0.165	0.091	0.452	04.49	00.99	04.71	

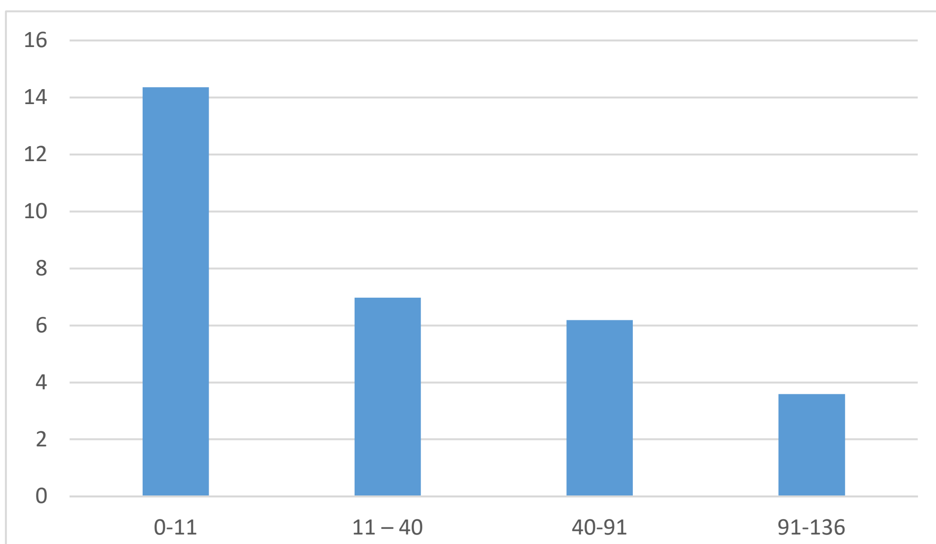
Organic carbon (g/kg)



Soil Depth (cm)

Fig. 7: Graphs showing the vertical distribution of Organic carbon at different depths

Total Nitrogen(g/kg)



Soil Depth (cm)

Fig 8: Graphs showing the vertical distributions of Total Nitrogen at different depths

CONCLUSION

Deforestation on chemical and nutritional properties is related to a decrease in organic matter content of the soil and to disruption in nutrient cycling mechanisms (Lal, 1986). Profile 2 (18.35 ha) had the highest mean values for pH, available phosphorus, percentage base saturation, exchangeable calcium, megnesium and sodium and was considered to have the best soil chemical properties. Profile 2, having the best chemical properties may be attributed to the high litter fall which has the possibility of increasing organic matter content, reducing surface run-off of the top soil, where most of the exchangeable basic cations are present and also due to little or no soil disturbance while profile 1 (19.35 ha) had the lowest mean values for pH, effective cation exchange capacity (ECEC), percentage base saturation, exchangeable calcium, megnesium and sodium and was considered to have the least soil chemical properties. Profile 1, having the least soil chemical properties may be attributed to frequent soil disturbance in form of tillage practices, fertilizer, herbicide, pesticide application and most especially under high rainfall and temperature regimes on a coastal plain sand parent material associated with this location, nutrients move down the profile, usually beyond the reach of most annual crops.

Furthermore, the following recommendations should be considered. Based on the findings in this area of study, Organic farming should be encouraged in Profile 2, in order to maintain and improve the soil fertility while in Profile 1, conservation tillage practices should be encourage in order to reduce surface run-off and leaching of exchangeable basic cations(Mg+2, Ca+2,Na+ and K+) from the top soils. Also in Profile 1, the cultivation of annual crops on a continuous basis is not advisable in this location and any other location with similar soil chaacteristics because nutrients move deep down the profile because of the effect of high rainfall. Therefore the continuous cultivation of tree crops yearly that have been properly evaluated for its suitability for such soils should be planted.

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