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COMPARATIVE EVALUATION OF SOME PHYSICAL AND CHEMICAL PROPERTIES OF ALFISOLS ALONG A TOPOSEQUENCE IN THE ARBORETUM OF FORESTRY RESEARCH INSTITUTE OF NIGERIA, IBADAN.

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ABSTRACT

The study was carried out at the arboretum and in the laboratory of the Soil and tree Nutrition Section of the Forestry Research Institute of Nigeria Ibadan (FRIN) to investigate the influence of topography on soil profile characteristics and the relationship between different topographic positions and soil fertility variation in the study area. Three profile pits measuring 1.5 m x 2 m x 2 m were dug along a toposequence and the pit were described using the Food and Agriculture Organization (FAO) 1998 procedure. Soil samples were also collected from each horizon of each pit for laboratory analysis. The results obtained indicted that there was a partial eluviation from the pedon of the crest of the toposequence while major eluviation of soil was noticed at the valley bottom of the toposequence with a characteristic soil structure ranging from weak granular to strong granular resulting into higher clay content (31 – 43 %) when compare to soils of the crest and the middle slope which ranges from (13 – 29 % and 11 – 21 %) respectively. The available phosphorus were generally very high across the toposequence (15 – 111. 6 mg/kg), suggesting that the soil reaction in the study area was favourable for phosphorus availability.

Fruit tree species where therefore recommended for production along the toposequence while the soil at the valley bottom were also recommended for rice production.

Keyword: Toposequence, Pedon, Profile pit, Horizon, Eluviation, Clay and Fertility

INTRODUCTION

Topography as a soil forming factor has dominant influence in determining differences among set of soil and their nutrient status. It is a principal factor in soil pedogenesis and variability of soil properties in response to topographic forms is used in predicting rates of ecosystem processes [1]. The set of soils formed as a result of topography as a primary soil forming factor are called toposequence. A toposequence is also referred to a sequence of soils of about same age, derived from similar parent material and occurring under similar climatic conditions, with different characteristics due to variations in relief and drainage [2]. [3], observed that the distribution of individual soil series on a toposequence itself has considerable influence on the soil properties and land use pattern. Soils along a toposequence differ as a result of erosion, transportation and deposition of chemical and particulate constituents in the soil [4]. [5], observed that the feature of soil usually accompanies the undulating characteristic landscape from one area (higher area) to another (lower level), which results to unequal distribution of these properties. One of the functions of soil survey as a soil management tool is to relate conservation practices to the soil characteristics and climate conditions. In the course of survey, attention is paid not only to the soils physical and chemical properties alone but also to other factors like climate, parent materials, organisms and topography which all play key roles in determining the soils physical and chemical characteristics. It is in the process of surveying the soil that different soil types will be identified and possibly mapped out and its properties studied with a view to maintaining or sustaining the fertility of a fertile soil and improving the productive capacity of a less fertile soil. The importance of this study is that information obtained will enrich our understanding of the soil characteristics and types in relation to topographic or geomorphic features in the arboretum of Forestry Research Institute of Nigeria (FRIN). Therefore, it is necessary to investigate the influence of topography on soil profile characteristics and the relationship between different topographic positions and soil fertility variation in the study area.

METHODOLOGY

The study was carried out at the arboretum and in the laboratory of the Soil and tree Nutrition section of the Forestry Research Institute of Nigeria Ibadan (FRIN). The study site is located on longitude 07^o23'18" N to 07^o23'43"N and latitude 03^o51'20"E to 03^o23'43"E. The climate of the area is West African monsoon with dry and wet seasons. The mean maximum temperature of the area at the period of the study was 31.11 ^oC, minimum 22.76 ^oC while the mean daily relative humidity was about 71.8% [6]. Three profile pits measuring 1.5 m x 2 m x 2 m were dug along a toposequence in the arboretum of Forestry Research Institute of Nigeria. Each profile pit locations were selected using sampling reconnaissance survey method where global positioning system (G.P.S) software was used to identify locations to represent the upper, middle and lower slopes across the toposequence. The profile pit description was done using the [7] procedure. .Soil samples were collected from each horizon of each pit for laboratory analysis. The soil samples were air dried and made to pass through a 2 mm diameter sieve and the soil particle size analysis was determined using the hydrometer method as described by [8]. The organic carbon of the soil was determined using the Walkley Black wet oxidation method [9], Total nitrogen was determined using micro-Kjeldahl method [9]. Available P was determined using Bray-1 method [10]. Samples were extracted with 1 *N* NH4OAc while Na and K were determined in the extract using flame photometer whereas Mg and Ca were determined with Atomic Absorption Spectrophotometer (AAS 210-VGP) [11].

RESULTS AND DISCUSSION

The coordinates of the three profile pits dug along the toposequence is as presented in Table 1 with the pedon at the Crest of the toposequence recording an elevation (2631 m) above sea level while that of the middle slope had (2292 m) elevation above sea level compared to that of the valley bottom (1410 m) elevation above sea level (Table 1). This fits into the description of Hall, (1983) that toposequence refers to a sequence of soils of about same age, derived from similar parent material and occurring under similar climatic conditions and topography [12]. [5] Also observed that the feature of soil usually accompanies the undulating characteristic landscape from one area (higher area) to another (lower level).

Table 1: Locations of the Pedons using G.P.S. Software

Pedon	Elevation	Coordinates
A (CREST)	2631.00 m	Lat $7^{0}24^{1}33.9012$"N
		Long. $3^{0}\,50^{1}$ 57.1596"E
B (MIDDLE SLOPE)	2292.00 m	Lat $7^{0}22^{1}37.38504$"N
		Long. $3^{0}\,51^{1}29.$ 9412"E
C (VALLEY BOTTOM)	1410.00 m	Lat $7^{0}23^{1}28.27248$"N
		Long. $3^{0}\,51^{1}$ 38.98944"E

Horizon differentiation in soil profiles 1, 2 and 3 of horizon Ap and AB were quite pronounced. In each case, the Ap horizons were quite distinct from the AB horizons and was marked by clear boundaries due to melanization by organic matter in the Ap horizons with a dark brown soil colour at both the Crest and the valley bottom (10R4/2 and 10R3/2) but with a light brownish grey colour (2.5YR5/2) at the middle slope which could be attributed to alluviation along the slope but the sub soil of the same middle slope pedon has a dark brown soil colour (10R5/3) (Table 2). The structure of the soil of the crest ranges from strong granular to blocky from Ap to Bt2 which also made the soil consistency to be friable at Ap but firm down the depth of the profile to BC (Table 2). Also, the soil structure of the middle slope ranges from strong granular to angular blocky from the Ap to Bt2 giving the soil a friable to loose consistency at Ap and AB which is an attribute of a partial eluviation from the pedon of the crest of the toposequence (Table 2). Similarly, a major eluviation of soil was noticed at the valley bottom of the toposequence with a characteristic soil structure ranging from weak granular to strong granular from the Ap soil to the BC soil (Table 2). This is also responsible for the loose soil consistency of the pedon located at the valley bottom of the toposequence showing a high eluviation of clay depicted by a soil textural class ranging from sandy clay to sandy clay loam (Table 2) with

Table 2: Morphological properties of the study area soil profile

Horizon	**Depth (cm)**	**Consistency**	**Texture**	**Structure**	**Colour**
		CREST			
Ap	0 -12	Friable	SL	Str.G	10R4/2
AB	12 -29.5	Firm	SL	Sub. ABLK	10R5/2
Bt1	29.5 – 85.5	Firm	SCL	ABLK	10R4/3
Bt2	85.5- 124.5	Firm	SCL	BLK	10R6/4
BC	124.5 – 166.5	Firm	SCL	BLK	10R5/4
		MIDDLE SLOPE			

AP	0 – 13	Friable	SCL	Str.G	2.5YR5/2
AB	13 – 19.5	Loose	LS	Sub. ABLK	10R5/3
Bt	19.5 - 56.5	Firm	SL	ABLK	2.5YR5/6
BC	56.5 - 125.5	Firm	SL	ABLK	10R6/3
			VALLEY BOTTOM		
AP	0 – 22	Friable	SC	WG	10R3/2
AB	22 – 52	Loose	LS	WG	10R3/3
Bt	52 – 77	Loose	SC	G	10R3/6
BC	77 – 153	Loose	SCL	SG	10R4/4

SCL = Sandy Clay Loam, SC = Sandy Clay, LS = Loamy Sand, ABLK = Angular Blocky, W = Weak, Str. = Strong, G = Granular

higher clay content (31 – 43 %) when compare to soils of the crest and the middle slope which ranges from (13 – 29 % and 11 – 21 %) respectively (Table 3). This also agrees with [13] that many wet soils have higher clay content. The silt/clay ratio is lower at the valley bottom (0.079 – 0.206 %) which indicates ferralitic pedogenesis [12] with higher water retention capacity compared to those of the middle slope (0.209 – 0.646 %) which is expected to make water retention weaker at the crest and the middle slope pedon (Table 3). The total nitrogen values of the top soil of the crest ranged from (0.05 – 0.09 %) considered to be very low [14] compared to those of the middle slope pedon (0.14 – 0.15 %) considered to be low [14].

Table 3: Particle size distribution of the Toposequence

Horizon	Depth (cm)	Sand %	Silt %	Clay %	Silt/Clay ratio %
		CREST			
AP	0 -12	80.6	6.4	13	0.492
AB	12 -29.5	78.6	6.4	15	0.427
Bt1	29.5 – 85.5	70.6	3.4	26	0.131
B2	85.5- 124.5	70.6	3.4	26	0.131
Bt2	124.5 – 166.5	60.6	4.4	29	0.152
		MIDDLE SLOPE			
AP	0 – 13	74.6	4.4	21	0.209
AB	13 – 19.5	82.6	6.4	11	0.582
Bt	19.5 - 56.5	78.6	8.4	13	0.646
BC	56.5 - 125.5	70.6	10.4	19	0.547
		VALLEY BOTTOM			
AP	0 – 22	53.6	3.4	43	0.079
AB	22 – 52	60.6	2.4	37	0.065
Bt	52 – 77	54.6	4.4	41	0.107
BC	77 – 153	62.6	6.4	31	0.206

The available phosphorus were generally very high across the toposequence (15 – 111. 6 mg/kg), suggesting that the soil reaction was favourable for phosphorus availability in the study area (Table 4). The organic carbon contents which reflects the organic matter content were generally low in the top and sub-surface soils of the three profile considered in the study area (Landon 1991). The cation exchange capacity (CEC) for all the profile where low (5.43 – 11.5 mg/kg) which suggest that the soil in the area may be the 1:1 clay lattice and are kaolinite in nature [15] (Table 4).

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Table 4: The chemical properties of the soil of the toposequence Pedon

Horizon	Depth (cm)	Org.C g/kg	Av.P (mg/kg)	T.N (g/kg)	Ca (mol/kg)	Mg (mol/kg)	K (mol/kg)	Na (mol/kg)	CEC (mg/kg)	Mn (mg/kg)	Fe (mg/kg)	Cu (mg/kg)	Zn (mg/kg)
						CREST							
AP	0 -12	0.55	109.5	0.05	0.8	3.7	0.073	1.13	5.70	168	200	2.2	20
AB	12 -29.5	1.08	104.5	0.09	2.5	7.7	0.053	1.25	11.50	124	80	2	16
Bt1	29.5– 5.5	1.13	93.6	0.1	1.0	4.2	0.047	1.17	6.42	20	300	1	32
Bt2	85.5 - 24.5	1.77	94.7	0.15	2.8	5.8	0.126	1.63	10.36	48	120	1.1	74
BC	124.5-166.5	1.97	77.7	0.17	2.1	4.5	0.053	0.93	7.58	20	560	1.5	32
						MIDDLE SLOPE							
AP	0 – 13	1.69	102.0	0.15	2.7	3.1	0.066	1.02	6.89	120	260	2.7	32
AB	13 – 19.5	1.65	111.6	0.14	1.8	2.5	0.027	1.10	5.43	42	80	2.7	22
Bt	19.5 - 56.5	2.57	104.9	0.22	1.4	3.6	0.146	1.06	6.21	110	140	3.4	68
BC	56.5 - 125.5	1.21	108.9	0.1	2.1	2.4	0.133	1.40	6.03	140	160	3.8	16
						VALLEY BOTTOM							
AP	0 – 22	1.37	65.7	0.12	2.1	4.7	0.033	0.99	7.82	326	180	1.8	16
AB	22 – 52	0.41	15.6	0.04	3.9	3.5	0.6	1.30	9.30	236	240	2.4	56
Bt	52 – 77	1.51	87.6	0.13	2.6	2.7	0.047	1.10	6.45	22	140	2.5	18
BC	77 – 153	1.33	78.8	0.11	1.8	2.6	0.073	1.21	5.68	40	240	2.4	40

CONCLUSION AND RECOMMENDATIONS

The result from this study revealed that topography affects the overall soil properties of the landscape. Morphological properties showed that the colour, texture, structure and consistency varied from one slope position to another. The CEC of the soils were low, likewise the organic carbon and Nitrogen content were also low but the concentrations of available phosphorus were generally high. The valley bottom soil had a high clay accumulation compared to soils of the crest and middle slope. Fruit tree species are therefore recommended for production along the toposequence because of the soils high reactivity with phosphorus while the soil at the valley bottom is recommended for agroforestry practice involving the cultivation of rice and tree species.

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