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Physico-chemical properties of three Fadama farm site soils in Ekiti state, Nigeria.

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ABSTRACT

Physico-chemical properties of three Fadama farm site soils located in Ado-Ekiti, Ikere-Ekiti and Ifaki - Ekiti, all in Ekiti State, Nigeria, were evaluated. The parameters evaluated for were pH, particle size distribution, free Fe_2O_3 and Al_2O_3, organic matter, base saturation percentage and total exchangeable bases in eleven zones and thirty-three soil samples. The pH values showed that the soils were saturated, clay was the smallest particle, soil was generally sandy loam. Both Fe_2O_3 and Al_2O_3 were low, organic matter was within the range for the first six inches (15.2cm) of surface tropical soils. For the total mean exchangeable bases, K and Mg were within the critical levels and Ca was below the critical level. The mean base saturation values showed that between 7/10 and 4/5 (66.8-88.6%) of the exchange capacity was satisfied by the bases.

Key words: Physico-chemical properties, Fadama farm soils, Ekiti State, Nigeria.

INTRODUCTION

Man is dependent on soils and to a certain extent good soils are dependent upon man and the use he makes of them. Soils are the natural bodies on which plants grow. Man enjoys and uses these plants because of their ability to supply fiber and food for himself and his animals. Man's standard of living is often determined by the quality of soils and the kinds and quality of plants and animals grown on them[1].

Soil definition can be approached edaphologically and pedologically. Certain aspects such as the origin of the soil, its classification, and its description, are involved in *pedology* (from the Greek word *pedon,* which means soil or earth). Pedology places minor emphasis on soil's immediate practical utilization. *Edaphology* (from the Greek word *edaphos,* which also means soil or ground) is the study of soil from the standpoint of higher plants. It considers the various properties of soils as they relate to plant production. The edaphologist is practical, having the production of food and fiber as an ultimate goal[1]. In this work, the dominant viewpoint will be that of the edaphologist.

Some works had recently been reported on the Fadama farm site soils in Ado-Ekiti, Ikere-Ekiti and Ifaki-Ekiti, all in Ekiti State of Nigeria. The first was the determination of trace metals in soils and plants in the zones[2] and the second was the determination of the distribution of major elements (Na, K, Ca, Mg) in the various anatomical parts of the Fadama crops[3]. The current work provides correlated information on the soil reaction as shown in pHH_2O, $pHCaCl_2$ and pHKCl; soil particles; the soil texture; free Fe_2O_3 and Al_2O_3, base saturation percent, organic matter and total exchangeable bases (meq/100g). All these were done in the three towns, eleven (11) zones with thirty-three (33) soil samples in the zones or a total of 498 parameters reported upon.

MATERIAL AND METHODS

Sampling

Soil samples were taken from three Fadama farms located in Ado-Ekiti (Central Division), Ikere-Ekiti (Southern Division) and Ifaki-Ekiti (Northern Division) of Ekiti State, Nigeria[2].

Soils were taken at the plough zone of 0-15 cm depth at 0-5, 5-10 and 10-15 cm depth. The radius of soil collection was about 8.0 cm. Collected soils were put in acid-leached polythene bags, properly labelled and transferred to the laboratory.

Sample treatment

The soil samples were transferred to the laboratory where they were spread on polythene sheets until dried. After air-drying and homogenising the soil samples were sieved using a 200 mm mesh size. The method of total elemental analysis of cations by hydrofluoric and perchloric acids digestion was employed to prepare the soil solutions for analyses[4]. A known weight (0.5g) of soil, plus 5 ml each of $HClO_4$ and HF were transferred into a platinum crucible and heated to dryness at 200-225°C. The residue was dissolved completely in HCl. At the end of the reactions, the contents were filtered into 100 ml flask and made up to mark with 0.1 M HCl.

Potassium, Ca, Mg and Na were analysed in the samples using a Perkin Elmer model 306 Atomic Absorption Spectrophotometer. Analyses were done in duplicate. The detection limits of all the elements were determined before the solutions were analysed[5]. Results here gave us the total cation present for each element.

Soil pH in water (1:1 soil/water ratio)

20 g soil was put into a 50 ml beaker, 20 ml of distilled water added and allowed to stand for 30 min. This was stirred occasionally with glass rod. Glass electrode on an EIL 7020 pH meter was used to measure the pH which was taken as soil pH measured in water[6].

Soil pH in 0.01 M $CaCl_2$

A 1:2 (soil: 0.01M $CaCl_2$) suspension by adding 10 g of soil to 20 ml of solution. The suspension stood for 30 min and stirred occasionally with glass rod. The pH result was taken as soil pH measured in 0.01M $CaCl_2$[6].

Soil pH in 1.0 M KCl (1:1 soil to solution ratio, 30 min)

pH reported as soil pH measured in 1.0 M KCl[6].

Particle size distribution

It was determined by the hydrometer method[7]. Sodium hexametaphosphate was used as the dispersing unit.

Organic matter

It was determined by the Walkley and Black method[8].

Determination of oxides of Fe and Al

Each was determined by treating the soils with citrate-dithionite bicarbonate solutions[9].

For the total exchangeable bases, the results were converted from ppm levels obtained in the wet digestion/AAS analysis using the formula:

$$\frac{0.1 \times 1 \text{ value in ppm}}{\text{equivalent mass of element}}$$

as described by Adepetu *et al*[9].

Labels used for the towns and zones were as depicted in Adeyeye[2]. All data generated were subjected to the determination of mean, standard deviation and co-efficient of variation percent[10].

RESULTS AND DISCUSSION

Table 1 shows the pH values for pHH_2O, $pHCaCl_2$ and pHKCl. In Ado-Ekiti, the A_1, B_1, C_1 and D_1 were consistently highest in all the different pH determinations. A_2 and A_3 had similar values of pH_2O, this trend was followed by B_2, B_3 and D_2, D_3. This trend also occurred under the pHKCl. All the pH values were all greater than 7.0. All coefficient of variation percent (CV%) were low with values of 0.9 – 5.0. In Ikere-Ekiti the pH H_2O was lower in C_1 (6.9) than the values in C_2 (7.6) and C_3 (7.4); this also happened in $D_1 < D_2 = D_3$. This trend was also observed in $pHCaCl_2$ for $A_1 < A_2 > A_3$; $D_1 < D_2 > D_3$. In pHKCl $A_1 < A_2 > A_3$; $B_1 > B_2 = B_3$; $C_1 < C_2 > C_3$ and $D_1 < D_2 > D_3$. This could be due to slight leaching from the top zone to the middle zone. Many pH values here were less than 7.0 and only in pHKCl D_1, D_2, D_3 did we record values of 8.0 – 8.3. As in Ado-Ekiti, the CV% values were low with a range of 0.6 – 4.9. The trend in Ifaki-Ekiti was generally similar to Ado-Ekiti, viz: A_1, B_1 and C_1 pH were best in their groups for pHH_2O, $pHCaCl_2$ and pHKCl. There was downward trend in pHH_2O with $A_1 = A_2 > A_3$; $B_1 > B_2 > B_3$, $C_1 > C_2 = C_3$. It is very clearly demonstrated in $pHCaCl_2$ with $A_1 > A_2 > A_3$; $B_1 > B_2 > B_3$ and $C_1 > C_2 > C_3$. The same trend was observed for pHKCl with the exception of group A where $A_1 > A_2 = A_3$. On the whole, the soil reaction here was more alkaline than both the Ado-Ekiti and Ikere-Ekiti soils because pH values generally range from 7.8 (pHH_2O)-8.4 (pHKCl) where C_1 recorded 8.9 (pHH_2O), C_2 recorded 9.1 ($pHCaCl_2$) and C_3 recorded 9.2 (pHKCl). The CV% were generally low (1.1- 10.0)

Table 1: pH values of the various Fadama farm site soils

Town	Zone	Depth (cm)[a]	Water (1:1) soil/ water	$CaCl_2$ (1:2) soil: 0.01M $CaCl_2$	KCl (1:1) Soil: 1.0M KCl
Ado-Ekiti		A_1	8.1	8.0	8.3
		A_2	7.6	7.7	7.9
	A	A_3	7.6	7.3	7.9
		Mean	7.8	7.7	8.0
		SD[b]	0.3	0.4	0.2
		CV%[c]	3.5	5.0	3.1
		B_1	7.7	7.6	8.0
		B_2	7.5	7.3	7.8
		B_3	7.5	7.5	7.9
	B	Mean	7.6	7.4	7.9
		SD	0.1	0.1	0.1
		CV%	1.8	1.9	1.3
		C_1	7.6	7.6	7.9
		C_2	7.4	7.2	7.8
		C_3	7.3	7.1	7.7
	C	Mean	7.4	7.2	7.8
		SD	0.2	0.1	0.1
		CV%	2.3	1.7	0.9
		D_1	7.8	7.5	8.1
		D_2	7.6	7.3	7.9
		D_3	7.6	7.5	7.8
	D	Mean	7.6	7.4	7.9
		SD	0.1	0.1	0.1
		CV%	1.3	1.9	1.8
Ikere-Ekiti		A_1	7.4	7.2	7.3
		A_2	7.4	7.4	7.7
		A_3	7.2	7.2	7.2
	A	Mean	7.3	7.3	7.4
		SD	0.1	0.1	0.3
		CV%	1.6	1.8	3.7
		B_1	7.3	7.3	7.2
		B_2	6.7	6.9	6.9
		B_3	7.0	6.9	6.9
	B	Mean	7.0	7.1	7.0
		SD	0.3	0.2	0.2
		CV%	4.0	3.4	2.3
		C_1	6.9	7.4	6.9
		C_2	7.6	7.5	7.9
		C_3	7.4	7.5	7.8
	C	Mean	7.3	7.5	7.5
		SD	0.4	0.1	0.5
		CV%	4.9	0.8	7.1
		D_1	7.8	7.8	8.0
		D_2	7.9	7.9	8.3
		D_3	7.9	7.8	8.2
	D	Mean	7.9	7.8	8.1
		SD	0.046	0.1	0.2
		CV%	0.6	0.9	2.0
Ifaki-Ekiti		A_1	7.9	8.1	8.3
		A_2	7.9	7.9	8.1
		A_3	7.6	7.8	8.1
	A	Mean	7.8	7.9	8.2
		SD	0.2	0.2	0.1
		CV%	2.3	2.0	1.1
		B_1	8.4	8.5	8.6
		B_2	8.0	7.9	8.3
		B_3	7.4	7.8	8.2
	B	Mean	7.9	8.0	8.3
		SD	0.5	0.4	0.2
		CV%	6.5	4.6	2.5
		C_1	8.9	9.1	9.2
		C_2	7.7	7.7	8.1
		C_3	7.7	7.6	8.0
	C	Mean	8.1	8.2	8.4
		SD	0.7	0.8	0.7
		CV%	8.5	10.0	7.9

[a](cm): 1 = 0-5; 2 = 5 – 10; 3 = 10-15.
[b]SD = standard deviation.
[c]CV% = coefficient of variation percent.

but higher than the values reported for the soils in Ado-Ekiti and Ikere-Ekiti. A general look at the results will show that pH levels in Ifaki-Ekiti > the levels in Ado-ekiti>the levels in Ikere-Ekiti. This could be a reflection of the rainfall pattern based on their location with Ikere-Ekiti (Southern Division) with better rainfall than Ado-Ekiti and Ifaki-Ekiti but highest pH values in Ifaki-Ekiti soils is probably because it is in the Northern Division which is already moving towards the semi savanna region.

The pH is a diagnostic figure of unique value-it's a tool in liming and similar problems- hence has become one of the routine tests made on soils. The pH value determinants are percentage base saturation, nature of colloidal micelle [colloidal materials and kind of adsorbed bases (or their ratio]. Fadamas in the Nigerian savanna are generally acid with pH values falling mostly below 6.0, that is moderately acid or more in reaction. The low pH values are sometimes associated with high exchangeable aluminium levels[11-14]. For example, means of various pH values of some Fadamas at Zaria were $pHCaCl_2$ of 4.5 – 5.4 in seven different sites; in another part of Northern Nigeria it was pHH_2O of 5.2 – 5.4 at depths of 0-91 cm and in Keffi it was pHH_2O of 5.6 – 5.8 and pHKCl of 4.6 – 4.9 at depths of 0-150 cm [12, 14]. All these values were far lower than our various pH values. Majority of our pH values were greater than 7.0. High pH values might occur when there is a comparatively high degree of base saturation. The presence of salts, especially Ca, Mg and Na carbonates, also gives a preponderance of hydroxyl ions over hydrogen ions in the soil solution. Under such conditions the soil is alkaline, sometimes very strong so, especially if Na_2CO_3 is present, a pH of 9 or 10 being common. Values of pH > 9.0 were reported for the soils in the Ifaki-Ekiti Fadama farm. Since both the $pHCaCl_2$ and pHKCl values were high in our samples it means the soil basicity would be high and the soil might likely be high in nitrogen.

Some elements, e.g. iron and manganese, are taken up less readily at high pH due to conversion of easily – absorbed ferrous (Fe^{2+}) and manganese (Mn^{2+}) ions to more highly oxidized, less available ferric (Fe^{3+}) and manganic (Mn^{3+}) ions. The failure of some 'calcifuge' plants, such as rhododendrons, to grow well in calcareous soils is attributable to an inability to absorb sufficient iron or manganese under these condition[15]. It was found in an earlier report[2] that the soils contained high level of iron and manganese but low or not detected in the crops grown in the soils. The problem can be overcome by supplying the elements in a chelated form, e.g. as in iron ethylene diamine – tetra – acetic acid (Fe – EDTA). Phosphate absorption is sensitive to pH because the univalent ion (H_2PO_4) which predominates in acid solution is more readily absorbed than either the bivalent or trivalent form [15].

Table 2 depicts the soil particle size distribution and the texture. In Ado-Ekiti, there was a downward reduction in the horizons (0-5, 5-10 and 10-15cm) in sand values. For example in zone A, it was 79.5% (depth 0-5cm) > 77.2 (depth 5-10cm) > 72.6% (depth 10-15cm), this is true in zone B but in zone C it was 86.7% (depth 0-5cm) < 87.8% (depth 5-10cm) and > 78.6% (depth 10-15cm), the trend in zone C was similar to the trend in zone D. The trend is very consistent in silt where for example it was 14.6% (0-5cm) < 18.8% (5-10cm) = 18% (10-15cm) in zone A whereas it was 14.6% (0-5cm) < 22.0% (5-10cm) < 26.8% (10-15cm) in zone B, in zone C, 10.9% (0-5cm) > 8.8% (5-10cm) and <12.5% (10-15cm) as it was also observed in zone D. For the clay values, it was highest in 10-15cm with a value of 9.4% (zone A), 9.6% in 5-10cm in zone B, 8.9% in 10-15cm in Zone C and 9.6% in 10-15cm in zone D. In all these three parameters (sand, silt and clay), sand was the least varied with CV% of 4.6 – 12.3 while clay was the most varied with CV% of 42.6 – 71.4. On texture distribution: it was 6 (50%) of loamy sand, 5(41.7%) of sandy loam and 1 (8.3%) of sand. In Ikere-Ekiti, the sand profile followed the trend as observed for the Ado-Ekiti Fadama soils. The distribution of the silt levels was very consistent and easily predictable, viz: in all the zones, the values of silt in depth 0-5cm < the silt in 5-10cm < the silt in 10-15cm; this was the opposite of the observation in Ado-Ekiti. The distribution of clay followed the trend in silt distribution in zones A and C whereas there was an irregular decrease down the profile in zones B and D as it was in the Ado-Ekiti Fadama soils. The CV% for the parameters were sand < silt < clay as in Ado-Ekiti soils. For the texture distribution it was loamy sand (3 or 25%), sandy loam (8 or 66.7%) and sand (1 or 8.3%).

Table 2: Particle size distribution of the Fadama farm soils

Town	Zone	Parameter (%)	Depth (cm) 0-5	5-10	10-15	Mean	SD	CV%
Ado-Ekiti	A	Sand	79.5	77.2	72.6	76.4	3.5	4.6
		Silt	14.6	18.8	18.0	17.1	3.2	13.0
		Clay	5.9	4.0	9.4	6.4	2.7	42.6
		Texture[a]	LS	LS	SL	-	-	-
	B	Sand	82.9	68.3	66.6	72.6	9.0	12.3
		Silt	14.6	22.0	26.8	21.2	6.1	29.0
		Clay	2.5	9.6	6.6	6.2	3.6	57.8
		Texture	LS	SL	SL	-	-	-
	C	Sand	86.7	87.8	78.6	84.4	5.0	5.9
		Silt	10.9	8.8	12.5	10.7	1.8	17.1
		Clay	2.4	3.4	8.9	4.9	3.5	71.4
		Texture	LS	S	SL	-	-	-
	D	Sand	80.6	84.3	66.3	77.1	9.5	12.3
		Silt	13.7	13.1	24.1	17.0	6.2	36.6
		Clay	5.7	2.6	9.6	6.0	3.5	58.8
		Texture	LS	LS	SL	-	-	-
Ikere-Ekiti	A	Sand	80.0	68.3	58.1	68.8	11.0	15.9
		Silt	14.4	25.1	30.5	23.3	8.2	35.1
		Clay	5.6	6.6	11.4	7.9	3.1	39.4
		Texture	LS	SL	SL	-	-	-
	B	Sand	89.6	72.4	65.8	75.9	12.3	16.2
		Silt	8.9	16.9	26.4	17.3	8.8	51.0
		Clay	1.7	10.7	7.8	6.7	4.6	68.4
		Texture	S	SL	SL	-	-	-
	C	Sand	80.1	73.8	63.2	72.4	8.5	11.8
		Silt	16.8	18.0	27.1	20.6	5.6	27.3
		Clay	3.1	8.2	9.7	7.0	3.5	49.6
		Texture	LS	SL	SL	-	-	-
	D	Sand	79.7	69.2	65.2	71.4	7.5	10.5
		Silt	16.3	17.3	27.9	20.5	6.4	31.3
		Clay	4.0	13.5	6.9	8.1	4.9	59.9
		Texture	LS	SL	SL	-	-	-
Ifaki-Ekiti	A	Sand	75.3	69.9	76.9	74.0	3.7	5.0
		Silt	20.1	21.2	19.6	20.3	0.8	3.9
		Clay	4.6	9.0	3.5	5.7	2.9	51.1
		Texture	LS	SL	LS	-	-	-
	B	Sand	73.9	68.0	69.4	70.4	3.1	4.4
		Silt	20.9	22.7	24.1	22.6	1.6	7.0
		Clay	5.2	9.3	6.5	7.0	2.1	30.1
		Texture	SL	SL	SL	-	-	-
	C	Sand	82.9	72.6	69.6	75.0	7.0	9.3
		Silt	12.5	22.1	23.1	19.2	5.9	30.4
		Clay	4.6	5.3	7.3	5.7	1.4	24.5
		Texture	LS	SL	SL	-	-	-

[a]LS = loamy sand; SL = sandy loam; S = sand.

In the Ifaki-Ekiti Fadama soils, sand distribution in zone C followed the trends in Ado-Ekiti and Ikere-Ekiti; in zone A the sand was 73.9% (0-5cm) > 68.0% (5-10cm) and < 69.4% (10-15cm) and also in zone B it was 73.9 (0-5cm) > 68.0 (5-10cm) < 69.4 (10-15cm). For the silt, its distribution increased from depths 0-5cm to 10-15cm in zones B and C. In zone A, the silt in depth 5-10cm had the highest level of 21.2%. The clay in zone C followed the trend of sand distribution whereas the highest clay values were recorded for depth 5-10cm in zones A and B. The values of CV% for sand, silt and clay followed the trend as in Ado-Ekiti and Ikere-Ekiti. For the soil texture in Ifaki-Ekiti farm, it was 3(33.3%) loamy sand and 6(66.7%) sandy loam.

The agricultural potentials of Fadama soils have been rated as medium to high, higher than those of adjacent upland soils[12]. Most of our textural values were in the group of sandy loam with a total percentage of 57.6. These results are in sharp contrast to the report of Esu[13] where variation in texture between a Levee and Backswamp profiles in Kaduna gave the following results: depth = 0-143 cm, sand = 12-13%, silt = 20-58% and clay = 30-68%, textural class = silty clay loam (20%), silty clay (60%) and clay (20%) in Backswamp; depth = 0-200 cm, sand = 40-57%, silt = 33-48% and clay = 8-18%, textural class = loam (5/6) and sandy loam (1/6) in Levee. The fertility of our soils would likely be less than these reference soils.

Table 3 depicts the chemical properties of the Fadama soils. The free Fe_2O_3 and Al_2O_3 values were all low in all the samples with low CV% of 1.9-39.8 (Fe_2O_3) and 7.4 – 20.6 (Al_2O_3). This low value was also observed for the organic matter whose values were only greater than 2% in Ifaki-Ekiti Fadama soils but less than 2% in zones in both Ado-Ekiti and Ikere-Ekiti Fadama soils; its CV% ranged from 1.0 – 32.3. The base saturation percent was high in all the samples. There was an increase down the horizons of base saturation in zone B in Ado-Ekiti with 78.0 (0 – 5 cm) < 81.2 (5 – 10 cm) and < 88.1 (10 – 15 cm); this was also observed in Ifaki-Ekiti zone C. In the other zones there was no consistency in the trend. The base saturation values were generally greater than 80% in zones A-D in Ado-Ekiti, generally greater than 90% in Ikere-Ekiti and generally greater than 60% in Ifaki-Ekiti. The implication here is that more than 4/5 of the Ado-Ekiti, > 9/10 of the Ikere-Ekiti and < 3/5 of the Ifaki-Ekiti soils exchange capacity would be satisfied by bases, the other by hydrogen and aluminium as the case may be in each of the soils.

Values of free iron oxides and those of aluminium oxides range from 0.17-1.29% and 0.06-0.46% respectively in six sandstone -derived soils of Nigeria[16]. These values were lower than our results. Values in the deeper horizons (under reference) are greater and ranged from 0.32- 9.27% for Fe_2O_3 and 0.10-1.96% for Al_2O_3. Our values were lower than the upper values reported for both Fe_2O_3 and Al_2O_3 although increases occurred irregularly down the profiles.

The relationship between H^+ and $Ca^{2+}$are expressed in percentage base saturation. The present BS tended to decrease from profile to profile in going from the zone of low to the zone of high rainfall. This is very clear in our results as shown in BS (Ifaki – Ekiti) < BS (at Ado-Ekiti) < BS (at Ikere-Ekiti). BS is at its maximum in the surface layer of each profile and at a minimum in one of the subsurface horizons. All these were in agreement with the observation of Ogunwale[16]. The recycling of Ca^{2+} by the vegetation adds that element to the surface layers continually and this accounts for higher values of % BS in the surface layers[16]. The relatively high organic matter (OM) contents of Fadamas, compared with adjacent upland soils, is the main basis for their generally superior fertility status [17]. The seasonally poor drainage conditions which prevail in Fadamas lead to reduced rates of soil OM decomposition and mineralization. Among Fadams, fertility status varies considerably from one place to the other, and even within the same Fadama[17]. This information is obvious in our samples. This is a direct consequence of the heterogeneous nature of the alluvial materials which constitute the soil parent materials. The dominant rock type in the parent materials therefore determines the fertility status of the Fadama at any given site[17]. Our OM levels are in close agreement with values reported for some Fadamas at Kaoje and Zaria in Northern Nigeria [17]. The OM content of the surface 6 inches of most tropical mineral soils falls in the range of 0.5-5% and decreases irregularly with depth in the soil[18]. The organic fraction is an

Table 3: Chemical properties of the Fadama soils

Town	Zone	Parameter (%)	Depth (cm) 0-5	5-10	10-15	Mean	SD	CV%
Ado-Ekiti	A	Fe_2O_3	2.5	3.1	2.5	2.7	0.4	13.0
		Al_2O_3	1.0	0.9	1.2	1.0	0.2	14.4
		OM[a]	1.2	1.3	1.3	1.3	0.03	2.4
		BS[b]	87.3	93.4	85.2	88.6	4.3	4.8
	B	Fe_2O_3	2.8	3.2	3.5	3.2	0.3	10.5
		Al_2O_3	1.2	1.4	1.4	1.3	0.1	7.4
		OM	1.0	1.0	0.9	1.0	0.02	2.1
		BS	78.0	81.2	88.1	83.1	4.4	5.3
	C	Fe_2O_3	3.8	2.9	1.6	2.7	1.1	39.8
		Al_2O_3	1.3	1.0	0.9	1.1	0.2	20.6
		OM	0.7	0.8	0.9	0.8	0.1	12.8
		BS	85.2	87.0	79.9	84.0	3.7	4.4
	D	Fe_2O_3	1.8	2.1	1.8	1.9	0.2	10.1
		Al_2O_3	1.2	1.3	1.4	1.3	0.1	7.6
		OM	0.8	1.6	1.2	1.2	0.4	32.2
		BS	87.2	85.2	88.1	86.9	1.5	1.7
Ikere-Ekiti	A	Fe_2O_3	3.2	2.8	3.1	3.0	0.2	7.9
		Al_2O_3	1.2	1.0	1.1	1.1	0.1	11.8
		OM	1.1	1.2	1.1	1.1	0.06	5.2
		BS	98.1	90.0	97.3	95.1	4.5	4.7
	B	Fe_2O_3	2.6	1.2	1.9	1.9	0.7	34.9
		Al_2O_3	0.9	1.0	1.2	1.0	0.1	12.9
		OM	1.0	1.0	0.9	1.0	0.1	6.3
		BS	94.3	94.3	97.4	95.3	1.8	1.9
	C	Fe_2O_3	2.4	2.5	2.9	2.6	0.3	9.7
		Al_2O_3	1.4	1.4	1.1	1.3	0.2	12.8
		OM	1.2	1.0	1.1	1.1	0.1	11.6
		BS	89.7	84.2	87.2	87.0	2.7	3.1
	D	Fe_2O_3	3.2	3.3	3.2	3.2	0.1	1.9
		Al_2O_3	1.3	1.0	1.0	1.1	0.2	15.1
		OM	1.0	1.0	1.0	1.0	0.01	1.0
		BS	97.3	98.7	89.2	95.1	5.1	5.4
Ifaki-Ekiti	A	Fe_2O_3	2.5	2.4	1.7	2.2	0.4	19.7
		Al_2O_3	1.3	1.0	1.2	1.2	0.2	15.5
		OM	2.1	2.0	2.0	2.0	0.1	3.0
		BS	68.7	64.3	67.6	66.8	2.3	3.5
	B	Fe_2O_3	1.8	1.8	2.4	2.0	0.4	19.2
		Al_2O_3	1.3	1.3	2.0	1.2	0.2	16.0
		OM	2.0	2.0	2.1	2.0	0.1	3.9
		BS	71.4	69.2	71.3	70.7	1.2	1.8
	C	Fe_2O_3	3.1	3.0	2.6	2.9	0.3	9.7
		Al_2O_3	0.9	1.3	1.2	1.2	0.2	19.0
		OM	2.5	2.2	1.9	2.2	0.3	13.7
		BS	68.2	68.8	71.2	69.4	1.6	2.3

[a]OM = organic matter. [b]BS = base saturation.

Table 4: Total exchangeable bases (meq/100g) of the Fadama soils[a]

Town	Zone	K	Ca	Mg	Na	Grand total
Ado-Ekiti	A_1	0.4 (9.6)	0.5(12.5)	2.3(59.6)	0.7(18.3)	3.0
	A_2	0.4 (9.1)	0.4(10.8)	2.3(57.7)	0.9(22.4)	4.0
	A_3	0.3 (8.2)	0.5(11.7)	2.2(57.3)	0.9(22.7)	3.9
A	Mean	0.4 (9.0)	0.5(11.7)	2.3(58.2)	0.8(21.1)	3.9
	SD	0.1 (0.7)	0.1(0.9)	0.1(1.2)	0.1 (2.5)	0.1
	CV%	15.7 (7.9)	12.4(7.3)	2.5(2.1)	13.9 (11.6)	1.5
	B_1	0.4 (8.5)	0.7(16.1)	2.1(50.8)	1.0(24.5)	4.2
	B_2	0.3 (7.8)	0.4(9.3)	2.5(62.0)	0.8(20.9)	4.0
	B_3	0.3 (8.3)	0.5(12.3)	2.2(57.5)	0.8(21.9)	3.8
B	Mean	0.3 (8.2)	0.5(12.6)	2.3(56.8)	0.9(22.4)	4.0
	SD	0.1 (0.4)	0.2(3.4)	0.2(5.6)	0.1(1.9)	0.2
	CV%	17.3 (4.4)	28.6(27.1)	9.2 (9.9)	13.3(8.3)	5.0
	C_1	0.3 (9.8)	0.4(11.6)	2.0(56.7)	0.8(21.9)	3.5
	C_2	0.3 (8.2)	0.5(12.5)	2.3(58.1)	0.8(21.2)	3.9
	C_3	0.4 (12.2)	0.4(12.5)	1.8(51.0)	0.8(24.3)	3.4
C	Mean	0.3 (10.1)	0.4(12.2)	2.0(55.3)	0.8(22.5)	3.6
	SD	0.1 (2.0)	0.1(0.5)	0.3(3.8)	0.05(1.6)	0.3
	CV%	17.3 (20.0)	13.3(4.3)	12.4(6.8)	7.5(7.2)	7.3
	D_1	0.5 (14.6)	0.4(12.3)	1.6(50.6)	0.7(22.5)	3.2
	D_2	0.4(14.5)	0.6(18.5)	1.4(46.3)	0.6(20.7)	3.0
	D_3	0.5 (13.0)	0.7(19.2)	1.8(50.4)	0.6(17.5)	3.6
D	Mean	0.5 (14.0)	0.6(16.7)	1.6(49.1)	0.6(20.2)	3.3
	SD	0.1 (0.9)	0.2(3.8)	0.2(2.4)	0.1(2.5)	0.3
	CV%	12.4 (6.4)	27.0(22.8)	12.5(4.9)	9.1(12.5)	9.4
Ikere -Ekiti	A_1	0.3 (13.9)	0.4(17.0)	0.8(35.3)	0.7(31.8)	2.2
	A_2	0.3 (14.3)	0.4(17.7)	0.7(34.1)	0.7(34.0)	2.1
	A_3	0.3 (11.4)	0.4(13.4)	1.2(44.4)	0.9(32.5)	2.6
A	Mean	0.3 (13.2)	0.4(16.0)	0.9(37.9)	0.8(32.7)	2.3
	SD	0.04 (1.6)	0.01(2.3)	0.3(5.6)	0.1(1.1)	0.3
	CV%	14.5 (11.9)	3.1(14.4)	29.4(14.8)	15.1 (3, 4)	11.5
	B_1	0.3 (13.8)	0.5(18.7)	0.9(35.6)	0.8(32.0)	2.4
	B_2	0.3 (13.3)	0.4 (15.8)	0.9(36.1)	0.8(34.8)	2.4
	B_3	0.3 (12.1)	0.4 (18.2)	0.9(38.1)	0.7(31.6)	2.3
B	Mean	0.3 (13.1)	0.4 (17.6)	0.9(36.6)	0.8(32.8)	2.4
	SD	0.03 (0.9)	0.1 (1.6)	0.01(1.3)	0.1 (1.7)	0.1
	CV%	8.7 (6.7)	13.3 (8.8)	1.7(3.6)	7.5(5.3)	2.4
	C_1	0.3 (12.6)	0.4(16.9)	1.0 (37.6)	0.9(32.9)	2.6
	C_2	0.3 (9.7)	0.4(13.5)	1.4 (50.0)	0.7(26.8)	2.7
	C_3	0.3 (9.3)	0.5(17.3)	1.4 (50.4)	0.6(22.9)	2.7
C	Mean	0.3 (10.5)	0.4 (15.9)	1.3(46.0)	0.7(27.5)	2.7
	SD	0.04 (1.8)	0.1 (2.1)	0.2 (7.3)	0.2(5.0)	0.1
	CV%	15.4 (17.1)	13.3 (13.1)	18.2 (15.8)	20.8(18.3)	2.2
	D_1	0.3 (10.9)	0.4 (15.3)	1.4(48.3)	0.7(25.4)	2.8
	D_2	0.4 (13.5)	0.5 (16.5)	1.4(46.5)	0.7(23.4)	2.9
	D_3	0.4 (12.4)	0.5 (17.1)	1.3(46.2)	0.7(24.3)	2.9
D	Mean	0.4 (12.3)	0.5 (16.3)	1.4(47.0)	0.7(24.4)	2.9
	SD	0.1 (1.3)	0.1 (0.9)	0.1(1.1)	0.02(1.0)	0.1
	CV%	15.7 (10.6)	12.4 (5.6)	4.2(2.4)	2.8(4.1)	2.0
Ifaki-Ekiti	A_1	0.4 (11.2)	0.3(9.6)	2.1(58.8)	0.7(20.4)	3.5
	A_2	0.4 (9.8)	0.3(8.3)	2.4(60.7)	0.9(21.9)	3.9
	A_3	0.4 (10.0)	0.3(6.8)	2.5(64.6)	0.7(18.6)	3.9

Table 4. Cont.

A	Mean	0.4 (10.3)	0.3(8.2)	2.3(61.4)	0.8(20.3)	3.8
	SD	0.003 (0.8)	0.04(1.4)	0.2(3.0)	0.1(1.7)	0.2
	CV%	0.8 (7.3)	12.8(17.0)	8.9(4.8)	15.1(8.1)	6.1
	B_1	0.5 (12.6)	0.3 (8.9)	2.1(55.0)	0.9(23.4)	3.8
	B_2	0.4 (10.8)	0.5 (13.3)	2.0(54.5)	0.8(21.4)	3.6
	B_3	0.5 (12.0)	0.6 (15.6)	2.1(53.5)	0.7(19.0)	3.9
B	Mean	0.5 (11.8)	0.5 (12.6)	2.1(54.3)	0.8(21.3)	3.8
	SD	0.1 (0.9)	0.2 (3.4)	0.1(0.8)	0.1(2.2)	0.2
	CV%	12.4 (7.8)	32.7(27.0)	2.8(1.4)	12.5(10.4)	4.1
	C_1	0.4 (9.7)	0.6(14.7)	2.3(57.7)	0.7(17.8)	3.9
	C_2	0.4 (9.5)	0.6(14.9)	2.3(54.9)	0.8(20.7)	4.1
	C_3	0.4 (10.1)	0.5(13.3)	2.3(56.7)	0.8(19.9)	4.0
C	Mean	0.4 (9.8)	0.6(14.3)	2.3(56.4)	0.8(19.5)	4.0
	SD	0.01 (0.3)	0.1(0.9)	0.14(1.4)	0.1(1.5)	0.1
	CV%	3.0 (3.1)	10.2(6.1)	6.0(2.5)	7.5(7.7)	2.5

[a]Values in parentheses are the percentage levels of each base.

extremely important one for the following reasons: it is the major source of cation exchange capacity (CEC) in tropical soils; it is a good source of essential nutrients, which are released during decomposition of the OM or are held by the OM in readily available form; it contributes to good soil structure; it has a high water holding capacity; it serves as a buffer against changes in pH[18]. All our OM values were within the bracket of 0.5-5%.

Table 4 shows the total exchangeable bases (meq/100g) of the Fadama soils. In Ado-Ekiti, K^+ value ranged between 0.3-0.5 with consistent downward reduction only in zones A and B. The CV% was close for K^+ since it ranged between 12.4 and 17.3. The Ca^{2+} values were correspondingly higher than the values in K^+; values ranged between 0.4-0.7 with higher CV% which ranged between 12.4-28.6. The Mg^{2+} values were comparatively very high when compared to the values of K^+ and Ca^{2+}; values ranged from 1.4 - 2.5 but with lower CV% of 2.5-12.5. The values for Na^+ were greater than the values of K^+ and Ca^{2+} but lower than the values of Mg^{2+}; values ranged from 0.6-1.0 with low CV% of 7.5-13.3. The percentage of each cation on overall values were calculated. In all it was Mg > Na > Ca > K. In Ikere-Ekiti farms, the general trends observed in Ado-Ekiti were also observed for all the bases. However, the percentage values of the K cation were generally higher than in Ado-Ekiti soils, percentage values of Ca were slightly lower, the percentage values of Mg were slightly lower while those of Na were slightly higher and on the whole the total values of the bases for each zone was lower than the corresponding Ado-Ekiti values. These major differences could be due to differences in rainfall and likely leaching in the Ikere-Ekiti soils. The observation in the Ifaki-Ekiti soils resembled the various trends observed in the Ado-Ekiti soils. The variations in the results were low because very low CV% were variously recorded. The critical levels for K is 0.18-0.24 meq/100g [19,20] whereas our own was 0.3-0.5 meq/100g, critical value for Ca is 2.0-2.6 [21,] our own was 0.3-0.6 meq/100g; critical value for Mg is 0.4 meq/100g whereas our value range was 0.6 – 0.9 meq/100g. From these results, no particular cation is in excess to be able to depress the availability of any other cation. While critical cation exchange capacity (CEC) value is > 4 meq/100g, our own results ranged between 2.3 – 4.0 meq/100g.

Of the fourteen essential elements obtained from the soil by plants, six are used in relatively large quantities and are thus referred to as macronutrients. They are N_2, P, K, Ca, Mg and S. Plant growth may be retarded because: these elements are actually lacking in the soil, because they become available too slowly, or because they are not adequately balanced by other elements. Sometimes all three limitations are operative[22]. N_2, P and K are called primary or fertilizer elements.

In some way, Ca, Mg and S are referred to as secondary elements. Ca and Mg are called lime elements. The total quantity of K, is usually plentiful except in sandy soils. The main problem is one of availability. Ca shows great variation but it is generally present in lesser amounts than in K; this assertion may not be correct in Fadama soils as seen in our Table 4. Mg is important as a nutrient, functions in soil much as Ca does. The quantity of simple inorganic salts such as KCl, NaCl and Na_2SO_4 in humid region soils is generally quite small. As one moves into more arid climates these salts are present in a somewhat higher concentration, especially in the lower horizons[22]. This is amply seen in Ifaki-Ekiti results in Table 4. Na is an element taken up by plants (as the Na^+ cation) and a number of crops are thought to benefit from sodium applications, sometimes even when the K supply is adequate, but nevertheless Na is not generally thought of as being an essential element.

From the data available it could be concluded that the Fadama farm soil samples showed that the soil reaction was saturated, soil texture was sandy loam, both the Fe_2O_3 and Al_2O_3 were low but the organic matter was within the tropical soil values. Exchange bases were within critical levels for K and Mg and no particular cation was in excess to be able to depress the availability of any other cation.

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