American-Eurasian J. Agric. & Environ. Sci., 2 (3): 312-317, 2007
ISSN 1818-6769

Properties, Classification and Suitability Evaluation of Some Selected Cocoa Soils of South-Western Nigeria

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Abstract: Some selected Cocoa soils of Ekiti State were characterized, classified and evaluated for Cocoa production. Soil samples from pedogenic horizons were analysed. The study revealed four major soil units located at four different sites (Aisegba, Ayedun, Ise and Ikoro). All the soils are well drained but concretional and gravelly in nature. Soil texture consists of sandyloam surface and clayloam/silt loam and clay in the subsurface. The soils are moderately acidic in reaction (6.16) and have low amounts of organic carbon (0.21-1.52%). The effective cation exchange capacities and percentage base saturations are low ranging from 0.70-1.51 meq/ 100 g of soil and 42.86-83.33%, respectively. The Aisegba and Ikoro soils classify as Tupic PIinthudult (Eutric Plinthosol-Ondo series) while Ayedun soils classify as Typic Udipsamment (Cambic Arenosol-Makun series and Ise soil was classified as Acrudoxic Plinthic Kandiudult (Eutric Plinthosol-Fagbo series). The major limitations of the soils are the gravelly Concretional nature of the soils, poor soil fertility and low rainfall distribution. On the basis of these limitations, all the soils have been classified as $S3_{cfs}$ (marginally suitable) for cocoa production.

Key words: Cocoa · Ekiti · classification · suitability

INTRODUCTION

One of the major factors limiting optimum cocoa production in Nigeria is the lack of detailed information on soil and land characteristics of cocoa growing areas. This is particularly true of soils formed on Granitic parent material in South-western Nigeria. When information is available on soil and land characteristics of selected cocoa growing areas, it would be very easy to manage the soils for optimum cocoa production. Information generated also would help to monitor soil and land use activities of these areas.

Information available revealed that soil survey was carried out within the cocoa belts of Nigeria between 1951 and 1962 [1]. The purpose of this survey was to describe and classify the soils of cocoa areas and to asses their agricultural potentialities, especially for cocoa cultivation. The survey revealed that about 62% of Nigeria cocoa is grown on good or fairly good soils and the remaining thirty eight per cent on poor or very poor soil. In furtherance to this, the work done by the Cocoa Research Institute of Nigeria (CRIN) also gave experimental evidence that the chemical and physical property of soil decline with cultivation [2, 3] and also those two major factors are responsible for the decline in cocoa yield. These two factors being poor site selection and lack of fertilizer use.

Most of the soil survey works done on cocoa growing areas in Nigeria were done at reconnaissance level. Most of the information generated from these surveys was not at detailed level. It is either they are also outdated or obsolete and are not relevant with reference to present large scale production of cocoa in Nigeria. Very few detailed soil survey and soil characterization studies culminated in the comprehensive classification of the soil are therefore not available.

The objectives of this study were:

- To make a detailed characterization of some selected cocoa soils of Ekiti State,
- To classify the soils using the criteria of the Soil taxonomy, FAO Revised Legend of the soil map of the world and into local series using Smyth and Montgomery and also
- To evaluate these soils for cocoa production.

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MATERIALS AND METHODS

Site description: Soil sampling sites were located on benchmark soils identified by Ekiti State Agricultural Development Project for Cocoa production. The selected sites are Ise (5° 26'E, 7° 28'N), Aisegba (5° 29'E, 7° 36'N), Ikoro (5° 03'E, 7°50'N) and Ayedun Ekiti (5° 35'E, 7°49'N), respectively [4]. Detail soil survey (Rigid grid) was carried out on each of the four sites after which the major soil of the area was picked that has the largest coverage area for cocoa production. Each site covered an area of 2 Hectares each. After the soil survey, the major soils were identified. One profile pit was dug at each of the major soil type identified, since these soils have been identified as benchmark soils. The morphological properties of the profiles were described in the field using the criteria of the soil survey manual of soil survey division staff [5] and the guidelines for soil profile description [6]. Soil samples were taken from pedogenic horizons or layers of the profiles for laboratory analysis.

Laboratory analysis and soil classification: Soil samples were air-dried in the laboratory ground and sieved through a 2 mm sieve. The percentage gravel was calculated on the basis of subsamples (500 g of each) of whole soil.

Particle-size distribution was determined by the hydrometer method. Soil pH was determined in water and O.I M kcl solution at 1:2.5 Soil/solution ratio: Exchangeable bases were displaced by NH_4^+ from neutral/MNH4Oac solution. Calcium (Ca) and Magnesium (mg) were determined by the atomic absorption spectrometer (AAS) and potassium (k) and sodium (Na) were determined by flame emission photometry. Cation exchange capacity (CEC) was determined by the neutral/MNH4OAc saturation method. Base saturation was calculated with reference to the NH4Oac-CEC.

Exchangeable acidity was extracted with IMKCL and determined by titration with NaOH solution. Organic carbon was determined by the dichromate wet oxidation method and total nitrogen (N) by the micro-kjeldahl technique. Available P was extracted by the Bray/method and determined colorimetrically. The micronutrients copper (Cu), Zinc (Zn), manganese (mn) and Iron (Fe) were extracted using diethyleretria minepentaacetic aci (CDPTA) and determined by AAS.

Soil classification was by the criteria of Soil taxanomy [5] and the FAO [6]. Revised legend of the soil map of the world while local soil classification was carried out using the Smyth and Montgomery [1] method.

Land evaluation: Suitability of the soils was assessed for cocoa production following the method of Sys [7]. Soils were placed in suitability classes by matching their characteristics with the requirement of cocoa (Table 1). The suitability class of a soil is that indicated by its most limiting characteristics. Thus the classes S1, S2, S3, N1 and N2 represent highly, moderately, marginally, actually not suitable but potentially suitable and actually and potentially not suitable respectively.

Table 1: Climatic, soil and land requirements for cocoa production [7]

Land, soil and climatic characteristics	S1	S2	S3	N1	N2
Climatic					
Annual rainfall (mm)	1,600-2,500 2,500-3,500	1,400-1,600 3,500-4,500	1,200-1,400	-	<1,200
Length of dry season (months)	<2	<3	<4	-	<4,400
Mean annual temperature (°C)	23-32	22-35	22-38	-	<21
Relative humidity (%)	40-65	35-75	30-85	any	-
Dryest month (%)	40-60	35-65	30-75	any	-
Topography (t)					
Slope (%)	<8	<16	<30	-	any
Wetness (w)					
Flooding	No	No	F1	F1	any
Drainage	Well	Moderate/better	Imperfect or better	Poor or better	Very poor/better
Physical soil characteristics(s)					
Texture/structure	C-60s to SC	C+60s to SCL	C+60s to LFS	C+60s to LFS	Cm to Cs
Coarse fragments (Vol.%)	<15	<35	<%	<55	any
Soil depth (cm)	>150	>100	>50	>50	any
Fertility characteristic (f)					
Apparent CEC (Meq/ 100 g soil)	>16	<16	any	-	-
Base saturation (%)	>35	>20	any	-	-
Organic matter (% C, 0-15 cm)	>1.5	>0.8	any	-	-`

F1 = Slight, C+60s to SCL = Very fine clay blocky structure to sandy clay loam, C-60V to L = Clay vertisol structure to loam, C+60s to fs = Very fine clay blocky structure to fine sand, C+60v to fs = Very fine clay vertisol to fine sand, C+60s to s = Very fine clay, vertisol structure to sandy soil, CM to SC = Massive clay to sandy clay

RESULTS AND DISCUSSION

Soil morphological properties: The soil of Aisegba was characterized by grey (5 Yr 6/1) sandy loam on top coming down to clay loam yellowish red (5 Yr 4/6) sub soil. The soil structure is angular blocky at all depths. The soil has an argillic horizon which increase in clay content with depth (Table 3). The soil was observed to be well drained. The soils are gravelly and concretional both at the topsoil and subsoils.

The soils of Ayedun (Tables 2 & 3) has no argillic horizon and is characterized by reddish brown (5 Yr 4/4) sandy loam on top coming down to yellowish red down (5 Yr 4/6) silt loam subsoil. There are some few yellowish red (5 Yr 4/4) mottles between 18 to 96 cm depth. The structural type is mostly angular blocky throughout the profile. The clay content of this soil is less than 15% throughout the soil profile. One unique factor of this soil type is that it is very silty throughout the soil profile (Table 3). Silt values ranges from 17.4% at the surface to 45.4% at the subsoil. This is an indication that these soils have been formed from colluvial wash from the crest or upper slope.

The profile at Ise was characterized by dark reddish brown (2.5 Yr 3/3) sandy clay loam on top coming down to reddish (2.5 Yr 4/6) in the middle depth and finally to silty loam red (2.5 Yr 5/8) at the subsoil. The structure is fine crumb at the surface coming down to moderate angular blocky at depth (Table 3). Again this soil type has unusual high silt content (51.4% Table 3). At depth (99-120 cm). This might be as a result of hill wash.

The Ikoro location was characterized by grayish brown (10 Yr 4/3) sandy loan topsoil coming to yellowish brown (10 Yr 5/8) clay subsoil.

There was a substantial increase in clay content right from the second horizontal at a depth of 34 cm (Table 3). This soil structure is crumby in nature at the top coming down to moderate angular blocky at the subsoil (Table 2).

Table 2: Field morphological description of selected cocoa soils of Ekiti State

Depth (cm)	Colour (dry)	Mottles +++	Textrure ++++	Structure *	Consistence +	Boundary **	Drainage class ***	Concretions +++++	Gravels VVV
Pedon A-Aisegba									
0-20	5Yr 6/1	-	SL	Cab	dh	w	IV	P	P, n
20-35	5Yr 5/2	M, yellow	SCL	Mab	Dh	S	IV	P, fe-mn	P, n
35-63	5Yr 4/4	F, reddish	CL	Mab	dsh	S	IV	P, fe-mn	P, n
63-99	5Yr 4/5	M, yellow	CL	Mab	dsh	gs	IV	P	P, n
>99	5Yr 4/6	F, reddish	CL	Mab	dsh	s	IV	P, fe-mn	P, n
Pedon B-Ayedun									
0-18	5Yr 4/4	-	SL	Fab	dh	S	IV	P, fe-mn	P, n
18-36	5Yr 4/6	F, yellowish red	SL	Fcr	dsh	S	IV	P, fe-mn	P, m
36-54	5Yr 4/4	F, yellowish red	SL	mab	dh	S	IV	P, fe-mn	P, n
54-96	5Yr 4/6	F, reddish yellow	SL-silt loam	mab	dsh	S	IV	P, fe-mn	P, n
96-100	5Yr 5/8	F, red	SL-silt loam	mab	dsh	S	IV	P, fe-mn	P, m
Pedon C-Ise									
0-16	2.5Yr 3/3	-	SCL	Fcr	dfr	s	IV	P	P, n
16-34	2.5Yr 3/6	-	CL	mab	dfr	gs	IV	P	P, n
34-50	2.5Yr 4/6	-	C	mab	dfi	s	IV	P	P, n
50-99	2.5Yr 5/6	F	CL	mab	dfi	s	IV	P, Fe-mn	P, m
99-120	2.5Yr 5/8	F	Silt loam	mab	Dfr	s	IV	P, Fe-mn	P, n
Pedon D-Ikoro									
0-14	10 Yr 4/3	-	SL	Fcr	mfr	s	IV	P	P, n
14-34	10 Yr 4/4	-	LS	Mcr	mfr	w	IV	P	P, n
34-54	10 Yr 5/6	F	C	Mcr	ms	s	IV	P, Fe-Mn	P, n
54-97	10 Yr 5 /8	F	C	mab	ms	w	IV	P, Fe-Mn	P, n

Texture ++++: SL = Sandy Loam, LS = Loamy sand, SC = Sandy Clay, C = Clay Loam, S = S and SCl = Sandy clay loam, C = clay, Mottles+++: M = many, f = few Structure*: m = medium, C = coarse, f-fine, cr = crumb ab = angular blocky. Consistence+: d = dry, m = moist, w = wet, l = loose, fr = friable, fi = firm, sh = slightly hard, h = hard, s = sticky. Boundary**: w = wavy, s = smooth, gs = gradual and smooth Drainage***: I = poorly drained, IV = well drained Concretions+++++: a = absent, p = present, Fe-Mn = Iron and Manganese concretion, n = numerous Gravels VVV: a = absent, p = present, n = numerous, f = few, m = moderate

Table 3: Physical and chemical properties of selected cocoa soils of Ekiti State

		Kcl	PH H20	Boron Ppm	Org. C %	Total N %	Ave. P ppm	Ca Me/100 g	Mg Me/100 g	Na Me/100 g	K Me/100 g	Ex. Ac Me/100 g	CEC Me/100 g	B. sat %	Mn ppm	Fe ppm	Cu ppm	Zn ppm	Gravel %	Text class %	Sand %	Silt %	clay %
A	10-20 cm	5.03	6.68	7.55	1.52	0.37	1.14	0.28	0.4	0.24	0.21	0.4	1.27	62.99	68.0	34.0	1.9	5.5	21.04	SL	69.2	15.4	15.4
Aisegba	20-5 cm	6.73	6.85	8.72	0.59	0.14	2.05	0.26	0.16	0.23	0.13	0.2	0.92	78.26	74.0	29.0	1.5	6.3	21.26	SCL	63.2	11.4	25.4
	35-3 cm	5.58	6.80	6.97	0.36	0.09	1.20	0.32	0.12	0.19	0.08	0.2	0.91	78.02	56.0	46.0	2.3	7.8	21.44	CL	57.2	11.4	31.4
	63-9 cm	5.60	6.69	11.04	0.23	0.06	0.48	0.41	0.18	0.24	0.12	0.4	1.35	70.37	63.0	53.0	2.7	7.1	21.92	CL	49.2	15.4	35.4
	99-100	5.54	6.54	12.20	0.39	0.09	0.66	0.36	0.17	0.25	0.19	0.4	1.37	70.80	48.0	39.0	1.1	4.3	21.32	CL	47.2	21.4	31.4
B	0-18 cm	5.76	6.58	10.46	0.24	0.06	8.01	0.33	0.17	0.22	0.10	0.4	1.22	67.21	53.0	41.0	1.4	3.6	20.98	SL	73.2	17.4	9.4
Aiyedun	18-36 cm	5.61	6.66	6.39	0.46	0.11	5.78	0.24	0.14	0.19	0.07	0.4	1.03	61.17	75.0	31.0	1.7	5.1	10.62	SL	67.2	23.4	9.4
	36-54 cm	5.40	6.36	9.88	0.67	0.17	2.53	0.16	0.08	0.21	0.06	0.6	1.11	45.96	79.0	37.0	2.2	4.3	11.33	SL	57.2	35.3	7.4
	54-96 cm	5.43	6.44	8.13	0.33	0.08	0.72	0.31	0.18	0.23	0.06	0.6	1.38	56.52	81.0	52.0	1.3	6.9	10.69	Silt loam	49.2	45.4	5.4
	96-100	5.52	6.16	12.78	0.46	0.11	0.36	0.30	0.13	0.20	0.08	0.8	1.51	47.02	88.0	44.0	1.7	7.5	10.66	Silt loam	49.2	45.4	5.4
C	0-16 cm	6.11	6.93	13.36	1.47	0.36	0.90	0.42	0.17	0.24	0.17	0.2	1.20	83.3	86.0	49.0	3.3	7.3	21.11	SCL	61.2	13.4	25.4
Ise	16-34 cm	6.10	6.93	8.72	0.93	0.23	3.01	0.30	0.10	0.24	0.20	0.2	1.04	80.77	92.0	27.0	2.6	6.1	11.05	Cl	57.2	13.4	29.4
	34-50 cm	5.93	6.96	9.88	0.44	0.11	1.63	0.28	0.14	0.22	0.08	0.2	0.92	78.26	88.0	21.0	1.6	8.3	11.18	C	45.2	11.4	43.4
	50-9 9 cm	5.23	6.20	12.78	0.39	0.09	0.18	0.38	0.15	0.27	0.06	0.6	1.46	58.90	76.0	33.0	1.9	7.6	10.74	CL	57.2	5..4	37.4
	99-120	5.79	6.97	7.55	0.39	0.09	0.12	0.35	0.16	0.24	0.14	0.2	1.09	81.65	83.0	37.0	3.1	4.8	10.89	Silt loam	35.2	51.4	13.4
D	0-14 cm	5.52	6.40	12.20	1.00	0.24	0.90	0.38	0.13	0.17	0.05	0.4	1.13	64.60	64.0	54.0	1.8	5.4	20.96	SL	71.2	15.4	13.4
Ikoro	14-34 cm	5.53	6.64	8.13	0.44	0.11	0.78	0.14	0.08	0.02	0.06	0.4	0.70	42.86	59.0	48.0	2.4	6.5	22.35	LS	77.2	77.4	15.4
	34-54 cm	5.94	7.07	10.46	0.54	0.13	0.66	0.22	0.18	0.32	0.10	0.2	1.02	80.39	55.0	38.0	3.5	6.9	21.21	C	43.2	7.4	49.4
	54-99 cm	5.18	6.20	11.62	0.21	0.05	0.48	0.19	0.12	0.24	0.09	0.6	1.26	50.79	51.0	45.0	3.2	7.0	21.07	C	37.2	11.4	51.4

All the four soil profiles are well drained. Three of the profiles (Aisegba, Ikoro and Ise) have argillic horizons. All the locations (Aisegba, Ayedun, Ise and Ikoro) are all gravelly and concretional in nature (Tables 2 and 3).

Soil chemical properties: The chemical properties of the soils are presented in Table 3. The soils are moderately acidic with highest values recorded in the surface horizons. The soil pH values in water ranged from 6.16 to 7.07. The percentage organic contents were observed to be low in all the locations (with values ranging from 0.21 to 1.52%). The low organic carbon content observed at all the four sites may be partly due to the effect of arable and land use activities being practiced by the farmers, high temperature and relative humidity which faviour rapid mineralization of organic matter. This finding here on organic matter decomposition confirmed the earlier results obtained by previous workers such as Agboola and Corey [8]. The organic matter has to be substantially increased through effective crop residue management, increased use of leguminous plants as well as the use of nitrogenous and phosphatic fertilizers.

The nitrogen content in all the soils are considerably low ranging from 0.05 to 0.37%. This is considered low when copared to the 1.80% N required by most crop [10-12]. The nitrogen content decreases progressively with depth. The soil nitrogen can be substantially increased through the use of nitrogenous fertilizers and effective crop residue management.

The available phosphorus contents in all soils are low ranging from 0.12 to 8.01 ppm. This value is lower than the average 12 ppm phosphorus value required by cocoa. Phosphate fertilizers are required as a soil management practice. Straws of crops residue should be incorporated into the soils.

The four locations are characterized by low potential for retaining plant nutrients, hence the necessity for adequate soil management. The low base saturation values (<99% by sum of cations [5] can be attributed to Kaolinitic clay content nature of the parent material from which the soils have been formed.

Previous work by Omotoso [12] has shown the importance of Boron to cocoa production. Low boron content had been known to display deficiency symptoms on a large scale. The boron content for all the soils are low on the average ranging from 6.97 to 12.78 ppm as against the 10-40 ppm requirement for cocoa.

Soil classification: The Aisegba soil profile has an argillic horizon which increases in clay content with depth. The organic matter content decreases progressively with depth. A low base saturation (<99% by sum of base method) characterizes the soil and the cation exchange capacity is rather low. Hence, the soil is grouped into the order Ultisol. The soil belongs to the suborder udult because of its udic moisture regime. It is grouped into Great group "Plinthudult" because of its high content of heavy concretions and gravels right from the surface to the lowest horizon below 99 cm. The soil has been classified as Typic Plinthudult at subgroup level. Using the FAO soil classification system. The soil has been classified as Eutric Plinthosol.

The soil is well-drained and has a medium texture down the profile which characterizes soils formed from fine-grained granitic rock and medium grained gneisses parent material. The soil has textures of very clayey sand ("clayey" sedimentary soil which includes iron concretions within 26 cm of the surface. At the series level the Aisegba soil has been classified as Ondo series. The soil colour between depth of 25-75 cm corresponds with the specification of Smyth and Montgomery [1].

Table 4: Physical and chemical properties of surface soil samples of cocoa soils of Ekiti State

Sample depth (cm)	Location	PH (H_{20}) 1:1	P (ppm)	% org. c	% N	Ca (meq/100g)	Mg (meq/100g)	Na (meq/100g)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	K (mwq/100g)	EA (Cmol/kg)	CEC	BS (%)	Particle % clay	Size % silt	Ana. % sand	Text. class
0-5	Aisegba (Pedon A)	7.10	9.58	2.352	0.243	3.501	3.378	0.823	100.41	80.61	25.36	9.66	0.823	1.314	9.877	86.70	4.8	18	77.2	SL
0-5	Ayedun (Pedon B)	6.65	25.17	1.867	0.194	2.992	2.507	0.589	71.12	64.37	20.54	7.47	0.589	1.223	8.134	85.00	6.8	20	73.2	SL
0-5	Ise (Pedon C)	6.60	32.89	2.037	0.211	3.467	3.146	0.763	93.12	64.81	24.60	9.37	0.763	0.816	9.042	86.50	8.8	24	67.2	SL
0-5	Ikoro (Pedon D)	6.41	7.87	1.764	0.183	3.339	2.881	0.665	86.95	53.93	19.84	8.74	0.603	0.603	8.333	92.80	12.8	26	61.2	SL

Table 5: Soil classification and land suitability evaluation of the selected cocoa soils of Ekiti State

	Soil Classification															
Location	Soil series	USDA	FAO	Rain fall (cm)	Length of Dry season (months)	Mean ann Temp (°C)	Flooding	Drain.	Texture	Coarse Frag.	Soil depth (cm)	CEC meq/100g	Bs %	Om %	Appa. CEC (meq/l00g soil)	Agg. Suitab.
Aisegba	Ondo	Typic plinthudult	Eutric plinthosol	1,300 S3	>3 S3	27 S1	Fo S1	Good S1	SC-LC S1	21.04 S2	100 S1	1.27 S3	62.99 S2	2.62 S2	8.2 S2	S3 cfs
Ayedun	Makun	Typic Udipsamment	Cambic Arenosol	1,300 S3	>3 S3	27 S1	Fo S1	Good S1	SL-Slit S2	20.98 S2	100 S1	1.22 S3	67.21 S2	0.41v S2	12.9 S2	S3 cfs
Ise	Fagbo	Acrudoxic plinthic kandiudult	Eutric Plinthosol	1,300 S3	>3 3	27 S1	Fo S1	Good S1	SCL-Slit loam S1	21.11 S2	100 S1	1.20 S3	83.33 S2	2.54 S2	4.7 S2	S3 cfs
Ikoro	Ondo	Typic plinthudult	Eutric Plinthosol	1,300 S3	>3 3	27 S1	Fo S1	Good S1	SL-C S1	20.96 S2	100 S1	1.13 S3	64.0 S2	1.73 S2	8.4 S2	S3 cfs

The soil of Ayedun has no argillic horizon and has clay content of <5% throughout the soil profile. The cation exchange capacity is equally low. The silt content is high and increases down the horizon (result of a colluvial wash), hence the soil is grouped into order Entisol. There is presence of iron and Manganese concretions and gravels from the topsoil to the lowest horizon. There is evidence of mottles at 18-36 cm even up to depth of 96 cm. The soil has been grouped as Psamment (suborder) and Great group Udipsamment. The soil is classified at subgroup level as Typic Udipsamment and Cambic Arenosol (FAO). The soil was formed from an hill-wash, that is formed from fine colluvial material. This accounts for the silty and fine texture of silt which increases down the depth. The parent material of the Ayedun soil is the fine-grained biotite gneisses and schist as the soil is developed to a great depth and has bright coloured mottles. The Ayedun soil has been classified at series level as Makun Series [1].

The Ise soil profile has argillic horizon with low cation exchange capacity and low base saturation (<99% by sum of bases method) and the organic matter deceases with depth hence it is classified as order Ultisol. It belongs to the suborder Udult due to its udic moisture regime and also fits into Kandiudult great group. The soil is classified as Acrudoxic plinthic kandiudult (USDA) and as Eutric Plinthosol (FAO). The Soil profile is suspected to be formed from fine-grained granitic rock and medium-grained gneisses parent material due to its slightly hard texture. The Ise soil has been classified at series level as Fagbo series because it is characterized by clayey sedentary property and brownish red to red colour within the 25-75 cm soil depth.

The Ikoro Soil profile has an argillic horizon and its organic matter content decrease with depth. The cation exchange capacity and the base saturation are low. Thus, it belongs to the order Ultisol. It belongs to the suborder Udult due to its udic Moisture regime. The soils is characterized by a lot of concretions and heavy gravels and similarly mottled, hence it belongs to the great group Plinthudult and consequently classified at subgroup level as Typic Plinthudult (USDA) and Eutric Plinthosol (FAO). I Ikoro Soil is suspected to have been formed from medium grained granites and gneisses. It is well-drained and has textures of very clayey sand to clay within the depth of 25 to 97 cm, respectively. Ikoro soil has been classified as Ondo series because of its brown to orange yellowish brown colour between the 25 to 75 cm depth.

Suitability evaluation for cocoa production: The conversion table (Table 1) of sys system [7] was used to match the land characteristics of all the sites. The result of the land evaluation for cocoa production is as presented in Table 5. Among the climatic parameters, the most important limitation to crop production in the topics is the amount and distribution of rainfall. Annual rainfall within all the study areas stands at about 1300 mm/ annum [4]. This is insufficient when compared with rainfall requirement for cocoa production (1600-2500 mm) as stated by Sys [7] (Table 1). This makes all the sites fall into suitability class S_3 with reference to rainfall. The mean annual temperature of all the study sites is within 27°C, hence they all fall within S1 (highly suitable) class with reference to temperature requirement. All the study sites are not flooded and are well drained and are therefore in the S1 suitability class when drainage and flooding are considered.

When textural class was used as an evaluation criteria, the Aisegba, Ise and Ikoro soils fall into the S1 suitability class, while Aiyedun soil falls into S2 suitability class because of the sandy loam and siltloam of the topsoil and subsoil, respectively. This is because the soil moisture reserve ability of the soil would be low. All the locations have gravels and concretions which pose an impediment for root development and movement; hence all the soil sites were all classified into S2 with reference to coarse fragments. The soils are all deep having depth ranging between 99-120 cm, hence classified as S2 class.

The soils have low cation exchange capacity (1.13 to 1.27 meq/ 100 g soils) and low base saturation (62.99 to 83.33%) and therefore fall into S3 and S2 classes, respectively. All the soils are moderately suitable (S2) when organic matter is taken as a yardstick for evaluation. Generally speaking, when all the parameters of land evaluation are considered, it was observed that some limitations are common to all the study sites (precipitation (low rainfall), low CEC, low base saturation, concretional and gravelly nature of the soils). Therefore all the sites have been classified as $S3_{cfs}$ (marginally suitable with rainfall, soil fertility and concretions as limitations) to cocoa production. The low CEC can be addressed by adding fertilizer supplements that contain such nutrient elements as Mg, K and Boron. Irrigation should be carried out to supplement inadequate precipitation especially during the dry season if farmers can afford it.

The different tree crops and deep feeders intercropped with cocoa should be replaced with shallow feeders and arable crops so as to reduce the nutrient uptake from the soils. Some leguminous crops can be planted to return nitrogen back into the soil.

CONCLUSIONS

Four selected cocoa soils developed from basement complex parent material were characterized and classified in Ekiti State, South-westhern Nigeria. The soils were found to be concretional and gravelly in nature. All the four soils are well drained. Three of the soils (Aisegba, Ikoro and Ise) has argillic horizons. All the soils except Ise soil have sandy loam texture on top coming down to either clay loam/siltloam or clay subsoil. All the soils are low in soil fertility. The soil were classified at subgroup level of soil Taxonomy [8] Local Series level [1] and the second level of FAO [6] (in parentheses) as Typic Plinthudult (Eutric Plinthosol and Ondo series-Aisegba). For Aiyedun soil, it has been classified as Typic Udipsamment (Cambic Arenosol and Makun series). The Ise soil has been classified as Acrudoxic Plinthic Kandidult (Eutric Plinthosol and Fagbo series). The Ikoro soil was classified as Typic Plinthudult (Eutric Plinthosol and Ondo series). The soils were further evaluated for cocoa production. The major limitations of these soils are concretional gravelly nature of the soils, poor soil fertility and low rainfall distribution. On the basis of these limitations, all the four soils were grouped into suitability classes for cocoa production as $S3_{cfs}$ (Marginally suitable).

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