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CHARACTERIZATION AND LAND SUITABILITY EVALUATION OF SELECTED SOIL OF RUBBER BELT OF NIGERIA
BY

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ABSTRACT

The morphological, physical and chemical characteristics of soils in eight major rubber (Hevea brasiliensis) production areas of southern Nigeria were studied. The soil were generally low in fertility and very acid (pH 4.2) to moderately acid (pH 5.5). The ECEC ranged between 1.56 and 8.93 cmoikg^{-1} while organic carbon and total Nitrogen ranged from 1.1 to 11.7 and 0.04 to 2.8gkg^{-1} respectively. Available phosphorous ranged from 2.4 to 24.4 ugg^{-1}. The soil occur on flat to gently sloping land, well drained, deep and are generally sandy. Clay content ranged from 1.2 to 33.3% with a mean of 14.2%. Soil structure varied from granular on the surface to moderate angular blocky and sub angular blocky in the subsoil with friable to slightly sticky consistency. The soils were evaluated to be suitable for rubber growth with only slightly limitations of fertility and low clay content in most areas and threatening erosion around Calabar. Data on latex yield showed that productivity ranking of the various locations per unit area was in the order: Calabar>Okhuo and Benin> Akwete>Odagwa. This, however differed from the suitability evaluation of the area which was in the following order Okhuo and Benin>Akwete>Odegwa> Calabar. The disparity in suitability rating and observed yield in adversely affect rubber production on the long run.

INTRODUCTION

The rubber-growing belt of Nigeria extends from Ogun to Cross Rivers States. The area us situated within longitudes 4^0 50 and 8^{0}30 E and latitudes 4^{0}50 and 5^{0}20N. Annual rainfall usually exceeds 200m and mean temperature is about 26^{0}C. The soils are underlain by Cretaceous and Tertiary sediments of the Abeokuta, Ewekoro, Ilaro, Benin, Nsukka, Imo and Ameki formations (Kogbe, 1975). A greater part of this area is widely termed Acid sands because they are light textured and associated with the removal of sesquioxide by the increasing leaching of nutrients. They are derived from unconsolidated sedimentary deposit of the Miocene-Pleistocene period (ILACO-Nadeco, 1966). The soil are generally characterized by deep, well-drained pedons with sandy textures and diffused horizons. Although these soils in their natural cover support luxuirant vegetation, they have been described as poor soils due to their excessive leaching (Tinker and Ziboh, 1959; Enwezor *et al* (1981) Lekwa and Whiteside, (1986). Despite these very widely held views of poor fertility, the soils have been rated as having immense agricultural potential for tree crops (Ataga *et al.* 1981). Several characterization studies for these soils with emphasis on chemical and pedological parameters (Lekwa and Whiteside, (1986); Kamalu *et al.* (2002). However, most of the schemes used in charactering the soil do not properly highlight the suitability and constraints of these soils to the cultivation of specific crops. This work is aimed at characterizing the soil supporting rubber in Nigeria and evaluation their suitability and constraints.

MATERIALS AND METHODS

The detailed morphological study of soils of selected rubber estates was done in each of the following rubber belt States; Edo, Delta, Rivers. Abia. Imo and Cross-River. Auger borings were made to cover all possible physiographic or land form units to a control section of 1.25m. Properties of soils obtained from auger boring were used to locate sites for representative pedons. Physical and morphological properties of representative pedons were characterized and evaluated along with samples taken from genetic horizons in addition to composite surface samples.

Soil chemical and physical properties were analyzed by standard laboratory procedures. The pH in 1:2 soil water ratio by Calomel pH meter, organic carbon by modified Walkley and Black (1934) method, available phosphorous by Bray and Kurtz 1(1945) method, total Nitrogen by Kjeldahi digestion and distillation, cation exchange capacity by summation of cations and particles size analysis by Hydrometer method of Bouyoucos (1951).

A suitability evaluation of the soil was done using a combination of guidelines suggested by Sys (1975); RRIM (1979); and Watson (1989) with slight local modification due to observed performance of rubber under various soil types in studied populations.

The land characteristics that have been identified as important to the growth and yield of rubber were rated using numerical scale ranging from one (1) for the lowest, to five (5) for the highest based on the limitation levels in each pedon. Scores were assigned to the land characteristics and a final suitability class for each pedon was calculated using the method described in Oluwatosin and Ogunkunle (1991). Efforts have been made to validate the suitability ratings of the soil with observed latex yield.

RESULT AND DISCUSSIONS

Chemical Properties

Results for chemical properties of representative pedons are given in Table 1. The soils range from very acid (pH4.2) to moderately acid (pH 5.5) suggesting a preponderance of variable charged colloids. Soil PH within the midwestern part (Iyanomo and Okhuo) described with deth while variation trend for Sapele and Urhonigbe. For the southeastern zone (Akwete and Odagwa), the pH level decreased down the profile across the various locations. However, the decrease was not consistent for Calabar. Watson (1989) noted that Hevea grows well on a majority of acid soil of the soil. On the average, surface soil of the southeastern zone tend to be more acid (pH 4.8) than those of the Midwestern Nigeria (pH 5.8) the same was the case for subsoil horizon. This may be due to the leaching of nutrient associated with high rainfall zone of the Eastern zone.

The exchangeable acidity also had a trend similar to that of pH except Benin where it was highest on the surface horizon. A range of 0.80 to 6.90 cmol/kg soil was obtained for the entire area. The distribution pattern for effective cation exchange capacity (ECEC).

Table 1: Nine Soil physico-chemical properties of selected Pedons of Rubber Growing belt of Nigeria.

Pedon Location/Depth	pH (H_2O)	Org. C (g/kg)	Total N (g/kg)	Avail P (ug/g)	Exch. Acid (cmol/kg)	ECEC (cmol/kg)	Base Sat. (%)	Clay Cont. (%)	Texture (Cm)
Iyanomo									
0-43	5.0	8.6	0.9	3.39	6.90	8.93	22.7	16.0	SL
43-85	4.8	4.7	0.4	9.75	5.10	6.91	26.2	18.0	SL
85-124	4.7	2.5	0.3	2.53	5.50	7.47	26.3	20.0	SCL
124-165	4.6	2.9	0.4	3.61	4.90	4.54	25.1	24.0	SCL
165-200	4.6	1.3	0.4	2.71	2.52	4.39	42.6	24.0	SCL
Okihuo									
0-18	5.5	10.3	1.2	9.30	1.68	5.58	70.1	18.0	SL
18-80	5.1	3.9	0.6	3.30	3.04	7.90	61.0	31.0	SCL
80-200	5.2	2.4	0.6	6.30	1.96	6.30	68.9	33.2	SCL
Sapele									
0-30	4.4	8.4	0.6	7.22	0.92	2.73	66.30	1.6	S
30-66	4.8	4.8	0.2	9.08	1.32	2.25	41.33	10.6	LS
66-103	4.8	4.6	0.3	8.36	2.44	4.37	44.16	16.6	SL
103-148	4.5	2.8	0.3	7.35	1.88	4.34	56.68	18.6	SL
148-200	4.7	2.7	0.2	7.09	1.28	1.56	17.95	14.6	SL
Urhonigbe									
0-10	4.8	6.7	0.6	10.26	0.84	1.23	31.71	2.8	S
10-35	5.0	5.4	0.5	4.18	1.12	2.88	61.71	4.8	S
35-70	5.0	3.9	0.3	6.08	1.44	2.79	28.39	6.8	S
70-125	5.2	3.7	0.4	5.07	1.68	6.94	75.79	8.8	LS
125-150	4.8	2.0	0.2	9.63	1.36	2.03	33.00	8.8	LS
150-200	4.8	2.2	0.2	8.74	1.04	1.63	36.20	8.8	LS
Odagwa									
0-12	5.1	11.7	2.8	22.40	2.48	4.10	39.50	12.0	LS
10-35	4.4	9.7	0.4	18.60	2.22	3.78	14.80	20.0	SL
32-72	4.4	4.6	0.3	17.10	3.27	3.83	14.60	20.0	SL
72-126	4.4	3.0	0.2	19.50	2.03	3.45	17.90	26.0	SCL
1265-200	4.5	2.5	0.04	12.00	2.48	2.82	12.00	26.0	SCL
Akwete									
0-5	4.6	8.1	1.3	13.40	1.68	3.25	43.30	2.2	S
5-18	4.5	8.5	1.0	13.00	0.88	2.30	61.70	4.2	S
18-40	4.5	7.6	0.9	17.60	2.88	4.30	34.90	7.2	LS
40-86	4.5	4.6	0.8	24.40	2.72	4.76	42.90	12.2	LS
72-126	4.4	3.0	0.2	19.50	2.03	3.45	17.90	26.0	LS
127-200	4.6	1.1	0.6	17.60	1.40	2.78	49.60	11.2	LS
Nekede									
0-20	5.1	7.0	1.0	4.90	0.80	1.94	35.60	17.0	LS
20-38	5.1	5.2	0.8	2.80	2.00	4.45	44.90	25.0	SL
38-57	5.1	2.8	0.8	4.90	1.20	2.09	29.20	10.0	LS
101-162	4.8	2.6	0.6	2.80	1.20	1.93	13.40	13.0	LS
162-200	4.5	1.5	0.4	5.90	1.20	1.87	20.80	13.0	LS
Calabar									
0-11	4.4	9.7	1.4	2.4	2.20	4.50	51.10	7.0	S
11-42	4.6	3.3	0.8	5.6	1.76	3.22	45.30	16.0	SL
42-80	4.6	4.5	0.8	5.2	2.60	4.80	45.80	16.0	SL
80-117	4.6	6.2	0.9	6.4	1.00	2.40	58.30	16.0	SL
117-164	4.6	3.3	1.0	5.2	1.84	3.28	43.90	18.1	SL
164-200	4.7	3.0	0.7	4.4	2.08	3.60	42.20	18.1	SL

*** S = Sand, SL = Sandy Loam, SCL = Sandy Clay Loam, LS = Loamy Sand**

did not differ from that of exchangeable acidity. A range of 1.56 to 8.93 cmo/kg soil was observed in the study area. The generally low levels of ECEC were attributed to the dominant sandy texture and the very high rainfall prevent in the area. The soils therefore have a low capacity to retain nutrients. This is in compliance with the observation of Swine (1996) who reported that high rainfall areas have characteristically low concentration of exchangeable bases, low saturation of. Cations and consequently low PH and high exchangeably acidity. The range for organic carbon on the surface horizons was 6.7 to 11.7gk'g while that of the substance was 1.1 to 9.7gkg'.organic carbon distribution in the study area seemed to be the opposite of ECEC. Total nitrogen and available phosphorus content had distribution patterns similar to that of organic carbon (Table 1). Eshett and Omueti (1989) attributed this pattern to heavy annual loses of nutrients as a result of leaching and fixation of nutrients. Generally, soil of the study area are highly leached due mainly to duration and amount of annual rainfall and the dominant sandy texture. Reliminary studies on nutrition of Hevea (Onuwaje and Uzu, 1978), Osodeke *et al* 1993) have revealed that all the soils under Hevea cultivation in Nigeria require N.P.K. Mg as nutrients during the establishment stage. Although the poor inherent fertility of the soils is not considered a threat to the suitability of the soils to Hevea, it is a constraint to optimal production. The yield and performance of Hevea will therefore be greatly improved by the application of appropriate fertilizer to the soils and adoption of soil fertility management practices at the early stage of plantation establishment.

Morphological Properties and the Suitability of the Soil to Hevea Cultivation

Table 2 shows a summary of the parameters evaluated and the suitability classification of representation pedons of the rubber growing soil of Nigeria. All the soil studied were deep to very deep with mean effective depth greater than 150cm. Shallow pedons were only observed in depressions along stream banks would retard and decrease the productivity of rubber. Textures of the soils were usually sandy changing from loamy sand on the surface to sandy clay loam in the substance. Clay content in the soils generally varied from 1.2% on the surface of most pedons to 33.2% in the substance horizons. The higher clay content in the lower horizons has been attributed to eluviations, a process of clay transfer from overlying horizons. Only few subsurface horizons of Okhuo, Iyanomo, Odagwa and Nekede have clay contents greater than 20%. The general low clay content and predominant sandy texture was noted to be major constraint of the soils to rubber cultivation. According to Sys (1975) optimum rubber growth is obtained in soils, which usually range from 25 to 45%, is expected to enhance moisture retention in the dry season. However, there were no stones and gravels within 200cm of the soils except in restricted areas near stream banks. The structure of the soils is weak to granular on the surface and sub-angular to angular blocky in the subsoil. This is suitable for good anchorage of tree crops. The granular structure on the surface enhances infiltration of water and good drainage. There are generally no massive structures. The soils have common to abundant micro and macro pores, which are evenly distributed, continuous, and interstitial. Soil consistency in the area varied greatly

Table 2; Morphological properties and suitability Evaluation of Selected Soils of Rubber belt of Nigeria

Location	Effective Soil Depth [Cm]	Texture	Consistency [Moist	Porosity	Structure	Slope[0/0]	Drainage	Summary of constraints to Rubber Cultivation	Suitability Class
Uyanomo [Benin	Very deep [200]	SL to SCL	friable to slightly Sticky	Abundant macro and micropores	Weeak to medium sub angular Blocky	Almost flat [0-2]	Moderately well drained to perfectly well-drained	low fertility	I
Okhuo [Near Benin	Deep 150	SL to SCL	f riable to Slightly Sticky	abundant macro to	Firm medium	Almost flat [0-3]	Well-drained	low fertility	I
Sapele	Very deep .200	S to LS	f riable	Many macro and Micro Pores	Weak medium sub angular blocky	Almost flat [0-3]	Perfect well drained	Sandy texture and low fertility	Il
Akwete [Near Aba]	Very deep . 200	S to LS	Loose to friable	abundant macro pores	Weak granuar to medium Angular Angular	Almost flat [0-3]	Perfect well drained	Sandy texture and low fertility	II
Nekede [Near Owerri]	Moderately deep about 150	LS	friable	abundant macro and macro Pores	Weak fine granular to Weak fine subangular	Gently sloping [2-5]	Moderately well-drained [ground water level At 180cm]	Sandy texture and low fertility	ii
Calabar	Deep about 150	LS	friable to sticky	Few macro and Abundant Micro Pores	Medium crumb to firm angular blocky	Medium slopes [3-9]	Modrately well-drained to perfectly well drained	Steep slopes, threatening erosion surfaces, low fertility	iii
Odagwa [Near Port Harcourt]	Very deep [greater than 200]	LS to SCL	friable to slightly Sticky	Many fine to medium interstitial Pores	Weak to moderate subangular blocky	Almost flat [0-2]	perfectly well drained	Sandy texture and low fertility	ii
Urhoonigbe	Very deep . 200	LS to SCL	friable	Abundant macro and Micro Pores	Weak fine subangular blocky	Almost flat [0-2]	perfectly well drained	Very sandy texture low fertility	ii

between loose to very friable on the surface to slightly sticky and slightly plastic in the subsoils. This according to RRIM (1979) encourages soil aeration.

The rubber growing belt of Nigeria are generally level to sloppy (0 to 3% slope). Incidence of erosion is therefore minimal. However, some parts of Calabar and its environs are undulating with occasional slopes greater than 8%. There is observable threat of soil erosion in these areas with meandering rivulets and shallow gullies developing beside some plantations. Soil of

The study areas are also perfectly well drained to moderately well drained. The ground water table in most areas was greater than i50cm. Only very few poorly drained areas around localized depressions were observed but were too few and far apart to be of any significance. Table 2outlinestheconstraints of representative pedons to the cultivation of rubber [Hevea brasiliensis]. data on latex yield collected from major plantation stations in Nigeria whose soils have been characterized have shown a productivity trend . Yield studies over a three year period in five experimenttal stations just opened for tapping showed an average annual yield rande of 1734 to 2870 kg/ha/year (Table 3). The productivity rankingwas in the order Calabar . Okhuo and Benin / Akwete /Odagwa. However, the suitability evaluation of the soils in the representaativestationswas ofthe order Okhuo and Benin / Akwete/ Odagwa / Calabar.

The observed discrepancy between soil suitability evaluationand latex yield rankingcould be attributed to short-term moisture use efficiency in the Calabar area and more Favourable environmental conditions on latex yield of individual trees. However, the area has greater slopes and is therefore prone to both wind destruction of mature rubber trees and accelerated erosion. Some shallow gullies were observed close to some rubber plantation in the course of this study, which confirmed the susceptibility of the area to erosion. Greater soil management inputs would be required for soils of the Calabar area than the other rubber growing soils for sustainable latex production hence its relative placing in the suitable rating.

SUMMARY AND CONCLUSION

The soil of the rubber belt of Nigeria studied have deep, well drained sandy soils. The soils are usually acidic with pH ranging from 4.0 to 5.5. Rainfall in the area is between 2000 and 3000mm annually, distributed within nine months of the year. There are usually no hardpans or impermeable layers and the terrains are almost flat to gently slopping. The area is also characterized by deep soils with good homogenous morphology and good drainage, which favour the cultivation of ruber *(Hevea brasiliensis)*. The generally poor nutrient status of the soils was not considered a threat to rubber productivity, as they are amenable to management.

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Table 3: Three Year Latex at Selected Locations in the Rubber Growing Belt of Nigeria

Location	First Year kg/h	2nd Year kg/ha	3rd Year kg/ha	Mean kg/ha
Calabar	2152	3014	3444	2870
Okhuo/Benin	1967	3195	3031	2731
Akwere	2583	1616	2260	2151
Odagwa	781	1300	3121	1734
VC (%)	41	42	17	

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