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FERTILITY CAPABILITY CLASSIFICATION OF ACID SANDS (SOILS) AS INFLUENCED BY PARENT MATERIALS IN AKWA IBOM STATE, NIGERIA.

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ABSTRACT

Fertility capability classification (FCC) was carried out using data obtained from field survey of acid sands soils in the Niger Delta area of Akwa Ibom State. The soils were studied on the basis of their parent materials, namely, coastal plain sands (CPS), beach ridge sands (BRS), sandstone/shale (SSS) and alluvial deposits (ALD). The result showed that most (60%) of the pedons from CPS had sandy (S) top and loamy (L) sub-soils and characterized by low cation exchange capacity (CEC) (e), acidic reaction (h) and potassium deficiency (k). Also, all pedons from BRS and SSS had uniformly (top-and sub-soils) sandy (S) profiles, with all BRS pedons also characterized by e, h and k constraints, while SSS pedons all had k as a general constraint to crop production. On the other hand, ALD pedons generally had loamy (L) top-and clayey (C) sub-soils, with k, h and gleying (g) as crop production constraints. Accordingly, the study showed that the dorminant FCC units for pedons of the four respective parent materials were as follows: *SL ehk* for CPS; *S ehk* for BRS. *S hk* for SSS and *LC ghk* for ALD. The result had shown that, in the area of study, the FCC system is efficient in grouping soils according to the kind of problems they present for agronomic management of their chemical and physical properties for optimum land productivity.

Key words: Fertility capability classification, acid sands, parent materials, agronomic management, Akwa Ibom State.

INTRODUCTION

The Fertility Capability Classification (FCC) is a technical system for grouping soils which have similar limitations and management problems in terms of the nutrient supply capacity of the soils (Buol *et al.,* 1975); Sanchez *et al.*, 1982). The system consists of three classification levels: type (topsoil texture), substratum type (subsoil texture) and certain other soil properties considered as condition modifiers or fertility constraints. The FCC unit is formed by the combination of the class designation from the three classification levels to categorize soils worldwide.

Information on the kinds of soils in an area is obtained through soil survey activities, which identify, characterize and classify the soils in the survey areas, and show their extent and distribution on map. However, while pedological information may be very useful to the Soil scientist, it may not be of immediate interest to the farmer and other land users. What the farmer needs most is an interpretation of the soil surveys, otherwise called land evaluation (FAO, 1976, Dent and Young, 1981). Land evaluation is the assessment of land performance when used for specified purposes. It can identify the most limiting land qualities/ characteristics and provide a good basis for advising farmers on appropriate management practice for optimum production in a particular agro-ecological zone (Chinene, 1992).

Most soils in Akwa Ibom State belong to the group of soils classified as ‘acid sands’ of Southern Nigeria (Udo and Sobulo, 1981). They are fragile, deep, strongly acid and low in native fertility. However, all the soils are not derived from the same parent material. Agricultural soils in the State are developed from parent materials which are grouped into coastal plain sands (CPS), beach ridge sands (BRS), sandstone/shale (SSS) and alluvial deposits (ALD). The characteristics of these soils are largely determined by these original (parent) materials and influenced by climate topography and the general agricultural land use pattern and management (Ibia and Udo, 2009, Ajiboye and Ogunwale, 2010).

The FCC system simplifies information about the profile and analysis of its soils for the benefit of those who are not familiar with soil classification system. It appears to be a suitable framework for agronomic soil taxonomy, one which is acceptable to both pedologists and agronomists (Lin, 1989).

The objective of this study, was to carry out the fertility capability classification of acid sands (soils) in the Niger Delta area of Akwa Ibom State on the basis of the different parent materials that formed the soils. This was with a view to testing the efficiency of the FCC system in grouping soils according to the kinds of problems they present for agronomic management of their chemical and physical properties, for optimum land productivity.

MATERIALS AND METHODS

Study Area

Akwa Ibom State is located in the South-South geo-political zone of Nigeria. It is one of the states in the Niger Delta Region. It lies within latitudes 4^o 31′ and 5^o 20′ N and longitudes 7^o 30′ and 8^o 30′ and 8^o 20′ E. The State is underlain mainly by coastal plain sands (CPS). Other parent materials which have serious influence on soil characteristics in the State are, beach ridge sands (BRS), sandstone/shale (SSS) and alluvial deposits (ALD). Physiographically, the landscape comprises low-lying plain and riverine areas with almost no portion of the State exceeding 175m above sea level.

The climate is humid tropical, with annual rainfall varying from 3000 mm along the coast to about 2250 mm at the extreme north. It has 1-3 dry months in a year, mean annual temperature varies between 26 and 28 ^oC and relative humidity is 75-80 % (Pethers *et al.*, 1989).

Field Work

Based on the extent of the State covered by each of the four parent materials, as shown by previous works (Petters *et al.*, 1989) four sites were selected to represent the CPS. Also three sites were selected for the BRS and two sites each, for the SSS and ALD, respectively. For the CPS, BRS and SSS, soils in each site, were examined along toposequences by locating a representative profile pit at the crest, middle slope and valley bottom, respectively. Also, for the ALD parent material, soil identification was first done by detailed and grid survey method in the two sites used for the study. Soil profiles were then sunk at locations typical of each of the eight identified mapping units. In all, 12, 9, 6 and 8 pits were studied for CPS, BRS, SSS and ALD parent materials, respectively. Each pit was described according to FAO guidelines for soil description (FAO, 1990). Soil samples were collected from each genetic horizon, for laboratory analyses.

Laboratory Analysis

Laboratory analyses of soil samples were carried out using appropriate standard procedures (IITA, 1979; Udo and Ogunwale, 1986, Udo *et al*., 2009). The following parameters were analysed for: particle size distribution, soil reaction (pH), electrical conductivity, organic carbon, total nitrogen, available phosphorus, exchangeable bases, exchangeable acidity and available micronutrients. The following were also determined: effective cation exchange capacity (ECEC), base saturation (BS) and exchangeable sodium percentage (ESP).

Fertility Capability Classification:

The results of the laboratory analyses and field morphological properties of the 35 pedons identified in the study area were used for fertility capability calssification. The conversion data used in evaluating the soils are as outlined by Sanchez *et al*. (1982). The system consists of three categorical levels, 'type' (texture of plough layer or top 20cm), 'substrata type' (texture of subsoils) and 'modifiers' (soil properties or conditions which act as constraints to crop performance). Class designations from the three categorical levels are combined to form a FCC unit. Thus, the soils were classified according to whether a characteristic was present or not. The FCC units of the 35 pedoms are shown in Table 2, while the FCC map of the state is shown in Fig. 2.

RESULTS AND DISCUSSION

Characteristics of Pedons in the Study Area

Some profile characteristics of the 35 pedons used for this study are shown in Table 1. The pedons were studied on the basis of their parent materials, which were identified as follows: (a) coastal plain sands (CPS), (b) beach ridge sands (BRS), (c) sand stone/shale (SSS) and (d) alluvial deposits (ALD).

General and Specific Characteristics of Pedons

From the data in Table 1, irrespective of the parent material, the soils generally had deep profiles. Twenty pedons (57: 14%) had profile thickness (topsoil and subsoil) > 200 cm. Eleven pedons (31.43%) had profile thickness > 100 < 200 cm, while four pedons (nos. 21, 32, 33, 34) (or 11.43%) had profile thickness < 100 cm.

Considering the particle size distribution, soils derived from CRS, BRS and SSS parent materials are generally coarse textured. Sand fraction dominates their profiles, and in most cases decreases down the profile while clay fraction increases with increasing depth. On the other hand, pedons derived from ALD parent material displayed relatively higher clay contents. Particularly in the deeper horizons, high clay and low sand contents were clearly observed.

Also, observed in Table 1, is the soil reaction which was generally acidic (pH 3.1 - 6.4) irrespective of the parent material. All the pedons of the CPS and BRS were strongly acidic (pH 3.1-5.0) although the latter displayed relatively lower pH values. On the other hand, pedons derived from SSS and ALD displayed relatively high pH values (4.8-6.4) with SSS pedons being less acidic than all the other pedons.

Pedons of CPS, BRS and SSS all had low exchangeable bases (Ca, Mg, K and Na). This also resulted in the general low effective cation exchange capacity (ECEC) in all these pedons. On the other hand, the ALD pedons had relatively high values of exchangeable bases and ECEC.

The result in Table 1 also showed that soils in the study area generally had low to medium values of base saturation. However, pedons of the CPS had the lowest values (8.2-70 %) both in the top and sub-soils. Pedons of the BRS generally had medium values (51-70 %), while ALD pedons had medium to high values (61-91 %).

The result of this study as analysed above, is in line with the observations of previous workers in this area. Vine (1970), described these soils as strongly acid in topsoil and subsoil (pH 4.0 – 5.0). They are included among the excessively leached acid latosols with low to medium humus content in areas of rainfall approximately 2200 to over 5000 mm per annum, in hot lowlands. Ojanuga *et al*. (1981), classified these soils as “acid sands” of Southern Nigeria. They described the soils as sands to sandy clays with deep, porous and strongly acid to very strongly acid in the subsoil, having very low base status and low CEC. Furthermore, both fraction dominates their profiles, and in most cases decreases down the profile while clay fraction increases with increasing depth. On the other hand, pedons derived from ALD parent material, displayed relatively higher clay contents. Particularly in the deeper horizons, high clay and low sand contents were clearly observed.

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Inspite of the similarities in some physical and chemical properties of these soils, it is evident from the result in Table 1, that there are certain inherent attributes which distinguish some pedons from others because of the basic differences in the initial materials from which these soils were formed.

According to Ibia and Udo (2009), most agricultural soils in Akwa Ibom State (the area of study), developed from parent materials which are grouped into coastal plain sands, beach ridge sands, sandstone/shale and alluvial deposits. Therefore, the characteristics of these soils are largely determined by these original materials and influenced by climate topography and the general agricultural land use pattern and management.

The above position has explained why pedons of CPS, BRS and SSS are relatively similar compared to those of ALD which are quite different in their characteristics. Whereas CPS, BRS and SSS are inherently sandy in texture, ALD is more clayey and finer in texture because of the nature of this initial material. Jungerius (1964), described soils derived from ALD as being developed from alluvial sediments with textures ranging from sand to clay but predominantly loamy. Also Tahal (1982), classified these soils as “alluvial (fine variant) series” due to their fine texture, while Petters *et al*. (1989), described soils from ALD as heavy textured.

Fertility Capability Classification (FCC) of Pedons in the Study Area

The result of the FCC of pedons in the study area is shown in Table 2. The conversion data used in evaluating the soils are as outlined by Sanchez *et al*., (1982). The system consists of three categorical levels: ‘type’ (texture of plough layer or top 20 cm); ‘substrata type’ (texture of subsoils) and ‘modifiers’ (soil properties or conditions which act as constraints to crop performance). Class designations from the three categorical levels are combined to form a FCC unit. The FCC units of the 35 pedons belonging to the four major parent materials (CPS, BRS, SSS and ALD) in the study area, were determined based on the soil profile characteristics (earlier presented in Table 1). Thus, the soils were classified according to whether a characteristic was present or not. Each FCC unit lists the ‘type’ and ‘substrata type’ in capital letters, and the modifiers in lower case letters.

The result of FCC in Table 2 shows that the dominant FCC unit of soils derived from CPS was SL ehk, which was represented by seven (or 58.33 %) of the 12 pedons. Other FCC units from CPS were L ehk – three pedons (or 25 %) and S ehk – two pedons (or 16.67 %). The result has shown that soils derived from CPS are dominated by sandy topsoil (S) and loamy subsoil, (L). Some pedons also have uniformly loamy (L) or sandy (S) profiles (top and sub-soils). However, they all have similar major constraints to crop performance. The constraints are: low cation exchange capacity (CEC), represented by e, they have acidic reaction, represented by h and are also deficient in exchangeable potassium, which is represented by k.

For soils derived from the BRS, the result in Table 2 shows that all the eight pedons are characterized by uniformly sandy profiles (S), and they all have similar constraints to crop performance – low CEC (e), acidic reaction (h) and exchangeable potassium deficiency (k). Pedons of SSS parent material were similar to those of BRS in terms of the ‘type’ and 'substrata type' which displayed a uniformly sandy profile (S). However, the six pedons did not have all the constraints to crop production in common. One pedon (no. 22) had low CEC (e), acidic reaction (h) and K deficiency. Two pedons (nos. 23 and 24) did not have e, but had h and k. Pedon 25 had e and k, but did not have h, as a major constraint to crop performance, whereas pedons 26 and 27 only had k as a major constraint to crop performance.

Furthermore, the result of FCC (Table 2), shows that the dominant FCC unit for soils derived from ALD was LC ghk, being represented by four (or 50 %) of the eight pedons from this parent material. One pedon each (or 12.5 %) also had LC gk and LCg, respectively, while two other pedons (nos 28 and 33) were represented by C gkh and L ghk, respectively. This result shows that soils derived from ALD in the area generally have loamy topsoil (L), clayey subsoil (C) and are also characterized by gleying (poor drainage) condition (g) as well as potassium deficiency (k), and acidic reaction (h). There are also few pedons which have uniformly clayey (C) or unformly loamy (L) profiles. Also, whereas the gleying condition is general to all pedons from ALD parent material, few pedons do not have h or k as constraints to crop performance.

The above result is in line with the works of Buol *et al.* (1975) and Sanchez *et al*. (1982), which showed that the FCC is a technical (land evaluation) system for grouping soils which have similar limitations and management problems in terms of the nutrient supply capacity of the soils. The profile characteristics and fertility constraints of soils derived from different parent materials have been identified to guide in efficient soil fertility management and fertilizer recommendation and formulation for optimum land productivity.

CONCLUSION

The result of this work has shown that the Fertility Capability Classification (FCC) as a technical (land evaluation) system is efficient in grouping acid sand soils in Akwa Ibom State according to the kinds of problems they present for agronomic management of their chemical and physical properties. The profile characteristics of these soils and their constraints to crop production have been shown to be highly influenced by their parent materials. This result shows that soils from different parent materials belong to different FCC unit(s) as follows: CPS: SL ehk; BRS: S ehk; SSS: S ehk & S k; and ALD: LC ghk. A simple fertility capability classification (FCC) map, showing the dominant FCC units in Akwa Ibom State has been produced. The result of this study is recommended as a guide in efficient soil fertility management and fertilizer recommendation and formulation for optimum and sustainable land productivity in the area of study and similar locations elsewhere.

Table 1: Some Soil Profile Characteristics in the Study Area

		Topsoil													Subsoil											
		Particle size				Ex. Bases									Particle Size				Ex. Bases							
Pedon	Thickness (Cm)	Sand (%)	Silt (%)	Clay (%)	TC	pH	Om (%)	Ca (comlkg^{-1})	Mg (comlkg^{-1})	K (comlkg^{-1})	Na (comlkg^{-1})	ECEC	B/Sat (%)	Thickness (cm)	Sand (%)	Silt	Clay	TC	pH	Om (%)	Ca (cmolkg^{-1})	Mg (cmolkg^{-1})	K (cmolkg^{-1})	Na (cmolkg^{-1})	ECEC	B/Sat (%)
Parent Material A: Coastal Plain Sand (CPS)																										
1	24	85.8	2.0	12.2	LS	4.9	2.16	0.11	0.06	0.02	0.05	1.13	33.4	176	75.8	02.0	26.2	SCL	5.1	0.51	0.08	0.01	0.01	0.04	0.98	8.36
2	14	85.8	2.0	12.2	LS	4.8	2.21	0.06	0.01	0.01	0.02	1.00	10.0	186	71.8	04.0	24.2	SCL	5.0	0.14	0.6	0.01	0.02	0.05	0.74	18.4
3	18	87.8	2.0	10.2	LS	4.7	1.80	0.05	0.02	0.01	0.03	0.71	16.3	86	75.8	02.0	22.2	SCL	5.4	0.69	0.05	0.02	0.01	0.03	0.71	15.4
4	29	83.8	6.0	10.2	LS	4.5	2.84	0.04	0.02	0.01	0.03	0.60	16.7	171	71.8	02.0	26.2	SCL	5.4	0.69	0.05	0.02	0.01	0.03	0.71	15.4
5	27	87.8	6.0	6.2	LS	4.9	3.40	0.17	0.05	0.01	0.03	0.65	38.8	173	69.8	02.0	28.2	SCL	5.5	0.73	0.05	0.02	0.01	0.04	0.91	12.5
6	39	55.8	20.0	24.2	SCL	4.8	6.73	0.68	0.39	0.03	0.06	1.66	69.9	161	65.8	06.0	28.2	SCL	5.0	0.75	0.14	0.06	0.08	0.03	0.64	14.6
7	21	79.8	10.0	10.2	LS	4.6	2.83	0.04	0.01	0.01	0.01	0.67	09.8	179	63.8	04.0	32.2	SCL	5.0	0.40	0.02	0.01	0.00	0.02	0.45	10.1
8	18	75.8	8.0	16.2	SL	4.4	2.50	0.02	0.01	0.01	0.02	0.55	09.5	190	61.8	04.0	34.2	SCL	5.0	0.43	0.03	0.02	0.01	0.04	0.57	12.0
9	32	83.8	8.0	8.2	LS	4.6	2.27	0.03	0.01	0.01	0.04	0.59	15.0	168	81.8	02.0	16.2	SL	4.9	0.34	0.34	0.04	0.01	0.03	0.59	17.7
10	24	81.8	4.0	14.2	LS	4.3	1.72	0.11	0.02	0.01	0.03	0.08	16.6	176	75.8	02.0	22.2	SCL	4.7	1.05	0.03	0.03	0.01	0.03	0.50	17.6
11	17	77.8	6.0	16.2	SL	4.3	1.67	0.03	0.01	0.01	0.03	0.68	11.2	183	73.8	02.0	24.2	SCL	5.0	1.73	0.03	0.01	0.01	0.04	0.48	16.0
12	27	87.8	4.0	8.2	LS	5.0	2.23	0.18	0.03	0.02	0.03	0.56	46.0	77	85.8	02.0	12.2	LS	5.3	1.78	0.05	0.02	0.01	0.03	0.31	34.4
Parent Material B: Beach Ridge Sands (BRS)																										
13	20	89.3	5.9	4.8	S	3.7	1.82	1.12	0.67	0.05	0.04	2.70	69.9	182	89.3	5.9	4.8	S	3.7	1.76	1.34	0.67	0.06	0.04	3.30	62.2
14	21	95.1	0.1	4.8	S	3.7	1.82	1.12	0.67	0.06	0.04	3.30	56.7	184	87.3	5.9	6.8	LS	3.9	1.86	1.34	0.67	0.05	0.05	2.80	75.1
15	24	89.3	5.9	4.8	S	3.5	1.82	1.34	0.67	0.05	0.05	2.90	72.2	128	85.3	8.9	8.8	LS	3.6	1.78	1.34	0.90	0.07	0.05	3.80	62.7
16	33	88.7	6.2	5.1	LS	4.1	1.83	2.69	1.12	0.07	0.06	6.02	65.7	167	80.7	8.2	11.1	LS	4.1	1.91	1.57	1.12	0.07	0.04	4.88	57.4
17	30	94.8	0.2	5.0	S	3.9	1.84	2.46	1.12	0.07	0.05	5.30	69.8	110	84.7	4.3	11.0	LS	4.0	1.87	1.79	1.12	0.06	0.04	4.46	67.7
18	10	93.8	0.7	5.5	S	3.8	1.98	1.79	1.12	0.07	0.05	5.00	6.12	90	94.8	0.2	5.0	S	4.0	1.77	1.57	0.67	0.06	0.06	4.60	51.3
19	22	93.3	1.9	4.8	S	3.3	1.88	1.34	0.90	0.07	0.04	3.86	6.12	186	95.1	0.1	4.8	S	3.2	1.80	1.12	0.90	0.05	0.05	3.58	60.7
20	26	93.3	1.9	4.8	S	3.1	1.88	1.35	0.70	0.06	0.04	3.86	61.2	187	95.1	0.1	4.8	S	3.3	1.75	1.12	0.90	0.05	0.05	3.58	59.2
21	30	95.3	0.1	4.6	S	3.7	2.04	1.12	0.67	0.06	0.05	3.07	61.9	50	93.3	1.9	4.8	S	3.4	2.11	1.34	0.90	0.06	0.04	3.49	67.1

Table 1 Continued: (Some Soil Profile Characteristics in the Study Area)

	……Topsoil……														……Subsoil……											
		…..Particle size…..				…..Ex. Bases…..									….. Particle Size …..				….. Ex. Bases …..							
Pedon	Thickness (Cm)	Sand	Silt	Clay	TC	pH	Om	Ca	Mg	K	Na	ECEC	B/Sat	Thickness (cm)	Sand	Silt	Clay	TC	pH	Om	Ca	Mg	K	Na	ECEC	B/Sat
		(%) ←		→			(%) ←	(comlkg^{-1}) →					(%)		(%) ←		→		(%) ←	(cmolkg^{-1}) →						(%)
Parent Material C: Sandstone/Shale (SSS)																										
22	19	93.0	2.4	4.6	S	6.0	3.9	2.64	2.40	0.08	0.06	6.46	80.2	181	85.0	6.4	8.6	LS	5.9	2.20	1.92	1.92	0.07	0.05	5.63	65.4
23	26	89.0	4.0	6.0	S	5.8	3.0	2.88	2.88	0.11	0.04	7.95	74.3	174	89.0	4.4	6.6	S	6.0	2.41	1.68	1.92	0.07	0.04	4.47	83.0
24	27	93.0	2.4	4.6	S	6.0	2.6	5.28	2.40	0.07	0.05	8.61	90.6	173	93.0	2.4	4.6	S	6.1	2.67	4.80	2.21	0.09	0.04	8.80	81.1
25	23	93.0	2.4	4.6	S	6.2	2.4	2.16	1.92	0.01	0.05	6.79	62.3	177	75.0	10.7	14.3	SL	6.0	1.21	2.64	2.56	0.05	0.05	8.00	60.8
26	33	91.0	2.4	4.6	S	6.4	1.5	2.88	2.56	0.01	0.06	8.00	70.0	167	79.0	14.4	6.6	LS	6.1	1.31	3.20	2.56	0.07	0.05	8.74	66.4
27	23	89.0	6.4	4.6	S	6.0	2.1	3.12	2.56	0.08	0.05	7.98	72.8	77	83.0	8.4	8.6	LS	6.1	1.69	2.64	2.56	0.10	0.07	8.69	61.8
Parent Material D: Alluvial Deposits (ALD)																										
28	20	51.8	11.4	36.8	SC	5.2	3.24	0.26	0.98	0.11	0.05	11.82	7.61	140	27.8	17.4	54.8	C	5.5	0.25	2.90	1.44	0.20	0.06	15.50	26.5
29	20	59.8	13.4	26.8	SCL	4.8	5.50	2.88	1.25	0.11	0.04	11.22	38.14	80	15.8	17.4	66.8	C	5.4	1.84	1.68	0.96	0.06	0.06	15.0	18.4
30	18	49.8	23.4	26.8	SCL	5.2	2.80	2.16	0.75	0.13	0.05	7.41	41.70	132	19.0	23.4	56.8	C	5.5	0.92	1.25	0.96	0.05	0.06	10.36	22.4
31	15	59.8	13.4	26.8	SCL	5.3	3.80	1.44	0.96	0.06	0.04	10.90	22.93	135	43.2	12.0	49.8	C	5.6	1.86	1.68	0.96	0.20	0.05	13.09	22.1
32	10	59.2	14.8	26.8	SCL	5.9	3.40	7.44	2.64	0.25	0.05	11.82	87.81	71	45.2	8.0	46.8	SC	5.1	1.90	7.20	6.72	0.09	0.09	29.26	48.2
33	13	61.2	8.0	30.8	SCL	5.5	3.40	0.40	9.60	7.20	0.11	22.38	76.64	57	71.2	10.0	18.8	SL	6.4	0.50	8.40	3.36	0.07	0.05	12.12	98.0
34	10	55.2	10.0	34.8	SCL	6.2	2.50	14.40	5.28	0.42	0.06	20.88	96.55	80	41.2	12.0	46.8	C	6.2	0.10	14.4	5.76	0.13	0.05	22.74	89.4
35	19	59.2	16.0	24.8	SCL	6.2	2.10	13.68	3.12	0.41	0.08	17.38	99.30	86	56.2	4.6	38.8	SCL	5.9	0.50	9.12	1.92	0.08	0.05	20.77	53.8

TC = textural class, S = sand, LS = loamy sand, SCL = sandy clay loam, SL = sandy loam, C – clay, SC – sandy clay.

Table 2: Fertility capability classification (FCC)* of pedons in the study area

Pedon	Type 1	Substrata Type 2	g	d	k	E	a	h	B	i	x	v	s	n	c	FCC Unit
			← Condition modifiers[3] →													
							Parent Material A: Coastal Plain Sands (CPS)									
1	S	L	-	-	+	+	-	+	-	-	-	-	-	-	-	SL ehk
2	S	L	-	-	+	+	-	+	-	-	-	-	-	-	-	SL ehk
3	S	L	-	-	+	+	-	+	-	-	-	-	-	-	-	SL ehk
4	S	L	-	-	+	+	-	+	-	-	-	-	-	-	-	SL ehk
5	S	-	-	-	+	+	-	+	-	-	-	-	-	-	-	S ehk
6	L	-	-	-	+	+	-	+	-	-	-	-	-	-	-	L ehk
7	S	L	-	-	+	+	-	+	-	-	-	-	-	-	-	SL ehk
8	L	-	-	-	+	+	-	+	-	-	-	-	-	-	-	L ehk
9	S	L	-	-	+	+	-	+	-	-	-	-	-	-	-	SL ehk
10	S	L	-	-	+	+	-	+	-	-	-	-	-	-	-	SL ehk
11	L	-	-	-	+	+	-	+	-	-	-	-	-	-	-	L ehk
12	S	-	-	-	+	+	-	+	-	-	-	-	-	-	-	S ehk
							Parent Material B: Beach Ridge Sands (BRS)									
13	S	S	-	-	+	+	-	+	-	-	-	-	-	-	-	S ehk
14	S	S	-	-	+	+	-	+	-	-	-	-	-	-	-	S ehk
15	S	S	-	-	+	+	-	+	-	-	-	-	-	-	-	S ehk
16	S	S	-	-	+	+	-	+	-	-	-	-	-	-	-	S ehk
17	S	S	-	-	+	+	-	+	-	-	-	-	-	-	-	S ehk
18	S	S	-	-	+	+	-	+	-	-	-	-	-	-	-	S ehk
19	S	S	-	-	+	+	-	+	-	-	-	-	-	-	-	S ehk
20	S	S	-	-	+	+	-	+	-	-	-	-	-	-	-	S ehk
21	S	S	-	-	+	+	-	+	-	-	-	-	-	-	-	S ehk

Table 2 Contd.: (Fertility capability classification (FCC)* of pedons in the study area)

Pedon	Type 1	Substrata Type 2	g	d	k	E	a	h	B	i	x	v	s	n	c	FCC Unit
			←					**Condition modifiers[3]**							→	
								Parent Material C: Sandstone/shale (SSS)								
22	S	S	-	-	+	+	-	+	-	-	-	-	-	-	-	S ehk
23	S	S	-	-	+	+	-	+	-	-	-	-	-	-	-	S ehk
24	S	S	-	-	+	+	-	+	-	-	-	-	-	-	-	S ehk
25	S	S	-	-	+	+	-	+	-	-	-	-	-	-	-	S ehk
26	S	S	-	-	+	+	-	+	-	-	-	-	-	-	-	S ehk
27	S	S	-	-	+	+	-	+	-	-	-	-	-	-	-	S ehk
								Parent Material D: Slluvial Deposits (ALD)								
28	C	C	+	-	+	-	-	+	-	-	-	-	-	-	-	C ghk
29	L	C	+	-	+	-	-	+	-	-	-	-	-	-	-	LC ghk
30	L	C	+	-	+	-	-	+	-	-	-	-	-	-	-	LC ghk
31	L	C	+	-	+	-	-	+	-	-	-	-	-	-	-	LC ghk
32	L	C	+	-	+	-	-	+	-	-	-	-	-	-	-	LC ghk
33	L	L	+	-	+	-	-	+	-	-	-	-	-	-	-	L ghk
34	L	C	+	-	+	-	-	+	-	-	-	-	-	-	-	LC ghk
35	L	C	+	-	-	-	-	+	-	-	-	-	-	-	-	LC gh

* After Sanchez *et al*., (1982)

1, 2: S = Sandy
L = Loamy

3: g = gley, d = dry, k = low K reserves
e = low cation exchange capacity, a = aluminium toxicity
h = acidic, b = basic, i = high fixation of P by iron
x = X-ray amorphous, v = vertisol
s = salinity, n = natric, c = cat clay

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