Soil Brief *Nigeria 2*

NIGERIA

Reference soils of the coastal swamps near Ikorodu (Lagos state)

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International Soil Reference and Information Centre

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ISRIC Soil Monoliths:

Number	*FAO-Unesco*	*Soil Taxonomy*
NG 19	Haplic Lixisol	Typic Kanhapludalf
NG 20	Gleyic Acrisol	Aquic Kanhapludult

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ABSTRACT

Two representative soils developed on quaternary sedimentary rocks in the Coastal Plains Sands of Nigeria were studied for the establishment of the Nigerian soil reference (NASREC) collection. The soil collection and description were done within the framework of the cooperative work of the University of Ibadan Nigeria with the International Soil Reference and Information centre (ISRIC), Wageningen, the Netherlands.

A brief geomorphic history of the southwestern Nigeria is given summarizing the pedogenetic environment of the reference profiles with regards to the vegetation and climate.

The soils, used for growing cassava, are also suitable for oil palms (*Elaeis guiniensis*). The soils are very deep.

NG19, located in the middle slope of the catena is well drained, and has been under fallow for many years. The soil has a high organic matter content (2.2%) in the topsoil. NG20 located in the lower slope position is imperfectly drained as reflected by the common iron-oxide mottles.

The soils are well protected by dense fallow vegetation. NG 19 may be easily eroded if the bush cover is cleared.

FOREWORD

The objective of a Soil Brief is to provide the description of a reference soil in its ecological setting. The Soil Brief is composed of a text part and data annexes. The text part consists of description and discussion of the major characteristics of the soil with figures and diagrams and includes classification and evaluation of the soil and land qualities. Attention is given to special topics such as erosion, soil formation etc. In the annexes the soil and environmental data available from the field, laboratory and office work are given.

The Soil Brief is written for soil specialists and non-soil specialist. For the latter group some of the details given in the annexes require further explication in the text. For the soil scientist the text can serve as reference information of soil and land qualities, soil management and soil formation. Additional information from research and discussions which cannot be stored in the computerized database, are also given.

In 1992, the Departments of Geography and Agronomy of the University of Ibadan in collaboration with the International Soil Reference and Information Centre (ISRIC) described and sampled 15 reference soils for the University of Ibadan Soil Reference Collection and Database (UISREC). The reference soils were selected from 3 major ecological regions in southern Nigeria. Reference soils NG 19 and NG 20 described in this paper, are representative for the coastal swamps near Sagamu.

This Soil Brief has been compiled in cooperation with Mr A.O. Ogunkunle, Mr S.A. Adebulujo (laboratory), Mr A. Gbadegesin, Mr Mokam and Mr G.A. Akinbola (fieldwork) of the University of Ibadan. The final result has been made possible with contributions from ISRIC's soil laboratory and Ms M.-B.B.J. Clabaut (text processing), Mr A.B. Bos, Mr J.H. Kauffman (fieldwork), Dr T. de Meester and Mr A.W. Vogel. Useful comments on the draft of this Soil Brief were obtained from Mr A.E. Hartemink.

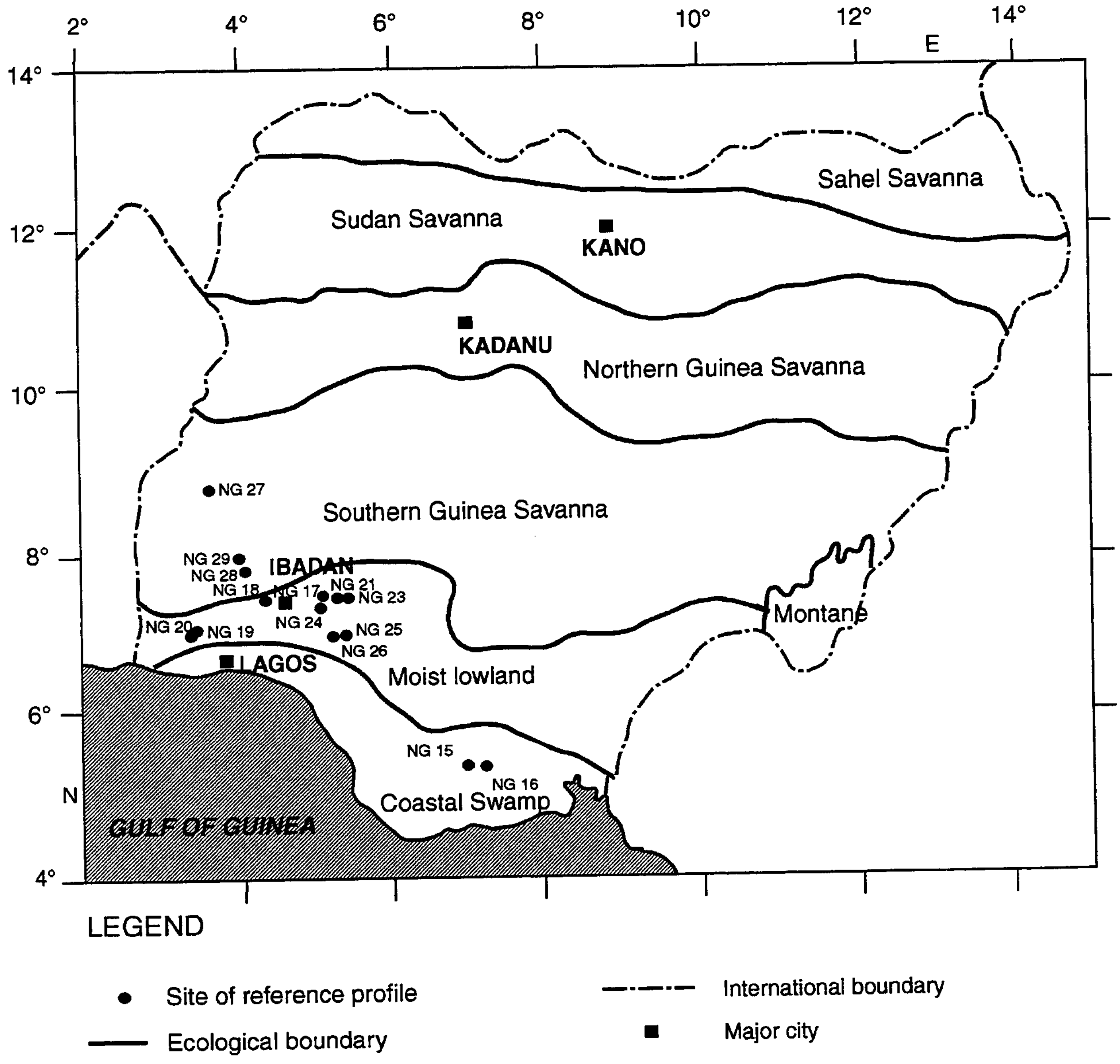

Figure 1 Geographical location of the reference sites.

1 THE MAJOR ECOLOGICAL REGIONS OF NIGERIA

Nigeria can be divided into the 7 major ecological regions (Fig. 1):

(1) The Coastal Swamp Region which includes the coastal forest and mangroves as well as the deltaic swamp forest
(2) The Moist Lowland Region
(3) The Southern Guineas Savanna Region
(4) The Montane Region
(5) The Northern Guinea Savanna Region
(6) The Sudan Savanna Region
(7) The Sahel Savanna Region

The location and extent of most of the regions coincide with the vegetation zones of the country as described by Keay (1953), Areola (1978) and Areola *et al.* (1982). The 12 reference soils (NG 15 to NG 29) are located in the southern part of the country in the following ecological regions: (i) Coastal Swamp, (ii) the Moist Lowland, and (iii) the Southern Guineas Savanna regions. The 3 regions are briefly discussed below.

The *Coastal Swamp Region* includes creeks, lagoons, the Niger delta and the coastal plain. The mean altitude of the creeks and lagoons area is around 40 m a.s.l. while along the coastal plain the elevation is around 160 m a.s.l. In this region, the total annual precipitation ranges from 429 mm at Bonny in the east to 1755 mm at Lagos in the west. The length of the rainy season is about 10 months. The soils are mainly hydromorphic and derived from marine and lacustrine parent materials. The vegetation consist of coastal forest, mangroves and deltaic swamp forest. The mangrove forest is dominated by varieties of red mangrove (*Rhizophera racemosa*), the swamp forest consist solely of slender trees. Reference Soils NG 19 and NG 20 are found in this region and described in this Soil Brief.

The *Moist Lowland Region* is underlain by rocks of the Basement Complex. The landscape is undulating and marked by numerous domed or sugar-loaf hills and by occasional flat-topped ridges. The summits of the hills ranges between 300 and 600 m a.s.l. Temperature is high throughout the year with an annual average between 28°C and 32°C. The rainy season lasts for 8 months and total annual rainfall is higher than 1100 mm. The region is covered with lowland forest consisting of evergreen hydrophytic plants with a large diversity. The forest is characteristically stratified. At the forest margins or in areas disturbed by man, woody lianas form an almost impenetrable tangle. The original or high forest is no longer as extensive as it used to be and restricted to a few forest reserves in Ondo, Benin and in the Cross River Basin along the border with Cameroon. The following Reference Soils were studied in this region: NG 17, NG 18 (this Soil Brief) and NG 21 to NG 26. The reference soils are described in Soil Brief *Nigeria 3, 4, 5* and *6*.

The *Southern Guinea Savanna Region* is also underlain by rocks of the Basement Complex. The landscape consists of inselbergs which are interspersed by numerous domed hills. The inselbergs are prominent along the Oyo-Iseyin-Saki axis where Reference Soils NG 27, NG 28, and NG 29 were studied (Soil Brief *Nigeria 7* and *8*). The rainy and dry season are well marked. The rainy season lasts for at least 7 months with a mean annual rainfall between 1000 mm and 1500 mm. The soils are ferruginous tropical soils with kaolinite as the dominant clay mineral. The Southern Guinea Savanna Region can be sub-divided into three types based on nature and proportion of woody species. These are (i) the savanna woodland where trees and shrubs form a fairly close canopy, (ii) the tree savanna where the trees and shrubs are scattered and, (iii) the shrub savanna where trees are absent.

2 SOUTHWESTERN NIGERIA

2.1 Geomorphology

The parent material of southern Nigeria can be divided into two major rock types: (i) Arenaceous sedimentary rocks and deposits, and (ii) Crystalline Basement Complex rocks. Each rock type has its unique landform, topography and soils. The sedimentary rocks and deposits are found on the coastal fringe of the region, parallel to the coastline. The coastal margin with elevation less than 15 m a.s.l., consists of beach ridge sands, mangrove swamp deposits, deltaic plain and recent alluvium deposits (Fig. 2). The oldest sedimentary rocks and materials are found inland where the elevation rises gradually to about 140 m a.s.l. Inland coastal plain sands, and undulating sandstone plain and ridges are found and the characteristic extensive flat topography is dissected by large river valleys filled up with thick alluvial deposits in the south.

The Basement complex rocks are of metamorphic origin and acid in composition. The major rock types are gneiss, migmatite, schists, quartzite and embrechite with small inclusions of granite, syenite and few basic materials of amphibolite. Elevation increases to 100 m a.s.l. at the foot of the escarpments of the major rivers of the Guinea Coast. The main geomorphic units distinguished are the residual hills, pediment surface and river valleys. The residual hills are massive rocks of high resistance to weathering and rise abruptly from the low-lying terrain. The quartzite ridges are covered with vegetation while the isolated boulders of exfoliated domes and inselbergs are often bare. The pediments are undulating plains with gentle slopes. The interfluves are characterised by rounded crests. The rejuvenated river valleys are narrow and v-shaped with no or little developed floodplain.

2.2 Pedogenesis

The soils of the region have been subject to high temperature and seasonal rainfall. Soil distribution has been strongly influenced by geology, geomorphology and vegetation. The influence of vegetation is mainly in nutrient cycling, biological activity and tempering the impact of climate. Differences in soils are related to differences in parent materials as well as in topographic position and drainage. The reports of previous studies on the soils of the region are documented in the works of Vine (1949), Smyth and Montgomery (1962), Albrook (1957), Moss (1957), and Murdoch *et al.*, (1976).

The three main soil groups based on geology are given below. The soil classification is in accordance with USDA (1975) Soil Taxonomy:

- Floodplain soils, coastal freshwater swamp and mangrove swamp soils. They are deep and poorly to imperfectly drained. Some of the dominant taxonomic units are Typic Tropopsamments, Typic Tropoquepts, Typic Tropaquents, Typic Tropofibrists.
- Soils derived from sedimentary rocks comprise coastal plain sandy soils and deltaic plain soils covered with dense forest. Dominant taxonomic units are Arenic Paleudalfs, Rhodic Paleudalfs, Oxic Tropudalfs, Typic Tropudults and Aquic Tropopsamments.
- Soils derived from Basement Complex rocks. These soils are very deep to moderately deep and found in a gently undulating landscape with forest and savanna vegetation, and an udic and an ustic soil moisture regimes respectively. Some dominant taxonomic units are Oxic Tropudalfs, Typic Tropaquepts, Oxic Paleudalfs, Oxic Paleustalfs and Typic Ustipsamments.

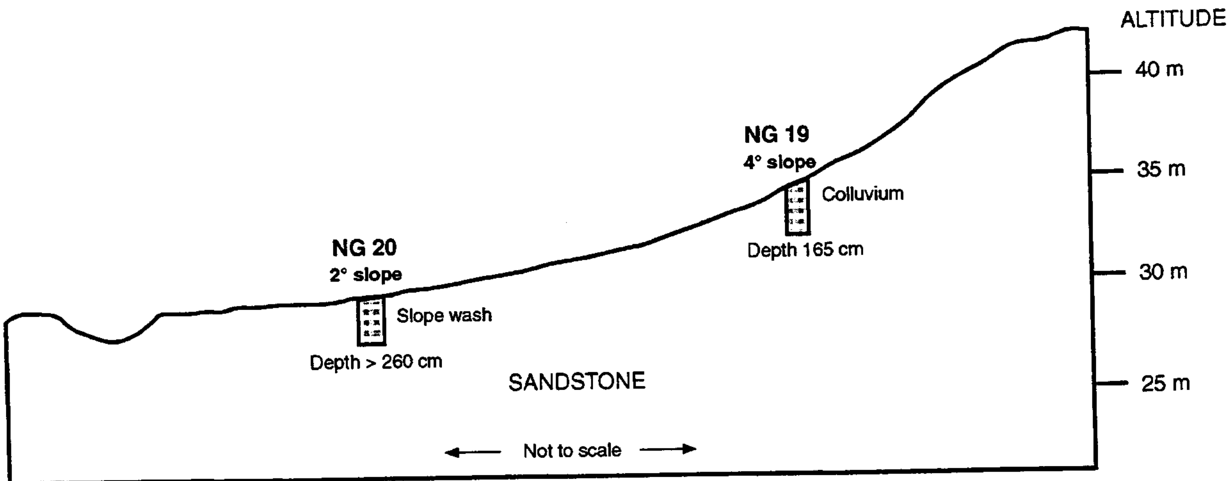

Figure 2 Cross section showing location of reference soils NG 19 and NG 20.

3 THE REFERENCE SOILS

In this section the two Reference Soils are described and discussed; their full descriptions and climatic data stored in the ISRIC soil information system (van Waveren and Bos, 1988) are presented in Annex 1A (NG 19) and 1B (NG 20).

3.1 Location and Occurrence

The reference soils NG 19 and NG 20 are located in the premises of the Lagos State Polytechnic in Ikorodu, about 19 km east of Ikeja in Lagos State. The soils form a toposequence on the sedimentary materials at the elevated terrace of the Nigerian Coastal Plain Sands. The two soils, locally referred to as *Alagba* and *Owode* series, are among the most predominant of the southwestern sedimentary formation. Their occurrence in a similar form were reported by Moormann (1981) who described the *Ikenne* toposequence, 30 km northeast of the reference soils. Soils like NG 19 are usually found on the middle/upper catenary position while soils like NG 20 are found in the lower position. The transition to the imperfectly drained soil NG 20 at the lower slope is gradual, featuring a long and gentle interfluve.

3.2 Climate

The climate of the region is humid to subhumid with distinct wet and dry seasons. The rainfall distribution pattern is bimodal, characterised by two peaks in June and September, which are separated by a dry spell in August when there is less than 100 mm of rain. Fig. 3 shows that rainfall exceeds evapotranspiration during May to October (except in August). Between November and April soil moisture is depleted but with a total annual rainfall of 1676 mm and an evapotranspiration of 1367 mm, there is a water surplus of 309 mm.

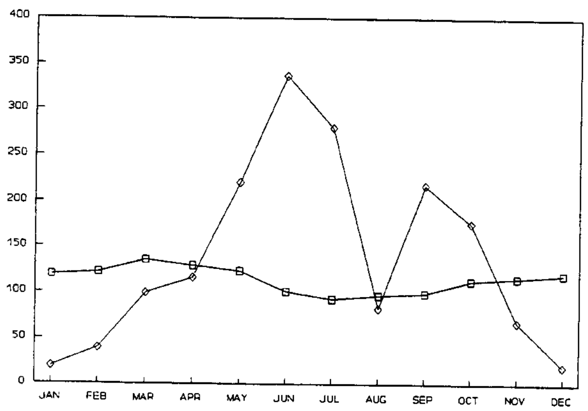

Figure 3 Precipitation (○) and evapotranspiration (□) in mm at Ikeja.

The temperature of the region is high throughout the year (26°C). The lowest temperatures (24 - 25°C) are usually between June and September when there is a thick cloud cover, reducing solar radiation and average daily sunshine hours ranging between 2.4 and 3.5. Relative humidity is high throughout the year.

3.3 Landscape

The landscape is a very gently undulating, low altitude plain. From a height of 45 m a.s.l., the land gradually descends towards sea level. Parent material consist of unconsolidated sandy materials of Pleistocene age. The parent material is deeply weathered and of uniform texture to a depth of about 390 cm. This illustrates the effect of the warm humid tropical climate and the vegetation on soil formation processes. The soils are permeable with a low degree of denudation. It has resulted in "old" soils in which weatherable materials are almost completely absent. Illuviation of clay particles has resulted in higher clay contents in the subsoil.

3.4 Vegetation and land use

The tropical rainforest has been replaced by semi-deciduous secondary forest devoid of some typical tropical species. Clearing of the forest is mainly carried out for small-scale farming with low input and technology. The reference soils are currently under fallow of *Chromolaena* and *Andropogonium* species. The major important cash crop is oil palm which is growing wild but also cultivated in small plantations. Important food crops are maize and cassava. The land under natural forest is adequately protected against the impact of the rain but without vegetative cover sheet erosion may occur.

3.5 Soil characterisation

3.5.1 The soil catena

The position of the reference soils on the toposequence is shown in Fig. 2. NG 19 is located at the middle position on a slope of 4%. The soils is very deep and well drained, with reddish brown to red colours. There is very little variability in colour and texture below the very dark (anthropogenic) topsoil. Soil depth increases as the toposequence descends gradually to the lower slope of an almost flat plain. Mottling is absent in NG 19 but mottles are found below 37 cm depth in NG 20. Even though the watertable is below the profile depth, the presence of olive brown to yellow mottles signify reducing conditions due to seasonal water saturation.

3.5.2 Brief field description

Reference soil NG 19 is a well drained, and the texture is sandy loam in the topsoil and sandy clay in the subsoil. Parent material of NG 19 is sandstone. The deep reddish profile extends to 250 cm depth and is moderately to strongly structured. Reference soil NG 20 has a sandy loam topsoil and clay to clay loam subsoil. NG 20 is imperfectly drained, and moderately structured with faint to clear olive yellow mottles.

3.5.3 Brief analytical characterisation

This section compares some of the soil analytical results of the reference soils with established mean values in the region. The soil samples were analyzed at ISRIC's soils laboratory according to the procedure described by van Reeuwijk (1993). The analytical data are presented in Annex 1A and 1B; in Table 1 the classification of some key properties is given (ISRIC, 1994; Landon, 1991). Some important soil data were selected and presented in a graphical way using SOLGRAPH (Brunt & Kauffman, 1995).
The particle size distribution of both reference soils with depth is shown in Fig. 4 and 5. The clay content of NG 19 increases with depth indicating clay accumulation

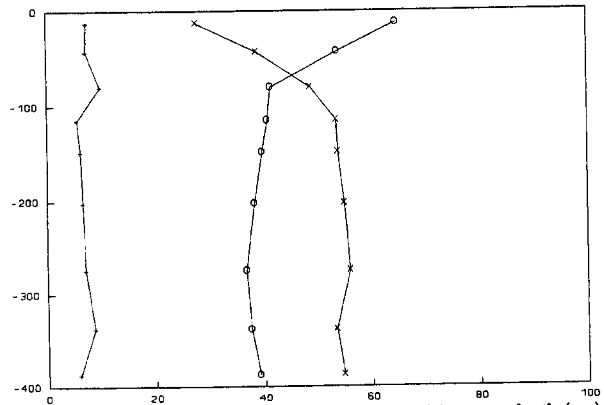

Figure 4 Percentages clay (x), silt (+) and sand (o) versus depth (cm) in profile NG 19.

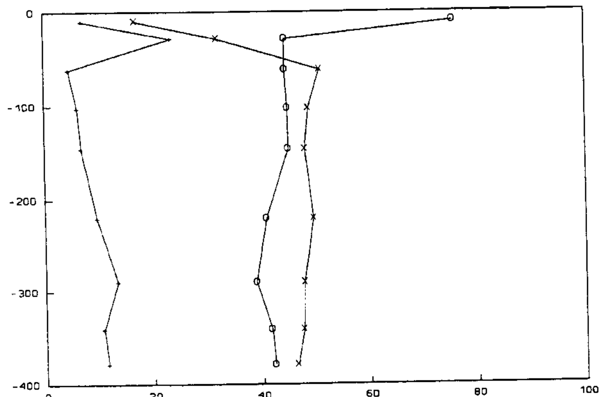

Figure 5 Percentages clay (x), silt (+) and sand (o) versus depth (cm) in profile NG 20.

in the subsoil as a result of illuviation. The sand fraction increases to 54% in the 25 to 60 cm soil horizon but decreases to 40% in 130 to 165 cm soil horizon. The sand fraction of NG 20 is almost constant although the content decreases sharply from 76% to 45% in the top layers. Fig. 6 and 7 show five chemical properties with depth: soil acidity (pH-H_2O and pH-KCl), organic C, sum of exchangeable bases (Ca, Mg, K and Na) and Effective Cation Exchange Capacity (ECEC). Organic C decreases sharply from a high level in the topsoil to very low in the subsoil of NG 19. The pattern shows that nutrient cycling and organic matter decomposition are virtually restricted to the topsoil. However, the relatively low organic C in the topsoil of NG 20 can be attributed to the exhaustive past land use and short fallow periods. Excluding exchangeable H and Al, the ECEC and the sum of bases are the same throughout the profile in soil NG 19, whereas soil NG 20 with its imperfect drainage, has an average of 21% aluminium saturation in the upper 85 cm. The distribution of the sum of bases, the ECEC and the organic C are similar. This confirms the influence of the organic C on the other two properties. In the region, organic C is significantly correlated with Na, K, Ca and Mg supply (Agboola and Corey, 1973). The relative higher value of the sum of bases in NG 19 in comparison with NG 20 is attributed to organic C. Soil NG 19 is slightly alkaline throughout the profile. The pH-$H_2 0$ is constantly about one unit higher than the pH-KCl.
Fig. 8 and 9 present the moisture retention curves (pF graphs). The intersection point of each curve with the x-axis gives the water content of the soils under saturated conditions which indicates the total pore-volume. The quantity of soil moisture between pF 0 and pF 2 is expressed by the air capacity which is a measure for the drainage and aeration conditions of a soil. The available soil moisture (ASM) is the quantity of moisture between pF 2 (field capacity) and pF 4.2 (permanent wilting point). The available moisture stored in the topsoil and subsoil of NG 19 is low. Soil NG 20 shows only minor changes with depth and the available soil moisture is medium. For both soils there is no direct relation between the available soil moisture and the increase of fine soil particles with depth. The air capacity of both soils decreases sharply with depth due to the textural changes.

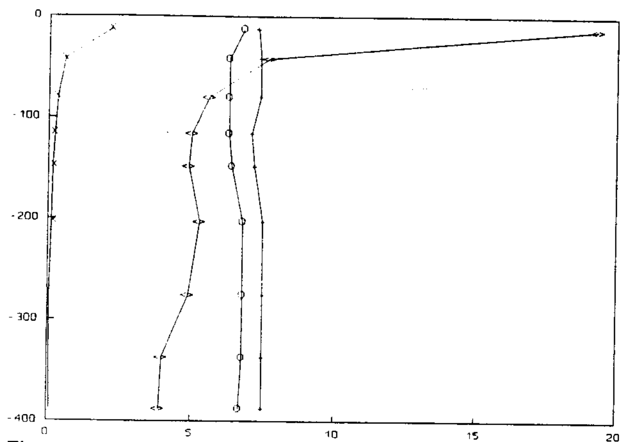

Figure 6 Sum of bases (cmol$_c$ kg^{-1} soil) (<>), pH-H_2O (+), pH-KCl (o) and organic carbon (x) versus depth (cm) in profile NG 19.

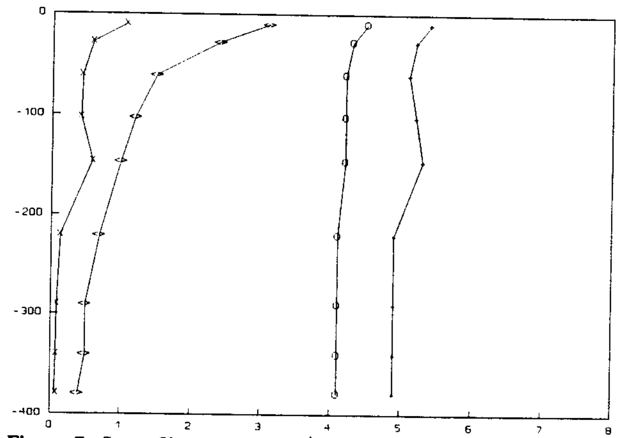

Figure 7 Sum of bases (cmol$_c$ kg^{-1} soil) (<>), pH-H_2O (+), pH-KCl (o) and organic carbon (x) versus depth (cm) in profile NG 20.

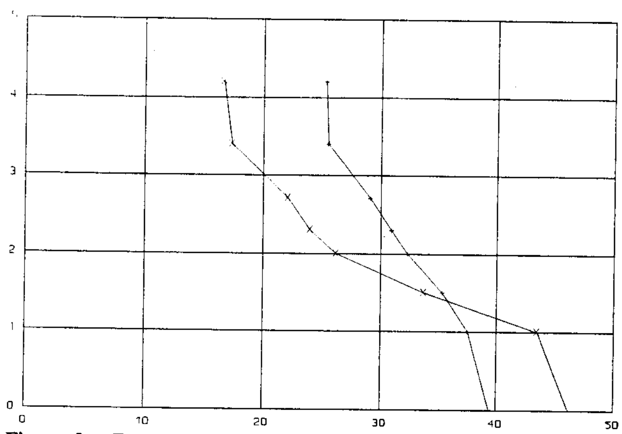

Figure 8 pF or moisture retention curves (water content in vol % versus suction) at depth 0-25 cm (x) and 25-50 cm (+) in profile NG 19.

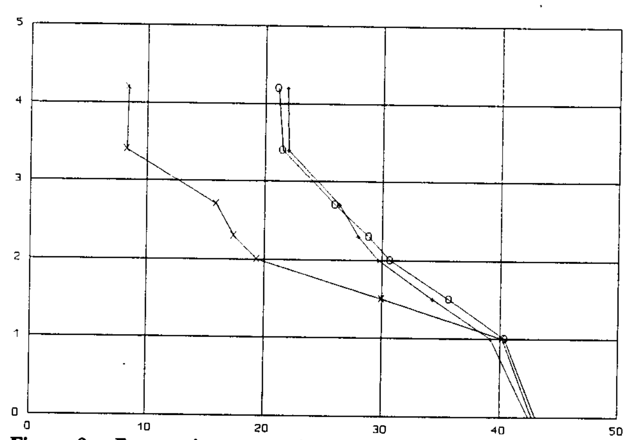

Figure 9 pF or moisture retention curves (water content in vol % versus suction) at depth 0-20 cm (x), 20-37 cm (+) and 37-85 cm (o) in profile NG 20.

Table 1 Key properties of soils NG 19/20

Texture	Sandy loam in the topsoil to sandy clay and clay in the subsoil and deeper subsoil of NG 19; sandy loam in the topsoil to clay (loam) in the subsoil and deeper subsoil of NG 20
Organic carbon	High in NG 19 (2.2% in topsoil); medium in NG 20 (1.1% in topsoil)
Acidity	Neutral in NG 19 (pH-H_2O 7.3 in topsoil); acid in NG 20 (pH-H_2O 5.4 in topsoil)
Sum of bases	In topsoil of NG 19 very high (19.3 cmol$_c$ kg^{-1} soil) and in subsoil medium (7.7 cmol$_c$ kg^{-1} soil); in topsoil of NG 20 low (3.1 cmol$_c$ kg^{-1} soil) and in subsoil low (2.4 cmol$_c$ kg^{-1} soil)
ECEC	In topsoil of NG 19 medium (19.3 cmol$_c$ kg^{-1} soil) and low (± 6 cmol$_c$ kg^{-1} soil) in subsoil; very low (< 3 cmol$_c$ kg^{-1} soil) throughout profile of NG 20
Aluminium sat.	Absent in NG 19; low (± 16%) in top 85 cm of NG 20
Clay mineralogy	In both soils kaolinite is dominant
Bulk density	Medium (± 1.3 kg dm^{-3}) in both soil profiles
Air capacity	High (20%) in the topsoil to low (7%) in the subsoil of NG 19; high in the topsoil (24%) to medium (12%) in the subsoil of NG 20
Av. soil moisture	Low (7%) throughout the profile of NG 19; medium (11%) in the topsoil to low (9%) in the subsoil of NG21

Landscape around pedon NG 19

Landscape around pedon NG 19

Pedon NG 19

3.6 Soil classification

Soil classification of NG 19

FAO-Unesco (1988)
The soil classifies as a Haplic Lixisol. The A horizon is well structured and dark with moderately high organic matter content and a base saturation of > 50% throughout within 125 cm of the surface. The thickness requirement of a mollic A horizon is met. The soil has an argic B horizon and a ferralic B horizon which starts within a depth of 130 cm (< 10% dispersable clay) which is too deep to be considered as a diagnostic horizon. The base saturation is > 50% and the soil is lacking gleyic and stagnic properties.

USDA Soil Taxonomy (1992)
The soil is classified as a Alfisol. It is not known if the region is characterized by an ustic or an udic soil moisture regime. The argillic horizon does not have a clay decrease of 20% or more with increasing depth and has a hue of 7.5YR or redder and a chroma of 5 or more in the matrix. The soil keys out as an Typic Kanhapludalf.

Soil classification of NG 20

FAO-Unesco (1988)
The soil has an ochric A horizon. In spite of its organic carbon content, high base saturation and dark colour, the A horizon is not more than 25 cm deep. The soil has an argic and ferralic B horizon that is neither red or dusky red nor yellow to pale yellow, which is not strongly humic and lacking geric properties. The soil keys out as a Gleyic Acrisol.

USDA Soil Taxonomy (1992)
The soil classifies as an Ultisol. It has an argillic horizon with a base saturation of < 35%. The kandic horizon has a CEC of < 16 $cmol_c$ kg^{-1} clay and no clay decrease with increasing depth of > 20%. The soil moisture regime is ustic but transitional to udic. The soil keys out as an Aquic Kanhapludult.

3.7 Soil suitability

A qualitative evaluation on the land qualities according to the Framework for Land Evaluation (FAO, 1983) was carried out for the two Reference Soils. The suitability of any land for any specific use is determined by the rating of individual land qualities when matched with the land utilization requirements. Both soil types were evaluated for cassava, the main crop at the site and its management is characterised by low input and technology. The requirements of maize were taken from Bunting (1981), ILACO (1981), Landon (1991) and Sys *et al.* (1993) and they are summarized in the following paragraphs. The results are presented in a list of soil and land qualities in Annex 2.

3.7.1 Climatic and Soil Requirements of Cassava

Cassava (*Manihot esculenta*) is a perennial plant, but as an agricultural crop it is normally harvested 9-18 months after planting. It needs a minimum of 500 mm of well distributed rainfall. The optimum amount of rainfall is 1400- 1800 mm y^{-1}. Cassava can survive a prolonged period of drought during the growing season but not at the time of planting. It is therefore valuable in regions with low and uncertain rainfall. Optimum average temperatures over the growing period are between 26 and 28°C. Below 15°C there is premature leaf shedding and growth is low. Variations in day and night temperatures promote carbohydrate storage in the tubers.
It is a deep rooting (at least 50 cm, preferably > 100 cm) crop, which responds well to soils with a good structure, a good internal drainage (moderately well to somewhat excessively drained) and a high organic matter content. Cassava is sensitive to waterlogging and flooding should be absent. Fairly light textured soils (sandy to sandy loam) are needed for root formation and facilitate harvesting in form of lifting up the roots by pulling. Harvesting can be spread over several months by leaving the roots in the soil. The pH may vary from 5.2 to 7.0. Liming is required at pH values < 5.0. It is a very exhaustive crop (especially K), requiring a correct rotation or intercropping. Intensified agriculture demands considerable amount of fertilizers, especially N and K. However, on very fertile soils the vegetative growth is very luxurious at the expense of the tuber and starch formation. A low available water capacity of the soil is well tolerated. The erosion hazard is medium before full canopy development has taken place.

3.7.2 Evaluation of NG 19 and NG 20 for Cassava

Annual temperature is optimal but other climatic parameters are slightly below optimum range, especially the length of the growing period which is suboptimal for cassava production. A thick cloud cover reduces the solar radiation. For maize this limitation is more serious than for cassava.
Serious limitations for cassava production are rainstorms, pests, diseases and weeds. The assessment of their effects on the potential crop yield will give an insight into the quantity of annual yield loss.
The reference soils are very deep and light textured and rooting depth is therefore not a limitation. Because the topsoils have a light texture also harvesting operations are not restricted.
For soil NG 19 the nutrient availability is suboptimal, for soil NG 20 it is moderate, although cassava can do well on poor soils. Nutrient retention, as indicated by the CEC and/or ECEC, is moderate in soil NG 19 and low in soil NG 20. Al toxicity in the subsoil of NG 20 is

moderately high and may affect crop production. In order to sustain crop production, there is need to improve the soil fertility by fertilizer applications. However, the right type should be used to avoid a further acidification of soil NG 20. Given the low level of organic matter, proper crop residue managements should be encouraged. Attention should be given to the adoption of alley cropping. Liming is required to decrease the Al saturation in NG 20. The potential danger of leaching of nutrients, especially exchangeable bases, should not be worsened by indiscriminate exposure of the soils.

The opening of virgin land for agriculture usually disrupts the delicate ecological balance in a region. Land hitherto assumed safe is suddenly exposed to a variety of hazards. Moreover the constraints to crop production are aggravated by improper land use. This threat is expressed by the low rating for the land quality "initial land preparation". Workability and oxygen availability for both soils are optimal, flooding hazard does not exist. Because of the sloping land at site NG 19 and its low soil stability there is a moderate water erosion hazard. This hazard is nihil for soil NG 20.

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Annex 1A ISIS Data Sheet NG 19

ISIS 4.0 data sheet of reference soil NG 19 Country : NIGERIA Print date (dd/mm/yy) : 25/04/95

FAO/UNESCO (1988) : Haplic Lixisol (1974 : Ferric Luvisol)
USDA/SCS SOIL TAXONOMY (1992) : sandy over clayey, kaolinitic, isohyperthermic (1975 : Typic Kanhapludalf)
LOCAL CLASSIFICATION : Alagba Series

DIAGNOSTIC CRITERIA USDA/SCS (1992) : Soil moisture regime : udic
FAO (1974) & USDA (1975) : Diagnostic horizons : argillic
: Soil moisture regime : udic

LOCATION : Lagos State, Ikorodu, Lagos Polytechnic
Latitude : 6°37′ 0′′ N Longitude : 3°30′ 0′′ E Altitude : 35 m a.s.l.
AUTHOR(S) : Gbadegesin, A., Mokam, Akinbola Date (mm/yy) : 1/91

GENERAL LANDFORM : low hill Topography : undulating
PHYSIOGRAPHIC UNIT :
SLOPE Gradient : 7% Aspect : Form : straight
POSITION OF SITE : middle slope
MICRO RELIEF Kind :
SURFACE CHAR. Rock outcrop : nil Stoniness : nil
Cracking : nil Slaking/crusting : nil
Salt : nil Alkali : nil
SLOPE PROCESSES Soil erosion :
Slope stability : stable

PARENT MATERIAL 1 : colluvium derived from : sandstone
Texture : sandy clay
Weathering degree : high Resistance :
Remarks :

EFFECTIVE SOIL DEPTH : 165 cm

WATER TABLE Depth : Kind : no watertable observed
DRAINAGE : well
PERMEABILITY : No slowly permeable layer(s) cm
MOISTURE CONDITIONS PROFILE : 000 - 165 cm dry

LAND USE : fallow
VEGETATION Type : semi deciduous forest Status : secondary

ADDITIONAL REMARKS :

BRIEF CHARACTERIZATION OF THE SOIL:
Very deep well drained red sandy clay, derived from sandstone, with mottling in the subsoil. Tubular pores. Few woody and many fibrous roots at the surface.

CLIMATE : Köppen: Aw
Station: IKEJA 6 36 N/ 3 20 E 30 m a.s.l 19 km W of site Relevance: good

	No. years of record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
pot. evapotransp. mm		119	122	135	129	123	101	93	97	99	113	116	120	1367
precipitation mm	23	19	39	99	116	221	337	280	83	218	176	68	20	1676
T mean °C		26.6	27.5	27.6	27.3	26.6	25.5	24.3	24.2	25.0	25.5	26.7	26.7	26.1
bright sunshine $h\ d^{-1}$		6.1	7.0	6.0	5.9	5.6	3.5	2.4	3.0	3.4	5.3	6.3	6.4	4.8

PROFILE DESCRIPTION :

Ap 0 - 25 cm 5.0YR 3.0/1.0, dry sandy loam; moderate medium subangular blocky non sticky, non plastic, friable, hard; many coarse discontinuous exped and inped tubular pores; many very fine to coarse roots throughout; gradual smooth boundary to

AB 25 - 60 cm weak red (2.5YR 4.0/2.0, dry) sandy clay loam; moderate medium subangular blocky non sticky, non plastic, firm, hard; many coarse discontinuous exped and inped tubular pores; many medium roots throughout; gradual smooth boundary to

Bt1 60 - 100 cm red (2.5YR 4.0/6.0, dry) sandy clay; strong medium subangular blocky slightly sticky, slightly plastic, firm, hard; few fine continuous inped tubular pores; few fine roots between peds; gradual smooth boundary to

Bt2 100 - 130 cm red (2.5YR 4.0/6.0, dry) sandy clay; strong medium subangular blocky slightly sticky, slightly plastic, firm; many medium continuous exped and inped tubular pores; few fine roots between peds; gradual smooth boundary to

Bt3	130 - 165 cm	red (2.5YR 4.0/6.0, dry) sandy clay; strong medium subangular blocky slightly sticky, slightly plastic, firm; few fine continuous inped tubular pores; few fine roots between peds; gradual smooth boundary to

ANALYTICAL DATA:

Hor. no.	Top - Bot	>2 mm	2000 1000	1000 500	500 250	250 100	100 50	TOT SAND	50 20	20 2	TOT SILT	<2 µm	DISP	BULK DENS	pF- 0.0	1.0	1.5	2.0	2.3	2.7	3.4	4.2
1	0 - 25	0	2	11	18	24	9	65	2	6	8	28	17.1	1.23	46	44	34	26	24	22	17	17
2	25 - 60	0	2	9	15	19	9	54	5	3	7	39	32.2	1.41	39	38	35	32	31	29	26	25
3	60 - 100	0	2	8	11	13	7	41	9	2	10	49	37.5	-	-	-	-	-	-	-	-	-
4	100 - 130	0	2	7	10	14	8	41	3	3	6	54	17.5	-	-	-	-	-	-	-	-	-
5	130 - 165	0	2	7	9	14	8	40	3	4	6	54	1.5	-	-	-	-	-	-	-	-	-
6	165 - 240	0	3	7	9	12	8	38	3	4	7	55	3.5	-	-	-	-	-	-	-	-	-
7	240 - 310	0	2	7	8	12	9	37	3	5	7	56	2.6	-	-	-	-	-	-	-	-	-
8	310 - 365	0	3	7	8	12	8	38	4	5	9	54	2.1	-	-	-	-	-	-	-	-	-
9	365 - 410	0	4	7	8	12	9	39	3	3	6	55	1.0	-	-	-	-	-	-	-	-	-

Hor. no.	pH- H2O	KCl	CaCO3 %	ORG- C %	MAT. N %	EXCH CAT. Ca	Mg	K	Na	sum	EXCH AC. H+Al	Al	CEC soil	clay	OrgC	ECEC	BASE SAT %	Al SAT %	EC 2.5 $mS\ cm^{-1}$
						$cmol_c\ kg^{-1}$													
1	7.3	6.8	1.9	2.20	0.10	15.8	2.1	0.0	1.4	19.3	-	-	17.9	64	7.7	19.3	108	-	0.15
2	7.4	6.3	0.6	0.58	0.06	5.8	1.1	0.0	0.8	7.7	-	-	7.6	20	2.0	7.7	101	-	0.05
3	7.4	6.3	0.8	0.32	0.05	3.9	1.1	0.0	0.6	5.6	-	-	5.5	11	1.1	5.6	102	-	0.04
4	7.1	6.3	0.5	0.23	0.04	3.1	1.4	0.0	0.5	5.0	-	-	3.6	7	0.8	5.0	139	-	0.04
5	7.2	6.4	0.6	0.16	-	3.1	1.5	0.3	0.0	4.9	-	-	4.6	9	0.6	4.9	107	-	0.04
6	7.5	6.8	0.5	0.12	-	2.8	2.1	0.4	0.0	5.3	-	-	4.7	9	0.4	5.3	113	-	0.06
7	7.5	6.8	0.5	0.06	-	2.2	2.2	0.5	0.0	4.9	-	-	3.7	7	0.2	4.9	132	-	0.05
8	7.5	6.8	0.5	0.07	-	1.9	1.4	0.7	0.0	4.0	-	-	3.6	7	0.2	4.0	111	-	0.05
9	7.5	6.7	0.4	0.09	-	2.1	1.0	0.8	0.0	3.9	-	-	4.2	8	0.3	3.9	93	-	0.05

ELEMENTAL COMPOSITION OF TOTAL SOIL (in weight %) AND MOLAR RATIOS

Hor. no.	SiO2	Al2O3	Fe2O3	CaO	MgO	K2O	Na2O	TiO2	MnO2	P2O5	IGN. LOSS	SiO2/ Al2O3	SiO2/ Fe2O3	SiO2/ R2O3	Al2O3/ Fe2O3
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

CLAY MINERALOGY (1 very weak,.., 8 very strong) / EXTRACTABLE Fe Al Si Mn (by AMM. OXALATE(o), Na DITHIONITE(d) & PYROPHO(p)

Hor. no.	MI	VE	CH	SM	KA	HA	ML	QU	FE	GI	GO	HE	Fe(o)	Al(o)	Si(o)	Fe(d)	Al(d)	Fe(p)	Al(p)	Pret	pHNaF
1	-	-	1	-	8	-	-	2	-	-	3	-	0.17	0.27	0.08	1.49	0.25	-	-	-	-
2	-	-	3	-	8	-	-	1	-	-	3	-	0.12	0.16	0.03	2.16	0.29	-	-	-	-
3	-	-	3	-	8	-	-	1	-	-	3	-	0.09	0.11	0.03	2.68	0.33	-	-	-	-
4	-	-	3	-	8	-	-	1	-	-	3	-	0.08	0.11	0.03	2.78	0.36	-	-	-	-
5	-	-	3	-	8	-	-	1	-	-	3	-	0.08	0.08	0.03	2.68	0.33	-	-	-	-
6	-	-	3	-	8	-	-	1	-	-	3	-	0.05	0.11	0.03	2.84	0.34	-	-	-	-
7	-	-	2	-	8	-	-	1	-	-	3	-	0.04	0.08	0.03	2.96	0.36	-	-	-	-
8	-	-	-	-	8	-	-	1	-	-	3	-	0.04	0.08	0.03	2.64	0.33	-	-	-	-
9	-	-	-	-	8	-	-	1	-	-	3	-	0.03	0.08	0.03	2.26	0.27	-	-	-	-

remarks (hor. 1 - 7): CHLOR=soil chlorite

Annex 1B ISIS Data Sheet NG 20

ISIS 4.0 data sheet of reference soil NG 20 Country : NIGERIA Print date (dd/mm/yy) : 25/04/95

FAO/UNESCO (1988) : Gleyic Acrisol (1974 : Ferric Luvisol)
USDA/SCS SOIL TAXONOMY (1992) : sandy over clayey, kaolinitic, isohyperthermic (1975 : Aquic Kanhapludult)
LOCAL CLASSIFICATION : Owode Series

DIAGNOSTIC CRITERIA USDA/SCS (1992) : Soil moisture regime : udic
FAO (1974) & USDA (1975) : Diagnostic horizons : argillic
: Soil moisture regime : udic

LOCATION : Lagos State, Ikorodu, Lagos Polytechnic
Latitude : 6°37′ 0′′ N Longitude : 3°30′ 0′′ E Altitude : 30 m a.s.l.
AUTHOR(S) : Oluwatosin, Akinbola Date (mm/yy) : 1/91

GENERAL LANDFORM : low hill Topography : undulating
PHYSIOGRAPHIC UNIT :
SLOPE Gradient : 4% Aspect : Form : straight
POSITION OF SITE : lower slope
MICRO RELIEF Kind :
SURFACE CHAR. Rock outcrop : nil Stoniness : nil
Cracking : nil Slaking/crusting : nil
Salt : nil Alkali : nil
SLOPE PROCESSES Soil erosion : no
Slope stability : stable

PARENT MATERIAL 1 : slope wash derived from : sandstone
Texture : sandy clay
Weathering degree : high Resistance :
Remarks :

EFFECTIVE SOIL DEPTH : 173 cm

WATER TABLE Depth : Kind : no watertable observed
DRAINAGE : well
PERMEABILITY : No slowly permeable layer(s) cm
MOISTURE CONDITIONS PROFILE : 000 - 037 cm dry 037 - 390 cm moist

LAND USE : fallow
VEGETATION Type : semi deciduous forest Status : secondary

ADDITIONAL REMARKS :

BRIEF CHARACTERIZATION OF THE SOIL:
Very deep, well drained reddish sandy clay derived from sandstone, with strong mottling and many horizontal tubular pores in the subsoil. Profile extends down to 390 cm.

CLIMATE : Köppen: Aw
Station: IKEJA 6 36 N/ 3 20 E 30 m a.s.l 19 km W of site Relevance: good

	No. years of record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
pot. evapotransp. mm		119	122	135	129	123	101	93	97	99	113	116	120	1367
precipitation mm	23	19	39	99	116	221	337	280	83	218	176	68	20	1676
T mean °C		26.6	27.5	27.6	27.3	26.6	25.5	24.3	24.2	25.0	25.5	26.7	26.7	26.1
bright sunshine $h\ d^{-1}$		6.1	7.0	6.0	5.9	5.6	3.5	2.4	3.0	3.4	5.3	6.3	6.4	4.8

PROFILE DESCRIPTION :

Ap 0 - 20 cm brown (7.5YR 4.0/2.0, dry) sandy loam; weak medium crumb, very friable, soft; many medium discontinuous exped and inped tubular pores; many coarse roots throughout; gradual wavy boundary to

BA 20 - 37 cm 5.0YR 4.0/6.0, dry sandy clay loam; strong medium subangular blocky, slightly plastic, friable, very hard; many medium discontinuous exped and inped tubular pores; many coarse roots throughout; clear smooth boundary to

Bt1 37 - 85 cm dark reddish brown (2.5YR 3.0/4.0, moist) sandy clay; strong medium subangular blocky, slightly plastic, firm; few medium faint clear mottles (2.5Y 5.0/6.0); many medium discontinuous exped and inped tubular pores; many medium roots between peds; gradual smooth boundary to

Bt2 85 - 120 cm red (2.5YR 4.0/6.0, moist) sandy clay; moderate medium subangular blocky, slightly plastic, very firm; common medium faint clear mottles (2.5Y 6.0/6.0); many fine continuous inped tubular pores; many medium roots between peds; gradual smooth boundary to

Bt3	120 - 173 cm	red (2.5YR 4.0/6.0, moist) sandy clay; moderate medium subangular blocky, slightly plastic, very firm; common coarse distinct clear mottles (2.5Y 6.0/6.0); many fine continuous inped tubular pores; many fine roots between peds; gradual smooth boundary to
Bt4	173 - 268 cm	red (2.5YR 4.0/6.0, moist) sandy clay; moderate medium subangular blocky, slightly plastic, very firm; common coarse distinct clear mottles (2.5Y 6.0/6.0); many fine continuous inped tubular pores;;

ANALYTICAL DATA:

Hor. no.	Top - Bot	>2 mm	2000 1000	1000 500	500 250	250 100	100 50	TOT SAND	50 20	20 2	TOT SILT	<2 μm	DISP	BULK DENS	pF- 0.0	1.0	1.5	2.0	2.3	2.7	3.4	4.2
1	0 - 20	0	2	10	20	31	13	76	3	4	7	17	9.7	1.28	43	40	30	19	17	16	8	8
2	20 - 37	0	1	7	12	17	7	45	16	7	24	32	23.9	1.32	42	39	34	30	28	26	22	22
3	37 - 85	0	2	8	11	16	8	45	3	2	5	51	3.1	1.33	43	40	36	31	29	26	22	21
4	85 - 120	0	2	8	11	16	8	45	4	2	6	49	1.1	-	-	-	-	-	-	-	-	-
5	120 - 173	0	3	7	11	16	8	45	2	5	7	48	0.9	-	-	-	-	-	-	-	-	-
6	173 - 268	0	4	7	8	14	9	41	3	7	10	50	1.8	-	-	-	-	-	-	-	-	-
7	268 - 313	0	3	6	7	13	9	39	4	10	13	48	2.5	-	-	-	-	-	-	-	-	-
8	313 - 368	0	4	7	8	13	9	42	3	8	11	48	2.0	-	-	-	-	-	-	-	-	-
9	368 - 390	0	3	7	8	15	10	42	3	8	12	46	3.9	-	-	-	-	-	-	-	-	-

Hor. no.	pH- H2O	--¦ KCl	CaCO3 %	ORG- C %	MAT. N %	EXCH CAT. Ca ¦---	Mg	K	Na	sum ---¦	EXCH AC.¦ H+Al	Al	CEC soil	clay	OrgC	ECEC ---¦	BASE SAT %	Al SAT %	EC 2.5 mS cm^{-1}
						cmol$_c$ kg^{-1}													
1	5.4	4.5	-	1.07	0.02	2.0	1.0	0.1	0.0	3.1	0.2	0.2	5.7	34	3.7	3.3	54	4	0.05
2	5.2	4.3	-	0.59	0.06	1.7	0.7	0.0	0.0	2.4	0.8	0.7	5.5	17	2.1	3.2	44	13	0.03
3	5.1	4.2	-	0.44	-	1.1	0.4	0.0	0.0	1.5	1.4	1.4	4.5	9	1.5	2.9	33	31	0.02
4	5.2	4.2	-	0.42	-	0.6	0.5	0.1	0.0	1.2	1.4	1.2	3.5	7	1.5	2.6	34	34	0.01
5	5.3	4.2	-	0.59	-	0.4	0.4	0.1	0.1	1.0	1.5	1.4	3.7	8	2.1	2.5	27	38	0.01
6	4.9	4.1	-	0.14	-	0.2	0.3	0.1	0.1	0.7	1.7	1.7	3.5	7	0.5	2.4	20	49	0.02
7	4.9	4.1	-	0.09	-	0.2	0.2	0.1	0.0	0.5	1.9	1.9	2.6	5	0.3	2.4	19	73	0.01
8	4.9	4.1	-	0.08	-	0.2	0.2	0.1	0.0	0.5	1.9	1.9	3.1	7	0.3	2.4	16	61	0.01
9	4.9	4.1	-	0.06	-	0.0	0.2	0.1	0.1	0.4	1.7	1.6	2.8	6	0.2	2.1	14	57	0.02

ELEMENTAL COMPOSITION OF TOTAL SOIL (in weight %) AND MOLAR RATIOS

Hor. no.	SiO2	Al2O3	Fe2O3	CaO	MgO	K2O	Na2O	TiO2	MnO2	P2O5	IGN. LOSS	SiO2/ Al2O3	SiO2/ Fe2O3	SiO2/ R2O3	Al2O3/ Fe2O3
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

CLAY MINERALOGY (1 very weak,.., 8 very strong) / EXTRACTABLE Fe Al Si Mn (by AMM. OXALATE(o), Na DITHIONITE(d) & PYROPHO(p)

Hor. no.	MI	VE	CH	SM	KA	HA	ML	QU	FE	GI	GO	HE	Fe(o)	Al(o)	Si(o)	Fe(d)	Al(d)	Fe(p)	Al(p)	Pret	pHNaF
1	-	-	4	-	8	-	-	1	-	-	4	-	0.08	0.10	0.02	1.01	0.18	-	-	-	-
2	-	-	4	-	8	-	-	-	-	-	4	-	0.10	0.13	0.03	1.71	0.27	-	-	-	-
3	-	-	3	-	8	-	-	-	-	-	4	-	0.10	0.13	0.03	2.18	0.37	-	-	-	-
4	-	-	3	-	8	-	-	-	-	-	4	-	0.09	0.13	0.03	2.05	0.29	-	-	-	-
5	-	-	3	-	8	-	-	2	-	-	3	-	0.08	0.13	0.03	2.20	0.31	-	-	-	-
6	-	-	1	-	8	-	-	1	-	-	3	-	0.05	0.11	0.03	2.39	0.33	-	-	-	-
7	-	-	1	-	8	-	-	1	-	-	3	-	0.03	0.10	0.03	2.55	0.39	-	-	-	-
8	-	-	1	-	8	-	-	1	-	-	3	-	0.03	0.08	0.03	2.40	0.34	-	-	-	-
9	-	-	1	-	8	-	-	1	-	-	3	-	0.03	0.08	0.05	2.40	0.34	-	-	-	-

remarks (hor. 1 - 9): CHLOR=soil chlorite

Annex 2 Evaluation of Soil/Land Qualities

LAND QUALITY Availability (1) | vh | h | m | l | vl |

vh = very high h = high m = moderate l = low
vl = very low

Hazard/Limitation (2) | n | w | m | s | vs |

n = not present w = weak m = moderate s = serious
vs = very serious

			NG 19					NG 20				
CLIMATE												
Radiation regime	- total radiation	1				■					■	
	- day length	1			■					■		
Temperature regime		1	■					■				
Climatic hazards (hailstorm, wind, frost)		2					■					■
Conditions for ripening		1										
Length growing season		1			■					■		
Drought hazard during growing season		2	■					■				
SOIL												
Potential total soil moisture		1										
Oxygen availability		1										
Nutrient availability		1				■				■		
Nutrient retention capacity		1			■						■	
Rooting conditions		1	■					■				
Conditions affecting germination		1	■					■				
Excess of salts	- salinity	2	■					■				
	- sodicity	2	■					■				
Soil toxicities (e.g. high Al sat.)		2				■				■		
LAND MANAGEMENT												
Initial land preparation		2					■					■
Workability		1	■					■				
Potential for mechanization		1	■					■				
Accessibility	- existing	1	■					■				
	- potential	1										
Erosion hazard	- wind	2										
	- water	2				■				■		
Flood hazard		2	■						■			
Pests and diseases		2				■					■	

COMMENTS

Annex 3 Methods of Soil Analysis

Preparation	Each sample is air-dried, cleaned, crushed (not ground), passed through 2 mm sieve, homogenized. Moisture content is determined at 105° C.
pH H_2O	(1:2.5): 20 g of soil is shaken with 50 ml of deionised water for 2 hours, electrode in upper part of suspension.
pH-KCl	likewise but shaken with 1 *M* KCl.
EC	(1:2.5): Conductivity of pH-H_2O suspension.
Particle-size distribution	Soil is treated with 15% hydrogen peroxide overnight in the cold, then on waterbath at about 80°C. Then boiled on hot plate for 1 hour. Washings until dispersion. Dispersing agent is added (20 ml solution of 4% Na-hexametaphosphate and 1% soda) and suspension shaken overnight. Suspension sieved through 50 μm sieve. Sand fraction remaining on sieve dried and weighed. Clay and silt determined by pipetting from sedimentation cylinder.
Exchangeable bases and CEC	Percolation with 1*M* ammonium acetate pH7 using automatic extractor. (If EC>0.5mS pre-leaching with ethanol 80%). Cations are determined in the leachate by AAS. CEC: saturation with sodium acetate 1*M* pH7; washed with ethanol 80% and then leached with ammonium acetate 1*M* pH7. Na determined by FES.
Exchangeable acidity and Aluminium	The sample is extracted with *1 M* KCl solution and the exchange acidity (H+Al) titrated with NaOH. Al is measured by AAS.
Carbonate	Piper's procedure. Sample is treated with dilute acidand the residual acid is titrated.
Organic carbon	Walkley-Black procedure. The sample is treated with a mixture of potassium dichromate and sulphuric acid at about 125°C. The residual dichromate is titrated with ferrous sulphate. The result expressed in % carbon (because of incomplete oxidation a correction factor of 1.3 is applied).
Total nitrogen	Micro-Kjeldahl. Digested in H_2SO_4 with Se as catalyst. Then ammonia is distilled, trapped in boric acid and titrated with standard acid.
Extractable Iron, Aluminium, Manganese and Silicon	All determinations by AAS. 1 "Free" (Fe, Al, Mn): Holmgren Shaken with sodium citrate (17%) + sodium dithionite (1.7%) solution for 16 hours. 2 "Active" (Fe, Al, Si): Shaken with acid ammonium acetate 0.2 *M* pH 3 for 4 hours in the dark. 3 "Organically bound" (Fe, Al): Shaken with sodium pyrophosphate 0.1 *M* for 16 hours.
Clay mineralogy	Clay is separated as indicated for particle-size analysis. about 10-20 mg of clay is brought on porous ceramic tile by suction and analyzed using a Philips diffractometer.
Soluble salts	Measuring pH, EC, cations and anions in water extracts. 1 1:5 extract. Shaking 30 g of fine earth + 150 ml of water for 2 hours. 2 saturation extract. Adding to 200-1000 g fine earth just enough water to saturate the sample. Standing overnight. After filtration Ca, Mg, Na, K are measured by AAS. Cl with the Chlorocounter and SO_4 turbidimetrically.
Gypsum	To 10 g of fine earth 100 ml of water is added, shaken overnight and centrifuged. Precipitation by adding acetone. Precipitate redissolved in water and determination of Ca by AAS.
Elemental composition	The fine earth is dried, ignited and fused with lithium tetraborate. The formed bead is analyzed by X-ray fluorescence spectroscopy.
Moisture retention	Moisture determinations on undisturbed core samples in silt box (pF1.0;1.5;2.0) and kaolinite box (pF2.3;2.7) respectivily and on disturbed samples in high pressure pan (pF3.4;4.2). Bulk density obtained from dry weight of core sample.

Annex 4 Units, Glossary, Classes and Acronyms

UNITS

$cmol_c\ kg^{-1}$	centimol charge per kilogram (formerly meq/100 g; 1 meq/100 g = 1 $cmol_c\ kg^{-1}$)
μm	micro-metre: 1/1000th of a millimetre.
$mg\ kg^{-1}$	milligram per kilogram (formerly parts per million (ppm))
$mS\ cm^{-1}$	milliSiemens per cm at 25°C (formerly mmho cm^{-1})
MJ	Megajoules (formerly kcal; 1 MJ = 4186.8 kcal)

GLOSSARY

Air capacity	Amount of pore space filled with air 2 or 3 days after soil has been wetted. It is calculated from the difference between amount of water under almost saturated conditions (pF 0.0) and moisture retained at "field capacity" (pF 2.0), and expressed as volume percentage.
Al saturation	Ratio of exchangeable aluminium to the CEC, expressed as percentage.
Available soil moisture	Amount of moisture retained between "field capacity" (pF 2.0) and "wilting point" (pF 4.2), expressed as volume percentage (also called "available water capacity"). It is indicative of the amount of moisture available for plant growth.
Base saturation	Ratio of the sum of bases to the CEC, expressed as percentage.
Bulk density	Weight of an undisturbed soil sample divided by its volume.
CEC	Cation exchange capacity, indicative of the potential nutrient retention capacity of the soil.
Clay mineralogy	Type of clay-sized (< 2μm) particles.
kaolinite	Clay mineral with a low nutrient retention capacity, common in soils from (sub)tropical regions.
smectite	Silica-rich clay mineral with a high nutrient retention capacity and the ability to absorb water, resulting in swelling of the clay particles.
illite	Potassium-rich clay mineral with a moderately high nutrient retention capacity, common in soils from temperate regions and in alluvial soils.
vermiculite	Clay mineral with a high nutrient retention capacity and strong potassium-fixation.
chlorite	Aluminium-rich clay mineral with a moderately high nutrient retention capacity, occurring in variable quantities in soils rich in aluminium.
halloysite	Clay mineral with a moderately high nutrient retention capacity, common in soils derived from volcanic ashes.
quartz	Residual silica, resistant to weathering.
feldspar	Residual primary mineral, unstable in soil environments and, if present, indicative of a slight to moderate degree of weathering.
hematite	Reddish coloured iron oxide, common in well drained soils of tropical regions.
goethite	Yellowish coloured hydrated iron oxide, common in soils of temperate regions.
gibbsite	Aluminium hydroxide, indicative of a high degree of weathering.
Consistence	Refers to the degree and kind of cohesion and adhesion of the soil material, or to the resistance to deformation or rupture.
ECEC	Effective cation exchange capacity. It is calculated by addition of the sum of bases and exchangeable acidity, and reflects the actual nutrient retention capacity of the soil.
ESP	Exchangeable sodium percentage, ratio of exchangeable sodium to the CEC, expressed as percentage.
Exchangeable acidity	Sum of exchangeable hydrogen and aluminium.
Fine earth fraction	Part of the soil material with a particle-size of 2 mm or less (nearly all analyses are carried out on this soil fraction).
Horizon	Layer of soil or soil material approximately parallel to the earth's surface.
Land characteristic	Measurable property of land (e.g. texture).
Land quality	Set of interacting land characteristics which has a distinct influence on land suitability for a specified use (e.g. erosion hazard, which is a.o. influenced by slope, rainfall intensity, soil cover, infiltration rate, soil surface characteristics, texture).
Leaching	Downward or lateral movement of soil materials in solution or suspension.
Mottle	Spot or blotch differing in colour from its surroundings, usually indicative of poor soil drainage.
Organic carbon	Content of organic carbon as determined in the laboratory (% org. C x 1.72 = % org. matter)
Parent material	The unconsolidated mineral or organic material from which the soil is presumed to have been developed by pedogenetic processes.
pF value	Measure for soil moisture tension.
SAR	Sodium adsorption ratio of the soil solution, indicative of sodication hazard.
Soil reaction (pH)	Expression of the degree of acidity or alkalinity of the soil.

Soil structure	Aggregates of primary soil particles (sand, silt, clay) called peds, described according to grade, size and type.
Sum of bases	Total of exchangeable calcium (Ca^{++}), magnesium (Mg^{++}), potassium (K^{+}) and sodium (Na^{+}).
Texture	Refers to the particle-size distribution in a soil mass. The field description gives an estimate of the textural class (e.g. sandy loam, silty clay loam, clay); the analytical data represent the percentages sand, silt and clay measured in the laboratory.
Water soluble salts	Salts more soluble in water than gypsum.

CLASSES OF SOME ANALYTICAL SOIL PROPERTIES

Organic Carbon - C (%)

< 0.3	very low
0.3 - 1.0	low
1.0 - 2.0	medium
2.0 - 5.0	high
> 5.0	very high

Acidity pH-H_2O

< 4.0	extremely acid
4.0 - 5.0	strongly acid
5.0 - 5.5	acid
5.5 - 6.0	slightly acid
6.0 - 7.5	neutral
7.5 - 8.0	slightly alkaline
8.0 - 9.0	alkaline
> 9.0	strongly alkaline

Available phosphorus (mg kg^{-1})	Olsen	Bray
low	< 5	< 15
medium	5 - 15	15 - 50
high	> 15	> 50

CEC [pH7] ($cmol_c$ kg^{-1} soil)

< 4	very low
04 - 10	low
10 - 20	medium
20 - 40	high
> 40	very high

Sum of bases ($cmol_c$ kg^{-1} soil)

< 1	very low
1 - 4	low
4 - 8	medium
08 - 16	high
> 16	very high

Base saturation - BS [CEC pH7] (%)

< 10	very low
10 - 20	low
20 - 50	medium
50 - 80	high
> 80	very high

Aluminium saturation (%)

< 5	very low
05 - 30	low
30 - 60	moderate
60 - 85	high
> 85	very high

Exchangeable sodium percentage - ESP (%)

Soil structure		*Crops*
< 5	very low	< 2
05 - 10	low	02 - 20
10 - 15	medium	20 - 40
15 - 25	high	40 - 60
> 25	very high	> 60

Bulk density (kg dm^{-3})

< 0.9	very low
0.9 - 1.1	low
1.1 - 1.5	medium
1.5 - 1.7	high
> 1.7	very high

ACRONYMS

FAO	Food and Agriculture Organization of the United Nations
ISIS	ISRIC Soil Information System
ISRIC	International Soil Reference and Information Centre
SCS	Soil Conservation Service
UNESCO	United Nations Educational, Scientific and Cultural Organization
USDA	United States Department of Agriculture

Soil Briefs of Nigeria

(ISSN: 1381-6950)

No.	Title	No. of soils*
Nigeria 1	Sandy reference soils of the moist lowlands near Ibadan (Oyo state)	2
Nigeria 2	Reference soils of the coastal swamps near Ikorodu (Lagos state)	2
Nigeria 3	Reference soils of the moist lowlands near Ife (Oshun state)	1
Nigeria 4	Reference soils of the moist lowlands near Ilesa (Oshun state)	2
Nigeria 5	Reference soils of the moist lowlands near Itagunmodi (Oshun state)	1
Nigeria 6	Reference siols of the moist lwlands near Ondo (Ondo state)	2
Nigeria 7	Reference soils of the Southern Guinea Savanna of south western Nigeria (Oyo state)	1
Nigeria 8	Reference soils of the Southern Guinea Savanna of central-western Nigeria (Oyo state)	2

Country Reports

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2	P.R. of China	51
3	Turkey	15
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5	Thailand	13
6	Colombia	18
7	Indonesia	48
8	Ecuador	in prep.
9	Brazil	28
10	Peru	21
11	Nicaragua	11
12	Costa Rica	12
13	Zambia	11
14	Uruguay	10
15	Gabon	6
16	Ghana	in prep.
17	Philippines	6
18	Zimbabwe	13
19	Spain	20
20	Italy	17
21	Greece	in prep.
22	India	in prep.
23	Kenya	in prep.
24	Mali	in prep.
25	Nigeria	in prep.
26	Mozambique	in prep.
27	Botswana	in prep.

* State of reference collections as of January 1995