Soil Brief *Venezuela 1*

VENEZUELA

Reference Soils of the Machiques Colon Area

N. Noguera
W. Peters
L. Jimenez

Universidad del Zulia - Facultad de Agronomía

ISRIC

International Soil Reference and Information Centre

CONTENTS

ABSTRACT iv

FOREWORD v

1. Main physiographic provinces and natural regions of Venezuela 1

2. The Maracaibo Lake Basin 3

3. Reference soils Zu-04 and Zu-05 5
3.1. Location and occurrence 5
3.2. Climate 5
3.3. Geology, geomorphology, vegetation and land use 5
3.4. Soil characteristics 5
3.5. Soil classification 7
3.6. Land classification and soil management 7

REFERENCES 8

ANNEXES
1A, 1B ISIS Data Sheets Zu-04 and Zu-05 9
2A, 2B Evaluation of land qualities 13
3 Glossary 15

FIGURES
1. Main physiographic provinces and natural regions of Venezuela vi
2. Rainfall distribution of the Maracaibo Lake Basin 4
3. Spatial variability of the rainfall in the Maracaibo Lake Basin. 4
4.Rainfall and Evaporation of the Catatumbo meteorological station. 4
5. Organic carbon, sum of cations, pH paste and $pH_{1:2}$ Zu-04, Zu-05 6

PHOTOGRAPHS
1 Profile of Zu-04 17
2 Landscape and land use of Zu-04 17
3 Profile of Zu-05 18
4 Landscape and land use of Zu-05 18

ABSTRACT

Two representatitve soils located in the Machiques Colon Area were studied for the establishment of a soil reference collection and pedon database of the Maracaibo Lake Basin, Venezuela.

A short description of the main physiographic regions of Venezuela is given and a more detailed analysis of geology, climate and vegetation of the Maracaibo Lake Basin.

Both soils are derived from materials belonging to the La Villa Formation of Pliocene age and are located within the Humid Tropical Forest with over 2900 mm of rainfall per year and a udic soil moisture regime.

The first soil (Zu-04) is a somewhat poorly drained greyish brown loam, strongly acid with very low natural fertility and relatively poor physical conditions. This soil is classified as Gleyic Acrisol according to FAO and as Aquic Hapludult according to Soil Taxonomy.

The second soil (Zu-05) is a well drained brown sandy loam in the surface layer and sandy clay loam in the subsoil, strongly acid with very low natural fertility but good physical conditions. This soil is classified as Haplic Acrisol according to FAO and Typic Paleudult according to Soil Taxonomy.

Both soils are used for grazing mainly with grasses adapted to the specific conditions of acidity and low fertility.

FOREWORD

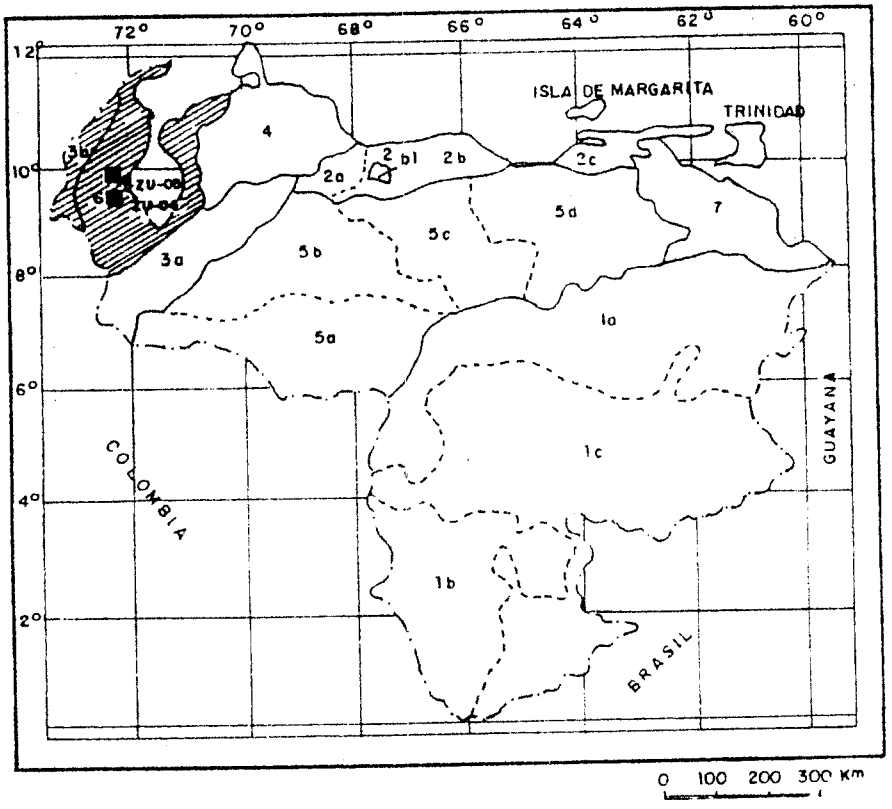
The main objective of this soil brief is to present a synthesis of the characteristics of two reference soils. Therefore a summary of the main morphological, physical and chemical characteristics is given as well as some relevant information on geology, geomorphology, land use and soil management.

Target user groups for this soil brief are both soils scientists and farmers.

This document presents two reference soils from the Maracaibo Lake Basin.

The project has been supported by ISRIC-NASREC and financed by CONDES (Council for Scientific and Technological Development of Zulia State University).

Figure 1. Main physiographic provinces and natural regions of Venezuela / Location map.



① **Guyana Shield**

- 1a Penillanura del Norte
- 1b Penillanura del Casiquiare
- 1c Tepuis y Gran Sabana

② **Costal Range**

- 2a Tramo Occidental
- 2b " Central
- 2b1 Depresión Lago Valencia
- 2c Tramo Oriental

③ **Andes System**

- 3a Cordillera de Mérida
- 3b Cordillera de Perijá

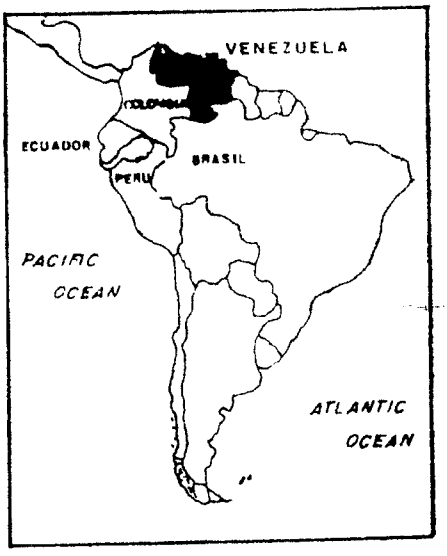
④ **Coreano System or North-Western Mountains System.**

⑤ **Central Plains**

- 5a Llanos Meridionales
- 5b Llanos Occidentales
- 5c Llanos Centrales
- 5d Llanos Orientales

⑥ **Maracaibo Lake Basin**

⑦ **Orinoco Delta**



1. MAIN PHYSIOGRAPHIC PROVINCES AND NATURAL REGIONS OF VENEZUELA

Venezuela is located in the Northern part of South America between 0 and 12° northern latitud and 50 and 73° western length and covers about 91.5 million hectares. The country presents a great diversity of soils due to a great variety of soil forming factors.

From the climatic point of view the life or bioclimatic zones cover the whole range between arid and semi arid with xerophytic plants and humid with the typical tropical rain forest. At the same time the temperature varies from 28° - 30°C (medium) in the low lands to 0°C at 4500 m a.s.l.

The topography presents every relief form between steep mountains and large plains.

Parent material consists of almost every kind of rock, sedimentary and metamorphic.

Soil age varies from the very old stable formations on the Guayana Shield to the very young sedimentary plains like the Orinoco Delta.

In order to synthesize the variety of soils the following subdivision of the country is made taking into account mainly geology, relief and hidrology (3,17):

a) Guayana Shield
b) Costal Range
c) Andes
d) Coro System or Western Central Mountain system
e) Central Plains
f) Maracaibo Lake Basin
g) Orinoco Delta

The Guayana Shield.

One of the oldest geological surfaces of the world is represented by the Guayana Shield. It covers about 45% of the national territory, represents 70% of its forested areas and 84% of its hydric resources. The parent material consists of a crystaline basement of igneous and metamorphic rocks. Water erosion has been modeling this area leaving a generally flat topography. On top of this basement sedimentary formations have been deposited like the Imataca Series (rich in iron). The Pastora Series (goldbearing) and the Roraima Formation (sandstone). This last formation is about 800 meters thick and is the main source of the sediments deposited in the Llanos and the Orinoco Delta. Remnants of this formation are the "tepuyes" (inselbergs). Rainfall in the area is over 2000 mm and increases from North to South. Soil formation has been very intensive during a long time leaving deeply weathered soils of low activity clays and low natural fertility.

The Orinoco Delta.

The general topography of the Orinoco Delta is flat. This enormous plain is very dynamic with continuous accumulation of fluvial and marine sediments and peat. As a direct consequence of this sedimentation pattern the soils are very young and their characteristics are determined by the parent materials. About 75% of the soils are mineral the rest are organic. Drainage of the delta is poor with most of the soils saturated permanently except the river levees and the areas with artificial drainage. Rainfall varies from 1200 in the east to 2600 in the west. Vegetation is typical of the humid to subhumid conditions with predominance of marshy formations.

The Llanos.

The Llanos are located in the central part of the country and cover about 30% of the

national territory. This region is subdivided in Central, Eastern, Western and Southern Llanos. In the past the Llanos consisted in a huge depression that has been filled with sediments from the Guayana Shield mainly. The general topography is flat with soils that vary from well developed with argillic horizons in the Eastern Llanos to very young alluvial soils in the rest of the Llanos. Rainfall varies from 900 mm in the east to 2000 in the west with well defined wet and dry seasons. Vegetation reflects this climate pattern and varies from savanas in the east to remnants of forests in the west. The Llanos are very important in agricultural production (Western and Central) and livestock production (Central and Eastern).

The Andes.

The Venezuelan Andes belong to the American Andes System. Within the Venezuelan territory the system splits in two: towards the northeast the Merida Range and towards the north the Perija Range with the Maracaibo Lake Basin in between. The Andes represents a geological mosaic of igneous, sedimentary and metamorphic rocks of all ages from Precambric to Quaternary. The height above sea level varies from 200 to more than 5000 mt that implies a great variety in rainfall and temperature. As a consequence of this wide ecological range the variability of the soils in the Andes is enormous. The area is very important because of horticultural production.

The Coro System and its Margins.

In this region three important mountain systems come together: the Coro System, the eastern part of the Coastal Range and the extremes of the Andes. The geological material presents a wide variety of igneous, metamorphic and sedimentary rocks. This region is subdivided in two climatic areas: semiarid in the north with less the 700 mm of rainfall per year and subhumid to humid in the south with rainfall between 800 and 1800 mm. This wide variability of climatic characteristics and of parent materials explains the enormous differences in soils of this region.

Coastal Range.

This system is subdivided in two subsystems, the Central and the Eastern, separated by the depression of Unare and Cariaco. Both subsystems are subdivided in two ranges each: the littoral and the interior with depressions in between like the Valencia Lake, the Tuy Valley and the Gulf of Cariaco.

The mountain areas consist in metamorphic rocks mainly with some igneous intrusions and sedimentary rocks in the Eastern Coastal Range mainly. The climatic characteristics are varying from desert conditions through subhumid to extremely humid with rain forests. Soils in the mountain areas vary according to parent material and climate whereas in the depressions they reflect the characteristics of the colluvial and alluvial materials.

2. THE MARACAIBO LAKE BASIN

The general landscape presents marked contrasts with a sequence of relief forms characterized by a decrease of slope grade from the mountains in the east and west (Andes and Perija Ranges) to the Maracaibo Lake. Within these sequence the follwing landscape types can be distinguished: mountains with heights of more than 4000 m.a.s.l., foothills with heights up to 300 m.a.s.l., and a very pronounced relief and the large plains that consist in alluvial plains and marshes (15).

The main climatic characteristic of the Maracaibo Lake Basin is the sequence of rainfall that exists from north to south with yearly values of 300 mm in the north and 2900 mm in the south (fig. 2 and 3).

The evaporation is high in the whole Basin with values in the north of 2700 that are decreasing to the south where they reach 1300 mm per year.

The mean annual temperature fluctuates between 26 and 29 ºC. The climate of the Maracaibo Lake Basin is warm and dry in the north and warm and humid in the south.

The formations of the natural vegetation reflect the climatic conditions. In the north the tropical desert shrubs and the very dry tropical forest are predominant, whereas in the south the dry and humid tropical forest can be found.

Figure 2. Rainfall distribution of the Maracaibo Lake Basin.

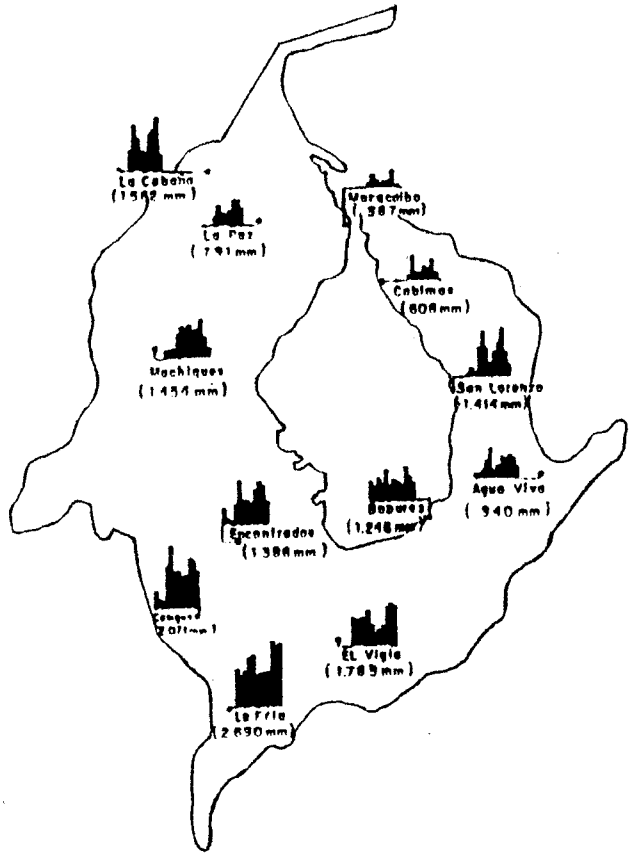


Figure 3. Spatial variability of the rainfall in the Maracaibo lake Basin.

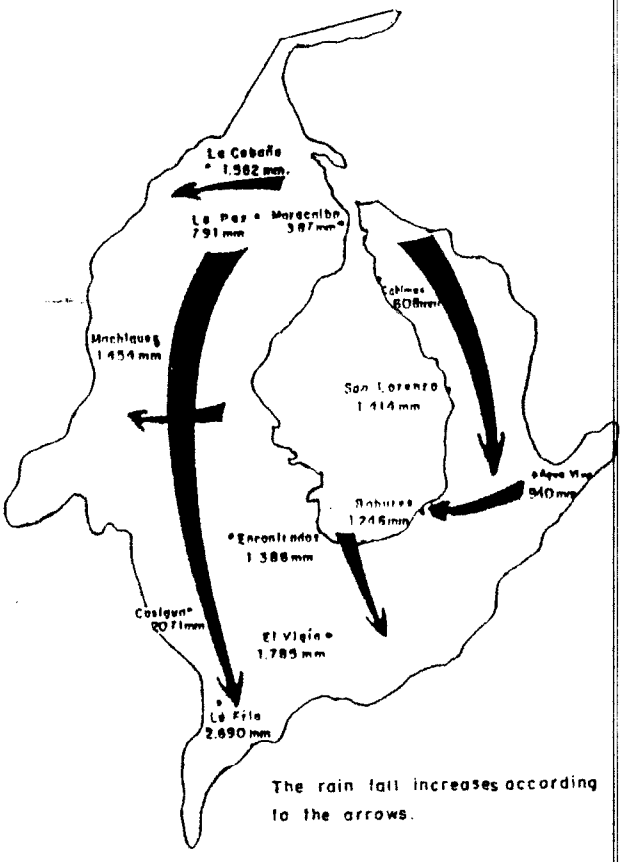
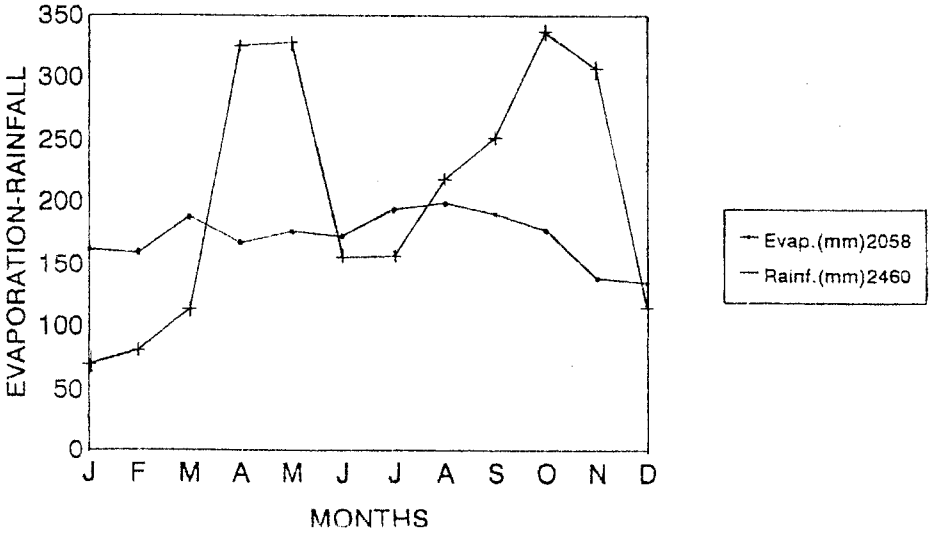


Figura 4
Rainfall and evaporation of the catatumbo meteorological station



3. REFERENCE SOILS ZU-04 AND ZU-05

A brief description is made of the main characteristics of two reference soils (Zu-04 and Zu-05). The data can be found in annexes 1A and 1B.

3.1 Location and occurrence.

The profiles Zu-05 (well drained) and Zu-04 (poorly drained) are located within the Machiques Colon area some 120 km south of Maracaibo in the Western part of the Basin. Both soils are within the area of influence of the Acid Soils Project and are representative of an area of about 500.000 Ha in the southwestern part of the Basin that belongs to the Humid Tropical Forest.

3.2 Climate

The area presents the characteristics of a humid tropical climate. The metereological station that is representative for this region is Catatumbo. Fig. 4 shows a total yearly rainfall of 2900 mm and an evaporation of 2000 mm. During at least nine months per year the rainfall exceeds the evaporation and for this reason the soil moisture regime is udic according to Soil Taxonomy. The rainfall distribution throughout the year shows two peaks (Fig. 4). The mean annual temperature is 28ºC and the mean solar radiation is 498 cal cm^{-2} day^{-1}, soil temperature regime is isohyperthermic according to Soil Taxonomy.

3.3 Geology, geomorphology, vegetation and land use.

The general landscape is of footslopes with two relief forms: a) dissected with high hills b) softly undulating with elongated low hills.

The soils of the area are residual developed in materials belonging to the "la Villa formation" of Terciary Age. This material consists in coloured compact sandstone of fine grains and white mottled claystone.

The natural vegetation belongs to the Humid Tropical Forest according to Holdridge (7). Only some remnants are left and the area is used mainly for grazing. In some areas a secondary vegetation can be seen.

The grass and leguminous species have been selected for their adaption to the very specific condition of poor acid soils.

The last few years the oil palm (Elaeis Guineensis) has been introduced succesfully in the area.

3.4 Soil Characteristics

Field description:

Zu-04: Somewhat poorly drained soil with a well developed argillic horizon, subangular blocky structure in the whole profile, sandy loam in the topsoil and loam in the subsoil.

Zu-05: Well drained soil with a well developed argillic horizon. Granular structure in the topsoil and subangular blocky in the subsoil, sandy loam in the topsoil and loam in the subsoil.

Soil analysis:

Soil samples were analyzed at the laboratory of the Agronomy School of Zulia State University, following the procedures which appear in the Methods of Soil Analysis, American Society of Agronomy (1, 2, 4, 5, 6, 10, 11, 16).

Fig. 5 shows the variability with depth of pH H_2O, organic carbon and sum of cations.

Figure 5
PH H2O; % organic carbon: sum of bases (cmol/kg) (x) versus depth (cm) in profile ZU-04

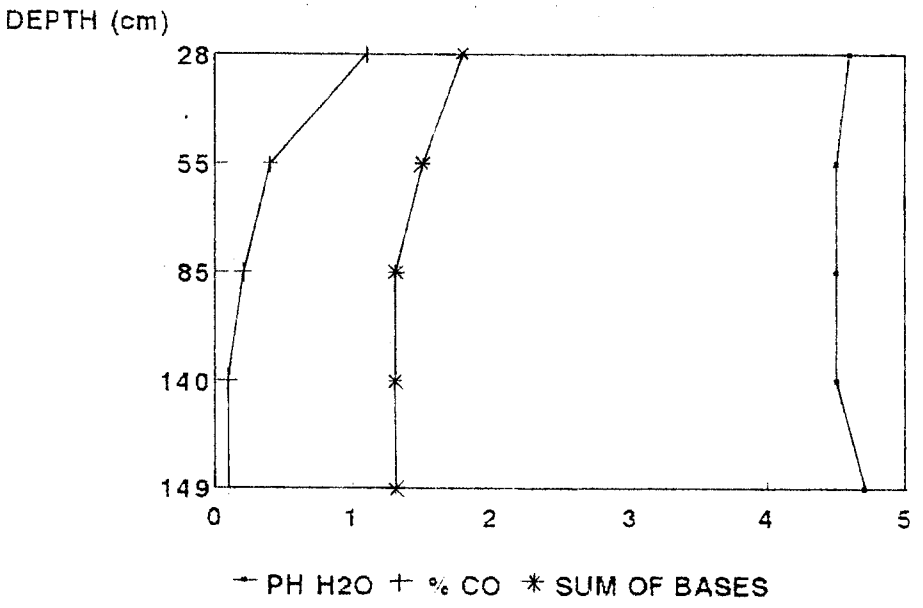
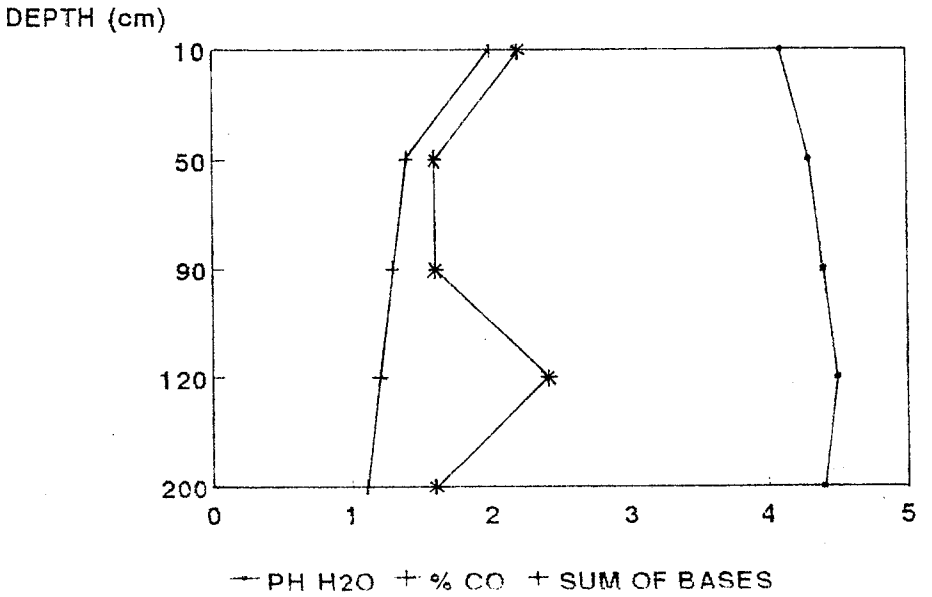


Figura 5
PH H20; % organic carbon; sum of bases (cmol/kg soil) (x) versus depth (cm) in profile ZU-05



Zu-04 texture: loamy throughout the whole profile.

Organic carbon: medium in the surface layer, low in the subsoil.

Acidity: strongly acid throughout the whole profile (pH 4.5-4.7) sum of cations: very low throughout the whole profile (1.3-1.3%).

Cation exchange capacity: low to very low throughout the whole profile (2.9-4.6 cmol/kg).

Zu-05 texture: sandy loam in the surface layer and sandy clay loam from 50 cm down.

Organic carbon: high in the surface layer and medium in the subsoil.

Acidity: strongly acid throughout the whole profile (pH 4.1-4.5)

Sum of cations: low throughout the whole profile (1.6-2.4%).

Cation exchange capacity: low throughout the whole profile (4.4-5.2) (see figure 5).

3.5 Soil Classification.

FAO-UNESCO (1980)	SOIL TAXONOMY (1992)
Zu-04 Gleyic Acrisol	Aquic Hapludult
Zu-05 Haplic Acrisol	Typic Paleudult

According to FAO-UNESCO (9) both soils were classified as Acrisols because they have an argic B horizon with a cation exchange capacity of less than 24 $cmolkg^{-1}$ and a base saturation of less than 50%. Zu-04 is a Gleyic Acrisol because of its gleyic properties within 100 cm from the surface.

Zu-05 is a Haplic Acrisol because it does not show any specific features.

In the USDA SCS Soil Taxonomy System (12) both soils were classified as Ultisols, Udults because of the presence of an argillic horizon with a base saturation of less than 35% and a udic soil moisture regime. Because of the presence of redoximorphic features Zu-04 keyed out as an Aquic Paleudult and Zu-05 as a Typic Paleudult.

3.6 Land classification and soil management.

The reference profile Zu-04 and Zu-05 present the specific problems related to acidity and low fertility. Within the area of influence part of the soils are highly erodable mostly in steep slope positions. Zu-04 represents the poorly drained soils an Zu-05 the well drained.

As a result of some 15 years of research a soil management package has been put into practice very succesfully in the area. A combination of grasses and leguminous plants with specific species for each of the two situations, poorly drained and well drained is used. The selected species are adapted to the soil acidity and low fertility conditions in order to maintain a low input (fertilizer) production system. At the same time the selected species protect the soil against erosion.

Recently oil palm (Elaeis guineensis) has been introduced in the area and the plantations cover about 8000 has. The oil palm is well adapted to the natural conditions of the area, however in order to reach acceptable production levels fertilization is necessary.

REFERENCES

1. Allison, L.E. 1965. Organic Carbon In: C.A. Black; Evans D.D.; White J.L.; Ensminger L.E.; Clark F.E. (Eds). Methods of soil analysis. American Society of Agronomy. Madison. Wisconsin. pp 1367-1378.

2. Bower, C. y L. Wilcox. 1965. Soluble salts. In: C.A. Black; Evans D.D.; White J.L.; Ensminger L.E.; Clark F.E. (Eds). Methods of soil analysis. American Society of Agronomy. Madison. Wisconsin. pp 914-926.

3. Cárdenas, A.L. 1964. Geografía Física de Venezuela. Talleres Gráficos Universitarios. Mérida.

4. Chapman, H. 1965. Cation Exchange capacity. In: C.A. Black; Evans D.D.; White J.L.; Ensminger L.E.; Clark F.E. (Eds). Methods of soil analysis. American Society of Agronomy. Madison. Wisconsin. pp 891-901.

5. Chapman, H. 1965. Total exchange bases. In: C.A. Black; Evans D.D.; White J. L.; Ensminger L.E.; Clark F.e.(Eds). Methods of soil analysis. American Society of Agronomy. Madison. Wisconsin. pp 902-904.

6. Day, P.R. 1965. Particle Fractionation and particle Size analysis. In: C.A. Black; Evans D.D.; White J.L.; Ensminger L.E.; Clark F.E. (Eds). Methods of soil analysis. American Sociery of Agronomy. Madison. Wisconsin. pp 544-567.

7. Ewel, J. and J. Madriz. 1968. Zonas de vida de Venezuela. Memoria explicativa sobre el Mapa Ecológico. Editorial Sucre.

8. FAO 1990. Guidelines for soil profile description, 3rd edition. FAO, Rome.

9. FAO. 1988. FAO/Unesco Soil Map of the World, Revised Legend. World Resources Report 60, FAO, Rome.

10. Peech, N. 1965. Hydrogen ion activity. In: C.A. Black; Evans D.D.; White J.L.; Ensminger L.E.; Clarks F.E. (Eds). Methods of soil analysis. American Sociery of Agronomy. Madison. Wisconsin. pp 914-926.

11. Richards, L. 1965. Physical condition of water in soil In: C.A. Black; Evans D.D.; White J.L.; Ensminger L.E.; Clark F.E. (Eds). Methods of soil analysis American Society of Agronomy. Madison Wisconsin. pp 128-152.

12 Soil Survey Staff. 1992. Key to soil Taxonomy, 5th. edition S.M.S.S. Technical Monograph N°19. Blacksburg, Virginia 541 pp.

13. Van Waveren, E.J., & Bos, A.B. 1988 ISRIC Soil information System. User manual. Technical Paper 15. ISRIC, Wageningen.

14. Van Waveren, E.J., & Bos, A.B. 1988. ISRIC. Guidelines for the description and coding of soil data.. Technical Paper 14, ISRIC, Wageningen.

15. Venezuela. 1974. Comisión del Plan Nacional de Aprovechamiento de los Recursos Hidraulicos (COPLANARH). Inventario Nacional de Tierras. Región del Lago de Maracaibo. Publication N°34. Caracas.

16. Whittig, L. 1965. X ray difraction techniques for mineral identification and mineralogical composition. In: C.A. Black; Evans D.D.; White F.L.; Ensminger L.E.; Clark F.E. (Eds). Methods of soil analysis. American Society of Agronomy. Madison. Wisconsin. pp. 228-236.

17. Zinck, A. 1980. Definición del Ambiente Geomorfológico con fines de Descripción de Suelos. Series: Suelo y Clima, SC-46. CIDIAT, Mérida.

Annex 1A ISIS Data Sheet Zu-04

monolith number: ZU 04 estado: ZULIA soil description LUZ-AGRO 01/01/80

CLASSIFICATION FAO/UNESCO,1974: gleyic acrisol (Final class.)
USDA,1975: hapludult aquic, loamy to sandy, kaolinitic, isohyperthermic
Diagnostic horizons: argillic
(other) Diagn. criteria:
Local classification: AQUIC HAPLUDULT

LOCATION : FINCA EL TRES DE ORO MACHIQUES COLON KM 110
: Latitude: 9 20 N Longitude: 72 25 E Altitude: 80 (m.a.s.l.)
AUTHOR(S) - DATE (mm.yy) : ING.NOGUERA PETER - 10.90

GENERAL LANDFORM : plateau Topography: rolling
PHYSIOGRAPHIC UNIT : MARACAIBO LAKE BASIN
SLOPE Gradient/aspect/form: 9 % ENE convex
POSITION OF SITE : upper slope
MICRO RELIEF Kind: dimples Pattern: isolated
SURFACE CHAR. Rockoutcrops: none Stoniness: none
Cracking: nil Sealing: nil Salt: nil Alkali: nil
SLOPE PROCESSES Soil erosion: slight sheet Aggradation: nil loc. unstable slope

---

PARENT MATERIAL I : colluvium Derived from: mixed lithology Texture: loamy
Weathering degree: high Resistence: high
Remarks: LA VILLA FORMATION

EFFECTIVE SOIL DEPTH(cm) : 200

WATER TABLE Depth(cm): 55 est.highest level: 0 est. lowest level:55 Kind: apparent
DRAINAGE : poor
PERMEABILITY : slow Slow permeable layer from (cm): 0 to: 55
FLOODING frequency: very poor Run off: slow
MOISTURE CONDITIONS PROFILE : 0 - 140 cm moist

LAND USE : cultivated pasture, casava, , ,
VEGETATION Structure: evergreen forest Status: secondary
Landuse/vegetation remarks: HUMID TROPICAL FOREST

CLIMATE koppen: Af Soil Moisture Regime: udic
Station: PUENTE PERU -----8 43 N/72 36 W;62 (m.a.s.l); 10 km S from site. Relevance: very good

	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
PUENTE PERU														
Precipitation (mm)		20	70	81	114	325	328	156	157	218	252	337	307	115	2464

PROFILE DESCRIPTION

Ah 0- 28cm 2.5Y 5.0/2.0 dry; ; leaves, decomposed; fine weak to moderate subangular blocky; slightly sticky slightly plastic friable; common fine distinct clear (2.5YR 4.0/8.0) mottles; no cutans ; nil inclusions; nil fragments; non cemented non cemented non cemented non cemented; frequent worm channels; non calcareous (by 10% HCL); pH(field): 4.7; clear smooth boundary to

E 28- 55cm 2.5Y 5.0/2.0 moist; 2.5Y 6.0/2.0 dry; loam; leaves, decomposed; fine moderate subangular blocky; slightly sticky slightly plastic friable; common fine distinct clear (2.5YR 4.0/8.0) mottles; no cutans ; nil inclusions; nil fragments; non cemented non cemented non cemented non cemented; few worm channels; non calcareous (by 10% HCL); pH(field): 4.7; clear wavy boundary to

Bt1 55- 85cm 10.0YR 5.0/4.0 moist; 10.0YR 6.0/4.0 dry; loam; organic matter, decomposed; fine moderate subangular blocky; slightly sticky slightly plastic friable slightly hard; many fine distinct clear (2.5YR 5.0/8.0) mottles; patchy thin clay cutans on on pedfaces ; nil inclusions; nil fragments; non cemented; few worm channels; non calcareous (by 10% HCL); pH(field): 4.7; clear wavy boundary to

Bt2 85-140cm 10.0YR 6.0/6.0 dry; loam; organic matter, decomposed; fine weak to moderate subangular blocky; sticky plastic firm; many medium distinct clear (2.5YR 5.0/8.0) and many medium distinct clear (10.0YR 4.0/6.0) mottles; continuous moderately thick clay cutans on on pedfaces ; nil inclusions; nil fragments; non cemented non cemented non cemented non cemented; few channels; non calcareous (by 10% HCL); pH(field): 5.2; clear wavy boundary to

Bt3 140-200cm 7.5YR 6.0/8.0 dry; loam; organic matter, decomposed; fine weak to moderate subangular blocky; sticky firm; many medium distinct clear (2.5YR 5.0/8.0) and many medium distinct clear (10.0YR 4.0/6.0) mottles; continuous moderately thick clay cutans on on pedfaces ; nil inclusions; nil fragments; non cemented non cemented non cemented non cemented; few channels; non calcareous (by 10% HCL); pH(field): 5.2;

---

monolith number: ZU 04 analytical data (missing value = -1) ISRIC: 01/01/80

NO	TOP	BOT	>2 mm	2000 1000	1000 500	500 250	250 100	100 50	TOT	50 20	20 2	<2 um	DISP	BULK DENS	pF- 0.0	1.0	1.5	2.0	2.3	2.7	3.4	4.2	SPEC SURF
1	0	28	0	0	7	17	16	9	49	30	13	8	0	0.00	0	0	0	0	0	0	0	0	0
2	28	55	0	0	6	17	16	9	48	23	20	9	0	0.00	0	0	0	0	0	0	0	0	0
3	55	85	0	0	7	18	15	6	45	24	16	15	0	0.00	0	0	0	0	0	0	0	0	0
4	85	140	0	0	6	15	15	7	43	25	15	17	0	0.00	0	0	0	0	0	0	0	0	0
5	140	149	0	0	6	14	15	8	43	25	10	22	0	0.00	0	0	0	0	0	0	0	0	0

No.	pH- H2O	pH- KCl	CaCO3 %	ORG- C %	MAT. N %	EXCH CAT. Ca	Mg	K	Na	sum	EXCH AC. H+Al	Al	CEC soil	CEC clay	CEC OrgC	ECEC	BASE SAT %	Al SAT %	EC 2.5 mS/cm
						meq /100g													
1	4.6	0.0	0.0	1.1	0.09	1.1	0.4	0.3	0.0	1.8	3.1	1.6	4.4	0	0	4.8	40	36	0.17
2	4.5	0.0	0.0	0.4	0.03	0.8	0.4	0.3	0.0	1.5	1.9	1.2	2.9	0	0	3.4	52	41	0.10
3	4.5	0.0	0.0	0.2	0.02	0.8	0.4	0.1	0.0	1.3	2.3	1.5	3.1	0	0	3.6	42	48	0.09
4	4.5	0.0	0.0	0.1	0.03	0.5	0.7	0.1	0.0	1.3	2.5	1.6	3.2	0	0	3.8	40	50	0.06
5	4.7	0.0	0.0	0.1	0.08	0.5	0.7	0.1	0.0	1.3	3.7	1.3	4.6	0	0	4.9	28	28	0.05

Annex 1B ISIS Data Sheet Zu-05

monolith number: ZU 05 estado: ZULIA soil description LUZ-AGRO 01/01/80

CLASSIFICATION FAO/UNESCO,1974: orthic acrisol (Tent. class.)
USDA,1975: paleudult , loamy-sandy, kaolinitic, isohyperthermic
Diagnostic horizons: argillic
(other) Diagn. criteria:
Local classification: Paleudult

LOCATION : CAMPO EXPERIMENTAL SUELOS ACIDOS MACHIQUES COLON
: Latitude: 10 N Longitude: 73 W Altitude: 150 (m.a.s.l.)
AUTHOR(S) - DATE (mm.yy) : ING.NOGUERA Y PETERS - 11.89

GENERAL LANDFORM : hill Topography: undulating
PHYSIOGRAPHIC UNIT : MARACAIBO LAKE BASIN
SLOPE Gradient/aspect/form: 3-8% NW undulating
POSITION OF SITE : upper slope
MICRO RELIEF Kind: dimples Pattern: isolated
SURFACE CHAR. Rockoutcrops: Stoniness:
Cracking: nil Sealing: Salt: nil Alkali: nil
SLOPE PROCESSES Soil erosion: severe rill loc. unstable slope

---

PARENT MATERIAL I : colluvium Derived from: mixed lithology Texture: sandy clay
Weathering degree: high Resistence: moderate
Remarks: LA VILLA FORMATION

EFFECTIVE SOIL DEPTH(cm) : 200

WATER TABLE Depth(cm): Kind: no watertable observed
DRAINAGE : well
PERMEABILITY : high
FLOODING frequency: Run off: medium
MOISTURE CONDITIONS PROFILE : 0 - 200 cm moist

LAND USE : cultivated pasture, , seasorly irrigated,
VEGETATION Structure: medium tall grassland
Landuse/vegetation remarks: HUMID TROPICAL FOREST

CLIMATE koppen: Af Soil Moisture Regime: udic
Station: CATATUMBO OFICINA -----9 11 N/72 40 W;85 (m.a.s.l); 25 km N from site. Relevance: very good

CATATUMBO OFICINA	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
EA (mm)	6	162	159	188	167	176	172	194	199	190	177	139	135	2060
Precipitation (mm)	15	47	57	69	285	364	284	326	360	410	401	267	115	2960
T mean (C)	6	27.5	28.2	28.7	28.4	28.4	28.3	27.9	28.1	28.1	27.8	27.1	27.6	28.1

PROFILE DESCRIPTION

Ap 0- 10cm 10.0YR 3.0/4.0 moist; 10.0YR 5.0/3.0 dry; sandy loam; leaves, decomposed; coarse moderate granular; non sticky non plastic very friable loose; nil mottles; no cutans ; nil pores; many roots; nil inclusions; nil fragments; non cemented; very frequent; non calcareous (by 10% HCL); pH(field): 4.1; clear wavy boundary to

E 10- 50cm 7.5YR 5.0/6.0 moist; 7.5YR 6.0/6.0 dry; sandy loam; , decomposed; very fine weak massive to subangular blocky; slightly sticky slightly plastic very friable soft; nil mottles; no cutans ; nil pores; common roots; nil inclusions; nil fragments; non cemented; frequent; non calcareous (by 10% HCL); pH(field): 4.3; gradual smooth boundary to

Bt1 50- 90cm 7.5YR 5.0/6.0 moist; 7.5YR 6.0/6.0 dry; sandy clay loam; , decomposed; very fine weak subangular blocky; sticky plastic friable hard; nil mottles; patchy thin clay cutans on on pedfaces ; nil pores; common roots; nil inclusions; nil fragments; non cemented; frequent worm channels; non calcareous (by 10% HCL); pH(field): 4.4; gradual smooth boundary to

Bt2 90-120cm 7.5YR 5.0/8.0 moist; 7.5YR 6.0/8.0 dry; sandy clay; , decomposed; very fine weak massive to subangular blocky; sticky plastic friable hard; nil mottles; patchy thin clay cutans on on pedfaces ; nil pores; common roots; very few ferrigenous concretions; nil fragments; non cemented; frequent worm channels; non calcareous (by 10% HCL); pH(field): 4.5; abrupt wavy boundary to

Bt3 120-200cm 7.5YR 5.0/8.0 moist; sandy clay; , decomposed; medium weak subangular blocky; sticky plastic friable; nil mottles; patchy thin clay cutans on on pedfaces ; nil pores; few roots; very few inclusions; nil fragments; non cemented; ; pH(field): 4.4;

monolith number: ZU 05 analytical data <missing value = -1> ISRIC: 01/01/80

NO	TOP	BOT	>2 mm	2000 1000	1000 500	500 250	250 100	100 50	TOT	50 20	20 2	<2 um	DISP	BULK DENS	pF- 0.0	1.0	1.5	2.0	2.3	2.7	3.4	4.2	SPEC SURF
1	0	10	0	6	16	20	18	8	68	13	10	9	0	0.00	0	0	0	0	0	0	0	0	0
2	10	50	0	2	11	18	17	8	56	17	10	17	0	0.00	0	0	0	0	0	0	0	0	0
3	50	90	0	2	11	17	16	7	53	20	9	18	0	0.00	0	0	0	0	0	0	0	0	0
4	90	120	0	5	10	17	14	7	53	14	10	23	0	0.00	0	0	0	0	0	0	0	0	0
5	120	200	0	5	10	15	14	7	51	10	8	31	0	0.00	0	0	0	0	0	0	0	0	0

No.	pH- H2O	pH- 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
						meq /100g-													
1	4.1	0.0	0.0	2.0	0.17	1.2	0.8	0.1	0.1	2.2	3.5	1.6	5.2	0	0	5.7	43	30	0.27
2	4.3	0.0	0.0	1.4	0.12	1.0	0.5	0.0	0.1	1.6	3.0	2.1	4.4	0	0	4.6	36	47	0.14
3	4.4	0.0	0.0	1.3	0.11	1.0	0.5	0.0	0.1	1.6	3.2	2.3	4.5	0	0	4.8	35	51	0.16
4	4.5	0.0	0.0	1.2	0.10	1.2	1.0	0.1	0.1	2.4	3.0	2.5	5.2	0	0	5.4	46	48	0.15
5	4.4	0.0	0.0	1.2	0.10	0.9	0.5	0.1	0.1	1.6	4.0	2.7	5.4	0	0	5.7	30	50	0.13

CLAY MINERALOGY < 1 very weak, 2 weak, 3 medium, 4 strong, 5 very strong > EXTRACT. Fe Al Si

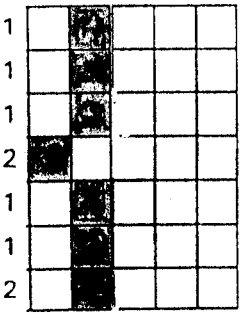
No	MICA/ ILL	VERM	CHLOR	SMEC	KAOL	HALL	MIX*	QUAR	FELD	GIBB	GOET	HEM	FEo	ALo	SIo	MNo	FEd	ALd	SId	FEp	ALp	
4	5	15					.7						0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Annex 2A Evaluation of Land Qualities of ZU-04

LAND QUALITY						
	Availability (1)	vh	h	m	l	vl
	Hazard / Limitation (2)	n	w	m	s	vs

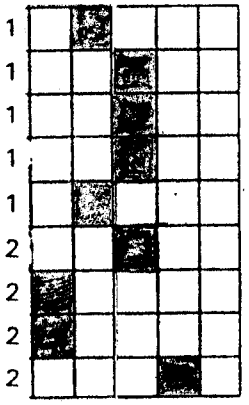
vh	very high	n	not present
h	high	w	weak
m	moderate	m	moderate
l	low	s	serious
vl	very low	vs	very serious

CLIMATE



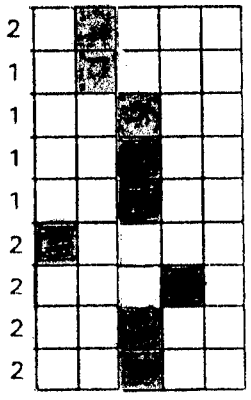
Radiation regime - total radiation	1
- day length	1
Temperature regime	1
Climatic hazards (hailstorm, wind, frost)	2
Conditions for ripening	1
Length growing season	1
Drought hazard during growing season	2

SOIL



Potential total soil moisture	1
Oxygen availability	1
Nutrient availability	1
Nutrient retention capacity	1
Rooting conditions	1
Conditions affecting germination	2
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

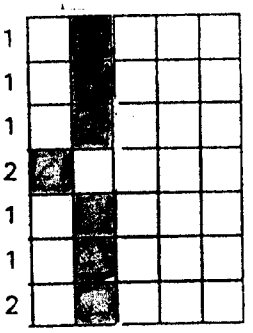
Annex 2B Evaluation of Land Qualities of ZU-05

LAND QUALITY						
	Availability (1)	vh	h	m	l	vl
	Hazard / Limitation (2)	n	w	m	s	vs

vh	very high	n	not present
h	high	w	weak
m	moderate	m	moderate
l	low	s	serious
vl	very low	vs	very serious

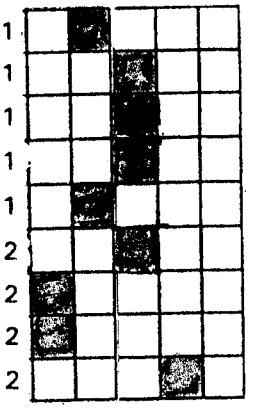
CLIMATE

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



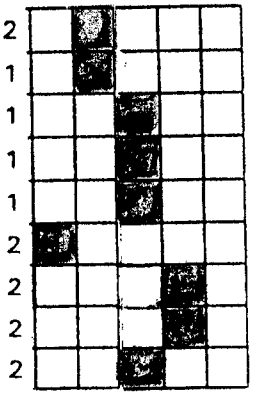
SOIL

Potential total soil moisture	1
Oxygen availability	1
Nutrient availability	1
Nutrient retention capacity	1
Rooting conditions	1
Conditions affecting germination	2
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



Annex 3 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})

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 (%)

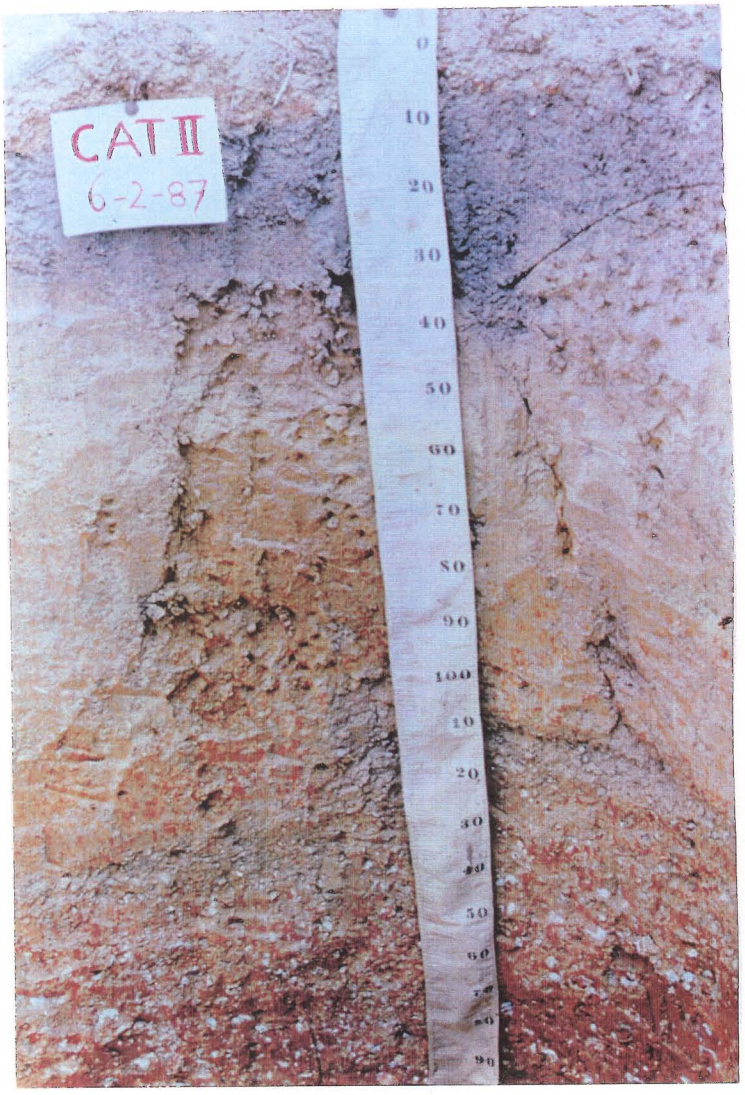
Soil structure		*Crops*
< 5	very low	< 2
05 - 10	low	02 - 20
10 - 15	medium	20 - 40
15 - 25	high	40 - 60
> 25	very high	> 60

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 Agricultural Organization of the United Nations
ISIS	ISRIC Soil Information System
ISRIC	International Soil Reference and Information Centre
L.U.Z.	Zulia State University
ISSAS	Institute of Soil Science - Academia Sinica
SCS	Soil Conservation Service
UNESCO	United Nations Educational, Scientific and Cultural Organization
USDA	United States Department of Agriculture
CONDES	Council for Scientific and Technological Development of Zulia State University



1

1. Profile ZU 4
2. Landscape and land use ZU 4

2

3

3. Profile ZU 5
4. Landscape and land use ZU 5

4