Soil Brief *Venezuela 2*

VENEZUELA

Reference Soils of the Maracaibo Plain

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CONTENTS

ABSTRACT

Two representative solis located in the Maracaibo Plain 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 El Milagro Formation formed during the transition between Pliocene and Pleistocene.

The first soil (Zu-01) is located within the Very Dry Tropical Forest and presents an aridic soil moisture regime and for this reason irrigation is essential for agricultural production. It is a deep well drained reddish brown loamy sand in the surface layer and sandy clay loam in the subsoil, that presents excellent physical conditions. This soil is classified as Cromic Luvisol according to FAO and as Typic Haplagird according to Soil Taxonomy.

The second soil (Zu-02) is located within the Dry Tropical Forest and presents an ustic soil moisture regime that permits permanent grazzing and some rainfed agriculture. It is a deep well drained reddish brown sandy loam in the surface layer and sandy clay loam in the subsoil, that present excellent physical conditions. This soil is also classified as Chromic Luvisol according to FAand as Typic Haplustalf according to Soil Taxonomy because of the ustic soil moisture regime.

In general the two soils are much alike and offer a promising potential use under irrigation.

FOREWORD

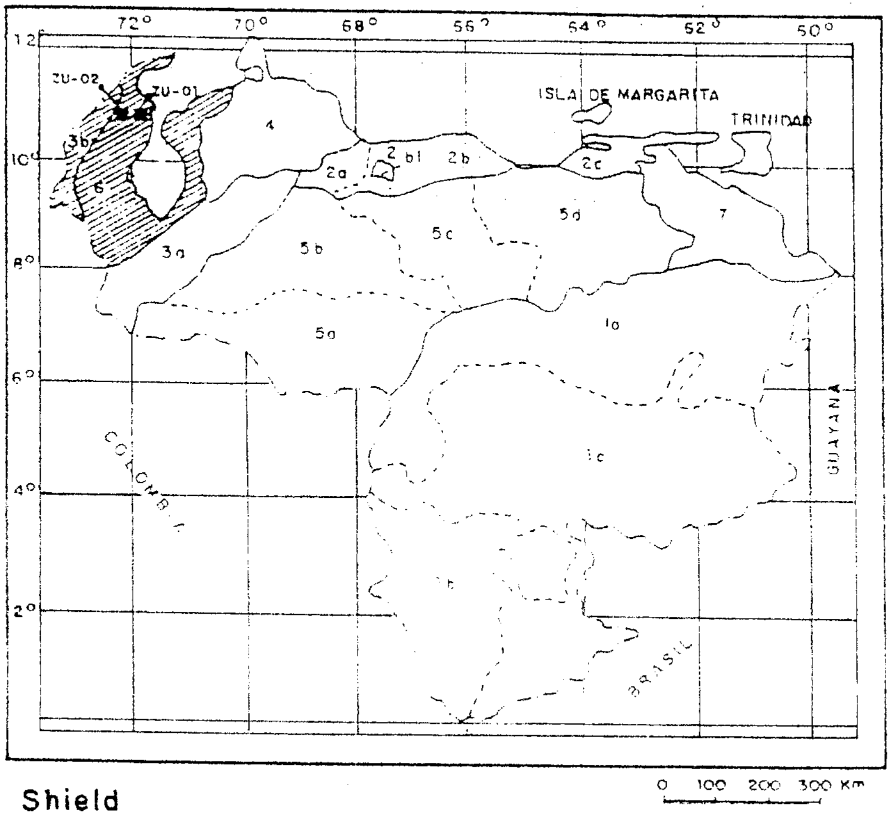
The main objective of this soil brief is to present a synthesis of the characteristics of two reference soils. Therefore a summary of the main morphological, physical and chemical characteristics is given as well as some relevant information on geology, geomorphology, land use and soil management.

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

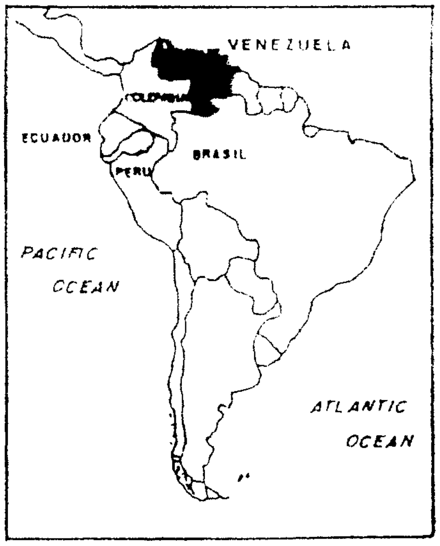
④ **Coreano System or North-Western Mountains System.**

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 latitude 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.

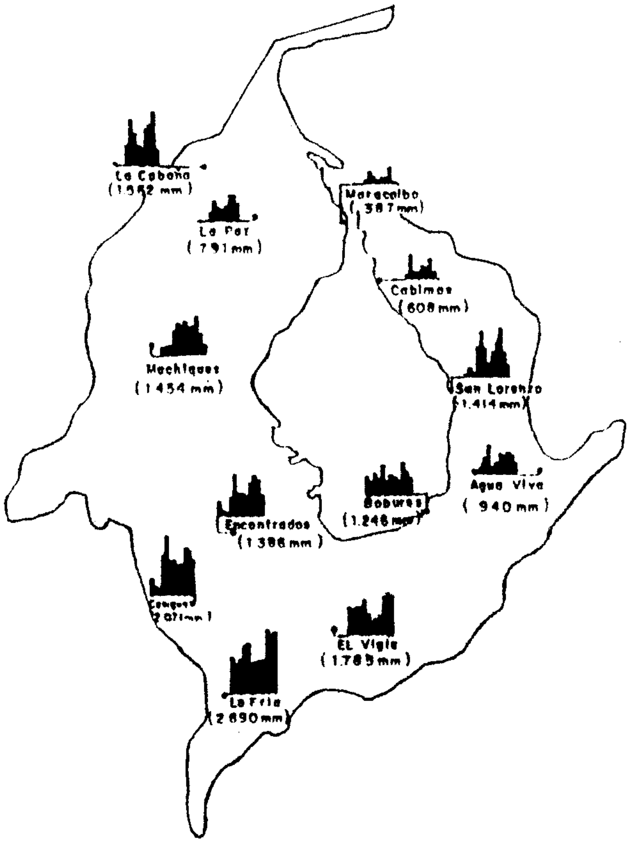
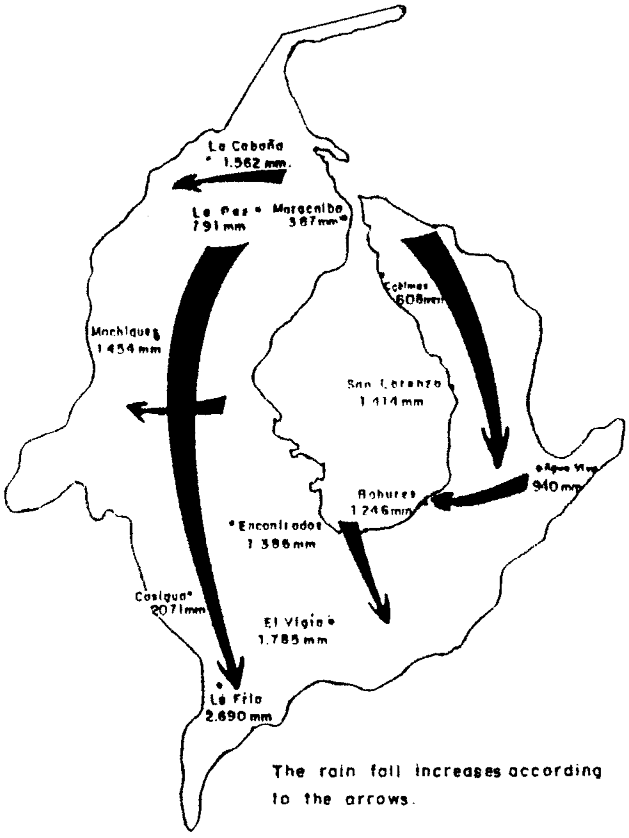


Figure 3. Spatial variability of the rainfall in the Maracaibo lake Basin.



The rain fall increases according to the arrows.

3. REFERENCE SOILS ZU-01 AND ZU-02

A brief description is made of the main characteristics of two reference soils (ZU-01 and Zu-02). The data can be found in annexes 1A and 1B.

3.1 Location and occurrence.

The Maracaibo Plain covers an area of about 460.000. Has and is located in the northern part of the Maracaibo Lake Basin. It can he subdivided in two climatic zones with aridic and ustic soil moisture regime that coincide with Very Dry Tropical Forest and Dry Tropical Forest respectively.

3.2 Climate

From the climatic point of view the Maracaibo Plain can be subdivided in two subregions, semiarid and subhumid.

Reference soil ZU-01 is located in the semiarid part and for this area the representative metereological station is Maracaibo LUZ. Fig. 4 shows the relation between evaporation (2917 mm per year) and rainfall (501 mm per year) and it is easy to see that there is almost no water available during the year. This means that production of even short cycle crops in rainfed agriculture is impossible. The soil moisture regime in this area is aridic according to Soil Taxonomy. For the subhumid part where ZU-02 is located, the metereological station of El Laberinto is considered representative. According to fig. 4 the total yearly rainfall amounts to 982 mm, whereas the evaporation is 1580 mm. In this area it is possible to produce at least one short cycle crop in rainfed a agriculture per year and the available water is sufficient to maintain livestock production including preservation of fodder crops. The soil moisture regime in this subregion is ustic according to Soil Taxonomy.

In both areas the rainfall distribution shows two peaks (fig. 4) and the rains are inconstant and of high intensity. The temperature is high throughout the year with mean values of about 27ºC and a variability of less than 3ºC. Mean solar radiation in both area is 497 cal $cm^{-2}day^{-1}$

3.3 Geology, geomorphology, vegetation and land use.

The materials of the Maracaibo Plain belong to the El Milagro Formation, accumulated towards the end of Pliocene in lacustrine conditions. These materials are very stable from the tectonic point of view.

The El Milagro Formation consists in the upper part mainly of soft sandstones of brownish yellow color and of medium to coarse texture with some interstratified grayish brown siltstone and brown claystone that can be hard and ferrugenous.

The different layers are in horizontal position because of absence of tectonic movement resulting in a flat topography without steep slopes except in the area near the lake were the topography is more undulating due to water erosion.

The predominant land type is a flat tableland. The natural vegetation in the whole Plain has been intervened very strongly in order to establish agricultural production system (Crops and Pastures). In these semiarid areas not intervened yet a typical vegetation of the Very Dry Tropical Forest can be found with cují (Prosopis sp.), cardón (lemaire Cereus) and tuna (Opuntia sp.).

The vegetation of the subhumid part belongs to The Dry Tropical Forest according to Holdridge (7) with trees like roble (Platymiscium sp), ebano (Caesalpinia granadillo) and vera (Bulnesia arborea).

Figura 4
Rainfall and evaporation of the Laberinto meteorological station

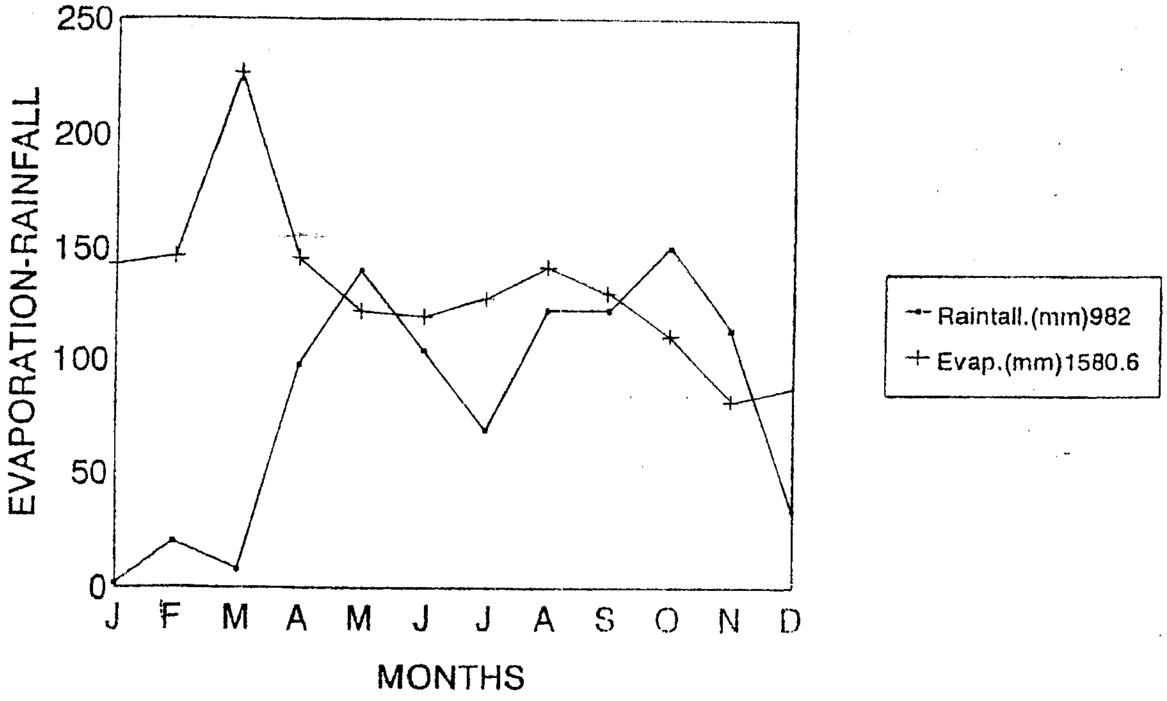
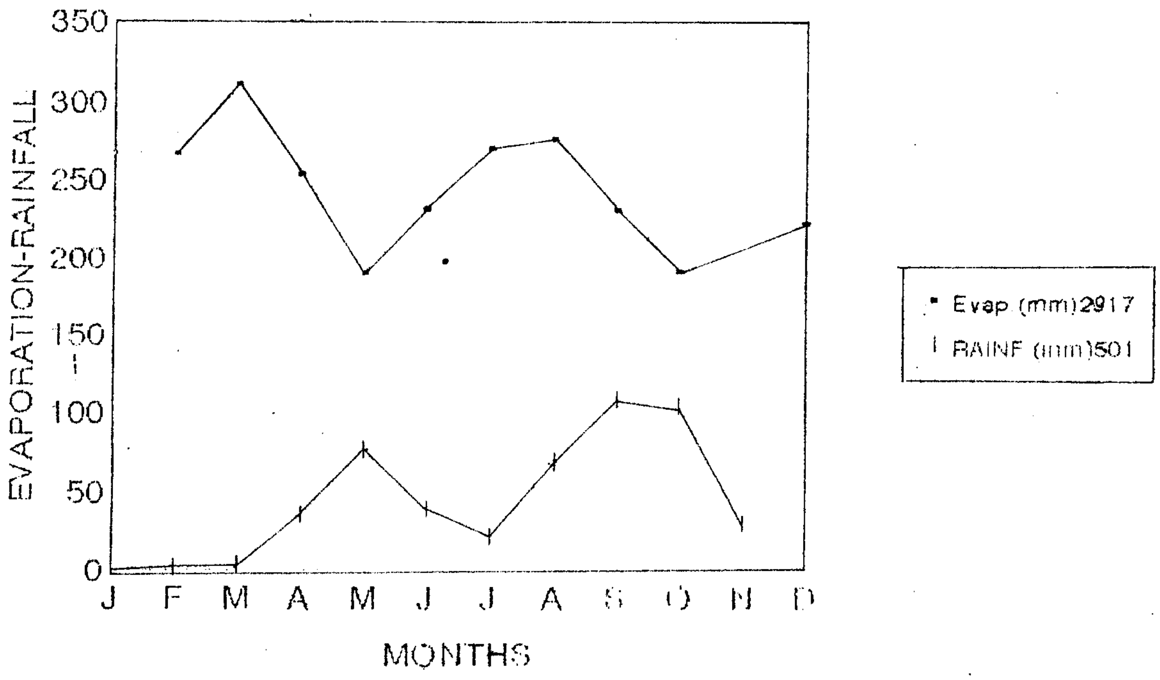


FIGURA 4
Rainfall and evaporation of the Maracaibo-LUZ meteorological station.



Land use in semi arid conditions is restricted to very extensive grazing of goats and sheep and fruit crops with irrigation.

The main land use in the subhumid part is grazing (pasture) and annual cropping of for instance sorghum during the last few years in the rainy season.

3.4 Soil Characteristics

Field description:

Zu-01: Well drained soil with an argillic horizon near the surface, fine subangular blocky structure in the upper part and medium in the subsoil, sandy loam in the topsoil and sandy clay loam in the argillic horizon.

Zu-02: Well drained soil with an argillic horizon from 52 cm on, weak subangular blocky structure in the topsoil, moderate in the subsoil, sandy loam in the topsoil and sandy clay loam in the argillic horizon.

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).

The variability of pH H_2O, organic carbon and sum of cations with depth is shown in fig. 5.

Zu-01: Texture: loamy sand in the surface layer, sandy clay loam in the subsoil

Organic carbon: medium throughout the profile (1.0-1.5%)

Acidity: varies between strongly and neutral (pH 4.9-7.1)

Sum of cations: high throughout the profile (base saturation 52-81%).

Cation exchange capacity: low in the surface layer and medium in the subsoil.

Zu-02: Texture: sandy loam in the surface layer and sandy clay loam in the subsoil.

Organic carbon: medium throughout the profile (1.0-1.5%).

Acidity: varies between strongly acid and neutral (pH 4.5-6.3)

Sum of cations: varies between medium and very high (base saturation 36-84%).

Cation exchange capacity: very low in the surface layer and low in the subsoil.

3.5 Soil Classification.

FAO-UNESCO (1980)	SOIL TAXONOMY (1992)
Zu-01 Chromic Luvisol	Typic Haplargid
Zu-05 Chromic Luvisol	Typic Haplustalf

According to FAO-UNESCO (9) both soils were classified as Luvisols because their cation exchange capacity is equal or more than 24 $cmolkg^{-1}$ and their base saturation is 50% or more.

In the USDA Soil Taxonomy (12) Zu-01 keyed out as Aridisol, Argid because of the presence of an argillic horizon and the aridic soil moisture regime, Haplargid because of the caracteristics of the argillic horizon . Zu-02 was classified as Haplustalf because of the ustic soil moisture regime and the argillic

Figure 5
PH H2O; % organic carbon; sum of bases (cmol/kg) (x) versus depth (cm) in profile ZU-02

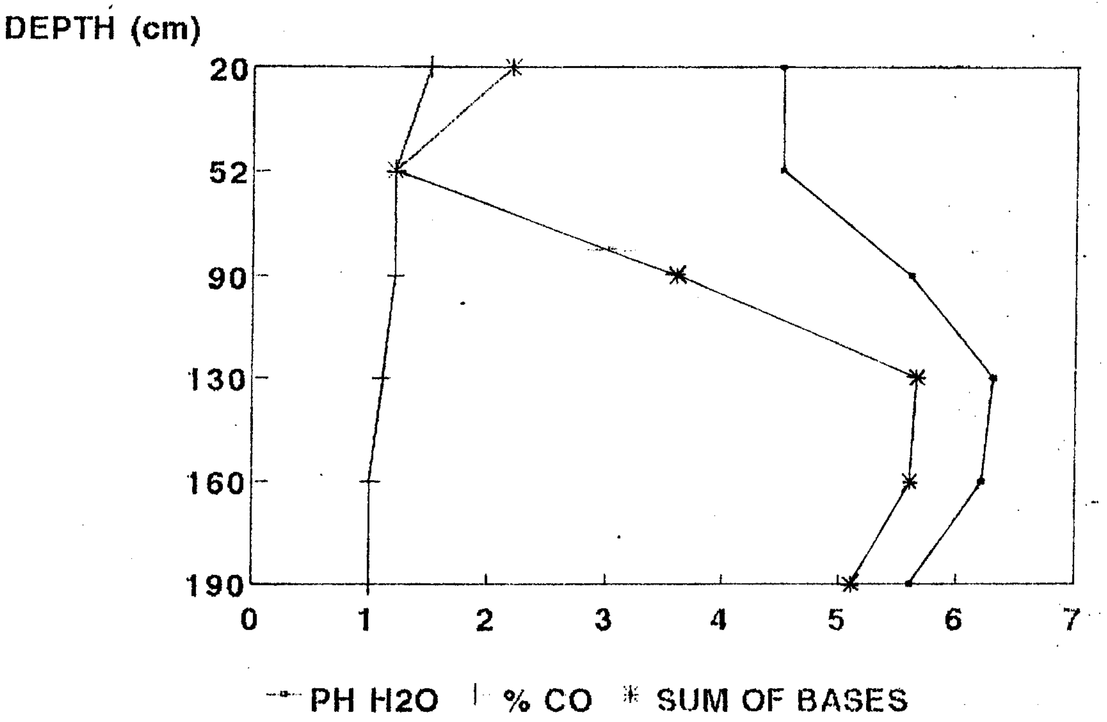
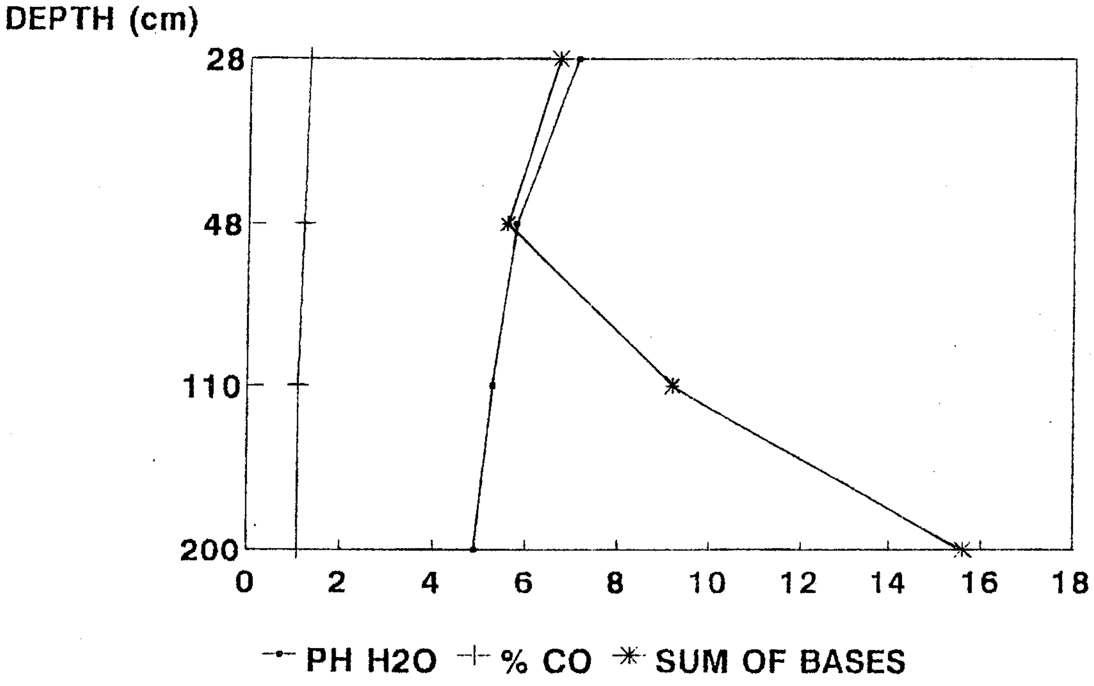


Figure 5
PH H2O; organic carbon; sum of bases (cmol/kg) (x) versus depth (cm) in profile ZU-01



horizon.

3.6 Land classification and soil management.

The soils of the Maracaibo Plain present some problems of low fertility. At the same time the depth of the top of the argillic horizon is very important. Inadequate use of implements (plowing, leveling) might leave the material of the argillic horizon exposed on the surface and cause hardening and cementation.

In order to plan soil management with adequate fertilizing and irrigation pratices it is necessary to know the depth of the argillic horizon.

The most important land use in the semi arid part is perennial cropping (fruits) under irrigation. The main crops are: guava (*Psidium guajaba*), medlar (*Achras zapote*), grapes (*Vitis vinifera*) and citrus.

In the subhumid area the most important land use is grazing with guinea grass (Panicum maximun) as the most important specie. Production is fluctuating according to the wet and dry seasons, nevertheless as a result of 10 years of research management practices of conservation of fodder crops are commonly used.

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Annex 1A ISIS Data Sheet Zu-01

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

CLASSIFICATION FAO/UNESCO,1974: chromic luvisol (Final class.)
USDA,1975: haplargid , sandy, kaolinitic, isohyperthermic
Diagnostic horizons: argillic
(other) Diagn. criteria:
Local classification: Typic Haplargid

LOCATION : ALTIPLANICIE DE MARACAIBO, CENTRO VITICOLA, MUNICIPIO MARA
: Latitude: 10 47 0 N Longitude: 71 52 0 W Altitude: 20 (m.a.s.l.)
AUTHOR(S) - DATE (mm.yy) : ING.NOGUERA Y PETERS - 10.89

GENERAL LANDFORM : plateau Topography: flat or almost flat
PHYSIOGRAPHIC UNIT : MARACAIBO LAKE BASIN
SLOPE Gradient/aspect/form: 1-3% N complex
POSITION OF SITE : flat
MICRO RELIEF Kind: level Pattern: none
SURFACE CHAR. Rockoutcrops: none Stoniness: none
Cracking: nil Sealing: nil Salt: nil Alkali: nil
SLOPE PROCESSES Soil erosion: slight wind Aggradation: nil stable slope

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PARENT MATERIAL I : lacustrine sediments Derived from: mixed lithology Texture: sandy
Weathering degree: high Resistence: moderate
---overlying II : colluvium Derived from: limestone/sandstone Texture:
Depth boundary I/II (cm):
Remarks: EL MILAGRO FORMATION

EFFECTIVE SOIL DEPTH(cm) : 200

WATER TABLE Depth(cm): Kind: no watertable observed
DRAINAGE : well
PERMEABILITY : high Slow permeable layer from (cm): n to: n
FLOODING frequency: nil Run off: medium
MOISTURE CONDITIONS PROFILE : 0 - 145 cm dry

LAND USE : medium level arable farming, grapes, continously irrigated, monoculture

VEGETATION Structure: evergreen woodland Status: primary
Landuse/vegetation remarks: VERY DRY TROPICAL FOREST

CLIMATE koppen: BS Soil Moisture Regime: aridic
Station: MARACAIBO LUZ -----10 32 N/72 12 W; 82 (m.a.s.l); 40 km N from site. Relevance: good

MARACAIBO LUZ	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
EA (mm)	3	267	266	311	253	190	233	270	276	230	191	208	220	2918
EA (mm)	3	267	266	311	253	190	233	270	276	230	191	208	219	2919
Precipitation (mm)	11	1	2	3	36	76	38	22	68	108	104	30	9	500
Precipitation (mm)	11	1	2	3	36	77	39	22	69	108	104	30	10	501
T mean (C)	3	28.8	28.8	29.7	28.4	28.8	28.8	28.6	30.5	30.1	28.9	29.9	29.1	29.2
T mean (C)	3	28.8	28.8	29.0	29.1	28.4	28.8	28.6	30.5	30.1	28.9	29.9	29.1	29.2

PROFILE DESCRIPTION

Ap 0- 28cm 10.0YR 4.0/6.0 moist; 10.0YR 5.0/6.0 dry; sand; leaves, decomposed; fine weak subangular blocky; non sticky non plastic very friable slightly hard; nil mottles; no cutans ; nil pores; few fine roots; nil inclusions; nil fragments; non cemented; few; non calcareous (by 10% HCL); pH(field): 7.1; clear smooth boundary to

Bt1 28- 48cm 7.5YR 5.0/8.0 moist; 7.5YR 6.0/8.0 dry; ,; leaves, decomposed; fine weak subangular blocky; slightly sticky slightly plastic friable hard; nil mottles; patchy thin clay cutans on on pedfaces ; nil pores; few roots; nil inclusions; nil fragments; non cemented; few; non calcareous (by 10% HCL); pH(field): 5.8; clear smooth boundary to

Bt2 48-110cm 5.0YR 5.0/8.0 moist; 5.0YR 6.0/8.0 dry; sandy clay loam; , decomposed; medium moderate subangular blocky; sticky plastic friable extremely hard; nil mottles; broken moderately thick clay cutans on on pedfaces ; nil pores; few roots; very few medium fine hard ferrigenous concretions; nil fragments; non cemented; few; non calcareous (by 10% HCL); pH(field): 5.2; clear smooth boundary to

Bt3 110-145cm 5.0YR 4.0/6.0 moist; 5.0YR 5.0/6.0 dry; sandy clay loam; , decomposed; medium moderate subangular blocky; sticky plastic firm extremely hard; nil mottles; broken moderately thick clay cutans on on pedfaces ; nil pores; few roots; very few medium fine hard ferrigenous concretions; nil fragments; non cemented; few; non calcareous (by 10% HCL); pH(field): 4.9;

monolith number: ZU 01 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	2	12	23	24	61	13	14	12	0	0.00	0	0	0	0	0	0	0	0	0
2	28	48	0	0	2	10	20	24	56	12	13	19	0	0.00	0	0	0	0	0	0	0	0	0
3	48	110	0	0	1	6	14	21	42	10	12	36	0	0.00	0	0	0	0	0	0	0	0	0
4	110	190	0	0	0	1	4	20	25	17	18	40	0	0.00	0	0	0	0	0	0	0	0	0

meq /100g-

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	7.1	0.0	0.0	1.3	0.11	4.5	1.5	0.4	0.3	6.7	2.2	0.0	8.2	0	0	8.8	81	0	0.62
2	5.8	0.0	0.0	1.2	0.10	4.1	0.9	0.2	0.4	5.6	3.7	0.0	8.7	0	0	9.3	64	0	0.77
3	5.3	0.0	0.0	1.1	0.09	4.1	4.7	0.2	0.2	9.2	7.2	0.0	17.5	0	0	16.3	52	0	0.36
4	4.9	0.0	0.0	1.1	0.09	4.3	10.5	0.3	0.5	15.6	8.0	0.0	21.8	0	0	23.5	71	0	0.53

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	Cp
3	5	14			7								0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Annex 1B ISIS Data Sheet Zu-02

monolith number: ZU 02 estado: ZULIA soil description LUZ-AGRO 01/01/8

CLASSIFICATION FAO/UNESCO,1974: chromic luvisol (Tent. class.)
USDA,1975: haplustalf , loamy-sandy, isohyperthermic
Diagnostic horizons: argillic
(other) Diagn. criteria:
Local classification: Typic Haplustalf

LOCATION : EL LABERINTO, ALTIPLANICIE DE MARACAIBO, VENEZUELA
: Latitude: 10 29 N Longitude: 72 15 W Altitude: 50 (m.a.s.l.)
AUTHOR(S) - DATE (mm.yy) : ING. NOGUERA-PETERS - 9.89

GENERAL LANDFORM : plateau Topography: flat or almost flat
PHYSIOGRAPHIC UNIT : MARACAIBO LAKE BASIN
SLOPE Gradient/aspect/form: 1-3% convex
POSITION OF SITE : flat
MICRO RELIEF Kind: level Pattern: none
SURFACE CHAR. Rockoutcrops: none Stoniness:
Cracking: nil Sealing: nil Salt: nil Alkali: nil
SLOPE PROCESSES Soil erosion: slight wind stable slope

PARENT MATERIAL I : lacustrine sediments Derived from: mixed lithology Texture: sandy clay
Weathering degree: high Resistence: moderate
Remarks: EL MILAGRO FORMATION

EFFECTIVE SOIL DEPTH(cm) : 200

WATER TABLE Depth(cm): Kind: no watertable observed
DRAINAGE : well
PERMEABILITY : moderate
FLOODING frequency: nil Run off: medium
MOISTURE CONDITIONS PROFILE : o - 190 cm moist

LAND USE : cultivated pasture, fodder crops, seasonly irrigated, ,
VEGETATION Structure: semi deciduous woodland Status: cut over
Landuse/vegetation remarks: DRY TROPICAL FOREST

CLIMATE koppen: Aw Soil Moisture Regime: ustic
Station: PARCELA EL LABERNT -----10 32 N/72 30 W;82 (m.a.s.l); 10 km W from site. Relevance: very good

PARCELA EL LABERNT	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Precipitation (mm)	16	2	20	8	98	140	104	69	122	122	150	113	34	982

PROFILE DESCRIPTION

Ap 0- 20cm 7.5YR 4.0/4.0 moist; sandy loam; leaves, decomposed; medium weak subangular blocky; non sticky non plastic very friable loose; nil mottles; no cutans ; nil pores; common roots; very few inclusions; nil fragments; non cemented; few; non calcareous (by 10% HCL); pH(field): 5.7; clear smooth boundary to

E 20- 52cm 7.5YR 5.0/6.0 moist; sandy loam; , decomposed; medium weak subangular blocky; slightly sticky slightly plastic friable; nil mottles; no cutans ; nil pores; common roots; very few inclusions; nil fragments; non cemented; frequent; non calcareous (by 10% HCL); pH(field): 4.5; clear smooth boundary to

Bt1   52- 90cm   5.0YR 5.0/8.0 moist; sandy clay loam; , decomposed; medium moderate subangular blocky;
sticky plastic friable; nil mottles; broken clay cutans ; nil pores; common roots;
very few medium ferrigenous concretions; nil fragments; non cemented; frequent;
non calcareous (by 10% HCL); pH(field): 4.7; gradual smooth boundary to

Bt2   90-130cm   5.0YR 5.0/8.0 moist; sandy clay loam; , decomposed; medium weak subangular blocky;
sticky plastic friable; nil mottles; patchy clay cutans ; nil pores; few roots; very few
medium ferrigenous concretions; nil fragments; non cemented; frequent; non calcareous (by 10% HCL);
pH(field): 5.6; gradual smooth boundary to

Bt3 130-160cm   7.5YR 5.0/8.0 moist; sandy clay loam; , decomposed; medium weak subangular blocky;
sticky plastic friable; nil mottles; patchy clay cutans ; nil pores; few roots; very few
medium ferrigenous concretions; nil fragments; non cemented; frequent; non calcareous (by 10% HCL);
pH(field): 6.3; gradual smooth boundary to

Bt4 160-190cm   5.0YR 5.0/8.0 moist; clay loam; , decomposed; medium weak subangular blocky;
sticky plastic friable; nil mottles; patchy moderately thick clay cutans on on pedfaces ;
nil pores; few roots; nil inclusions; nil fragments; non cemented; few;
non calcareous (by 10% HCL); pH(field): 6.2;

```
monolith number: ZU 02        analytical data     <missing value = -1>                ISRIC:        01/01/80
--------------------------------------------------------------------------------------------------------------


ND TOP BOT    >2 2000 1000 500 250 100  TOT  50  20  <2   DISP   BULK  pF- --- --- --- --- --- --- ---     SPEC
              mm 1000  500 250 100  50       20   2  um          DENS  0.0 1.0 1.5 2.0 2.3 2.7 3.4 4.2     SURF


1   0  20     0    1    9  20  26   9   65   8   6  21      0   0.00    0   0   0   0   0   0   0   0        0
2  20  52     0    0    5  17  24  11   57   5   5  33      0   0.00    0   0   0   0   0   0   0   0        0
3  52  90     0    1    4  12  15   8   40  14  10  36      0   0.00    0   0   0   0   0   0   0   0        0
4  90 130     0    0    3  11  16   9   39  18  23  20      0   0.00    0   0   0   0   0   0   0   0        0
5 130 160     0    0    3  11  14   7   35  15  12  38      0   0.00    0   0   0   0   0   0   0   0        0
6 160 190     0    0    4  12  17   9   42  20  10  28      0   0.00    0   0   0   0   0   0   0   0        0

--------------------------------------------------------------------------------------------------------------


No. pH- --!  CaCO3  ORG- MAT.   EXCH CAT. ---- ---- ---!   EXCH AC.!    CEC ---- ---!   ECEC   BASE     Al EC 2.5
    H20 KCl      %   C %  N %     Ca   Mg    K   Na  sum   H+Al   Al   soil clay OrgC          SAT %  SAT %  mS/cm
                                ----  ---  ---- ---- meq /100g- ---- ------ ---- ---- ------


1   4.5 0.0    0.0   1.5 0.13    0.5  0.5  0.1  1.1  2.2    2.0  0.4    2.5    0    0    3.1     36      0   0.42
2   4.5 0.0    0.0   1.2 0.10    0.5  0.5  0.2  0.0  1.2    2.0--0.4    2.5    0    0    3.1     53     16   0.42
3   5.6 0.0    0.0   1.2 0.10    3.0  0.5  0.1  0.0  3.6    4.0  0.4    6.8    0    0    3.9     53      6   0.18
4   6.3 0.0    0.0   1.1 0.09    4.0  1.5  0.1  0.0  5.6    2.0  0.0    8.6    0    0    9.6     65      0   0.17
5   6.2 0.0    0.0   1.0 0.09    4.0  1.5  0.1  0.0  5.6    2.0  0.0    6.6    0    0    7.6     85      0   0.21
6   5.6 0.0    0.0   1.0 0.09    3.0  2.0  0.1  0.0  5.1    2.0  0.0    6.1    0    0    7.1     84      0   0.25

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


No   MICA/ VERM CHLOR SMEC KAOL HALL MIX* QUAR FELD GIBB GOET HEM     FEo  ALo  SIo  MNo   FEd  ALd  SId   FEp  ALp   Cp
     ILL


4    5    14              7                                          0.0  0.0  0.0  0.0   0.0  0.0  0.0   0.0  0.0  0.0

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Annex 2A: Evaluation of Land Qualities of ZU-01

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-02

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})

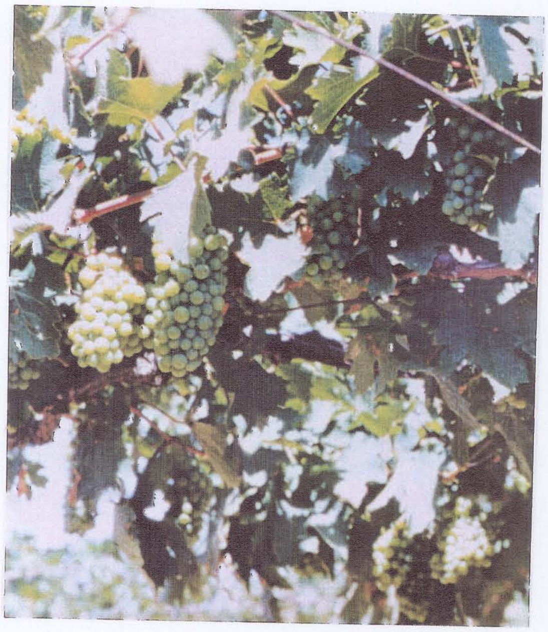
< 0.9	very low
0.9 - 1.1	low
1.1 - 1.5	medium
1.5 - 1.7	high
> 1.7	very high

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

2



3

4

5

1. Landscape and land use of Maracaibo Plain
2. Profile ZU 1
3. Land use ZU 1: grapes

4. Vegetation ZU 1
5. Land use ZU 1: mangos

6. Landscape ZU 2

6