Soil Brief *Cuba 2*

CUBA

Salt-Affected Reference Soil of the Guantánamo Valley

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International Soil Reference and Information Centre

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Salt-Affected Reference Soil of the Guantanamo Valley

ISRIC Soil Monolith:

Number	*FAO-Unesco*	*Soil Taxonomy*
CU 15	Calcic Solonchak	Aeric Halaquept

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CONTENTS

FOREWORD

This Soil Brief has the objective of providing information on Reference Profile CU 15 and is part of a serie of similar documents. The Soil Brief deals with reference soils belonging to the National Soil Collection implemented by the Soil Department of the Instituto Nacional de Investigaciones de la Caña de Azúcar (INICA).

A joint cooperation project of the Instituto Nacional de Investigaciones de la Caña de Azúcar and the International Soil Reference and Information Centre was initiated in 1990. The project operates in the framework of ISRIC's National Soil Reference Collection and Database (NASREC) programme. The NASREC goals are to support the establishment of soil expositions, databases with accompanying publications. In Cuba, it aims to describe and sample a series of reference soils, representative for the sugarcane areas of Cuba. Duplicates of these soils were collected for the Cuban soil collection in Villa Clara and for the world soil collection of ISRIC in Wageningen, The Netherlands.

This Soil Brief was compiled in cooperation with ISRIC staff: M.B.B.J. Clabaut (text processing), L.P. van Reeuwijk (laboratory), R.A. Smaal (diagrams), J.H. Kauffman, T. de Meester and A.E. Hartemink (editing). In the fieldwork, G. Cervera and R. Cabrera from the Sugarcane Experiment Station of Guantánamo province were participating.

This publication is the basic document of the Reference Soil Cuba number 15. Reference profile CU 15 represents a unique Cuban region because of its climatic characteristics. It also reflects one of the most important degradation processes damaging agriculture, namely secondary salinization of the fertile soils. This phenomena and its causes are emphasized.

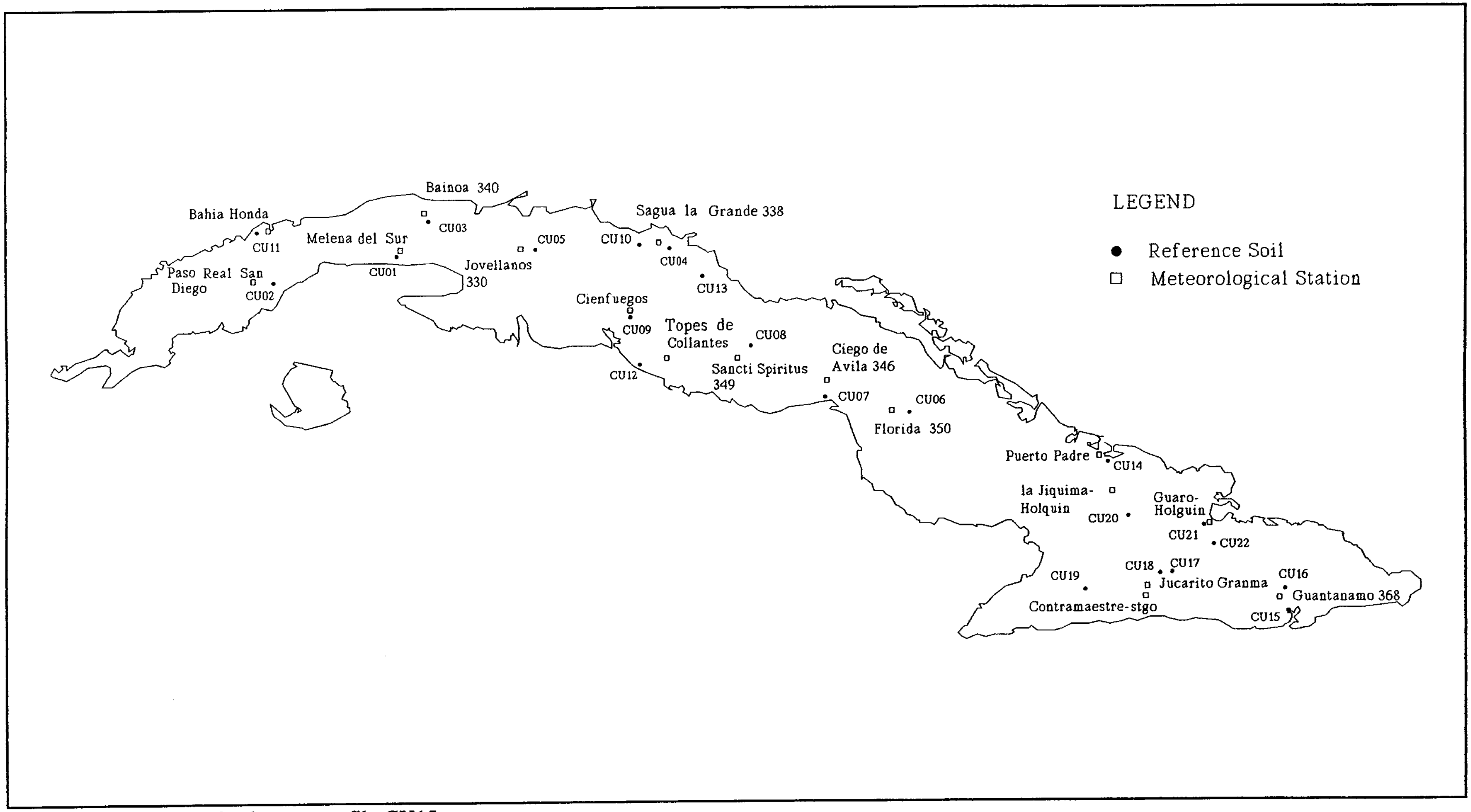


Figure 1 Location of reference profile CU15

1 THE GUANTANAMO VALLEY

The Guantanamo Valley is located in the eastern region of Cuba. It is surrounded by three mountain ranges: the Sierra Maestra in the West, the Guaso plateau in the North and the Sierra Maquey in the East (Figure 1). The Valley is part of a Graben which since its emergence has functioned as a basin receiving sediments and salts released by the weathering of rocks of the mountains.
From climatic viewpoint, it belongs to the eastern subregion of Cuba characterized by the interaction between humid air masses of the prevailing trade winds and the relief (Academia de Ciencias, 1989) which resulted in a narrow strip with a dry tropical climate. These dry zones with scarce rainfall (Köppen-BS) alternate with high rainfall zones of tropical rainforest (Af) in the mountains. The Guantanamo Valley differs greatly from the maritime tropical climate (Aw) prevailing in the major part of Cuba.
The economy of the region is based on sugar production from sugarcane with six mills in the Guantanamo Valley, namely, Costa Rica, Argeo Martinez, Manuel Tames, Honduras, Paraguay and El Salvador.

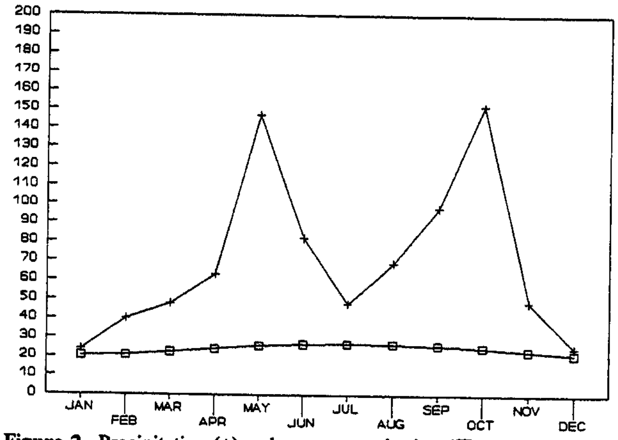


Figure 2 Precipitation (+) and evapotranspiration (□) in mm near the CU15 site.

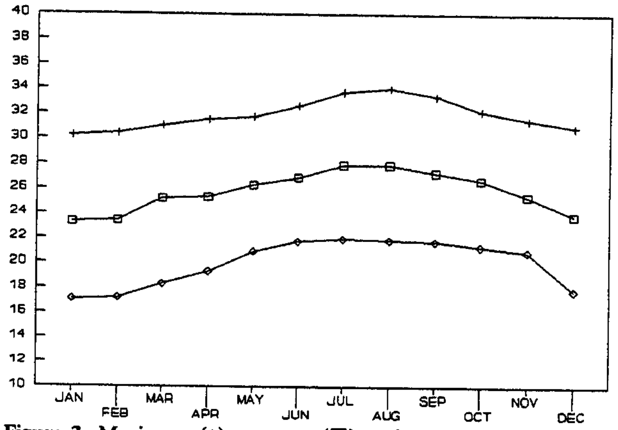


Figure 3 Maximum (+), average (□) and minimum (◊) monthly temperature in °C near the CU15 site.

1.1 Climate

The reference profile is located in the transition zone among the narrow subarid strip and the dominant subhumid area. As a consequence it has a soil water regime in which rainfall exceeds evaporation throughout the year. This is illustrated in Figure 2 based on the data collected at the climatological station of "La Juanita", which is representative for the Guantanamo Valley zone. The valley is one of the driest region of the country with an annual rainfall of 838 mm and a minimum average temperature over 20°C from May to November (see Fig. 3). The rainy season extends from May to October (receiving 71 % of the annual rainfall) and the dry period from November to April (29%). July is a dry month.
All diagrams in this Soil Brief were made with Solgraph (Brunt & Kauffman, 1995).

1.2 Landscape and Soils

The Guantanamo Valley is a fluvio-marine plain smoothly sloping towards the sea. It consists of (i) abrasive-erosive undulating surfaces and terraces with an altitude of 40 m; (ii) an abrasive accumulative and deltaic, slightly undulating plain between 10 and 40 m altitude; and (iii) a deltaic plain which is partially marshy below 7 m altitude (Academia de Ciencias, 1989). There are also residues of ancient accumulative terraces, which are witnesses of the landscape transformations that took place in the Quaternary (Ortega and Arcia, 1982).
Halomorphic and gleyic processes took place in soils with a mineral-rich groundwater at shallow depth.

According to the Cuban Soil Map, scale 1:250 000, the following soils are found based on the classification system of FAO/Unesco (1974) and Soil Taxonomy (ST) (1975):

- Soils in the depression zones and other areas highly affected by salts due to a saline water table:
  Mollic Solonchak (FAO), Haplustoll (ST).
- Brown limestone-derived soils in highlands:
  Gleyic Cambisol (FAO), Ustochrept (ST)
  Calcaric Phaeozem (FAO), Calciustoll (ST).
- Soils derived from recent alluvial deposits:
  Eutric Fluvisol (FAO), Ustifluvent (ST)
  Eutric Gleysol (FAO), Haplaquept (ST)
  Calcaric Gleysol (FAO)
- Soils that are a result of an ancient or recent solonetz formation process:
  Solonetz (FAO), Natrustoll (ST)

Additional information on the formation, distribution and characteristics of the halomorphic soils of the Valley is given in Herrera *et al.* (1983) and Ortega *et al.* (1982).

2 REFERENCE SOIL CU 15

This soil is representative for salt-affected soils in Cuba. Field and laboratory data are shown in Annex 1, according to the Soil Information System of ISRIC (Van Waveren & Bos, 1988).

2.1 Location and Occurrence

The reference soil is located at 20°82' N and 75°10' W in the sugarcane plantations of the mill "Paraguay" at the southeast of Guantanamo City. Altitude is 21 m a.s.l. This soil is representative for the Guantanamo Valley. During the last decades, the economy of this region has been strongly affected because of the increasing salinization, caused by the rise of the mineral-rich water table (Ortega *et al.*, 1982).
The presence of saline soils in this region, which is the driest of Cuba, was earlier reported by Bennett and Allison (1928). Primary salinization can only be found in a narrow strip with a rainfall average inferior to 700 mm/year, however, secondary salinization of arable land is common.
More than 28% of the arable soils of the Island are affected by soil salinity and poor drainage due to various reasons (Ortega, 1986).

2.2 Relief, Geology, Vegetation and Land use

Soil CU 15 covers most of the slightly undulating alluvial plain with slopes of less than 4%. The parent material consists of loam and clay alluvium-colluvium, characteristic for the San Luis formation (Eocene) where limestones, sandstones and conglomerates are also found. The xeromorphic, spiny coastal vegetation has been replaced by cotton and sugarcane cultivation in the 19th century. A salinity increase during the last three decades caused a production stop and a spontaneous herbaceous hallophitic vegetation took over. Locally, there are patches without a humus-rich layer, where salts cristallize at the surface. Recently, after soil rehabilitation works were carried out in different parts of the Valley, these areas became productive again. Besides sugarcane, other important crops are bananas, tubers and vegetables.

2.3 Soil characterization

Brief field description

Moderately deep, poorly drained, brown to light olive brown clay loam. Soil structure moderately angular blocky and medium prismatic to columnar. There are calcareous mottles in the subsoil.
A detailed description of soil horizons is presented in Annex 1 according to the Guidelines for Soil Description (FAO/ISRIC, 1990). Soil samples were analyzed at the soil laboratory of ISRIC according to the procedures described by Van Reeuwijk (1987).

Texture: Clay.
Acidity: Slightly alkaline in the upper layers to alkaline in the subsoil (pH H_2O 8.2-9.2).
Na saturation: More than 15% exchangeable Na (sodic properties).
Cation Exchange Capacity: High throughout the profile decreasing with depth.
Bulk density: Medium, with higher values in the B horizon (1.2-1.3 kg dm^{-3}).
Air capacity: Topsoil low (9%) subsoil very low (2%).
Available soil moisture: Topsoil medium (11%), subsoil high (15%).
Clay mineralogy: Prevalence of smectite with a mixture of other minerals and kaolinite.

Figure 4 shows the particle size distribution with depth, and clearly reveals the absence of coarse particles (>50 μm).
The soil reaction is characterized by an increase of alkalinity with depth as a result of the presence of sodium adsorbed in the exchange complex (Figure 5). Dispersion explains the increase of bulk density in the middle horizons and the decrease of the air capacity.
The mineralogical composition of the clay points to the prevalence of smectite and the low degree of weathering of the quaternary parental sediments, which contain important quantities of easily transformed primary minerals such as feldspar. Hence, it could be that the kaolinite present in these soils comes from the alluvial-colluvial of the materials of San Luis formation. On the other hand, the high content of mixed minerals is related to the sodicity and poor drainage conditions favouring the hydrolysis of clay minerals.

2.4 Classification

FAO-Unesco (1988)
The soil has a weak columnar structure. Although it has a high content of exchangeable Na (>15%), it does not fulfil the requirements of a natric B horizon, because it has not a coarser textured horizon overlying an argic B horizon. Because of the presence of a calcic horizon, a cambic B and "sodic properties", it classifies as Sodi-Calcic Solonchak.

USDA-Soil Taxonomy (Soil Survey Staff, 1992)
Taking into account the ustic moisture regime and following the previously expressed criteria, it is classified as Aeric Halaquept.

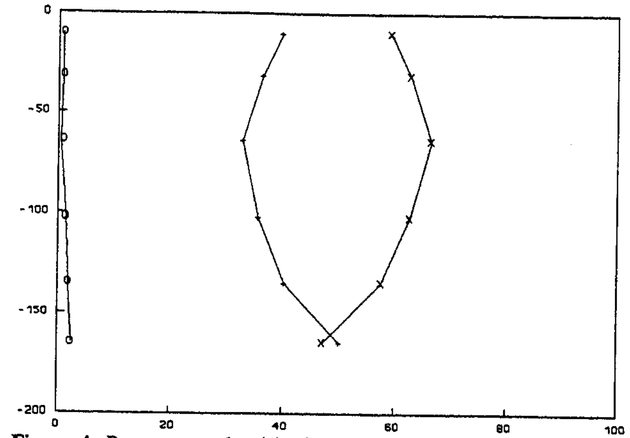


Figure 4 Percentages clay (x), silt (+) and sand (o) versus depth (cm) in profile CU 15.

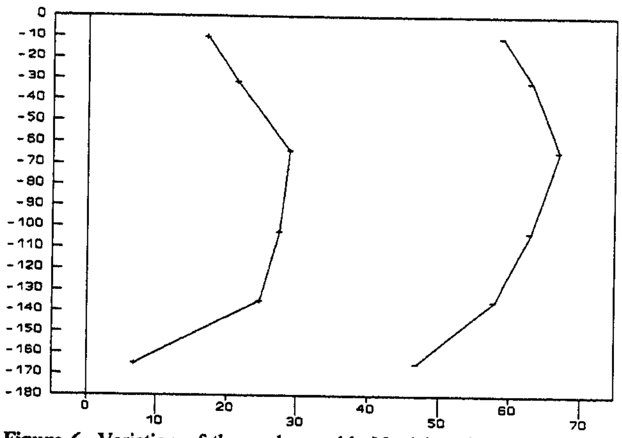


Figure 6 Variation of the exchangeable Na (+) and clay (-) content throughout the profile CU 15.

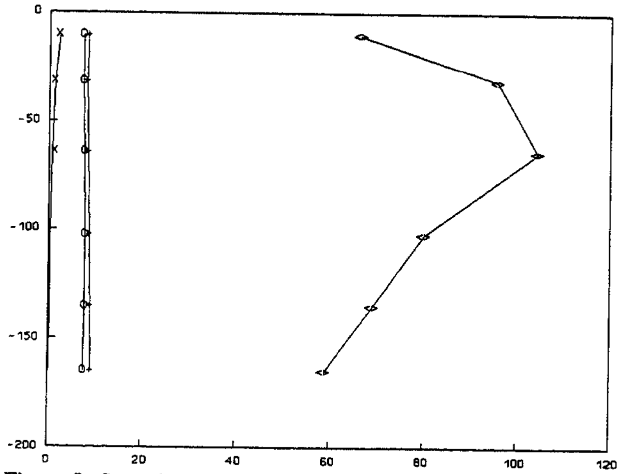


Figure 5 Sum of bases (cmol$_c$ kg^{-1} soil) (< >), pH-H_2O (+), pH-KCl (o) and organic carbon (×) versus depth (cm) in profile CU 15.

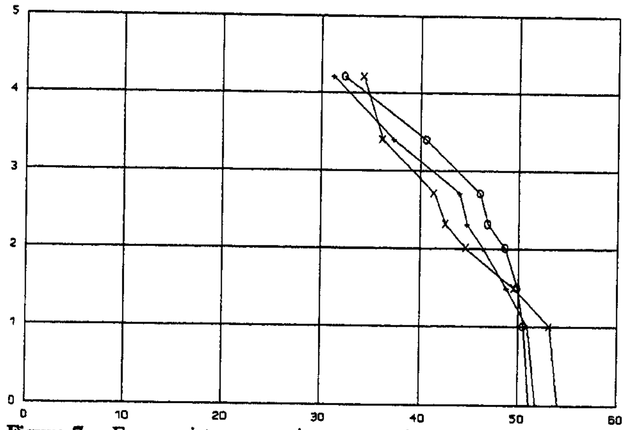


Figure 7 pF or moisture retention curves (water content in vol % versus suction) at depth 0-20 cm (×), 20-43 cm (+), 43-95 cm (o) in profile CU 15.

National classification (Instituto de Suelos, 1975)

The soil is classified as Typical Solonchak but in an earlier national classification it is classified as "Solonchak solonetizado", due to the high exchangeable Sodium content.

2.5 Land quality assessment

A qualitative evaluation of the site according to the guide evaluation for dryland farming is shown in Annex 2 (FAO, 1983 and ISRIC, in prep.). The main restrictions of these soils are related to salinity, and the high sodium content of the exchange complex. The poor drainage is determined by the geomorphological position and the deterioration of the soil physical properties. In addition, the dry climate in this part of the Valley is a constraint for agriculture.

The increase of salinity is closely related to the increase of irrigated areas without the construction of drainage facilities. The obstruction or elimination of the natural drainage network, unsuitable agronomical practices and the application of poor quality irrigation water have led to an increase of the level of the water table. This is the main cause of the salinization of the Guantánamo Valley. This salinization has strongly and negatively affected the sugarcane crop during all its development stages, resulting in a decrease of the net sugar production.

In sugarcane these effects will differ among varieties (Table 1). However, it is claimed that in general it does not affect the cropping period, which shortening is attributed to other causes such as drought.

Improvement of the described situation can be achieved by control of the watertable regime through a deep drainage network. Studies by Cabrera (1992) have shown that the natural trend of this soil is toward leaching, according to the infiltration flux related to the frequency and intensity of rainfall on the area if the water table is below 2.0 m.

The gypsum contents (0.2-0.4 %) makes it easier to obtain good results from soil improvement, reclamation and the establishment of suitable technologies.

Reclamation is difficult in soils with a high exchangeable sodium percentage. Cabrera (1992) demonstrated that filter cake applications of 50 t/ha are sufficient to prevent the solonetz formation in these soils during the leaching process.

A complete package of reclamation should include:
- land levelling
- construction of deep drainage
- application of gypsum and others amendments
- utilization of tolerant crop varieties
- agronomical practices improving surface drainage and aeration.

2.6 Soil formation

The soil was formed from sedimentary materials of the San Luis formation. Parallel to the detrital period of these materials took place the erosion of the metamorphic and peridotite mountain masses emerging at the late Cretaceous. The latter is confirmed by the presence of heavy minerals in these soils (Fundora *et al.*, 1985).

Sedimentation of the new materials took place under arid conditions and rivers lost their volume giving rise to continental deposits during the glacial periods (Ortega and Arcia, 1982).

Increase in rainfall which took place in the Holocene, could not completely leach the salts deposited in depressions limited by the low filtration of the rocks of the Eocene, which remained as edaphic relics in the form of carbonated shells and ancient solonetz horizons.

The highly mineralized groundwater did not significantly affect the soil except in a narrow strip where arid characteristics could be still found, until the hydrological regime of the Valley was disturbed causing a rise of the groundwater and the secondary salinization of large areas. With artificial leaching of the soils for their improvement and reclamation, a change could be introduced in their formation.

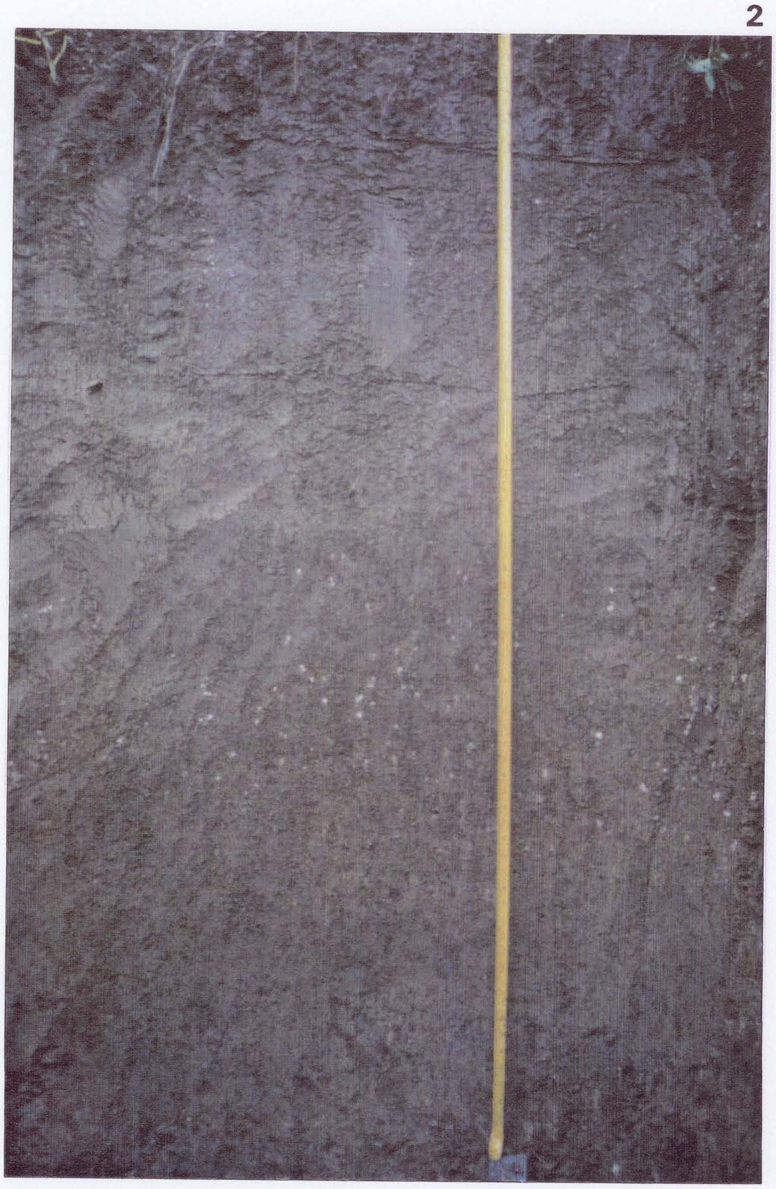
Table 1 Agricultural yields of plant cane for the different varieties and salinity levels (Cabrera, 1992)

	Mean values observed per variety (t/ha)					
Initial salt level	C87-51	B72-74	C568-75	C120-78	Ja60-5	C266-70
0.1-0.2	147	150	162	169	152	163
0.2-0.3	87	80	116	110	106	110
0.3-0.4	55	50	78	80	60	75
0.4-0.5	21	17	50	46	40	53
0.5-0.6	0	0	21	24	17	25
0.6-0.7	0	0	10	6	3	8

Table 2 Response of sugarcane to salinity and soil improvement in the root layer (Cabrera, 1992).

Salts	Salt degree	Losses without improv. (%)	Sugarcane damage	Improvement means	Losses with improv. (%)
< 0.1	No salts	0	None	To keep a proper hydrosaline regime	0
0.1-0.15	Low salinity	0-10	Slight	To keep a proper hydrosaline regime	0
0.15-0.3	Slight salinity	10-40	Slight-medium	Deep drainage and to achieve a washing hydrosaline regime without surplus application	< 15
0.3-0.5	Medium salinity	40-70	Medium to strong	Deep drainage and to accelerate the washing process by artificial means, application of 35% surplus with irrigation in plant cane	15-25
0.5-0.7	Strong	70-100	Very strong	Deep drainage and to accelerate the washing process by artificial means, application of 50% surplus with irrigation in plant cane	25-40
> 0.8	Very strong	-	No sugarcane	Deep drainage and strong washing	-

1



2

1. Landscape CU 15
2. Profile CU 15

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Annex 1 ISIS Data Sheet CU 15

Reference soil CU 15, CUBA

Print date: 28 June 1995

FAO/UNESCO (1988) : Sodi-Calcic Solonchak
(1974) : Orthic Solonchak, sodic phase
USDA/SCS SOIL TAXONOMY (1992) : Aeric Halaquept, clayey, montmorillonitic (calc.), isohyperthermic
(1975) : -do-)
LOCAL CLASSIFICATION : Solonchak tipico

DIAGNOSTIC CRITERIA FAO (1988) : ochric A, cambic B, salic properties
USDA/SCS (1992): ochric epipedon, cambic horizon, calcic horizon
Soil moisture regime : ustic
Soil temperature regime : isohyperthermic

LOCATION : Cuba Prov. y Mun. Guantanamo CAI "Paraguay" Bloque El Algarrobo.
Latitude / Longitude : 20°2'0"N / 75°10'0"W — Altitude : 21 m a.s.l.
AUTHOR(S) : MARIN/REGLA/CABRERA — Date : December 1991

GENERAL LANDFORM : alluvial plain — Topography : flat or almost flat
PHYSIOGRAPHIC UNIT : almost flat slightly undulated
SLOPE Gradient, Form : 4%, straight, — Position of site : flat
MICRO RELIEF Kind : level — Pattern (height) : linear (30 cm)
SURFACE CHAR. Rock outcrop : nil — Cracking : large cracks
Salt : strong — Alkali : moderate
Slaking/crusting :
SLOPE PROCESSES Soil erosion : slight sheet
Slope stability : stable

PARENT MATERIAL 1 type, texture : alluvium derived from sedimentary rock
PARENT MATERIAL 2 type, texture :
Remarks :

EFFECTIVE SOIL DEPTH : 100 cm
WATER TABLE Kind, Depth : groundwater table, 102 cm — Estimated high/low level : 60 cm / 200 cm
DRAINAGE : poorly
PERMEABILITY : moderate — Slowly permeable layer from : 43 to 85 cm
FLOODING Frequency : nil — Run off : medium

MOISTURE CONDITIONS PROFILE : 0-160 cm moist, 160-180 cm wet

LAND USE : high level arable farming (sugar cane), continuously irrigated
VEGETATION Type : shrub — Status : degraded

CLIMATE Köppen : Bs
MET. STATIONS Name, Location : HORQUETA, 30°30' / 340°23', 100 m a.s.l
Distance to site (relevance) : HORQUETA lays 12 km SW of the site (very good)

HORQUETA	No. years of record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1 (see remarks)	28	75.0	73.0	72.0	72.0	76.0	77.0	73.0	74.0	79.0	81.0	78.0	75.0	75.0
act. evapotransp. mm	28	164	173	197	225	203	219	238	237	199	185	158	147	2345
EP (see remarks)	21	20.5	20.8	22.6	24.1	25.8	26.6	26.9	26.7	26.1	25.1	23.2	21.6	24.2
EP Penman mm	28	102	107	141	148	147	140	157	154	129	115	104	101	1546
precipitation mm	28	24	40	48	63	147	82	48	69	98	152	49	25	838
T mean °C	28	23.3	23.4	25.2	25.3	26.3	26.9	27.9	27.9	27.3	26.7	25.4	23.8	25.8
T max °C	28	30.2	30.4	31.0	31.5	31.7	32.6	33.7	34.0	33.4	32.2	31.5	30.9	31.9
T min °C	28	17.1	17.2	18.3	19.3	20.9	21.7	21.9	21.8	21.7	21.3	20.9	17.8	20.0
windspeed(at 2m) $m\ s^{-1}$	28	1.9	2.2	2.4	2.4	1.9	1.9	2.1	2.2	1.8	1.6	1.6	1.9	2.0

PROFILE DESCRIPTION :

Ap 0 - 20 cm brown (10YR 5.0/3.0, moist) clay loam; moderate medium prismatic to strong medium angular blocky slightly sticky, slightly plastic, friable; no mottles; no cutans; common fine pores; moderately porous; many very fine to coarse roots throughout; no inclusions; no fragments; frequent channels; non calcareous (10% HCL) throughout; clear smooth boundary to

B1 20 - 43 cm light olive brown (2.5Y 5.0/4.0, moist) clay loam; strong medium to coarse prismatic and moderate medium columnar slightly sticky, slightly plastic, firm; no mottles; no cutans; common fine pores; moderately porous; common medium roots throughout and common fine roots throughout; no inclusions; no fragments; non calcareous (10% HCL) throughout; gradual smooth boundary to

BC 43 - 85 cm 10Y 6.0/3.0, moist clay loam; moderate fine to medium prismatic and moderate medium columnar sticky, plastic, very firm; no mottles; no cutans; few medium pores; moderately porous; few very fine to coarse roots throughout; no inclusions; no fragments; strongly cemented continuous massive salt pan; non calcareous (10% HCL) throughout; gradual wavy boundary to

Cg1 85 - 120 cm 10Y 6.0/3.0, moist clay loam; moderate medium columnar sticky, slightly plastic, firm; no mottles; no cutans; few medium pores; moderately porous; few medium roots throughout and few fine roots throughout; very frequent medium spherical soft calcareous nodules; no fragments; non calcareous (10% HCL) throughout; clear smooth boundary to

Cg2 120 - 180 cm 10Y 6.0/4.0, moist loam; massive non sticky, non plastic, friable; no mottles; no cutans; few medium pores; moderately porous; no roots; very frequent medium spherical soft calcareous nodules; no fragments; non calcareous (10% HCL) throughout;

ADDITIONAL REMARKS

Short field description:
Moderately deep, imperfectly drained, brown to light olive brown clay loam. Soil structure moderate angular blocky and medium prismatic to columnar. There are frequent calcareous nodules in the subsoil.
Geology: Eogene mid-higher. San Luis Formation: limestone, marls, conglomerate, sandstones.
Geomorphology: marine plain and terrace, erosive and undulating.

ANALYTICAL DATA:

			PARTICLE SIZE DISTRIBUTION (μm)													pF							
Hor.	Top	Bot.	>2 mm	2000 1000	1000 500	500 250	250 100	100 50	TOT SAND	50 20	20 2	TOT SILT	<2	WDIS CLAY	BULK DENS	0.0	1.0	1.5	2.0	2.3	2.7	3.4	4.2
Ap	0	20	-	0	0	0	0	1	1	9	31	40	59	21.1	1.21	54	53	50	45	43	41	36	34
B1	20	43	-	0	0	0	0	1	1	10	27	36	63	5.8	1.27	52	51	49	46	45	44	37	31
BC	43	85	-	0	0	0	0	0	1	15	18	33	67	6.0	1.32	51	51	50	49	47	46	41	32
Cg1	85	120	-	0	0	0	0	1	2	8	27	36	63	5.7	-	-	-	-	-	-	-	-	-
Cg2	120	150	-	0	0	0	0	2	2	12	29	40	58	46.2	-	-	-	-	-	-	-	-	-
Cg2	150	180	-	0	0	0	0	2	3	18	33	50	47	36.8	-	-	-	-	-	-	-	-	-

Hor.	pH H2O	pH KCl	CaCO3	ORG. MATTER C	N	EXCHANGEABLE CATIONS Ca	Mg	K	Na	sum	EXCH. ACID. H+Al	Al	CEC soil	CEC clay	CEC OrgC	ECEC	BASE SAT	AL SAT	EC2.5	ESP
Ap	8.4	7.4	29.4	2.2	0.23	37.2	9.8	1.4	18.0	66.4	-	-	37.0	62	7.8	66.4	179	-	3.10	
B1	8.2	7.5	27.8	1.3	0.23	53.9	13.2	0.9	27.7	95.7	-	-	36.4	58	4.4	95.7	263	-	10.00	
BC	8.5	7.7	31.0	0.8	0.08	62.0	16.5	0.2	25.8	105	-	-	35.3	53	2.7	105	296	-	10.00	
Cg1	8.8	7.9	33.2	0.3	0.04	41.8	13.2	0.2	24.9	80.1	-	-	31.4	50	1.2	80.1	255	-	7.00	
Cg2	9.0	7.9	34.2	0.3	0.03	34.1	10.2	0.6	24.2	69.1	-	-	30.0	52	1.0	69.1	230	-	2.10	
Cg2	9.2	7.7	32.2	0.2	0.02	32.4	10.1	0.2	16.2	58.9	-	-	26.7	56	0.6	58.9	221	-	4.20	

remark sample 1 - 6: 4x prewashed (80% alcohol) for exch.bases

CLAY MINERALOGY (1 = very weak .. 8 = very strong)

Hor.	MI	VE	CH	SM	KA	HA	ML	QU	FE	GI	GO	HE
Ap	·	·	·	8	4	·	5	3	3	·	·	·
B1	·	·	·	8	5	·	5	3	3	·	·	·
BC	·	·	·	8	5	·	5	3	3	·	·	·
Cg1	·	·	·	8	5	·	5	3	3	·	·	·
Cg2	·	·	·	8	5	·	5	3	3	·	·	·
Cg2	·	·	·	8	4	·	5	3	3	·	·	·

EXTRACTABLE Fe, Al, Si, Mn by amm. oxal.(o), Na dith(d) & pyroph.(p)

Hor.	Fe(o)	Al(o)	Si(o)	Fe(d)	Al(d)	Fe(p)	Al(p)	Pret	pHNaF
Ap	-	-	-	-	-	-	-	-	-
B1	-	-	-	-	-	-	-	-	-
BC	-	-	-	-	-	-	-	-	-
Cg1	-	-	-	-	-	-	-	-	-
Cg2	-	-	-	-	-	-	-	-	-
Cg2	-	-	-	-	-	-	-	-	-

Annex 2 Evaluation of Soil/Land Qualities of CU 15

LAND QUALITY Availability (1)

Hazard/Limitation (2)

vh	h	m	l	vl
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

CU 15

↓

CLIMATE

Land quality		(1)/(2)	vh / n	h / w	m / m	l / s	vl / vs
Radiation regime	- total radiation	1	X				
	- day length	1	X				
Temperature regime		1		X			
Climatic hazards (hailstorm, wind, frost)		2			X		
Conditions for ripening		1		X			
Length growing season		1			X		
Drought hazard during growing season		2				X	

SOIL

Land quality		(1)/(2)	vh / n	h / w	m / m	l / s	vl / vs
Potential total soil moisture		1		X			
Oxygen availability		1				X	
Nutrient availability		1		X			
Nutrient retention capacity		1		X			
Rooting conditions		1			X		
Conditions affecting germination		1			X		
Excess of salts	- salinity	2			X		
	- sodicity	2					X
Soil toxicities (e.g. high Al sat.)		2					

LAND MANAGEMENT

Land quality		(1)/(2)	vh / n	h / w	m / m	l / s	vl / vs
Initial land preparation		2			X		
Workability		1					
Potential for mechanization		1	X				
Accessibility	- existing	1	X				
	- potential	1					
Erosion hazard	- wind	2					
	- water	2		X			
Flood hazard		2			X		
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 analysis	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 1M 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 procedure. 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: 1/1000[th] 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.
montmorillonite	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
INICA	Instituto Nacional de Investigaciones de la Caña de Azúcar
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 Cuba

(ISSN: 1381-6950)

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Cuba 1	Reference Soil of the Central Valley, derived from Alluvium	1
Cuba 2	Salt-Affected Reference Soil of the Guantánamo Valley	1
Cuba 3	Strongly weathered Reference Soils of the Central and Northeastern Regions	4
Cuba 4	Hydromorphic Reference Soils	3
Cuba 5	Brown Calcareous Reference Soils derived from Limestone	4
Cuba 6	Brown Reference Soils	2
Cuba 7	Humus-rich Calcareous Reference Soil	1
Cuba 8	Cracking Heavy Clay Reference Soils (Vertisols)	3

Country Reports

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7	Indonesia	48
8	Ecuador	in prep.
9	Brazil	28
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13	Zambia	11
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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