Soil Brief *Cuba 6*

CUBA

Brown reference soils

R. Chang
C. Balmaseda
R. Villegas
D. Ponce de León

ISRIC

Instituto Nacional de Investigaciones de la Caña de Azúcar

International Soil Reference and Information Centre

INICA

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ISRIC Soil Monoliths:

Number	*FAO-Unesco*	*Soil Taxonomy*
CU 9	Eutric Vertisol	Udic Haplustert
CU 11	Eutric Cambisol	Typic Ustropept

R. Chang
C. Balmaseda
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D. Ponce de León

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ISRIC
P.O. Box 353
6700 AJ Wageningen
The Netherlands

INICA
Ave. Van Troi # 17203
CP 19210, Boyeros
C. Habana, Cuba

CONTENTS

FOREWORD

A Soil Brief, has as objective the characterization of reference soils together with a qualitative assessment of its qualities. In this Soil Brief, special reference is made to sugarcane, the major crop in Cuba.
Different aspects related to the brown soils formed from non calcareous rocks and a strong sialitic evolution degree are presented and discussed.
These soils are the most fertile arable soils in the country. However, they are affected by erosion, and a section on soil erosion is included in this Soil Brief.
A joint cooperation project of INICA and ISRIC 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 and 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 national soil collection of Cuba 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). During fieldwork, N. Arzola and H. Pérez (CU 9), and L. Bouzo and J. Acosta (CU 11) from Sugarcane Experiment Station of Cienfuegos and Pinar del Río provinces made important contributions.

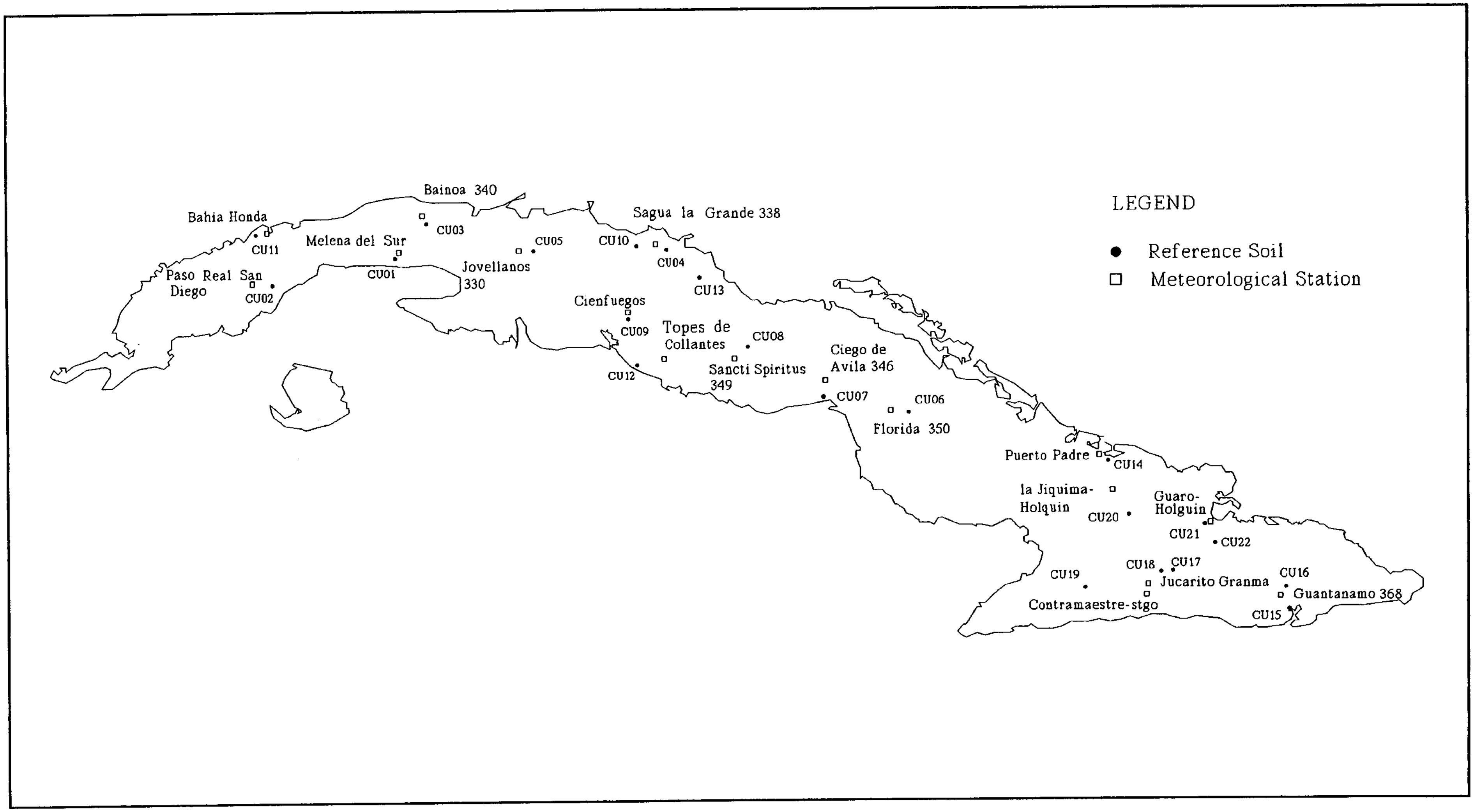

Figure 1 Geographical location of the reference sites.

1 Brown soils derived from non-calcareous rock in Cuba

According to the "2da Clasificación Genética de los Suelos de Cuba" (Instituto de Suelos, 1975), the Brown Soils group is characterized by a relatively young sialitic evolution leading to different soil types depending on the conditions prevailing during sialitization which could be in a Calcium carbonate rich medium or an evolution from granodiorite rocks or from intermediate and basic rocks. The soils "Pardos con carbonators" belong to the latter type. Their extent is less than the Brown soils derived from calcareous rock (limestone), which are the subject of another Soil Brief.

Table 1 Percentage distribution of Brown soils in Cuban sugarcane agriculture.

Province	Brown calcareous %	Brown non-calcareous %	Total of sugarcane plantations %
Pinar del Río	12	20	33
La Habana	17	-	17
Matanzas	21	-	21
Villa Clara	32	13	46
Cienfuegos	43	13	57
Sancti Spíritus	35	-	35
Camagüey	30	8	39
Las Tunas	21	13	34
Holguín	13	-	13
Santiago de Cuba	61	-	61
Granma	12	-	12
Guantanámo	89	-	89

The Brown soils from non-calcareous rock are susceptible to degradation such as erosion, influenced by environmental conditions and anthropogenic activity during past centuries. They are also affected by secondary salinization especially when situated in lower topographic positions and in the presence of saline groundwater.

1.1 Climate

The soils are situated in a tropical climate with a dry winter (Aw). The rainfall distribution varies with the geographical location of the site. The west part of the country has higher rainfall (Díaz Cisneros, 1989), determined by the local characteristics of the atmosphere circulation. Better conditions for crop growth are found in this region.

1.2 Landscape

Brown soils derived from non-calcareous rocks are usually associated to a hilly topography in abrasive and abrasive accumulative marine terraces. The dominant land cover is savannah vegetation. These soils are also found in depressions where they may have vertic properties.

2 THE REFERENCE SOILS

2.1 Location and occurrence

Reference soil CU 9 was sampled in Cienfuegos province Palmira municipality, in areas of the "Espartaco" mill, in a block under sugarcane (Fig. 1). It is located at the middle part of a slope (22°16' N and 80°19' W) at 45 m altitude.
The soil is highly representative for the area. It occupies 53% of the mill area and more than 10% of the sugarcane area in the province.
Reference soil CU 11 is located in areas of the "Harlem" mill in Pinar del Río province Bahia Honda municipality, (Fig.), (22°55' N and 83°17' W) at 25 m altitude.
It was sampled at the upper part of a low hill in a field of the Sugarcane Experimental Station.

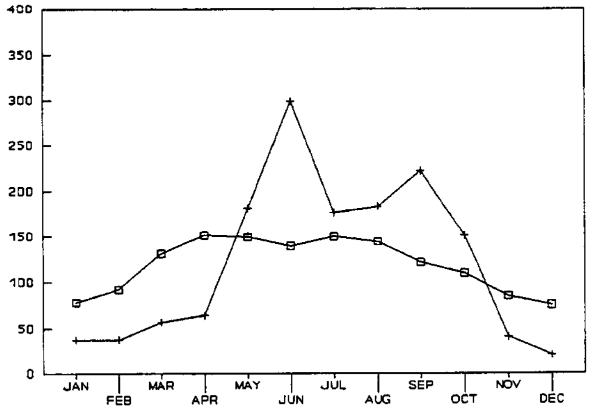

Figure 2 Precipitation (+) and evapotranspiration (□) in mm at the Cienfuegos meteorological station (CU09 site).

2.2 Climate

The Cienfuegos Meteorological Station is representative for the climatic conditions of the CU 9 site. Climatic data are presented in Annex 1A. This station and the site are located in the central part of the country (Fig. 1). The rainfall and potential evapotranspiration diagram (Fig. 2) shows a marked seasonal moisture regime, with a humid period from May to October, with more than 82% of the annual rainfall, and a relatively dry period from November to April. July is the month with a somewhat lower rainfall although it is not so dry to interrupt plant growth.
The highest temperatures are in July and August (Fig. 3). Relative humidity is high throughout the year, the monthly average varies between 74 and 84%.

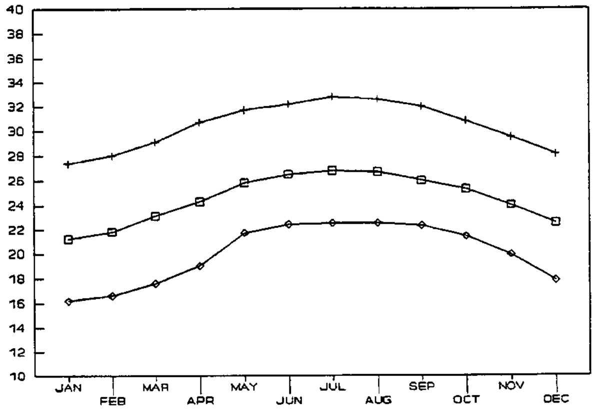

Figure 3 Maximum (+), average (□) and minimum (◊) temperature in °C at the Cienfuegos meteorological station (CU09 site).

The CU 11 site is represented by the Bahía Honda station located in the west province of the country with a high annual rainfall (1538 mm), see Annex 1B.
Fig. 4 shows that rainfall is prevailing throughout the year, except in March and April.
All diagrams in this Soil Brief were made with Solgraph (Brunt and Kauffman, 1995).

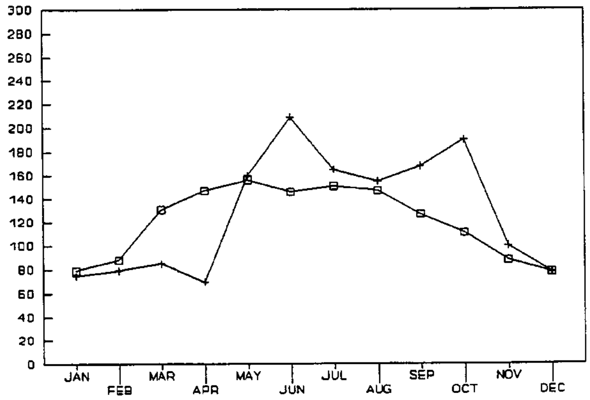

Figure 4 Precipitation (+) and evapotranspiration (□) in mm at the Bahia Honda meteorological station (CU11 site).

2.3 Landscape, Geology, Vegetation and Land Use

The landscape is an alluvial abrasive-erosive plains. The topography around the CU 9 site is undulating with slopes from 2 to 8%. The lower parts may be flooded during the rainy season.
The geological materials belong to the Ataguá formation of the inferior Cretaceous, consisting of calcareous effusive rocks, basic and intermediate lava and other rocks. The specific lithology of this soil type consists of basalt and andesite-basalt (Formell Cortina, 1989).
The original vegetation of typical "mesophyll", semi-deciduous forest (Del Risco R., 1989), was replaced by agricultural crops. Dominant is sugarcane, while pasture land and isolated patches of shrubs are typical as secondary vegetation.

The prevailing landscape at the CU 11 site is low hilly with 12% slopes, consisting of undulating to almost flat abrasive plains and abrasive marine terraces. The parent material is composed of igneous rocks of the San Luis geological formation which consists of biodetrital limestones, conglomerates and loams from the upper Cretaceous. The original vegetation is similar to the CU 9 site, associated partly with natural savannah containing xeromorphic vegetation. In the latter case serpentinite is parent rock.
The main type of land use is sugarcane cultivation although pasture land and some other crops are also grown.

2.4 Brief soil characterization

A complete field description of the reference profiles and sites according to the Guide for profiles description of FAO (1989) is presented in Annexes 1A and 1B, together with the analytical characterization according to the ISRIC procedures (Van Reeuwijk, 1987).

CU 9 is a deep, moderately well drained, dark yellowish brown clay with gravel. The soil is moderately porous and has a strong angular blocky structure, showing slickensides on the tilted shearplanes.

CU 11 is a shallow, well drained, dark yellowish brown clay. The soil has mottles, hard calcareous and soft manganese nodules, and a massive fragipan which is weakly cemented.

Brief analytical characterization of the CU 9 and CU 11 profiles

The increase in clay content in the shallow subsoil is caused by vertical and/or lateral clay removal (Fig. 5). Generally, these soils have a lower clay content in comparison to soils derived from calcareous rocks (Instituto de Suelos, 1975). The processes induced by the alternating wet-dry periods is similar. The soil cracks during the dry period develop a granular structure, while during the wet season, the clay will expand and the soil loses its previous structure (Hernández *et al.*, 1976).
These processes are dependent on the actual climatic conditions. That is the reason for these mechanisms being seen in the CU 11 site, which presents a less marked relatively dry period. Both profiles have a very low air capacity. In Fig. 6 the pF curve of CU 9 is shown.
The soils have a very high sum of bases and a very high base saturation (see Fig. 7 and Table 2). Hernández *et al.* (1976) refer to an "autoblocking" of the soil evolution process through the decrease of clay expansion, base washing and intensity of formation and transformation processes of clay minerals which lead to an abundance of alkaline-earth elements with prevalence of Ca^{+2} and Mg^{+2}. However, the relative youth of these soils could also be explained by the paleoclimatic hypothesis that there was a dryer climate than the present one, during the period of glaciation in other parts of the world (Ortega and Arcia, 1982).
The high cation exchange capacity is characteristic for the smectite clay. The medium kaolinite and mixed minerals content can be explained as a result of the mineralogical transformations resulting from weathering.

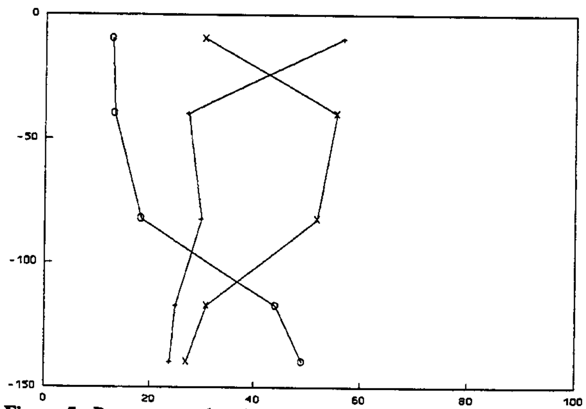

Figure 5 Percentages clay (×), silt (+) and sand (o) versus depth (cm) in profile CU 9.

2.5 Soil classification

Some considerations regarding the position of the reference profiles in the taxonomic systems of FAO-Unesco (1988), USDA-Soil Taxonomy (1992) and the local classification, referred to the "2da Clasificación Genética de los Suelos de Cuba" (Instituto de Suelos, 1975) are given in this section.

Table 2 Selected analytical properties of CU 9 and CU 11 profiles.

	CU 9	CU 11
Texture	Silty clay	Clay loam
Sum of bases	Very high throughout the profile	-
Cation Exchange Capacity	Very high throughout the profile	High throughout all the profile
Clay Mineralogy	Smectites dominant with medium kaolinite and mixed minerals content	-
Soil reaction	Neutral to slightly alkaline	Neutral to slightly acid
Air Capacity	Very low throughout (1%)	Very low throughout (<3%)
Moisture Availability	Medium (11-13%) in the first meter to low in the deeper subsoil (9%)	-
Bulk Density (kg dm^{-3})	Medium (1.2-1.4)	Low to medium

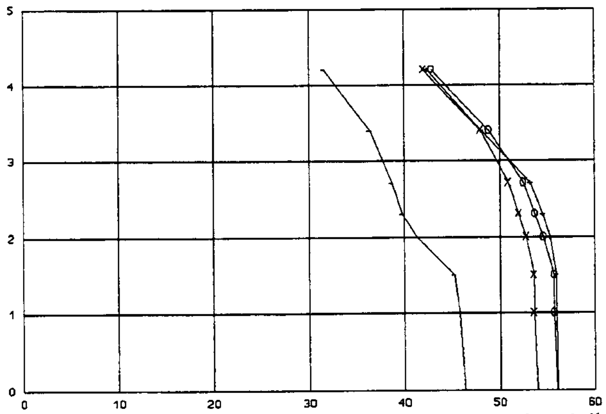

Figure 6 pF or moisture retention curves (water content in vol % versus suction) at depth 0-20 cm (×), 20-60 cm (+), 60-105 cm (o) and 105-130 cm (-) in profile CU 9.

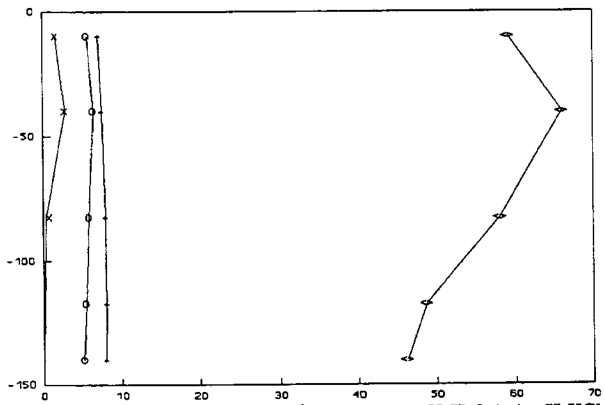

Figure 7 Sum of bases ($cmol_c$ kg^{-1} soil) (< >), pH-H_2O (+), pH-KCl (o) and organic carbon (×) versus depth (cm) in profile CU 9.

CU 9

FAO-Unesco (1988)
The soil has vertic properties as presented by strong wedge-shaped structure, tilted shearplanes, slickensides and large cracks. It classifies as Eutric Vertisol because of the high base saturation and its dark color.

USDA-Soil Taxonomy (1992)
The soil has vertic properties, and an ustic soil moisture regime. It is assumed that the length of the dry period with cracks is less than 150 days a year, therefore it classifies as Udic Haplustert.

2da. Clasificación Genética de los Suelos de Cuba (1975)
The soil is classified within the "Pardo con carbonato" type according to the sialitization process that takes place and taking into account the importance of the color for its diagnosis, and the presence of carbonate through the profile, what make sure the high base saturation and pH, while the presence of vertic characteristics such as cracking and slickensides places it within the plastogenic subtype.

CU 11

FAO-Unesco (1988)
The A horizon of this soil does not classify as mollic as it is too shallow. It has a cambic B horizon and a high base saturation and is therefore classified as Eutric Cambisol.

USDA-Soil Taxonomy (1992)
Similar to the previous described characteristics and the ustic moisture regime, it is classified as Typic Eutrochrept.

2da. Clasificación Genética de los Suelos de Cuba (1975)
The soil is classified as "Pardo sin carbonato Gleyzoso: due to the sialitization process and other characteristics

for this type of soil. There are hydromorphic mottles and segregation of manganese in the middle and lower horizons.

2.6 Soil evaluation and management

Annexes 2a and 2b contain a summary of the evaluation of relevant soil, climate and land management qualities for sugarcane, according to the Guidelines for land evaluation (FAO, 1983, and ISRIC, 1994). This methodology recommends the evaluation for different types of land use, but in this case it is only applied for sugarcane cultivation based on its economic importance. Limiting factors of these soil types are the effective soil depth, the risk of soil erosion, and the seasonal distribution of rainfall required for irrigation.

CU 9 is a deep, imperfectly to moderately well drained soil with moderately permeability limited by a compact layer below 60 cm with high bulk density. Its main limitation is the scarcity of large pores, reflected in low air capacity, anaerobic processes, soil mottling which affects soil tillage and germination.
The loss of the topsoil due to erosion is another factor reducing crop production.
The moisture deficit is an important stress factor for sugarcane cultivation (for both winter and spring planting) and irrigation is required for optimal production. Experimental results show no fertilizer response (N, P, K) up to the 5th ratoon in plants of 10 months age.

CU 11 is limited by its effective depth of 40 cm classifying it as moderately shallow for sugarcane cultivation. A serious limitation is the very low air capacity throughout the profile and the presence of a low permeable layer at about 18 and 44 cm depth. These conditions and the swelling clay type provoke run-off and erosion. The soil has a high natural fertility, not responding to fertilization up to the 3rd ratoon. Fertilizer recommendations for this soil type and for CU 9 are presented in Table 3.

2.7 Erosion and soil conservation

According to Hernández *et al.* (1980) the causes of erosion are: the undulating hilly topography, the clay type and texture of the upper soil horizons, the high dispersion and the rainfall intensity of the present climate, and improper agronomic practices. The same author has reported on the practice of migratory agriculture in pre-mountainous zones of Sierra Maestra since the last century. Deforestation began before 1492 with agricultural practices of the original inhabitants, however, at that time this was not significant (Waibel, 1943). Since the 18th century, with land distribution among the Spanish settlers, this process became more intensive and the expansion of sugarcane area transformed the original forest into the present day anthropogenic savannah. Natural savannah can only be found on shallow soils developed over granodiorites and serpentinites (Bennett and Allison, 1928). Some practices are especially risky for sugarcane, such as burning, together with continuous ploughing induces the formation of compact horizons. Moreover, the presence of swelling clay decreases, the infiltration capacity, provoking run-off and erosion. On the other hand, once established and closed, sugarcane covers the soil completely, which is beneficial to control erosion as it reduces greatly the erosive impact of the rain.

Table 3 Fertilizer recommendations for sialitic non calcic soils. (INICA, 1986).

	NITROGEN (kg N/ha)								PHOSPHORUS (kg P_2O_5/ha)					POTASSIUM (kg K_2O/ha)			
	Expected yield (t/ha)								P_2O_5 content in soil (mg/100g)					K_2O content in soil (mg/100g)			
Crops	<34.8	34-51	52-68	69-84.5	85-101	102-118	119-135	>135	>6	4.6-6	3-4.5	1.5-2.9	<1.5	>30	20-30	10-19.9	<10
Planting of:																	
Spring	25	25	25	35	35	35	35	35	0	15-20	25	35	50	0	0	100	100
Winter	40	40	40	50	50	60	60	60	0	15-20	25	35	50	0	0	100	100
1st Ratoon	50	50	50	60	60	75	75	75	0	15-20	25	35	50	0	0	150	160
2nd Ratoon	75	80	90	100	100	100	100	100	0	15-20	25	35	50	0	0	150	160
3rd Ratoon or further	90	100	120	140	150	150	180	200	0	15-20	25	35	50	70	70	160	160

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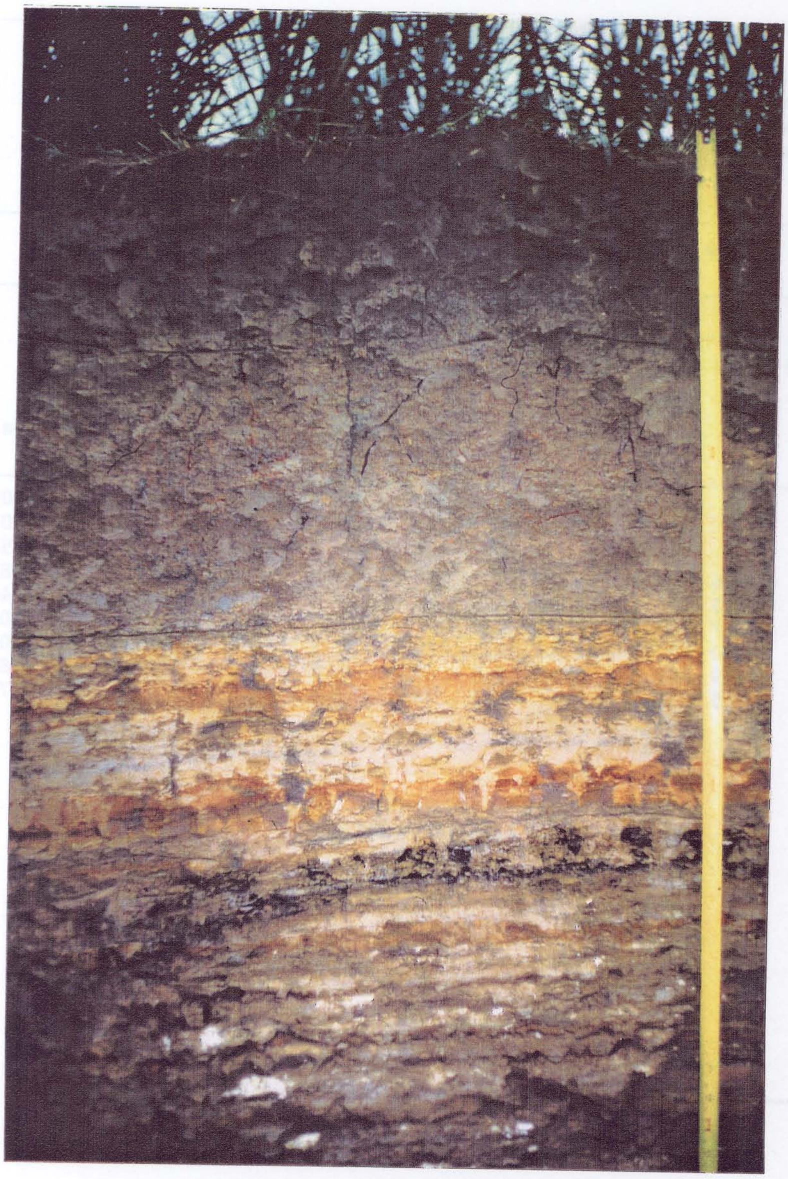
2

1. Landscape CU 9
2. Profile CU 9

1

2



1. Landscape CU 11
2. Profile CU 11

Annex 1A ISIS Data Sheet CU 9

Reference soil CU 9, CUBA

Print date: 3 July 1995

FAO/UNESCO (1988) : Pelli-Vertisols
(1974) : Pellic Vertisol
USDA/SCS SOIL TAXONOMY (1992) : Udic Haplustert, fine, montmorrilonitic, isohyperthermic
(1975) : Udic Pellustert
LOCAL CLASSIFICATION : Pardo sin carbonato plast.

DIAGNOSTIC CRITERIA FAO (1988) : mollic A, argic B, slickensides
USDA/SCS (1992) : mollic epipedon, argillic horizon, slickensides
Soil moisture regime : ustic
Soil temperature regime : isohyperthermic

LOCATION : Cuba Prov. Cienfuegos Mun.Palmira CAI Espartaco EPICA Banco de semilla
Latitude / Longitude : 22°16'0"N / 80°19'0"W — Altitude : 45 m a.s.l.
AUTHOR(S) : Marín/Regla/Balmas. — Date : July 1991

GENERAL LANDFORM : alluvial plain — Topography : undulating
PHYSIOGRAPHIC UNIT : undulated
SLOPE Gradient, Form : 2%, undulating, — Position of site : middle slope
MICRO RELIEF Kind :
SURFACE CHAR. Rock outcrop : nil — Cracking : large cracks
Stoniness, Size, Form : very few stones, 20 cm, , angular irregular
Slaking/crusting : nil
SLOPE PROCESSES Soil erosion : moderate rill — Aggradation : not apparent
Slope stability : stable

PARENT MATERIAL 1 type, texture : solid rock derived from coarse-grained basic igneous
PARENT MATERIAL 2 type, texture :
Remarks :

EFFECTIVE SOIL DEPTH : 100 cm
WATER TABLE Kind, Depth : no watertable observed, -
DRAINAGE : imperfectly to moderately well
PERMEABILITY : moderate, slowly permeable layer from 60 to 70 cm
FLOODING Frequency : irregular, fresh water — Run off : medium

MOISTURE CONDITIONS PROFILE : 0-150 cm moist

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

CLIMATE Köppen : Aw
MET. STATIONS Name, Location : CIENFUEGOS, 22°18' / 80°19', 45 m a.s.l
Distance to site (relevance) : CIENFUEGOS lays 15 km SW of the site (good)

CIENFUEGOS		No. years of record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
EP Penman	mm	13	78	92	131	151	149	139	150	144	121	109	85	75	1430
relative humidity	%	12	79	78	75	74	78	82	81	82	84	84	83	81	80
precipitation	mm	12	38	38	57	64	181	299	176	183	222	151	41	20	1475
tot.glob.rad.	MJ/m²	6	14.1	16.8	20.3	23.6	21.9	21.0	21.8	21.0	18.2	16.1	13.7	12.8	18.[illegible]
T mean	°C	13	21.2	21.8	23.1	24.3	25.8	26.5	26.8	26.7	26.0	25.3	24.0	22.5	24.[illegible]
T max	°C	13	27.4	28.0	29.1	30.7	31.7	32.2	32.8	32.6	32.0	30.8	29.5	28.1	30.[illegible]
T min	°C	13	16.2	16.6	17.6	19.0	21.7	22.4	22.5	22.5	22.3	21.4	19.9	17.8	20.[illegible]
windspeed(at 2m)	m/s	12	7.3	11.2	12.4	10.9	9.0	8.5	9.5	8.4	6.8	8.4	9.1	10.2	8.[illegible]
bright sunshine	h/d	6	7.0	7.4	8.2	9.5	8.1	7.6	8.3	8.1	7.3	7.4	7.1	6.9	7.[illegible]

PROFILE DESCRIPTION :

Ap	0 - 20 cm	very dark gray (10YR 3.0/1.0, moist) clay loam; strong coarse subangular blocky and strong medium granular; slightly sticky, slightly plastic, firm; few fine pores and few medium pores; moderately porous; common fine roots throughout; frequent channels; non calcareous (10% HCL) throughout; gradual smooth boundary to
Ah	20 - 60 cm	very dark gray (10YR 3.0/1.0, moist) clay loam; strong coarse subangular blocky parting to strong medium granular; slightly sticky, slightly plastic, firm; few medium distinct diffuse mottles (10YR 5.0/4.0); no cutans; common medium pores and common fine pores; moderately porous; few fine roots throughout; no inclusions; no fragments; frequent channels; non calcareous (10% HCL) throughout; clear irregular boundary to
Bt1	60 - 105 cm	dark yellowish brown (10YR 4.0/4.0, moist) clay loam; strong coarse subangular blocky and moderate medium prismatic; sticky, plastic, very firm; no mottles; broken moderately thick slickensides cutans throughout; common fine pores and common medium pores; moderately porous; no roots; no inclusions; no fragments; few channels; non calcareous (10% HCL) throughout; diffuse smooth boundary to
CB	105 - 130 cm	yellowish brown (10YR 5.0/4.0, moist) gravelly clay loam; structureless; non sticky, non plastic, friable; no mottles; no cutans; common fine pores and few medium pores; moderately porous; no roots; no inclusions; few medium weathered fragments; non calcareous (10% HCL) throughout; diffuse irregular boundary to
Cr	130 - 150 cm	dark brown (10YR 4.0/3.0, moist) gravelly clay loam; structureless; non sticky, non plastic , friable; no mottles; no cutans; common fine pores and few medium pores; moderately porous; no roots; no inclusions; very few medium weathered fragments; non calcareous (10% HCL) throughout;

ADDITIONAL REMARKS

Short field description:
Deep, moderately well drained, dark yellowish brown clay with gravel. The soil is moderately porous and has a strong angular blocky structure, showing slickensides on the tilted shearplanes.
Undulating site with different slope gradient toward the lowest parts. The site is flooded during the raining season. There is a not well defined prismatic structure in the third horizon. Small gravels throughout the profile; increasing gravel size with depth.
Geology: Aptiano-Albiano lower Cretaceous. Ataguá formation: calcareous tuff, basic and intermediate lavas, limestone and clastic rock. Geomorphology: abrasive, erosive, undulating marine plains.

ANALYTICAL DATA:

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	pF 0.0	1.0	1.5	2.0	2.3	2.7	3.4	4.2
			PARTICLE SIZE DISTRIBUTION (μm)																				
Ap	0	20	-	2	2	2	4	3	13	5	51	57	31	-	1.21	54	54	54	53	52	51	48	42
Ah	20	60	-	1	2	2	4	4	13	9	18	27	56	-	1.19	56	56	56	55	55	53	48	42
Bt1	60	105	-	4	4	3	4	3	18	5	25	30	52	-	1.21	56	56	56	55	54	53	49	43
CB	105	130	-	11	12	9	8	5	44	7	18	25	31	-	1.43	46	46	45	41	40	39	36	32
Cr	130	150	-	12	14	10	9	5	49	7	17	24	27	-	-	-	-	-	-	-	-	-	-

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	7.1	5.6	4.8	1.7	0.02	41.4	16.4	1.1	0.3	59.2	-	-	57.3	188	-	59.2	100	-	0.27	
Ah	7.5	6.4	7.0	2.8	0.33	48.7	15.1	2.0	0.2	66.0	-	-	54.8	99	-	66.0	100	-	0.39	
Bt1	7.9	5.8	5.4	0.3	-	39.9	17.3	0.4	0.5	58.1	-	-	50.4	97	-	58.1	100	-	0.19	
CB	8.0	5.4	6.4	0.1	-	34.6	13.4	0.2	0.5	48.7	-	-	40.9	132	-	48.7	100	-	0.14	
Cr	7.9	5.1	5.9	0.1	-	33.1	12.3	0.2	0.6	46.2	-	-	37.2	137	-	46.2	100	-	0.10	

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

Hor.	MI	VE	CH	SM	KA	HA	ML	QU	FE	GI	GO	HE
Ap	1	0	0	8	4	0	3	0	0	0	0	0
Ah	1	0	0	8	4	0	3	0	0	0	0	0
Bt1	1	0	0	8	4	0	3	0	0	0	0	0
CB	1	0	0	8	3	0	3	0	0	0	0	0
Cr	1	0	0	8	3	0	3	0	0	0	0	0

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	1.0	0.2	0.4	-	-	-	-	-	-
Ah	1.0	0.3	0.4	-	-	-	-	-	-
Bt1	0.5	0.3	0.3	-	-	-	-	-	-
CB	0.2	0.4	0.7	-	-	-	-	-	-
Cr	0.1	0.5	0.9	-	-	-	-	-	-

Reference soil CU 11, CUBA Print date: 3 July 1995

FAO/UNESCO (1988) : Orthi-Eutric Cambisol
(1974) : Eutric Cambisol
USDA/SCS SOIL TAXONOMY (1992) : Typic Ustropept, montmorrilonitic, isohyperthermic
(1975) : -do-
LOCAL CLASSIFICATION : Pardo sin carbonato

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

LOCATION : Cuba Prov. Pinar del Rio Mun. Bahia Honda CAI"Harlem" Bloque 91
Latitude / Longitude : 22°55'0"N / 83°17'0"W Altitude : 25 m a.s.l.
AUTHOR(S) : Marín/Regla/Balmas. Date : November 1991

GENERAL LANDFORM : low hill Topography : rolling
PHYSIOGRAPHIC UNIT : undulated
SLOPE Gradient, Form : 12%, undulating, Position of site : crest
MICRO RELIEF Kind :
SURFACE CHAR. Rock outcrop : nil Cracking : nil
Stoniness, Size, Form : very few stones, 15 cm, , angular irregular
Slaking/crusting :
SLOPE PROCESSES Soil erosion : slight sheet
Slope stability : stable

PARENT MATERIAL 1 type, texture : marine sediments derived from sedimentary rock
Remarks :

EFFECTIVE SOIL DEPTH : 55 cm
WATER TABLE Kind, Depth : no watertable observed, -
DRAINAGE : moderately well
PERMEABILITY : slow, slowly permeable layer from 18 to 44 cm
FLOODING Frequency : nil Run off : rapid

MOISTURE CONDITIONS PROFILE : 0-90 cm moist

LAND USE : high level arable farming (sugar cane)

CLIMATE Köppen : Aw
MET. STATIONS Name, Location : BAHIA HONDA, 22°55' / 83°10', 3 m a.s.l
Distance to site (relevance) : BAHIA HONDA lays 14 km ENE of the site (good)

BAHIA HONDA		No. years of record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
act. evapotransp.	mm	21	151	148	184	201	215	190	196	198	173	168	151	148	2128
EP Penman	mm	21	79	88	131	147	156	146	151	147	127	111	88	78	1455
relative humidity	%	21	78	78	77	76	79	81	81	82	83	83	82	80	80
precipitation	mm	21	75	79	85	70	160	209	165	155	168	190	100	78	1538
tot.glob.rad.	MJ/m²	21	403.2	448.0	638.6	690.1	682.0	630.0	651.0	651.0	540.0	486.7	390.0	372.0	6582.6
T mean	°C	21	21.1	21.3	22.9	24.4	25.9	26.7	26.9	26.9	26.3	25.1	23.6	22.2	24.5
T max	°C	21	26.2	26.4	28.3	29.6	30.7	31.4	32.1	32.3	31.6	29.9	28.3	27.0	29.5
T min	°C	21	16.4	16.5	18.0	19.1	21.2	22.5	22.7	22.8	22.5	21.6	19.8	17.8	20.1
windspeed(at 2m)	m/s	21	2.3	2.5	3.2	2.6	2.6	2.2	1.9	1.9	2.1	2.2	2.4	2.5	2.3
bright sunshine	h/d	21	6.4	7.3	8.5	9.2	8.5	7.9	8.1	8.1	7.4	7.2	6.9	6.4	7.6

PROFILE DESCRIPTION :

Ap	0 - 18 cm	very dark grayish brown (10YR 3.0/2.0, moist) clay loam; strong medium angular blocky; slightly sticky, plastic; no mottles; no cutans; few very fine pores and common medium pores; moderately porous; common medium roots throughout; no inclusions; no fragments; frequent worm channels and channels; non calcareous (10% HCL); gradual irregular boundary to
Bw	18 - 44 cm	dark yellowish brown (10YR 3.0/4.0, moist) clay loam; strong medium subangular blocky; slightly sticky, plastic, firm; common fine distinct clear mottles (10YR 5.0/8.0); no cutans; few micro pores; slightly porous; few very fine roots throughout; no inclusions; no fragments; few worm channels; non calcareous (10% HCL); clear irregular boundary to
BC	44 - 55 cm	dark yellowish brown (10YR 4.0/4.0, moist) sandy clay loam; structureless; slightly sticky , slightly plastic, firm; many heterogeneous distinct diffuse mottles (10YR 5.0/8.0) and few fine faint clear mottles (10YR 5.0/1.0); no cutans; few micro pores and few very fine pores; slightly porous; no roots; few large spherical hard calcareous nodules and frequent large irregular hard manganiferous soft segregations; frequent medium weathered hor.bed.clayst. fragments; non calcareous (10% HCL); clear irregular boundary to
C	55 - 90 cm	dark yellowish brown (10YR 4.0/4.0, moist) structureless; non sticky, firm; many coarse prominent diffuse mottles (7.5YR 2.0/0.0); no cutans; no pores; no roots; frequent large spherical hard calcareous nodules and few large irregular hard manganiferous soft segregations; frequent coarse weathered hor.bed.clayst. fragments; slightly calcareous (10% HCL) locally; gradual irregular boundary to
CR	90 - 115 cm	yellowish brown (10YR 5.0/8.0, moist) structureless; non sticky, non plastic, firm; many coarse distinct diffuse mottles (7.5YR 5.0/8.0) and common medium distinct diffuse mottles (2.5Y 5.0/2.0) ; no cutans; no pores; no roots; frequent large spherical hard calcareous nodules; very frequent medium fresh hor.bed.clayst. fragments; slightly calcareous (10% HCL) locally;

ADDITIONAL REMARKS

Short field description:
Shallow, well drained, dark yellowish brown clay. There are mottles, hard calcareous and soft managanese nodules, and a massive fragipan which is weakly cemented.
Geology: Cretaceous superior, Campaniano-maestrichtiano. Formation: San Juan y Martinez, biodetritic limestone, conglomerate, marls, at the site igneous rocks.
Geomorphology: marine plains and terrace abrasive and abrasive accumulative, undulating and slightly 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	5 -	18	-	-	-	-	-	-	-	-	-	-	-	-	1.08	59	59	59	58	58	57	-	-
Bw	20 -	25	-	-	-	-	-	-	-	-	-	-	-	-	0.99	63	62	62	62	62	61	-	-
BC	50 -	55	-	-	-	-	-	-	-	-	-	-	-	-	1.14	57	56	56	54	54	53	-	-

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	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bw	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

CLAY MINERALOGY (1 = very weak .. 8 = very strong) / EXTRACTABLE Fe, Al, Si, Mn by amm. oxal.(o), Na dith(d) & pyroph.(p)

Hor.	MI	VE	CH	SM	KA	HA	ML	QU	FE	GI	GO	HE	Fe(o)	Al(o)	Si(o)	Fe(d)	Al(d)	Fe(p)	Al(p)	Pret	pHNaF
Ap	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bw	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Annex 2 Evaluation of Soil/Land Qualities of CU 9 and CU 11

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

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

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

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

CLIMATE

			CU 9					CU 11				
Land quality		(1)/(2)	vh/n	h/w	m	l/s	vl/vs	vh/n	h/w	m	l/s	vl/vs
Radiation regime	- total radiation	1	X					X				
	- day length	1	X					X				
Temperature regime		1	X					X				
Climatic hazards (hailstorm, wind, frost)		2		X								
Conditions for ripening		1	X					X				
Length growing season		1		X	X				X			
Drought hazard during growing season		2		X	X				X			

SOIL

			CU 9					CU 11				
Land quality		(1)/(2)	vh/n	h/w	m	l/s	vl/vs	vh/n	h/w	m	l/s	vl/vs
Potential total soil moisture		1			X			X				
Oxygen availability		1	X			X				X		
Nutrient availability		1		X					X			
Nutrient retention capacity		1	X					X				
Rooting conditions		1	X						X			
Conditions affecting germination		1	X						X			
Excess of salts	- salinity	2	X					X				
	- sodicity	2	X					X				
Soil toxicities (e.g. high Al sat.)		2	X					X				

LAND MANAGEMENT

			CU 9					CU 11				
Land quality		(1)/(2)	vh/n	h/w	m	l/s	vl/vs	vh/n	h/w	m	l/s	vl/vs
Initial land preparation		2	X	X				X	X			
Workability		1	X	X					X		X	
Potential for mechanization		1	X	X						X	X	
Accessibility	- existing	1	X					X				
	- potential	1	X					X				
Erosion hazard	- wind	2	X					X				
	- water	2			X				X	X		
Flood hazard		2	X	X				X				
Pests and diseases		2	X					X				

COMMENTS

Annex 3 Methods of Soil Analysis

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

Annex 4 Units, Glossary, Classes and Acronyms

UNITS

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

GLOSSARY

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

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

CLASSES OF SOME ANALYTICAL SOIL PROPERTIES

Organic Carbon - C (%)

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

Acidity pH-H_2O

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

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

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

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

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

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

Base saturation - BS [CEC pH7] (%)

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

Aluminium saturation (%)

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

Exchangeable sodium percentage - ESP (%)

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

Bulk density (kg dm^{-3})

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

ACRONYMS

FAO	Food and Agriculture Organization of the United Nations
ISIS	ISRIC Soil Information System
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)

No.	Title	No. of soils*
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	Organic matter-rich Calcareous Reference Soil	1
Cuba 8	Cracking Heavy Clay Reference Soils (Vertisols)	3

Country Reports

(ISSN: 1381-5571)

No.	Country	No. of soils*
1	Cuba	22
2	P.R. of China	51
3	Turkey	15
4	Côte d'Ivoire	7
5	Thailand	13
6	Colombia	18
7	Indonesia	48
8	Ecuador	in prep.
9	Brazil	28
10	Peru	21
11	Nicaragua	11
12	Costa Rica	12
13	Zambia	11
14	Uruguay	10
15	Gabon	6
16	Ghana	in prep.
17	Philippines	6
18	Zimbabwe	13
19	Spain	20
20	Italy	17
21	Greece	in prep.
22	India	in prep.
23	Kenya	in prep.
24	Mali	in prep.
25	Nigeria	in prep.
26	Mozambique	in prep.
27	Botswana	in prep.

* State of reference collections as of January 1995