Soil Brief *Cuba 8*

CUBA

Cracking heavy clay reference soils (Vertisols)

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Cracking heavy clay reference soils
(Vertisols)

ISRIC Soil Monoliths:

Number	*FAO-Unesco*	*Soil Taxonomy*
CU 19	Calcic Vertisol	Typic Calciustert
CU 20	Calcic Vertisol	Typic Calciustert
CU 21	Eutric Vertisol	Sodic Haplustert

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CONTENTS

FOREWORD

The Reference profiles presented in this Soil Brief are representative for the central plains of the eastern provinces of Cuba. These soils are typical for the climates with a marked dry period.

Vertisols, or cracking heavy clay soils, are cultivated mainly with sugarcane (230,000 ha) throughout Cuba but significant areas are also used for rice and pastures.

The objective of this Soil Brief is to summarize geological, geomorphological, chemical and physical characteristics of these soils and to present a detailed description and evaluation of soil qualities for sugarcane cultivation. Soil Briefs are written for both soil specialists and non-soil specialists.

A joint cooperation project of INICA and ISRIC was initiated in 1990. The project operates in the framework of ISRIC's National Soil Reference Collections and Databases project (NASREC). The NASREC goals are to support the establishment of soil expositions, databases and accompanying publications. In Cuba, the project aims to describe and sample a series of soils, representative for the sugarcane areas of Cuba. Monoliths 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. Clabaut (text processing), L.P. van Reeuwijk (laboratory), R.A. Smaal (diagrams), T. de Meester and A.E. Hartemink (editing). During fieldwork, J. Barter (CU 19), E. Angarica, E. Pérez and B. Montero (CU 20 and CU 21) from the Sugarcane Experiment Station of Granma and Holguín provinces made important contributions.

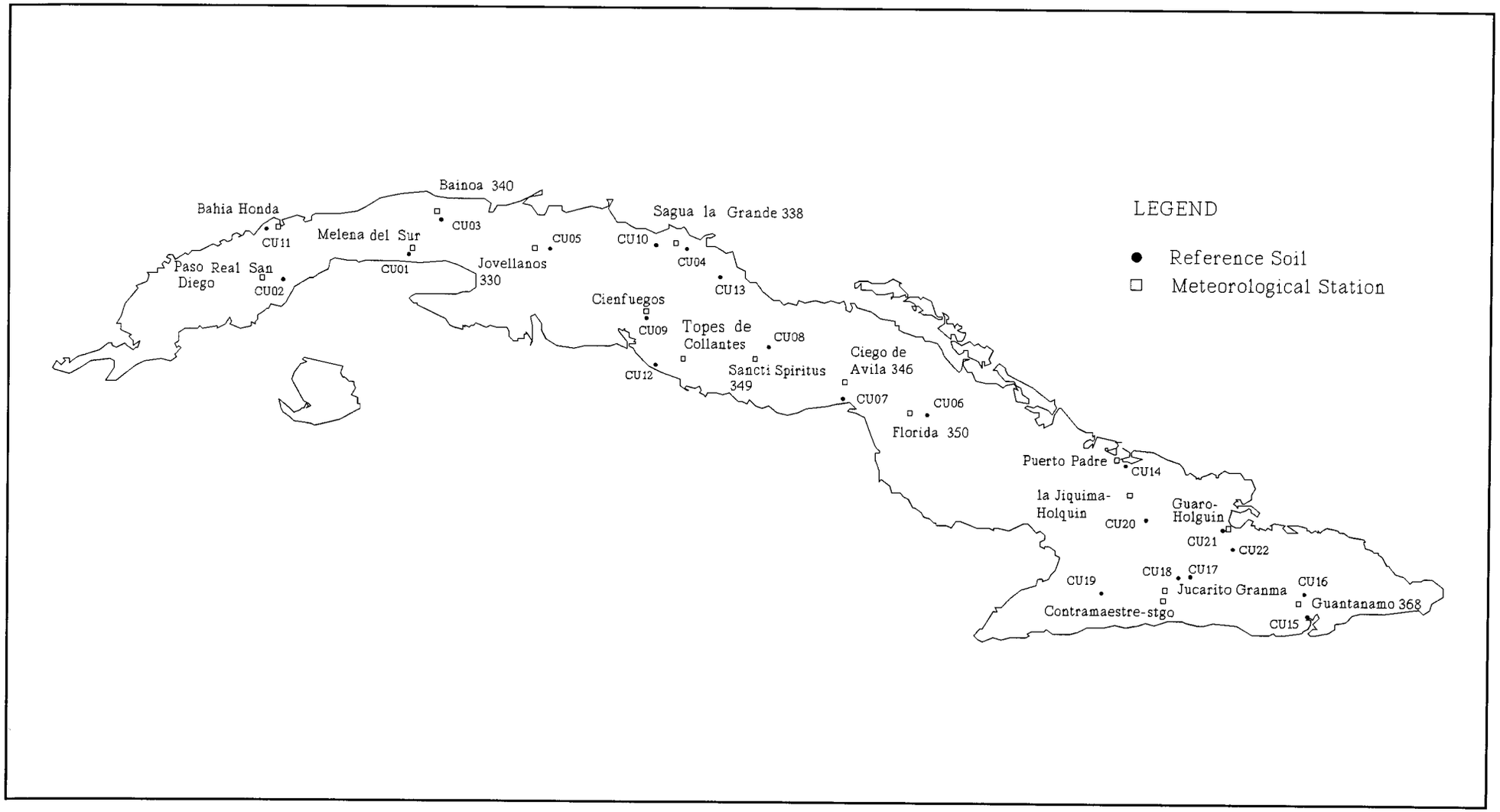


Figure 1 Geographical location of the reference sites.

1

2

1. Landscape CU 19
2. Profile CU 19

1

2

1. Landscape CU 20
2. Profile CU 20
3. Cracking characteristics CU 20

3

1 THE REFERENCE SOILS

1.1 Location and distribution

Cracking heavy clay soils, further referred to as Vertisols, cover extensive areas in the (sub)tropics and are also found to a limited extent in temperate zones (FAO-Unesco, 1975). In Cuba, these soils were studied by Bennett and Allison (1928), Hernandez (1966), Zonn *et al.* (1966), Angarica Baró (1985), and Fernández Pérez (1988).
The three selected reference soils are located in the provinces of Granma (CU 19) and Holguín (CU 20 and CU 21) in the eastern region of Cuba. CU 19 was sampled at the Sugarcane Experiment Station (EPICA), in the mill "Arquímides Colina", Bayamo municipality, at 20°12' N and 76°45'W at 60 m altitude. CU 20 was sampled near the sugar mill "Cristino Naranjo", San Pedro de Cacocum municipality, at 20°45'N and 76°25'W at 106 m altitude. CU 21 was sampled near the sugar mill "Guatemala", Mayarí municipality, at 20°40'N and 75°50'W at 20 m altitude (Fig. 1).
The three reference soils are representative for the Vertisols of those eastern plains, which cover 24% of the sugarcane areas of Granma province and 60% of Holguín province. About 14% of the area with Vertisols in Cuba is used for sugarcane cultivation.

1.2 Geology, relief and vegetation

During the late Jurassic, tectonic movements and foldings took place which determined at the end of the period two zones of sedimentary accumulation: miogeosynclinal in the North coast and eugeosynclinal in the South zone (Academy of Sciences, 1989).
Reference soil CU 19 has been developed in clay, calcareous sand and lime, originating from the Medium-Superior Dry Pleistocene. CU 20 and CU 21 have been developed in parent material (clay, loam, sandstone, conglomerates and dolomites) from the Medium Miocene (CU 20) and Inferior (CU 21).

The sites (see photograph) are in abrasive and accumulative marine plains, which have a slightly undulated and flat topography. The gradient at the sites is flat or almost plain with slopes <2% (CU 19 and CU 20) and undulating in CU 21 with slopes ranging from 2 to 8%.

The original vegetation of the sites is typical 'mesophyll' for CU 19 and 'mesophyll' with fluctuating humidity in CU 20 and CU 21 (Academy of Sciences, 1989). There is a strong anthropogenic influence and at present the land is cultivated with agricultural crops, patches of pasture and secondary vegetation.

1.3 Climate of the sites

According to Díaz Cisneros (1989), based on the General Climatic Regionalization of Cuba, the sites have a seasonal moisture regime, high evaporation and high temperatures.
There are two distinct seasons, a dry one from November to April and the rainy season from May to October. The rainfall-evapotranspiration diagram (Figs. 2, 3 and 4), shows a large moisture deficit during a long period.
Figures 5, 6 and 7 show the average monthly temperature near the reference sites, with a mean annual average of 25°C for all sites, a mean minimum temperature of 19°C and a mean maximum of 32°C.
From the climatic viewpoint, the area of the reference soils is favourable for sugarcane (Arveladze, 1989).

All diagrams in this Soil Brief were made with Solgraph (Brunt and Kauffman, 1995).

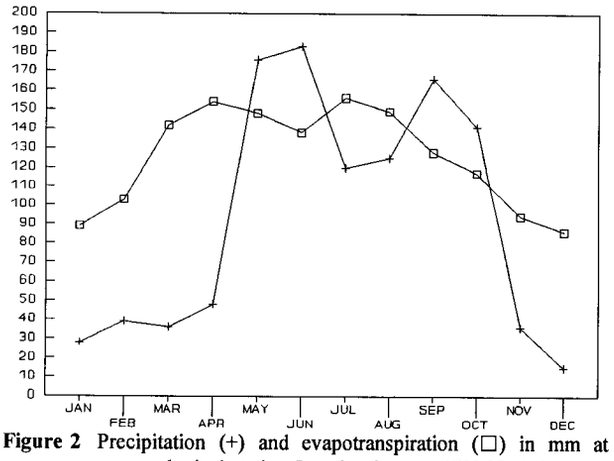


Figure 2 Precipitation (+) and evapotranspiration (□) in mm at meteorological station Jucarito Granma (CU 19 site).

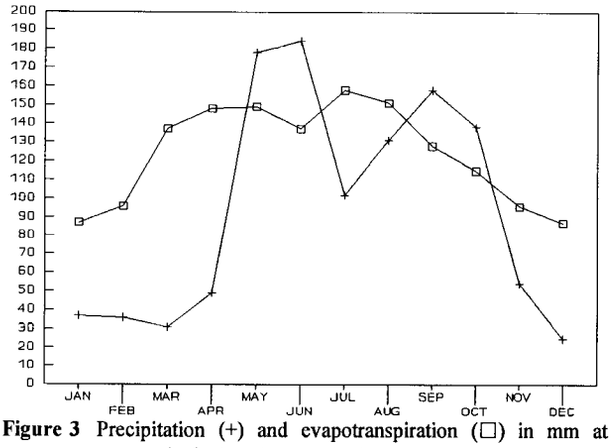


Figure 3 Precipitation (+) and evapotranspiration (□) in mm at meteorological station La Jiquima-Holguin (CU 20 site).

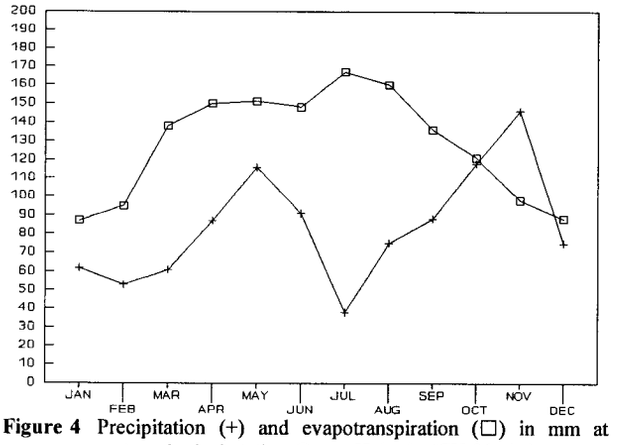


Figure 4 Precipitation (+) and evapotranspiration (□) in mm at meteorological station Guaro-Holguin (CU 21 site).

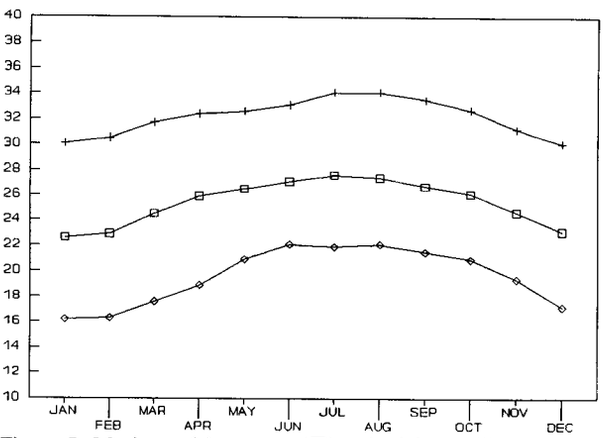


Figure 5 Maximum (+), average (□) and minimum (◊) temperature in °C at meteorological station Jucarito Granma (CU 19 site).

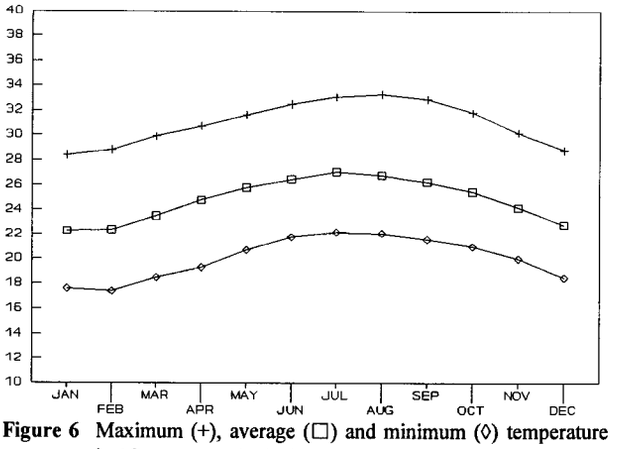


Figure 6 Maximum (+), average (□) and minimum (◊) temperature in °C at meteorological station La Jiquima-Holguin (CU 20 site).

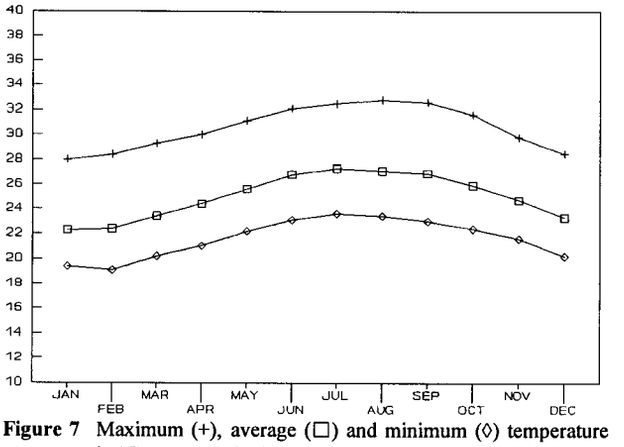


Figure 7 Maximum (+), average (□) and minimum (◊) temperature in °C at meteorological station Guaro- Holguin (CU 21 site).

2 SOIL CHARACTERIZATION

2.1 Field description

CU 19 is a deep, imperfectly drained, very dark brown clay. The soil has large cracks when dry, prismatic angular structure, with presence of slickensides, and moderate porosity.

CU 20 is a deep, imperfectly drained, black clay. The soil has large cracks when dry, subangular to angular structure with presence of slickensides, and is slightly porous (see photograph).

CU 21 is a deep, imperfectly drained, yellowish brown clay. The soil has large cracks when dry, moderately fine subangular blocky structure, and calcareous conglomerates.

Large cracks in the dry season are common in all three reference soils (see photograph). "Gilgai" topography is found when the soils are not cultivated.

A detailed description of the soils, according to the Guidelines for Soil Profile Description (FAO, 1990), is presented in Annex 1A (CU 19), Annex 1B (CU 20) and Annex 1C (CU 21).

2.2 Analytical characterization

Soil samples were analysed at the ISRIC laboratory (Van Reeuwijk, 1992) and the analytical data are presented in the Annex 1A, 1B and 1C. Table 1 presents a selection of soil analytical characteristics.

Soil CU 19 has a medium content of organic matter (Ascanio *et al.*, 1983; Angarica and Montero, 1984; Hernandez *et al.*, 1983). Soil pH is slightly alkaline in topsoil to alkaline in subsoil (Figure 8).
Bulk density is medium in the first 60 cm, the air capacity is very low and the available soil moisture is medium (Figure 13).

Soil CU 20 is similar to CU 19 with respect to organic matter, nitrogen content and pH (Figure 9).
The Exchangeable Sodium Percentage (ESP) at a depth of 20 to 90 cm is 6.

Soil CU 21 is slightly alkaline to alkaline with an ESP of 14 at a depth of 75 and 95 cm. This soil shows a very low air capacity and a very high available moisture (Figure 14).

Table 1 Some characteristics of CU19, CU20 and CU21.

	CU19	CU20	CU21
Texture	Clay throughout the profile	Clay, sandy clay in subsoil	Clay throughout the profile
Organic Carbon	Medium in the first 25 cm, low in subsoil	High in the first 20 cm, medium in subsoil	Medium in the first 27 cm, very low in subsoil
Sum of Bases	Very high throughout	Very high throughout	Very high throughout
CEC	Very high throughout	Very high throughout	Very high throughout
Mineralogy	Smectite dominant	Smectite dominant	Smectite dominant

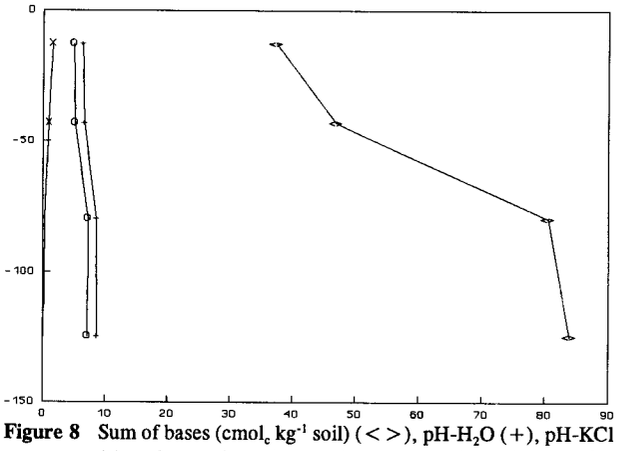


Figure 8 Sum of bases ($cmol_c\ kg^{-1}$ soil) (< >), pH-H_2O (+), pH-KCl (o) and organic carbon (×) versus depth (cm) in profile CU 19.

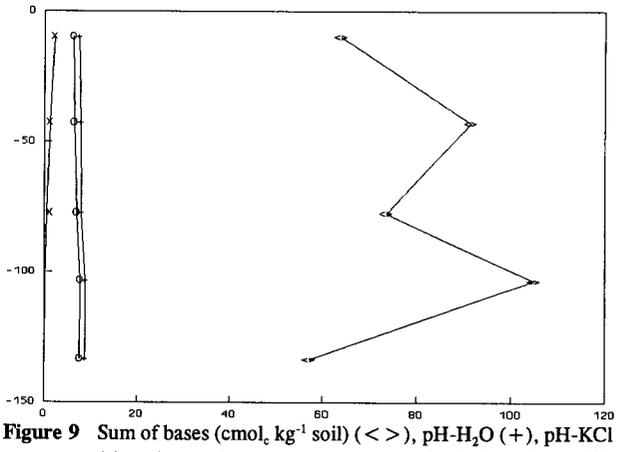


Figure 9 Sum of bases ($cmol_c\ kg^{-1}$ soil) (< >), pH-H_2O (+), pH-KCl (o) and organic carbon (×) versus depth (cm) in profile CU 20.

Soils CU 19, CU 20 and CU 21 have a high content of expandable clay with dominant smectite throughout the profile (Fig. 10, 11 and 12). The three reference soils have limited soil development as reflected by the content of sand and clay colloidal fraction (Fernandez Perez, 1988). The presence of easily weatherable minerals in the sand/silt fraction indicates the high natural fertility and nutrient reserve.

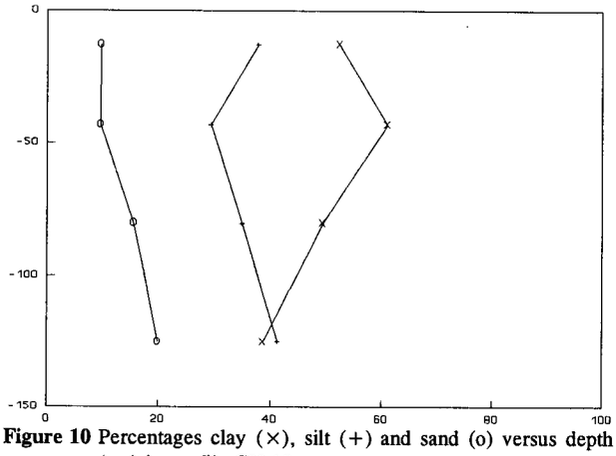


Figure 10 Percentages clay (×), silt (+) and sand (o) versus depth (cm) in profile CU 19.

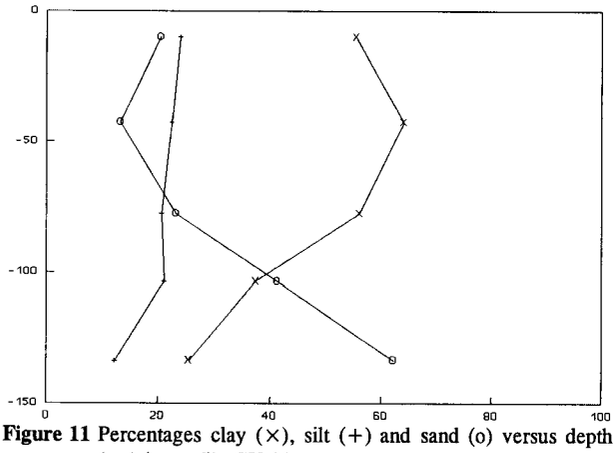


Figure 11 Percentages clay (×), silt (+) and sand (o) versus depth (cm) in profile CU 20.

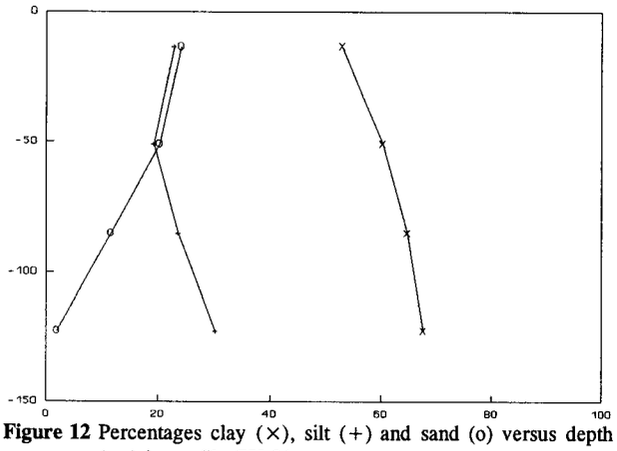


Figure 12 Percentages clay (×), silt (+) and sand (o) versus depth (cm) in profile CU 21.

Other general aspects of these soils were quoted by Angarica Baró (1988), such as the high content of available phosphorus, a high total potassium content with a good equilibrium between the exchangeable and the labile potassium stocks, which is favourable for sugarcane production.

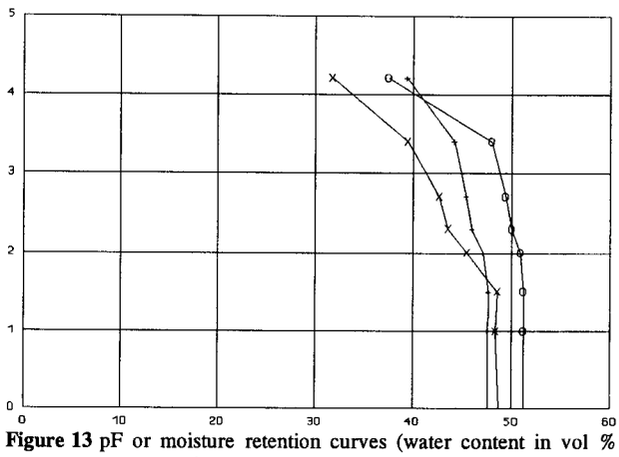


Figure 13 pF or moisture retention curves (water content in vol % versus suction) at depth 0-26 cm (×), 20-40 cm (+) and 40-60 cm (o) in profile CU 19.

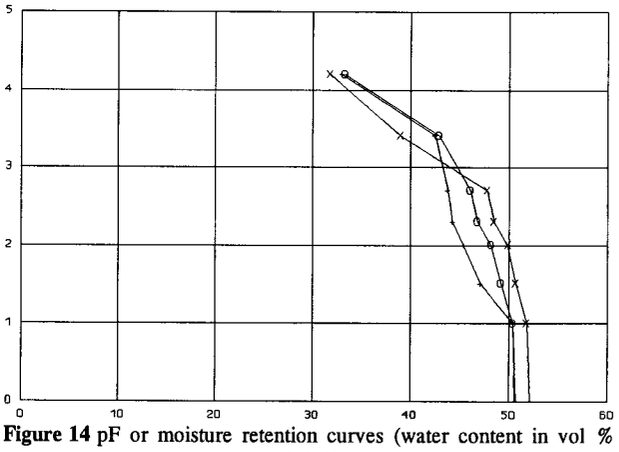


Figure 14 pF or moisture retention curves (water content in vol % versus suction) at depth 0-27 cm (×), 25-40 cm (+) and 65-70 cm (o) in profile CU 21.

3 SOIL CLASSIFICATION

CU 19 profile

FAO-UNESCO (1988)
The reference soil is classified as a Calcic Vertisol, because of the presence of cracks, a clay content of over 30% throughout the profile (more than 100 cm depth), slickensides, and assuming a calcic horizon or concentration of soft powdery lime within 125 cm of the surface. The gilgai relief was not observed at the site because of cultivation, however, this characteristic was evident in the surrounding areas.

USDA Soil Taxonomy (1992)
The soil is classified as a Typic Calciustert, based on the presence of vertic properties, a clay content of 30% or more in all horizons to 50 cm depth or more, the presence of cracks in some time of most of the years to 50 cm depth with at least 1 cm width, an Ustic moisture regime, and the assumed calcic horizon within 100 cm depth.

2da Clasificación Genética de los Suelos de Cuba (1975)
It classifies as Oscuro Plástico because the typical vertisol properties which appear very clear throughout the profile and others characteristics as colour, structure, and mottles, in the intermediate horizons.

CU 20 profile

FAO-UNESCO (1988)
Similar to CU 19, this soil is classified as Calcic Vertisol because of similar diagnostic properties as given for CU 19, and a dark matrix colour.

USDA Soil Taxonomy (1992)
The soil is classified as Typic Calciustert because of similar diagnostic properties as given for CU 19.

2da Clasificación Genética de los Suelos de Cuba (1975)
This soil has similar characteristics as CU 19, but the colour is black and the subsoil has an olive grey colour due to a close watertable. Therefore the soil is classified as Oscuro Plástico gleyzado gris.

CU 21 profile

FAO-UNESCO (1988)
The reference soil is classified as Eutric Vertisol, because of similar diagnostic properties as given for CU 19, except for the absence of a calcic horizon.

USDA Soil Taxonomy (1992)
The soil is classified as Sodic Haplustert because it has similar diagnostic properties as given for CU 19, except for the absence of a calcic horizon, and the presence of an ESP larger than 15.

2da Clasificación Genética de los Suelos de Cuba (1975)
This soil has the same properties as CU 19 and CU 20, and the colour is dark grey. The soil has a prismatic structure and relevant exchangeable sodium content in the middle of the profile. These characteristics come from a previous stage of development. It is classified as Vertisols (Oscuro Plástico Gleyzado gris amarillento) due to its structure and high clay content. There is no influence of the watertable.

4 SOIL MANAGEMENT

A general evaluation of the sites, according to FAO (1983) and ISRIC (1994) criteria regarding its qualities and land use is presented in Annex 2. Specific criteria for each site about the agronomical management of sugarcane are also presented (Angarica Baro, 1985; Morales Mendez, 1985; INICA, 1986).

Evaluation of CU 19

The soil is moderately deep and is imperfectly drained. Wetness and a heavy texture make mechanized farming difficult. Natural nutrient availability is high (no response to nitrogen fertilizers is found in sugarcane). Phosphorus and potassium levels are high for sugarcane. Yields up to 112 t ha^{-1} could be obtained at the reference site but there is a marked decrease under extensive production conditions to 53 t ha^{-1}, which is characteristic for the Cauto Alluvial Plain (Arcia *et al.*, 1993).
Soils similar to reference soil CU 19 should focus on the improvement of the internal drainage.

Evaluation of CU 20

This soil is deep and imperfectly drained. The structure is coarser than CU 19 and CU 21. It has an impermeable layer between 45 and 60 cm. Nutrient availability is high, and similar to CU 19, no response to nitrogen fertilizers is found. Phosphorus and potassium levels are high.

Potential agricultural yields of 162 t/ha could be obtained at the reference site, while under average production conditions 54 t ha^{-1} is obtained, a common yield in the Eastern Central Plain (Arcia *et al.*, 1993). Similar management recommendations as mentioned for CU 19 apply for this soil.

Evaluation of CU 21

The soil is moderately deep, imperfectly drained and moderately permeable. The fertility and response to mineral fertilizers is similar to CU 19 and CU 20. The reference site, located at the Nipe-Baguanos Coastal Plain (Arcia *et al.*, 1993), presents potential yields up to 102 t ha^{-1}, while under extensive production conditions this is only 44 t ha^{-1}. The management of soils for intensive exploitation of sugarcane is be the same as recommended for CU 19 and CU 20.
Based on different studies carried out in Cuba, Table 2 summarizes mineral fertilizer recommendations for sugarcane in Vertisols. It shows that the soils discussed have good levels of available nutrients.
Table 3 presents the results of irrigation and drainage management studies carried out in areas near reference site CU 20. It proves that irrigation and drainage are required to obtain maximum production. Results of this study can be extrapolated to most Vertisols in the eastern region of Cuba.

Table 2 Mineral fertilizer recommendations for sugarcane in Vertisols (Villegas *et al.*, 1986).

	NITROGEN (kg N ha^{-1})								PHOSPHORUS (kg P_2O_5 ha^{-1})					POTASSIUM (kg K_2O ha^{-1})			
	Expected yield (t ha^{-1})								P_2O_5 content in soil (mg $100g^{-1}$)					K_2O content in soil (mg $100g^{-1}$)			
Crops	<40	40-	61-	81-	101-	121-	141-	>160	>6.0	4.6-6.0	3.0-4.5	1.5-2.9	<1.5	>30.0	20.0-	10.0-	<10.0
Planting of:																	
Spring	25	25	25	35	35	35	35	35	0	0	25	35	50	0	0	80	120
Winter	40	40	50	50	60	60	75	75	0	0	25	35	50	0	0	80	120
1st Ratoon	50	50	60	60	70	70	90	90	0	0	25	35	50	0	80	120	180
2nd Ratoon	85	95	105	115	125	150	175	175	0	0	25	35	50	0	80	120	180
3rd Ratoon or further	100	110	140	170	180	190	200	200	0	0	25	35	50	120	120	180	180

Table 3 Effect of irrigation and surface drainage on yields of sugarcane (Fonseca *et al.*, 1986).

TREATMENTS	YIELD (t/ha)	YIELD (t/ha/month)	Variation Related to Treatment 4 in %	Variation Related to Treatment 5 in %
1. Irrigation and drainage	175	8	22	47
2. Irrigation without drainage	171	8	20	44
3. Drainage without irrigation	158	7	10	32
4. Control (with only irrigation)	143	6	-	20
5. Control (without irrigation and drainage)	119	6	(20)	-

Annex 1A ISIS Data Sheet CU 19

Reference soil CU 19, CUBA Print date: 3 July 19

FAO/UNESCO (1988)	:	Orthi-Calcic Vertisol
(1974)	:	Chromic Vertisol
USDA/SCS SOIL TAXONOMY (1992)	:	Typic Calciustert, clayey, montmorillonitic, isohyperthermic
(1975)	:	Typic Chromustert
LOCAL CLASSIFICATION	:	Oscuro plastico gleysoso
DIAGNOSTIC CRITERIA FAO (1988)	:	ochric A, cambic B, vertic properties
USDA/SCS (1992)	:	ochric epipedon, cambic horizon, calcic horizon, slickensides
		Soil moisture regime : ustic
		Soil temperature regime : isohyperthermic
LOCATION	:	Cuba Prov. Granma Mun. Bayamo CAI Arquimides Colina Bloque Exp.1 EPICA
Latitude / Longitude	:	20°12'0"N / 76°45'0"W Altitude : 60 m a.s.l.
AUTHOR(S)	:	REGLA/MARIN/BATLE Date : December 1991
GENERAL LANDFORM	:	peneplain Topography : flat or almost flat
PHYSIOGRAPHIC UNIT	:	flat or almost flat
SLOPE Gradient, Form	:	0%, straight, Position of site : flat
MICRO RELIEF Kind	:	
SURFACE CHAR. Rock outcrop	:	nil Cracking : large cracks
Stoniness	:	nil
Slaking/crusting	:	
SLOPE PROCESSES Soil erosion	:	
PARENT MATERIAL 1 type, texture	:	marine sediments derived from claystone
Remarks	:	
EFFECTIVE SOIL DEPTH	:	150 cm
WATER TABLE Kind, Depth	:	no watertable observed, -
DRAINAGE	:	imperfectly
PERMEABILITY	:	high, slowly permeable layer from 30 to 60 cm
FLOODING Frequency	:	Run off : slow
MOISTURE CONDITIONS PROFILE	:	0-150 cm moist
LAND USE	:	high level arable farming (sugar cane)
Improvements	:	levelling
VEGETATION Type	:	semi deciduous shrub Status : secondary
CLIMATE Köppen	:	Aw
MET. STATIONS Name, Location	:	JUCARITO GRANMA, 20°41' / 76°54', 11 m a.s.l
Distance to site (relevance)	:	JUCARITO GRANMA lays 1 km SW of the site (very good)

		No. years of record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
JUCARITO GRANMA															
act. evapotransp.	mm	5	168	178	238	243	214	193	202	188	180	162	141	139	2250
EP Penman	mm	21	89	103	142	154	148	138	156	149	128	117	94	86	1504
relative humidity	%	21	77	75	72	71	76	80	77	78	82	82	82	79	78
precipitation	mm	21	28	39	36	48	176	183	120	125	166	141	36	15	1117
tot.glob.rad.	MJ/m²	21	468.1	504.0	660.3	675.0	654.1	624.0	672.7	647.9	570.0	539.4	450.0	437.1	6902.
T mean	°C	21	22.6	22.9	24.5	25.9	26.5	27.1	27.6	27.4	26.7	26.1	24.6	23.1	25.
T max	°C	21	30.1	30.5	31.7	32.4	32.6	33.1	34.1	34.1	33.5	32.7	31.2	30.1	32.
T min	°C	21	16.2	16.3	17.6	18.9	20.9	22.1	21.9	22.1	21.5	20.9	19.4	17.2	19.
windspeed(at 2m)	m/s	21	1.8	2.2	2.5	2.4	1.8	1.2	1.7	1.5	1.2	1.1	1.6	1.9	0.
bright sunshine	h/d	21	7.4	7.9	8.7	8.8	7.7	7.5	8.3	8.1	7.7	8.0	7.7	7.5	1.

PROFILE DESCRIPTION :

Ap	0 - 26 cm	very dark grayish brown (10YR 3.0/2.0, moist) clay; strong medium prismatic and strong coarse prismatic; sticky, plastic, very firm; no mottles; patchy thin slickensides cutans throughout; few very fine pores and few medium pores; moderately porous; common fine roots throughout and common very fine roots throughout; very few medium spherical hard manganiferous concretions; no fragments; few channels; non calcareous (10% HCL) throughout; gradual irregular boundary to
Aw	26 - 60 cm	very dark brown (10YR 2.0/2.0, moist) clay; very strong coarse angular blocky; very sticky, very plastic, firm; patchy moderately thick slickensides cutans throughout; few medium pores and few fine pores; moderately porous; few fine roots throughout and few very fine roots throughout; very few medium spherical hard manganiferous concretions; non calcareous (10% HCL) throughout; clear wavy boundary to
Cw	60 - 100 cm	dark grayish brown (10YR 4.0/2.0, moist) clay; moderate coarse subangular blocky; slightly sticky, slightly plastic, firm; common fine pores and common medium pores; moderately porous; no roots; very few medium spherical hard manganiferous concretions; calcareous (10% HCL) throughout; gradual irregular boundary to
C	100 - 150 cm	dark yellowish brown (10YR 4.0/4.0, moist) clay loam; moderate medium subangular blocky; slightly sticky, slightly plastic, friable; common fine pores and common medium pores; moderately porous; no roots; very few medium spherical hard manganiferous concretions; calcareous (10% HCL) throughout;

ADDITIONAL REMARKS

Short field description:
Deep, imperfectly drained, very dark brown clay. Large cracks when dry, prismatic angular structure, with presence of slickensides, moderately porous.
Geology: Cauto Formation: clays, sandstones, limestones and silt.
Geomorphology: fluvio-marine deltaic plain and terrace, plain 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	0	26	-	0	0	0	2	7	10	14	24	38	52	23.9	1.22	49	48	49	46	44	43	40	32
Aw	26	60	-	0	0	1	3	6	10	12	18	29	61	34.1	-	-	-	-	-	-	-	-	-
	20	40	-	-	-	-	-	-	-	-	-	-	-	-	1.37	48	48	48	47	46	45	44	39
	40	60	-	-	-	-	-	-	-	-	-	-	-	-	1.30	51	51	51	51	50	49	48	38
Cw	60	100	-	0	0	0	5	10	16	12	23	35	49	19.3	-	-	-	-	-	-	-	-	-
C	100	150	-	0	0	0	7	12	20	19	23	41	39	14.7	-	-	-	-	-	-	-	-	-

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	6.3	4.9	2.0	1.5	0.14	21.1	14.6	0.4	1.2	37.3	-	-	39.1	75	5.3	37.3	95	-	0.16	
Aw	6.6	5.1	2.6	0.9	0.08	22.4	22.1	0.3	2.2	47.0	-	-	49.0	80	3.3	47.0	96	-	0.18	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Cw	8.6	7.2	10.8	0.2	0.03	56.3	21.0	0.4	2.8	80.5	-	-	38.9	79	0.8	80.5	*	-	0.29	
C	8.7	7.1	4.8	0.1	0.02	61.1	19.7	0.2	2.9	83.9	-	-	34.6	89	0.2	83.9	*	-	0.30	

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

Hor.	MI	VE	CH	SM	KA	HA	ML	QU	FE	GI	GO	HE
Ap	0	0	0	8	4	0	0	2	2	0	1	0
Aw	0	0	0	8	6	0	0	2	2	0	2	0
	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-
Cw	0	0	0	8	6	0	0	2	2	0	2	0
C	0	0	0	8	5	0	0	2	2	0	2	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	-	-	-	-	-	-	-	-	-
Aw	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-
Cw	-	-	-	-	-	-	-	-	-
C	-	-	-	-	-	-	-	-	-

Annex 1B ISIS Data Sheet CU 20

Reference soil CU 20, CUBA

Print date: 3 July 1995

FAO/UNESCO (1988) : Pelli-Calcic Vertisol
(1974) : Pellic Vertisol
USDA/SCS SOIL TAXONOMY (1992) : Typic Calciustert, clayey, montmorillonitic, isohyperthermic
(1975) : Typic Pellustert
LOCAL CLASSIFICATION : Oscuro plastico gleysoso negro

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

LOCATION : Cuba Prov. Holguin Mun. San Pedro de Cacocum CAI Cristino Naranjo
Latitude / Longitude : 20°45'0"N / 76°25'0"W Altitude : 106 m a.s.l.
AUTHOR(S) : REGLA/MARIN/ANGARICA Date : December 1991

GENERAL LANDFORM : low hill Topography : flat or almost flat
PHYSIOGRAPHIC UNIT : flat or almost flat
SLOPE Gradient, Form : 0%, straight, Position of site : flat
MICRO RELIEF Kind :
SURFACE CHAR. Rock outcrop : Cracking : large cracks
Stoniness, Size, Form : very few stones, 4 cm, , angular blocky
Slaking/crusting :
SLOPE PROCESSES Soil erosion : no

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

EFFECTIVE SOIL DEPTH : 120 cm
WATER TABLE Kind, Depth : flooded, 150 cm Estimated high/low level : 100 cm / 150 cm
DRAINAGE : imperfectly
PERMEABILITY : slow, slowly permeable layer from 45 to 60 cm
FLOODING Frequency : nil Run off : medium

MOISTURE CONDITIONS PROFILE : 0-117 cm moist, 117-150 cm wet

LAND USE : high level arable farming (sugar cane)
VEGETATION Type : grassland Status : degraded

CLIMATE Köppen : Aw
MET. STATIONS Name, Location : LA JIQUIMA-HOLGUIN, 20°56' / 76°32', 105 m a.s.l
Distance to site (relevance) : LA JIQUIMA-HOLGUIN lays 6 km ENE of the site (moderate)

		No. years of record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
LA JIQUIMA-HOLGUIN															
act. evapotransp.	mm	21	163	177	237	249	226	214	244	240	196	174	149	146	2421
EP Penman	mm	21	87	96	137	148	149	137	158	151	128	115	96	87	1496
relative humidity	%	21	82	79	77	76	80	83	81	82	84	85	84	83	81
precipitation	mm	21	37	36	31	49	178	184	102	131	158	138	54	25	1128
tot.glob.rad.	MJ/m²	15	471.2	509.6	672.7	681.0	663.4	618.6	682.0	657.2	567.0	523.9	444.0	437.1	6927.1
T mean	°C	21	22.3	22.4	23.5	24.8	25.8	26.5	27.1	26.8	26.3	25.5	24.2	22.8	24.8
T max	°C	21	28.4	28.8	29.9	30.7	31.6	32.5	33.1	33.3	32.9	31.8	30.2	28.8	31.0
T min	°C	21	17.6	17.4	18.5	19.3	20.7	21.8	22.2	22.1	21.6	21.0	20.0	18.5	20.1
windspeed(at 2m)	m/s	4	2.2	2.3	2.9	2.7	2.5	2.0	2.5	2.4	1.8	1.6	2.6	2.7	0.3
bright sunshine	h/d	15	7.5	8.1	9.0	8.9	7.9	7.4	8.4	8.2	7.6	7.7	7.6	7.6	7.9

PROFILE DESCRIPTION :

Ap 0 - 20 cm black (2.5Y 2.0/0.0, moist) clay; strong medium to coarse subangular blocky and strong medium to coarse angular blocky; slightly sticky, plastic, friable; no mottles; no cutans; few medium pores and few fine pores; slightly porous; many very fine to coarse roots throughout; no inclusions; no fragments; frequent worm channels and pedotubules; slightly calcareous (10% HCL) throughout; gradual smooth boundary to

Aw 20 - 65 cm 2.5Y 5.0/1.0, moist clay; strong coarse to very coarse prismatic; sticky, very plastic, firm; no mottles; continuous moderately thick slickensides cutans throughout; few medium pores and few fine pores; slightly porous; common very fine to coarse roots throughout; no inclusions; no fragments; few worm channels; slightly calcareous (10% HCL) throughout; clear irregular boundary to

CA 65 - 90 cm 10Y 3.0/1.0, moist sandy clay; weak medium prismatic and strong medium subangular blocky; slightly sticky, slightly plastic, friable; few fine faint diffuse mottles (2.5Y 5.0/4.0); patchy thin slickensides cutans throughout; many medium pores and few fine pores; slightly porous; few fine roots throughout; no inclusions; no fragments; calcareous (10% HCL) throughout; clear irregular boundary to

C 90 - 117 cm light olive brown (2.5Y 5.0/4.0, moist) sandy clay; massive; slightly sticky, slightly plastic, friable; few fine faint diffuse mottles (10Y 5.0/2.0); no cutans; many medium pores and few fine pores; slightly porous; few fine roots throughout; no inclusions; no fragments; strongly calcareous (10% HCL) throughout; clear irregular boundary to

ADDITIONAL REMARKS

Short field description:
Deep, imperfectly drained, black clay. Large cracks when dry, subangular to angular structure with presence of slickensides, slightly porous.
Geology: Pleistocene. undifferentiated, marine-alluvial deposits. Cauto Formation: sands, clayey sands and guijarros-sands, with intercalation of silt, gravels and guijarros-gravels (colors: grey and greyish yellow).
Geomorphology: marine plain and terrace, abrasive-erosive undulating.

ANALYTICAL DATA:

			PARTICLE SIZE DISTRIBUTION (µm)																			
			>2	2000	1000	500	250	100	TOT	50	20	TOT		WDIS	BULK	pF						
Hor.	Top	Bot.	mm	1000	500	250	100	50	SAND	20	2	SILT	<2	CLAY	DENS	0.0	1.0	1.5	2.0	2.3	2.7	3.4	4.2
Ap	0	- 20	-	1	2	4	8	7	21	9	15	24	56	32.1	-	-	-	-	-	-	-	-	-
Aw	20	- 65	-	0	1	3	5	5	13	7	16	23	64	39.8	-	-	-	-	-	-	-	-	-
CA	65	- 90	-	1	2	4	8	8	23	15	6	21	56	3.7	-	-	-	-	-	-	-	-	-
C	90	- 117	-	7	6	6	12	12	41	11	10	21	38	3.1	-	-	-	-	-	-	-	-	-
	117	- 150	-	19	14	11	12	6	62	7	5	12	26	1.6	-	-	-	-	-	-	-	-	-

	pH	pH		ORG. MATTER		EXCHANGEABLE CATIONS					EXCH. ACID.		CEC	CEC	CEC		BASE	AL		
Hor.	H2O	KCl	CaCO3	C	N	Ca	Mg	K	Na	sum	H+Al	Al	soil	clay	OrgC	ECEC	SAT	SAT	EC2.5	ESP
Ap	7.5	6.3	3.8	2.3	0.21	35.3	27.3	0.5	0.8	63.9	-	-	76.7	138	7.9	63.9	83	-	0.27	
Aw	7.9	6.6	2.6	1.3	0.07	26.6	60.0	0.3	4.7	91.6	-	-	-	-	4.7	91.6	-	-	1.00	
CA	8.1	7.1	2.6	0.7	0.04	19.0	49.8	0.2	4.7	73.7	-	-	50.3	90	2.3	73.7	100	-	1.10	
C	8.9	7.8	25.6	0.2	0.02	35.3	68.0	0.1	1.6	105	-	-	22.5	60	0.5	105	*	-	0.38	
	8.9	7.7	23.4	0.1	0.01	29.8	26.2	0.1	1.1	57.2	-	-	19.9	78	0.2	57.2	*	-	0.28	

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

Hor.	MI	VE	CH	SM	KA	HA	ML	QU	FE	GI	GO	HE	MX
Ap	0	0	0	8	2	0	3	0	0	0	0	0	3
Aw	0	0	0	8	2	0	3	0	0	0	0	0	4
CA	0	0	0	8	2	0	3	0	0	0	0	0	5
C	0	0	0	8	3	0	3	0	0	0	0	0	5
	0	0	0	8	3	0	3	0	0	0	0	0	5

remark sample 1 - 5: MINX=palygorskite

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

	Fe(o)	Al(o)	Si(o)	Fe(d)	Al(d)	Fe(p)	Al(p)	Pret	pHNaF
	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-

Annex 1C ISIS Data Sheet CU 21

Reference soil CU 21, CUBA

Print date: 3 July 1995

FAO/UNESCO (1988) : Orthi-Eutric Vertisol, sodic phase
(1974) : Chromic Vertisol, sodic phase
USDA/SCS SOIL TAXONOMY (1992) : Sodic Haplustert, clayey, montmorillonitic, isohyperthermic
(1975) : Typic Chromustert
LOCAL CLASSIFICATION : Oscuro plastico gleysoso gris

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

LOCATION : Cuba Prov. Holguin Mun. Mayari CAI Guatemala area 3
Latitude / Longitude : 20°40'0"N / 75°50'0"W Altitude : 20 m a.s.l.
AUTHOR(S) : MARIN/REGLA/BEATRIZ Date : December 1991

GENERAL LANDFORM : low hill Topography : undulating
PHYSIOGRAPHIC UNIT : undulated
SLOPE Gradient, Form : 2%, undulating, Position of site : flat
MICRO RELIEF Kind :
SURFACE CHAR. Rock outcrop : Cracking : large cracks
Stoniness, Size : very few stones, 4 cm, Salt : slight
Slaking/crusting :
SLOPE PROCESSES Soil erosion : slight rill
Slope stability : stable

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

EFFECTIVE SOIL DEPTH : 100 cm
WATER TABLE Kind, Depth : no watertable observed, 300 cm
DRAINAGE : imperfectly
PERMEABILITY : moderate, slowly permeable layer from 120 to 150 cm
FLOODING Frequency : nil Run off : medium

MOISTURE CONDITIONS PROFILE : 0-150 cm wet

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

CLIMATE Köppen : Aw
MET. STATIONS Name, Location : GUARO-HOLGUIN, 20°41' / 75°47', 20 m a.s.l
Distance to site (relevance) : GUARO-HOLGUIN lays 8 km ENE of the site (moderate)

		No. years of record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GUARO-HOLGUIN															
act. evapotransp.	mm	21	126	142	204	213	207	196	232	226	184	156	124	117	2131
EP Penman	mm	21	87	95	138	150	151	148	167	160	136	121	98	88	1545
relative humidity	%	21	82	80	78	77	79	81	79	80	82	82	83	83	80
precipitation	mm	21	62	53	61	87	116	91	38	75	88	118	146	75	1014
tot.glob.rad.	MJ/m²	10	461.9	487.2	654.1	693.1	669.6	642.4	678.9	657.2	558.0	511.5	432.4	430.9	6876.3
T mean	°C	21	22.3	22.4	23.4	24.4	25.6	26.8	27.3	27.1	26.9	25.9	24.7	23.3	25.0
T max	°C	21	28.0	28.4	29.3	30.0	31.1	32.1	32.5	32.8	32.6	31.6	29.8	28.5	30.5
T min	°C	21	19.4	19.1	20.2	21.0	22.2	23.1	23.6	23.4	23.0	22.4	21.6	20.2	21.6
windspeed(at 2m)	m/s	4	2.1	2.5	3.4	3.1	2.8	2.5	3.6	3.2	2.6	2.2	2.5	2.5	2.8
bright sunshine	h/d	10	7.5	7.7	8.7	9.1	7.9	7.9	8.3	8.2	7.5	7.6	7.5	7.6	7.9

PROFILE DESCRIPTION :

Ap 0 - 27 cm brown (10YR 5.0/3.0, moist) clay; moderate fine subangular blocky; slightly sticky, slightly plastic; no mottles; no cutans; few fine pores and few medium pores; slightly porous; common very fine to coarse roots throughout; very frequent large irregular hard calcareous unspec. inclusions; no fragments; frequent channels; non calcareous (10% HCL) throughout; clear irregular boundary to

B 27 - 75 cm yellowish brown (10YR 5.0/4.0, moist) clay; moderate medium angular blocky and moderate medium prismatic; sticky, plastic; common coarse distinct clear mottles (10YR 6.0/6.0); patchy slickensides cutans throughout; few medium pores and few fine pores; slightly porous; few fine roots throughout; very frequent large irregular hard manganiferous unspec. inclusions and very frequent large irregular hard calcareous unspec. inclusions; no fragments; frequent channels; non calcareous (10% HCL) throughout; gradual wavy boundary to

BC 75 - 95 cm brownish yellow (10YR 6.0/6.0, moist) clay; moderate coarse angular blocky and moderate coarse prismatic; sticky, plastic; few coarse distinct clear mottles (10YR 5.0/8.0); continuous slickensides cutans throughout; common fine pores and common very fine pores; moderately porous; no roots; few medium irregular soft calcareous nodules; no fragments; weakly cemented continuous petroferric; non calcareous (10% HCL) throughout; gradual irregular boundary to

C 95 - 150 cm brownish yellow (10YR 6.0/8.0, moist) clay; structureless massive;, plastic; few distinct clear mottles (10YR 5.0/8.0); patchy moderately thick slickensides cutans on pedfaces; few to common, fine pores; slightly porous;; frequent small irregular hard manganiferous concretions; slightly calcareous (10% HCL) throughout;

ADDITIONAL REMARKS

Short field description:
Deep, imperfectly drained, yellowish brown clay. Large cracks when dry, moderately, (sub)angular blocky structure, presence of calcareous conglomerates. Third and fourth horizon are very hard. The inclusions in the first and second horizon are gravels.
Geology: mid-lower Miocene, clays, sands, marls, limestones and conglomerate.
Geomorphology: marine plain and terrace, abrasive, slightly undulating and plain.

ANALYTICAL DATA:

			PARTICLE SIZE DISTRIBUTION (µm)																			
			>2	2000	1000	500	250	100	TOT	50	20	TOT		WDIS	BULK	pF						
Hor.	Top	Bot.	mm	1000	500	250	100	50	SAND	20	2	SILT	<2	CLAY	DENS	0.0	1.0	1.5	2.0	2.3	2.7	3.4	4.2
Ap	0	27	-	5	5	5	5	4	24	7	16	23	53	42.2	1.22	52	52	51	50	49	48	39	32
B	27	75	-	4	4	4	5	3	20	3	16	19	60	41.8	-	-	-	-	-	-	-	-	-
	25	40	-	-	-	-	-	-	-	-	-	-	-	-	1.34	51	50	47	45	44	44	43	33
	65	70	-	-	-	-	-	-	-	-	-	-	-	-	1.35	51	50	49	48	47	46	43	33
BC	75	95	-	1	2	2	4	3	12	2	22	24	65	38.4	-	-	-	-	-	-	-	-	-
C	95	150	-	0	0	0	1	1	2	3	27	30	68	37.5	-	-	-	-	-	-	-	-	-

	pH	pH		ORG. MATTER		EXCHANGEABLE CATIONS					EXCH. ACID.		CEC	CEC	CEC		BASE	AL		
Hor.	H2O	KCl	CaCO3	C	N	Ca	Mg	K	Na	sum	H+Al	Al	soil	clay	OrgC	ECEC	SAT	SAT	EC2.5	ESP
Ap	8.1	7.2	7.0	1.6	0.21	60.9	7.5	1.0	0.6	70.0	-	-	49.7	94	5.6	70.0	100	-	0.29	
B	8.7	7.2	15.0	0.3	0.04	56.0	11.0	0.4	4.7	72.1	-	-	45.3	75	1.1	72.1	*	-	0.36	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
BC	9.0	7.3	18.4	0.2	0.03	53.9	12.8	0.4	11.2	78.3	-	-	44.1	68	0.7	78.3	*	-	0.72	
C	8.8	7.2	13.0	0.1	0.03	47.9	12.6	0.4	19.0	79.9	-	-	45.9	68	0.2	79.9	*	-	1.20	

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

Hor.	MI	VE	CH	SM	KA	HA	ML	QU	FE	GI	GO	HE
Ap	0	0	0	8	4	0	0	3	0	0	2	0
B	0	0	0	8	4	0	0	3	0	0	3	0
	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-
BC	0	0	0	8	4	0	0	3	0	0	3	0
C	0	0	0	8	4	0	0	3	0	0	3	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	-	-	-	-	-	-	-	-	-
B	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-
BC	-	-	-	-	-	-	-	-	-
C	-	-	-	-	-	-	-	-	-

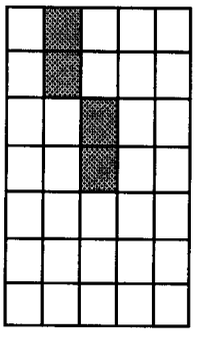
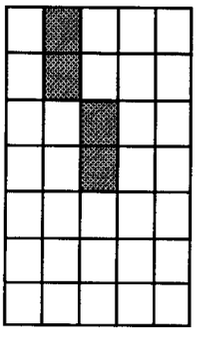
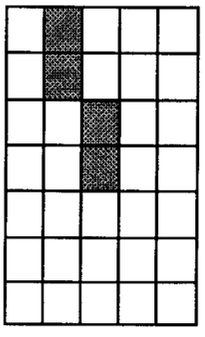
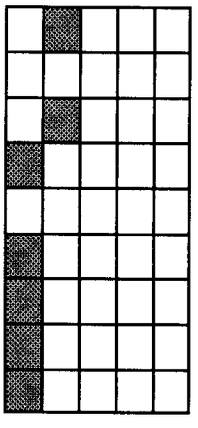
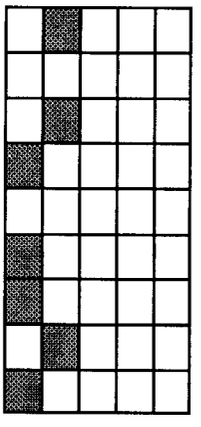
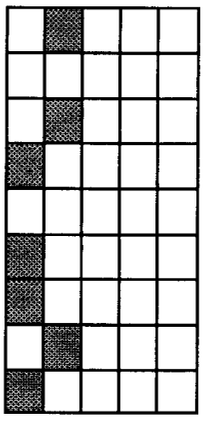
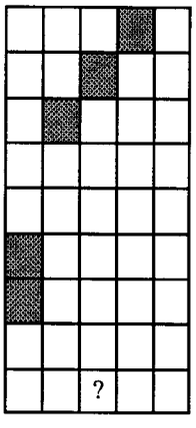
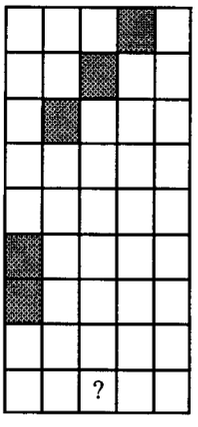
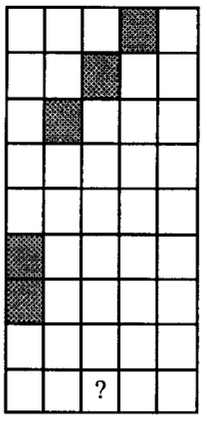
Annex 2 Evaluation of Soil/Land Qualities of CU 19, CU 20 and CU 21

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

			CU 19	CU 20	CU 21
CLIMATE					
Radiation regime	- total radiation	1			
	- day length	1			
Temperature regime		1			
Climatic hazards (hailstorm, wind, frost)		2			
Conditions for ripening		1			
Length growing season		1			
Drought hazard during growing season		2			
SOIL					
Potential total soil moisture		1			
Oxygen availability		1			
Nutrient availability		1			
Nutrient retention capacity		1			
Rooting conditions		1			
Conditions affecting germination		1			
Excess of salts	- salinity	2			
	- sodicity	2			
Soil toxicities (e.g. high Al sat.)		2			
LAND MANAGEMENT					
Initial land preparation		2			
Workability		1			
Potential for mechanization		1			
Accessibility	- existing	1			
	- potential	1			
Erosion hazard	- wind	2			
	- water	2			
Flood hazard		2			
Pests and diseases		2	?	?	?

COMMENTS

Annex 3 Methods of Soil Analysis

Preparation Each sample is air-dried, cleaned, crushed (not ground), passed through 2 mm sieve, homogenized. Moisture content is determined at 105° C.

pH H_2O (1:2.5): 20 g of soil is shaken with 50 ml of deionised water for 2 hours, electrode in upper part of suspension.

pH-KCl likewise but shaken with 1 *M* KCl.

EC (1:2.5): Conductivity of pH-H_2O suspension.

Particle-size distribution Soil is treated with 15% hydrogen peroxide overnight in the cold, then on waterbath at about 80°C. Then boiled on hot plate for 1 hour. Washings until dispersion. Dispersing agent is added (20 ml solution of 4% Na-hexametaphosphate and 1% soda) and suspension shaken overnight. Suspension sieved through 50 μm sieve. Sand fraction remaining on sieve dried and weighed. Clay and silt determined by pipetting from sedimentation cylinder.

Exchangeable bases and CEC Percolation with 1*M* ammonium acetate pH7 using automatic extractor. (If EC>0.5mS pre-leaching with ethanol 80%). Cations are determined in the leachate by AAS. CEC: saturation with sodium acetate 1*M* pH7; washed with ethanol 80% and then leached with ammonium acetate 1*M* pH7. Na determined by FES.

Exchangeable acidity and Aluminium The sample is extracted with *1 M* KCl solution and the exchange acidity (H+Al) titrated with NaOH. Al is measured by AAS.

Carbonate Piper's procedure. Sample is treated with dilute acidand the residual acid is titrated.

Organic carbon Walkley-Black procedure. The sample is treated with a mixture of potassium dichromate and sulphuric acid at about 125°C. The residual dichromate is titrated with ferrous sulphate. The result expressed in % carbon (because of incomplete oxidation a correction factor of 1.3 is applied).

Total nitrogen Micro-Kjeldahl. Digested in H_2SO_4 with Se as catalyst. Then ammonia is distilled, trapped in boric acid and titrated with standard acid.

Extractable Iron, Aluminium, Manganese and Silicon All determinations by AAS.

1 "Free" (Fe, Al, Mn): Holmgren Shaken with sodium citrate (17%) + sodium dithionite (1.7%) solution for 16 hours.

2 "Active" (Fe, Al, Si): Shaken with acid ammonium acetate 0.2 *M* pH 3 for 4 hours in the dark.

3 "Organically bound" (Fe, Al): Shaken with sodium pyrophosphate 0.1 *M* for 16 hours.

Clay mineralogy Clay is separated as indicated for particle-size analysis. about 10-20 mg of clay is brought on porous ceramic tile by suction and analyzed using a Philips diffractometer.

Soluble salts Measuring pH, EC, cations and anions in water extracts.

1 1:5 extract. Shaking 30 g of fine earth + 150 ml of water for 2 hours.

2 saturation extract. Adding to 200-1000 g fine earth just enough water to saturate the sample.

Standing overnight. After filtration Ca, Mg, Na, K are measured by AAS. Cl with the Chlorocounter and SO_4 turbidimetrically.

Gypsum To 10 g of fine earth 100 ml of water is added, shaken overnight and centrifuged. Precipitation by adding acetone. Precipitate redissolved in water and determination of Ca by AAS.

Elemental composition The fine earth is dried, ignited and fused with lithium tetraborate. The formed bead is analyzed by X-ray fluorescence spectroscopy.

Moisture retention Moisture determinations on undisturbed core samples in silt box (pF1.0;1.5;2.0) and kaolinite box (pF2.3;2.7) respectivily and on disturbed samples in high pressure pan (pF3.4;4.2).

Bulk density obtained from dry weight of core sample.

Annex 4 Units, Glossary, Classes and Acronyms

UNITS

$cmol_c\ kg^{-1}$	centimol charge per kilogram (formerly meq/100 g; 1 meq/100 g = 1 $cmol_c\ kg^{-1}$)
μm	micro-metre: $1/1000^{th}$ 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.
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

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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	Humus-rich Calcareous Reference Soil	1
Cuba 8	Cracking Heavy Clay Reference Soils (Vertisols)	3

Country Reports

(ISSN: 1381-5571)

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

* State of reference collections as of October 1995