Soil Brief *Cuba 3*

CUBA

Strongly weathered reference soils of the central and northeastern regions

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Strong weathered reference soils of
the central and northeastern regions

ISRIC Soil Monoliths:

Number	*FAO-Unesco*	*Soil Taxonomy*
CU 5	Rhodic Ferralsol	Rhodic Eutrustox
CU 7	Haplic Ferralsol	Typic Eutrustox
CU 12	Ferralic Cambisol	Oxic Dystropept
CU 22	Geric Ferralsol	Anionic Acrustox

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CONTENTS

FOREWORD

The objective of the present Soil Brief is to summarize the environment, soil chemical and physical characteristics, and to provide a detailed description and evaluation of soil qualities of four reference soils in Cuba. Soil Briefs are written for soil specialists and non-soil specialists.

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

Duplicates of these soils were collected for the 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). In the fieldwork had an important participation A. Fernández and R. Justiz and R. Blanco (CU 5); J. González and M. de León Ortíz (CU 7); H. Pérez and N. Arzola (CU 12); E. Angarica, E. Pérez and B. Montero (CU 22), from Sugarcane Experiment Station of Matanzas, Ciego de Avila, Cienfuegos and Holguín provinces.

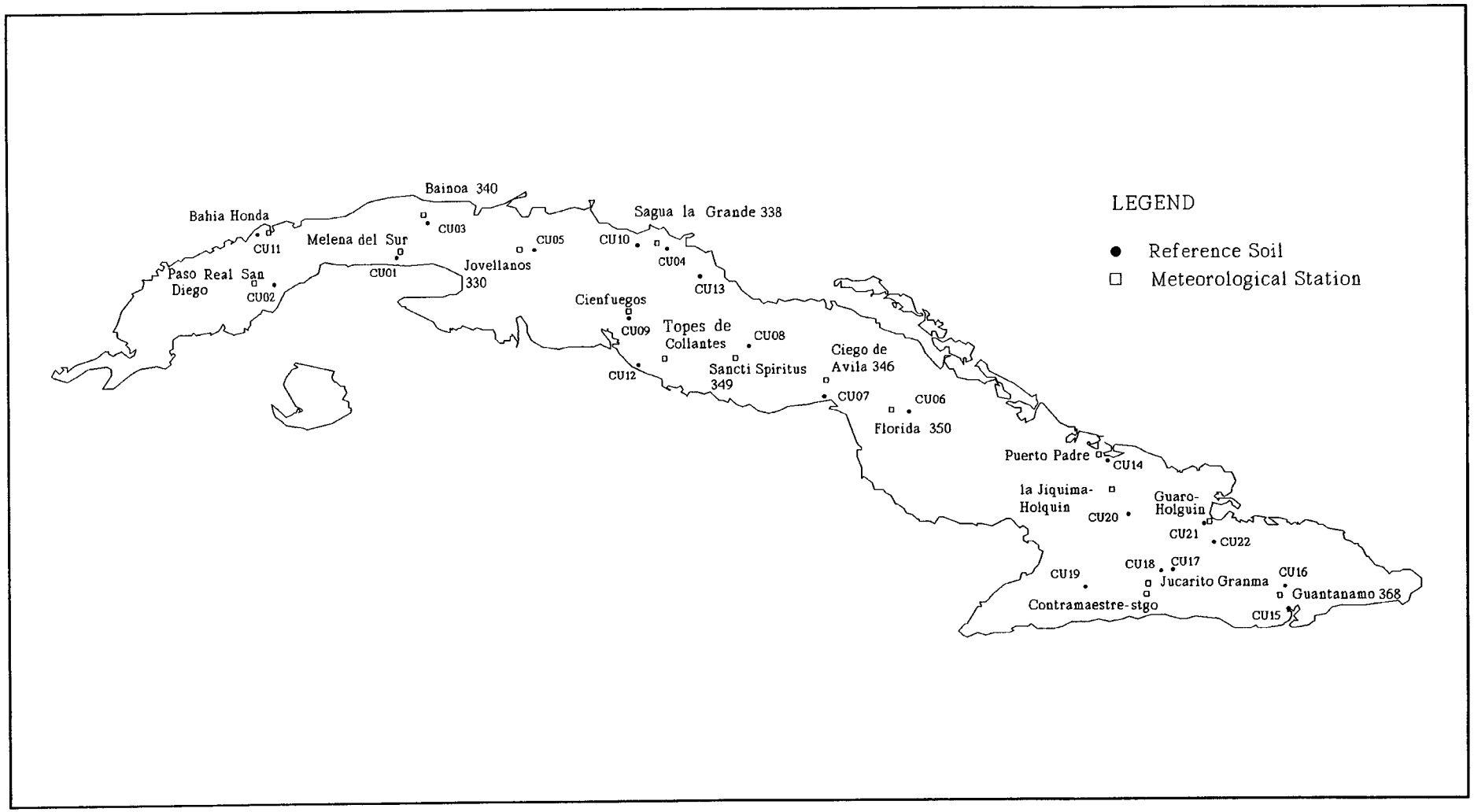

Figure 1 Geographical location of the Reference Sites.

1 THE SITES

This series of four Reference Soils, representing very deep and strongly weathered soils, were sampled in different ecological regions in 1991. The objective is to show the main characteristics of these soils under the influence of sugarcane cultivation and a number of soil forming factors. Two of the monoliths discussed, CU 5 and CU 7, are representative of the carsic plain of the Central Region while CU 12 and CU 22 are typical for the mountain regions of Cuba.
The soils (CU 5 and CU 7) are named as Typical Red Ferralitic according to the 2nd Genetic Cuban Soil Classification and are used for sugarcane cultivation, cover some 317,600 ha (Ascanio and Sulroca, 1986).
CU 12 and CU 22 are mountain soils, the first is a Red Ferralitic with limited leaching and the second one a Purple Ferralitic with excess leaching.

1.1 Location and occurrence of the soils

Reference Soil CU 5 was sampled in the Matanzas province, in areas of the Sugarcane Experiment Station (EPICA) in the Jovellanos municipality, at 22°47'05" N and 81°11'07" W, altitude is 25 m (Fig. 1).
Reference Soil CU 7 is located in the Red soil plain of Ciego de Avila province, in the Sugarcane Experiment Station (EPICA), at 21°40' N and 78°47' W, altitude is 25 m (Fig. 1).
Profiles CU 12 and CU 22 were sampled at the Escambray and Nipe mountain ranges, respectively. The first is located at 21°55' N and 80°15' W, at 1100 m altitude. CU 22 was sampled in the North part of the Nipe Mountain Range at 20°33' N and 75°45' W and 600 m altitude (Fig. 1).

1.2 Geomorphology, geology, vegetation and land use

The landscape of the area of CU 5 and CU 7 consists of abrasive and accumulative slightly undulated plains, and plains which are underlain by hard limestones from the Miocene, with slopes of less than 2% (see photograph). Natural and secondary vegetation consist of latifolia sub-perennifolia Tropical Forest with Pines (*Pinus caribaea*), Royal Palm (*Reistonea regia*), aroma (*Acacia sp*), guinea grass (*Panicum maximum*) and other spontaneous species (pastures).
The climate, the relatively flat topography and the reclaimed forest soil are suitable for high production. Major crops are potatoes, beans (*Phaseolus sp.*), sugar cane and citrus (CU 5 and CU 7), enabling a high input farming with utilization of mechanization, fertilizers and pesticides.
The topography of the area in which CU 12 profile is located is mountainous and consists of limestone, schists, marble and calcarenite. CU 22 area presents a landscape of low mountains with ultra basic rocks (serpentine and peridotite).
The natural vegetation of sites CU 12 and CU 22 are probably remnants of a latifolia perennifolia Tropical Forest.
The main crop here is coffee (Coffea arabica) and there are a number of reforestation projects.

1.3 Climate

The plain region of sites CU 5 and CU 7, and the mountainous region of sites CU 12 and CU 22 have different climates. According to the Cuban National Atlas (Academy of Science, 1989) the two regions are described as follows:
The plain region of sites CU 5 and CU 7 has a relatively stable seasonal moisture regime, high evaporation and high temperatures. Figures 2, 3, 5 and 6 show the rainfall, evapotranspiration and temperature regime diagrams for both sites.
The mountainous region of CU 12 and CU 22 has a high rainfall, low evaporation and cooler temperatures. The climatic variables of the sites CU 12 and CU 22 are shown in Figures 4 and 7.

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

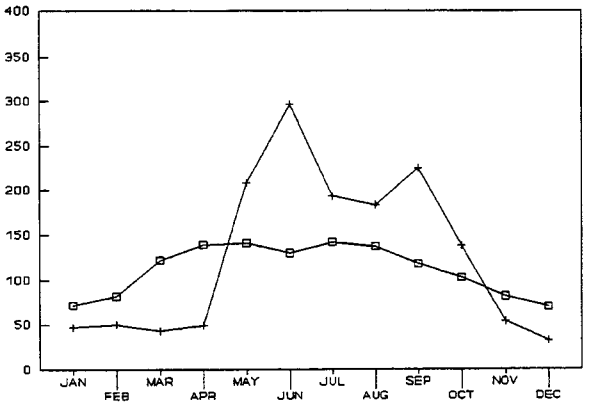

Figure 2 Precipitation (+) and evapotranspiration (□) in mm at Jovellanos meteorological station (CU 5 site).

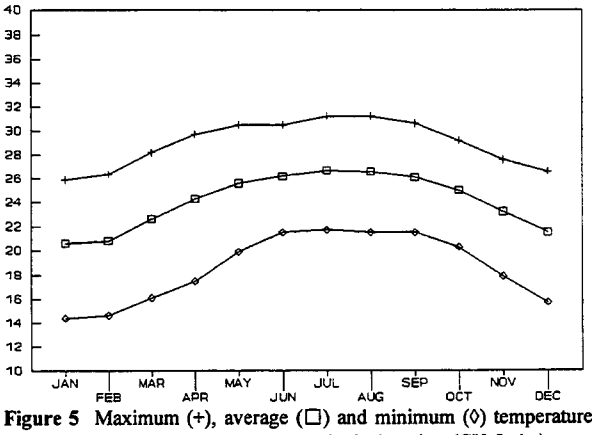

Figure 5 Maximum (+), average (□) and minimum (◊) temperature in °C at Jovellanos meteorological station (CU 5 site).

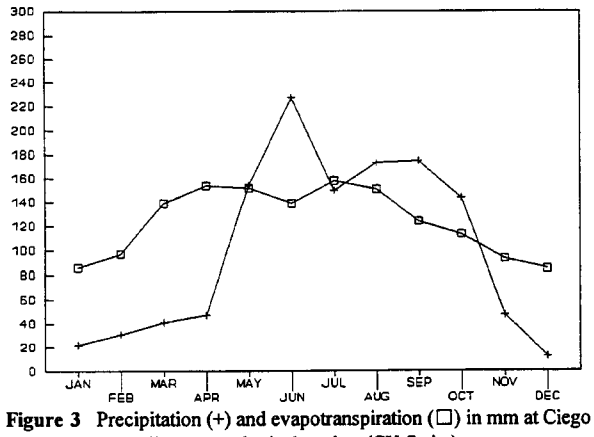

Figure 3 Precipitation (+) and evapotranspiration (□) in mm at Ciego de Avila meteorological station (CU 7 site).

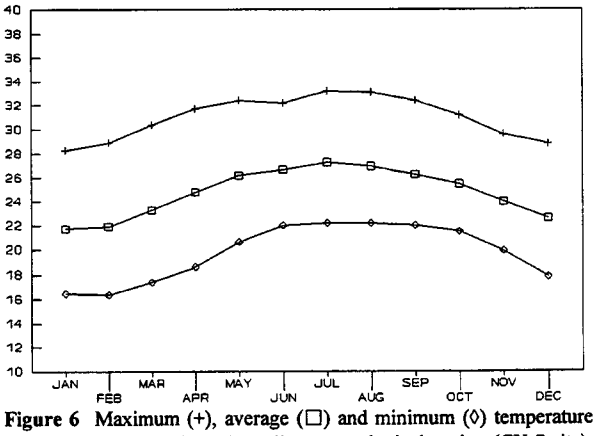

Figure 6 Maximum (+), average (□) and minimum (◊) temperature in °C at Ciego de Avila meteorological station (CU 7 site).

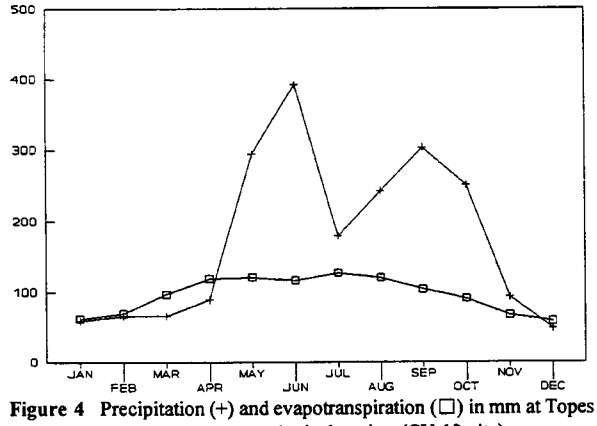

Figure 4 Precipitation (+) and evapotranspiration (□) in mm at Topes de Collantes meteorological station (CU 12 site).

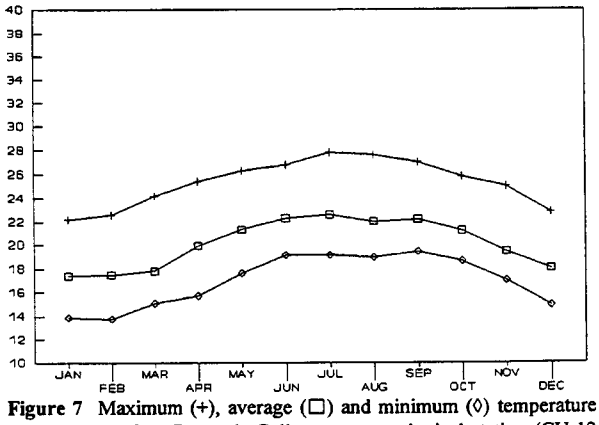

Figure 7 Maximum (+), average (□) and minimum (◊) temperature in °C at Topes de Collantes meteorological station (CU 12 site).

2 SOIL CHARACTERIZATION

2.1 Brief field description

CU 5 is a very deep, well drained, red, clay with diffuse horizon boundaries and moderately structured.
CU 7 is a very deep, well drained, red, clay, which is well structured and has small iron concretions.
CU 12 is a very deep, well drained, strong brown, clay loam. The soil is well structured, with diffuse horizon boundaries, porous, with ferromanganese concretions.
CU 22 is a very deep, well drained, dark red, gravelly clay. The soil is moderately structured and has iron concretions and diffuse horizon boundaries.
A detailed description of these soil profiles according to the FAO description guide (1990) is presented in Annex 1A (CU 5), Annex 1B (CU 7), Annex 1C (CU 12) and Annex 1D (CU 22).

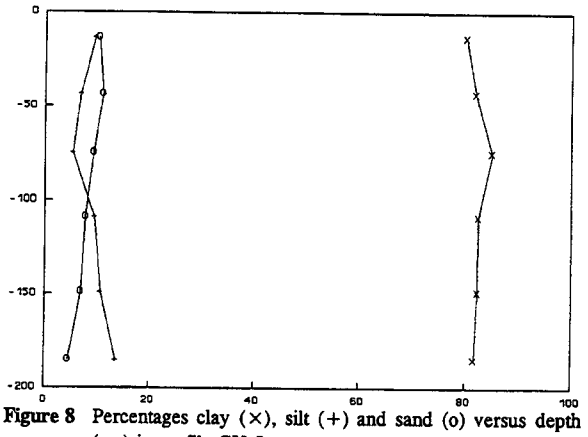

Figure 8 Percentages clay (×), silt (+) and sand (o) versus depth (cm) in profile CU 5.

2.2 Analytical characterization

Soil samples were analysed at ISRIC laboratory according to procedures described by Van Reeuwijk (1992). Table 1 presents a selection of properties of the Reference Soils.
Soils CU 5 and CU 7 have a high clay content (Figs. 8 and 9), mainly kaolinite, with small quantities of gibbsite in CU 5 and goethite in CU 7. These soils have a medium to high natural fertility and are slightly acid to neutral (Figures 10 and 11). A medium to high sum of bases indicates that a great part of its bases has not been leached. Organic carbon content is medium, decreasing with depth, which is closely related to the air capacity of the soil (Figures 12 and 13). Soil moisture availability enhances mineralization of the organic matter. Table 2 shows a medium exchangeable phosphorus and potassium content in the top layer. In both cases values are near to those reported as critical (5-7 ppm P) by Cabrera (1991) and Lopez *et al.* (1988) and 0.38 $cmol_c\ kg^{-1}$ soil of potassium (Rubio, 1982) with a clear drop below the first 20 cm.

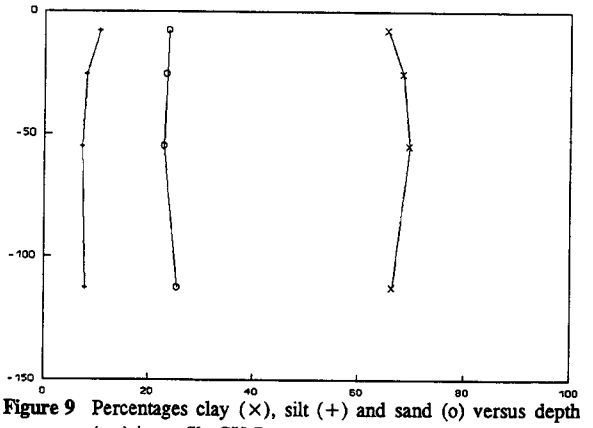

Figure 9 Percentages clay (×), silt (+) and sand (o) versus depth (cm) in profile CU 7.

Profiles CU 12 and CU 22 present a clay loam texture (Figs. 14 and 15) with predominance of goethite and gibbsite. Soil reaction is acid (Figs. 16 and 17) and the delta pH becomes negative in the subsoil of CU 22. The latter is related to the high values of iron and aluminium oxide and the strong leaching of exchangeable bases (Cardenas *et al.*, 1978; Gonzalez *et al.*, 1980). The natural fertility is low and it has a high phosphorus retention (Driessen and Dudal, 1991).

Table 1 Some characteristics of the reference soils.

	CU 5	CU 7	CU 12	CU 22
Texture	Clay throughout	Clay throughout	Silty clay loam throughout	Clay loam in top layer, subsoil sandy clay
Organic Carbon	Medium in the top horizon decreasing to very low with depth	Medium to 35cm depth decreasing to very low with depth		High in the top (0-20 cm)
Sum of Bases	Medium in topsoil (7.7 $cmol_c\ kg^{-1}$) increasing to high in the subsoil	High throughout the profile (11 and 8 $cmol_c\ kg^{-1}$ soil)	Low throughout the profile (1-2 $cmol_c\ kg^{-1}$ soil)	Low to very low
Cation exchange capacity (CEC)	Medium in the topsoil (13.2 $cmol_c\ kg^{-1}$ soil) decreasing to 90 cm depth	Medium in the two top layers (12-11 $cmol_c\ kg^{-1}$ soil), lowin the subsoil	Low in the top horizons and very low in depth (2-3 $cmol_c\ kg^{-1}$ soil)	Low in 0-30 cm (5.2 $cmol_c\ kg^{-1}$ soil) and very low in subsoil
Clay mineralogy	High kaolinite content throughout the profile	High kaolinite and goethite content throughout the profile	Mixed with presence of goetite, kaolinite and small quantities of feldspar and mica	High goetite and gibbsite content
Soil moisture availability	Medium to low in the profile (6-11%)	Medium to low (8-12%)	High	
Bulk density	Medium in the top (1.33 kg dm^{-3}) and high in the subsoil	Medium in first 35 cm (1.13-1.3 kg dm^{-3}), high in subsoil	High in top (1.42 kg dm^{-3}) and medium in subsoil	

Table 2 Phosphorus and potassium content of 40 Ferralsols (Ferralítico Rojo Típico) taken from the INICA Soil Database.

Depth (cm)	N	Total P (mg kg^{-1})	Available P Bray/Kurtz (ppm)	Exchangeable K ($cmol_c\ kg^{-1}$ soil)
0-20	40	2138.5	7.46	0.43
20-40	40	1920	3.11	0.23
40-60	30	2002	2.19	0.17

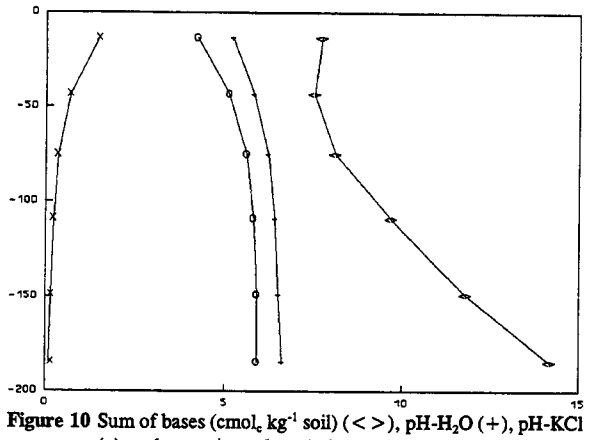

Figure 10 Sum of bases ($cmol_c\ kg^{-1}$ soil) (< >), pH-H_2O (+), pH-KCl (o) and organic carbon (×) versus depth (cm) in profile CU 5.

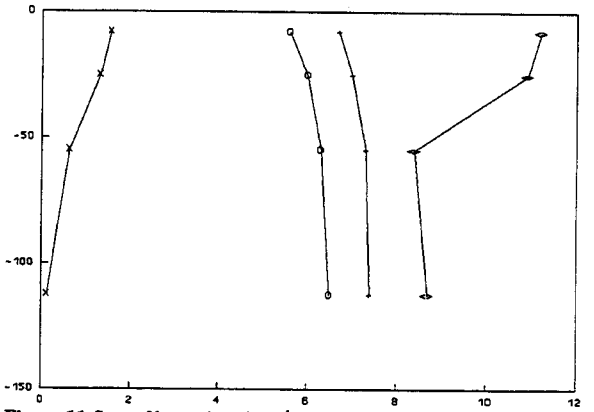

Figure 11 Sum of bases ($cmol_c\ kg^{-1}$ soil) (< >), pH-H_2O (+), pH-KCl (o) and organic carbon (×) versus depth (cm) in profile CU 7.

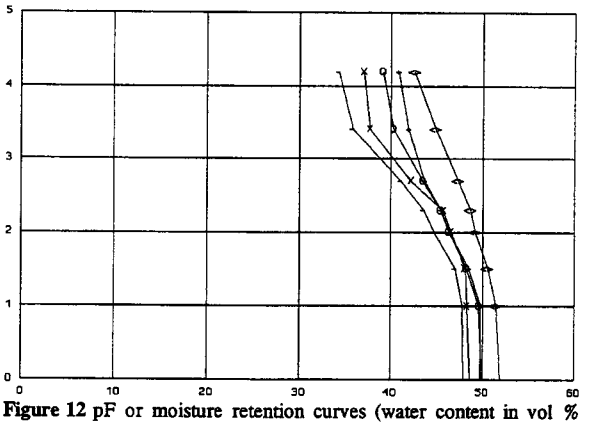

Figure 12 pF or moisture retention curves (water content in vol % versus suction) at depth 0-27 cm (×), 27-60 cm (+), 60-90 cm (o), 90-128 (-) and 128-170 (< >) in profile CU 5.

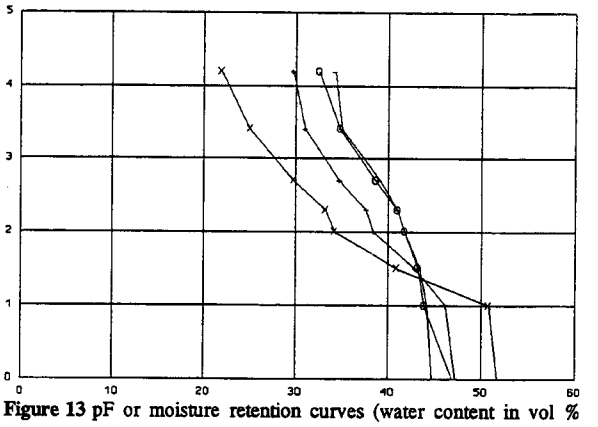

Figure 13 pF or moisture retention curves (water content in vol % versus suction) at depth 0-16 cm (×), 16-35 cm (+), 35-75 cm (o) and 75-150 cm (-) in profile CU 7.

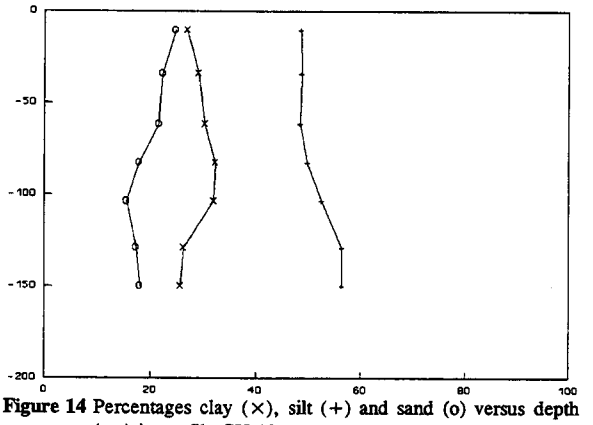

Figure 14 Percentages clay (×), silt (+) and sand (o) versus depth (cm) in profile CU 12.

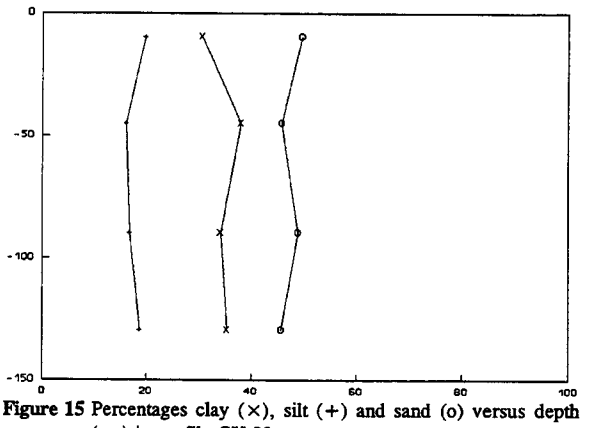

Figure 15 Percentages clay (×), silt (+) and sand (o) versus depth (cm) in profile CU 22.

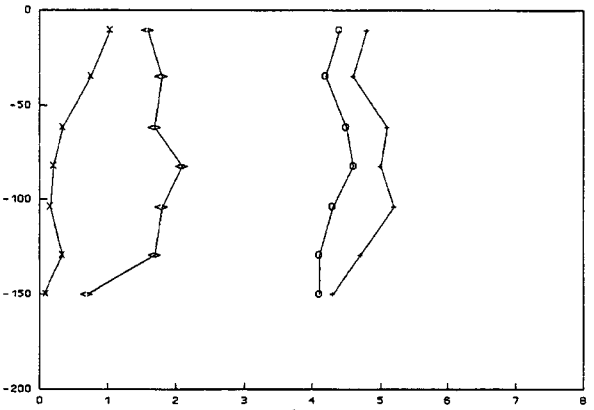

Figure 16 Sum of bases ($cmol_c\ kg^{-1}$ soil) (< >), pH-H_2O (+), pH-KCl (o) and organic carbon (×) versus depth (cm) in profile CU 12.

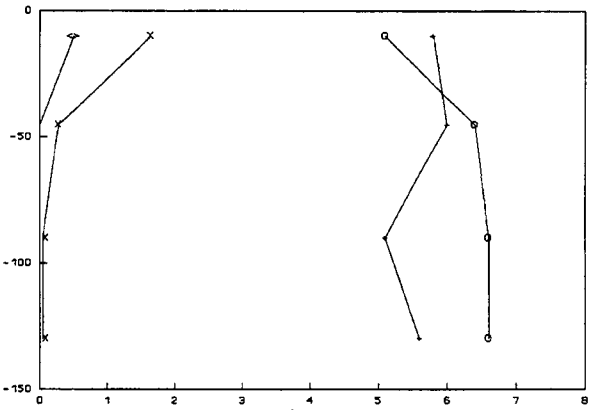

Figure 17 Sum of bases ($cmol_c\ kg^{-1}$ soil) (< >), pH-H_2O (+), pH-KCl (o) and organic carbon (×) versus depth (cm) in profile CU 22.

3 SOIL CLASSIFICATION

Classification of CU 5

FAO-UNESCO (1988)
The soil is classified as Rhodic Ferralsol. It has an ferralic horizon, the cation exchange capacity is 11 $cmol_c\ kg^{-1}$ clay, the water dispersable clay is 6%, and the colour in all horizons is 2.5YR, with diffuse horizon boundaries.

USDA Soil Taxonomy (1992)
The soil is classified as Rhodic Eutrustox, because it has an oxic horizon with low cation exchange capacity, very low weatherable mineral content, a moderate structure (subangular blocky) and an ustic moisture regime. The base saturation is > 35% and the B horizon has a red colour.

2nd Genetic Cuban Soils Classification
The soil is classified as Typic Red Ferralitic, resulting from a clear Ferralitic evolution process with a strong alteration of primary minerals, the removal of a great part of the bases and silica. The subtype Typic refers to deep soils with less than 5% concretions and red colour throughout the profile.

Classification of CU 7

FAO-UNESCO (1988)
The soil is classified as Haplic Ferralsol, because of the presence of a ferralic B horizon. It shows a uniform clay content in the profile and diffuse horizon boundaries.

USDA Soil Taxonomy (1992)
The soil is classified as Typic Eutrustox. It has an oxic horizon. The soil has a colour of 2.5 YR in all the profile with a value of 4 which is not sufficient for Rhodic.

Classification of CU 12

FAO-UNESCO (1988)
The soil has all the requirements for a ferralic horizon except for the high silt/clay ratio. It classifies therefore as Xanthi-Ferralic Cambisol bordering Eutri-Xanthic Ferralsol.

USDA Soil Taxonomy (1992)
It is assumed that the weatherable mineral content is too high for an oxic horizon. It therefore classifies as Oxic Dystropept bordering Typic Haplustox.

2nd Genetic Cuban Soils Classification
The soil classifies as Red Ferralitic with scarce lixiviation, a variant of Ferralitic showing a slight clay lixiviation toward the underlying B horizon.

Classification of CU 22

FAO-UNESCO (1988)
The soil classifies as Geric Ferralsol, because it has all the requirements for a Ferralic horizon and a very low CEC/100g clay. Because of the slight clay increase, it qualifies as argic at the third level.

USDA Soil Taxonomy (1992)
Similar to the requirements as given before, the soil classifies as Acrustox. Because of the positive delta pH, it is classified in the Anionic subgroup.

2nd Genetic Cuban soils Classification
It classifies as Purple Red Ferritic, presenting an almost complete alteration of primary minerals, strong bases washing, high content of Fe sesquioxides and a CEC less than 10 $cmol_c\ kg^{-1}$ soil.

4 LAND EVALUATION

Potential and limitations for sugarcane cultivation

Several schemes on the potentials and limitations of these soils for sugarcane cultivation have been put forward in Cuba (Mesa and Suárez, 1978; Mesa *et al.*, 1984; Roldós, 1986). Soil qualities according to FAO (1983) Methodology and ISRIC (1994), are shown for the different reference sites in Annexes 5, 6, 7 and 8.

Evaluation of CU 5 and CU 7

Highly productive soils with good physical properties. The chemical properties are poor in comparison to other Cuban soils. The soils are very deep, with adequate drainage and structural stability, but the moisture storage capacity is low.
Fertility of these Ferralsols could be considered medium to high compared with similar soils in South America and Central Africa (Driessen and Dudal, 1991).
Its main restrictions are related to the low available phosphorus and potassium content of the subsoil. In addition, other limitations such as high content of concretions (CU 22), compaction and a low base saturation may also reduce the agricultural productivity of these soils. Table 3 presents the effect of of some soil properties on sugarcane production. In both sites, under experimental conditions, mean agricultural yields have achieved 160 t/ha while in extensive production areas about 50 and 60 t/ha is obtained, which are typical yields of the South and East plains of Havana-Matanzas and the lime plain of West Camaguey (Arcia *et al.*, 1993).
Improvements should aim at removing the nutritional deficiencies through adequate fertilizer gifts, the application of irrigation and an efficient agronomic management.

Table 3 Effect of soil properties on sugarcane production (Cabrera, 1991).

Yield (t/ha)	CEC $cmol_c\ kg^{-1}$ soil	BS (%) CL:63	Available P (ppm) CL:7	Exchang. K cmol(+)/kg soil CL:0.38
64	7.8	61	1.9	0.16
115	7.1	91	15.0	0.09
134	14.0	98	4.1	0.28
247	13.0	85	7.4	0.63
270	24.0	97	22.6	0.18

CL means critical level for the different properties.

Evaluation of CU 12 and CU 22

The mountainous topography of the regions, the low natural fertility and the high acidity constitute the main factors limiting the agricultural productivity of these soils.
These soils are mainly used for coffee or forest exploitation and only small areas are devoted to sugarcane with yields of about 50 and 60 t ha^{-1}.
Plantation management in these regions must be focused on soil conservation in view of the high rainfall and the accentuated relief.
Planting in contour lines is a basic management practice for these soils.

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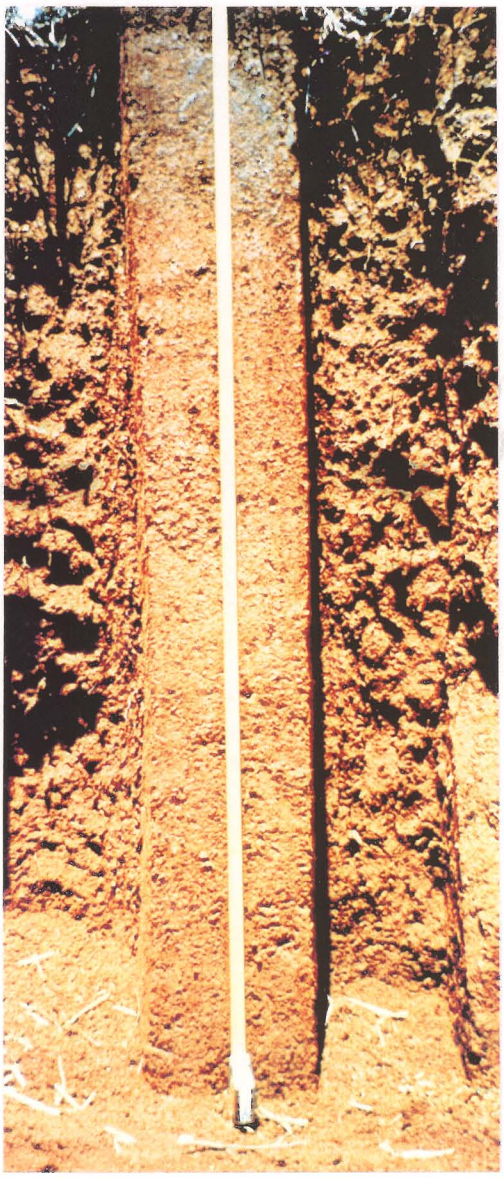
1



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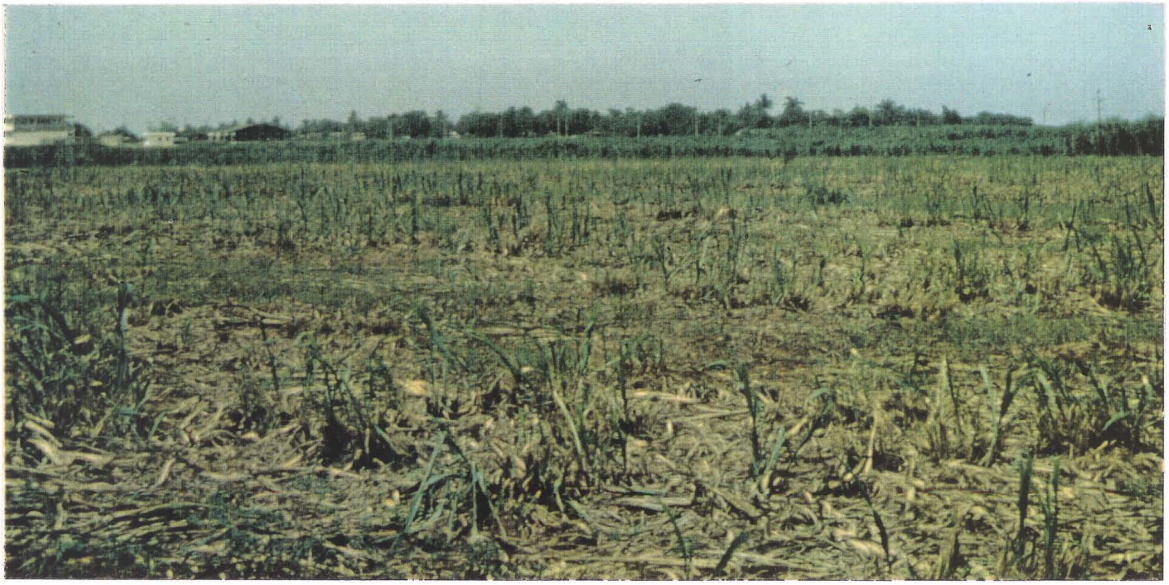
1. Profile CU 5

2. Profile CU 7
3. Landscape CU 7



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1. Landscape CU 12
2. Profile CU 12

3. Profile CU 22
4. Landscape CU 22

3

4

Annex 1A ISIS Data Sheet CU 5

Reference soil CU 5, CUBA

Print date: 10 July 1995

FAO/UNESCO (1988) : Eutri-Rhodic Ferralsol
(1974) : Rhodic Ferralsol
USDA/SCS SOIL TAXONOMY (1992) : Rhodic Eutrustox, clayey, kaolinitic, isohyperthermic
(1975) : Tropeptic Eutrustox
LOCAL CLASSIFICATION : Ferralitico rojo típico

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

LOCATION : Cuba, Matanzas, Jovellanos, EPICA, Banco de Semilla (CAI J.R. Cairo)
Latitude / Longitude : 22°45'0"N / 81°30'0"W Altitude : 25 m a.s.l.
AUTHOR(S) : Marin/Regla/Balmas. Date : May 1991

GENERAL LANDFORM : plain 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 : nil
Stoniness : nil
Slaking/crusting : nil
SLOPE PROCESSES Soil erosion : no

PARENT MATERIAL 1 type, texture : solid rock derived from limestone
Remarks :

EFFECTIVE SOIL DEPTH : 160 cm
WATER TABLE Kind, Depth : no watertable observed, -
DRAINAGE : well
PERMEABILITY : high, slowly permeable layer from 170 to 200 cm
FLOODING Frequency : nil Run off : rapid

MOISTURE CONDITIONS PROFILE : 0-200 cm moist

LAND USE : high level arable farming (sugar cane), seasonal irrigated
VEGETATION Type : semi deciduous woodland Status : secondary

CLIMATE Köppen : Aw
MET. STATIONS Name, Location : JOVELLANOS 330, 22°47' / 81°11', 25 m a.s.l
Distance to site (relevance) : JOVELLANOS 330 lays 1 km NNE of the site (very good)

		No. years of record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
JOVELLANOS 330															
EA class A pan	mm	15	124	142	202	218	206	172	188	181	146	151	124	119	1977
EP Penman	mm	21	72	82	122	139	141	130	142	137	118	103	82	70	1345
relative humidity	%	21	80	78	76	73	77	82	82	83	84	85	83	82	80
precipitation	mm	21	47	50	43	49	208	297	193	183	225	138	54	32	1524
tot.glob.rad.	MJ m^{-2}	19	403.0	467.0	600.0	682.0	630.0	600.0	630.0	630.0	540.0	480.0	415.0	403.0	5850.0
T mean	°C	21	20.6	20.8	22.6	24.3	25.6	26.2	26.7	26.6	26.1	25.0	23.2	21.5	24.1
T max	°C	21	25.9	26.4	28.2	29.7	30.5	30.5	31.2	31.2	30.6	29.2	27.6	26.6	29.0
T min	°C	21	14.4	14.6	16.1	17.5	19.9	21.5	21.7	21.5	21.5	20.3	17.9	15.7	18.5
windspeed(at 2m)	m s^{-1}	4	1.8	2.1	2.4	2.1	1.7	1.2	1.2	1.1	1.1	1.3	1.8	1.8	1.7
bright sunshine	h d^{-1}	23	6.9	7.5	8.5	8.9	7.8	7.2	8.0	7.9	7.3	7.2	7.2	6.9	7.6

Reference soil CU 5, CUBA

Print date: 10 July 1995

PROFILE DESCRIPTION :

Ap	0 - 27 cm	dark red (2.5YR 3.0/6.0, moist) clay loam; moderate medium granular; non sticky, slightly plastic; no mottles; no cutans; common fine pores and few medium pores; highly porous; many coarse roots throughout; few small spherical hard ferrigenous concretions; no fragments; few worm channels; non calcareous (10% HCL) throughout; gradual smooth boundary to
B	27 - 60 cm	dark red (2.5YR 3.0/6.0, moist) clay; moderate medium subangular blocky; non sticky, slightly plastic; no mottles; no cutans; few fine pores and few medium pores; common fine roots throughout; few small spherical hard ferrigenous concretions; no fragments; few worm channels; non calcareous (10% HCL) throughout; diffuse smooth boundary to
Bs1	60 - 128 cm	dark red (2.5YR 3.0/6.0, moist) clay; moderate medium subangular blocky parting to moderate fine to very fine subangular blocky; slightly sticky, slightly plastic; no mottles; no cutans; common very fine pores and few fine pores; few fine roots throughout; frequent medium spherical hard ferrigenous concretions; no fragments; non calcareous (10% HCL) throughout; diffuse smooth boundary to
Bs2	128 - 170 cm	red (2.5YR 4.0/8.0, moist) clay; moderate medium subangular blocky parting to moderate fine to very fine subangular blocky; slightly sticky, slightly plastic; no mottles; no cutans; few very fine pores and few fine pores; few fine roots throughout; frequent medium spherical hard ferrigenous concretions; no fragments; non calcareous (10% HCL) throughout; diffuse smooth boundary to
BC	170 - 200 cm	red (2.5YR 4.0/8.0, moist) clay loam; moderate medium subangular blocky; slightly sticky, non plastic; few fine distinct diffuse mottles (7.5YR 6.0/8.0); no cutans; common very fine pores and common fine pores; few fine roots throughout; few small spherical hard ferrigenous concretions; no fragments; non calcareous (10% HCL) throughout;

ADDITIONAL REMARKS

Short field description:
Very deep, well drained, red clay. Diffuse horizon boundaries and moderately structured. From 3 meter starts the hard rock.

The profile was studied and sampled after a heavy rainy season, which ended about 10 days ago.
Geology: mid-low Miocene, Neogene Era. Guines Formation: biogenous limestone, detritic, dolomitics.
Geomorphology: marine plain, abrasive and accumulative abrasive, slightly undulated 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	-	2	3	1	3	2	10	3	7	10	80	38.0	1.33	49	48	48	47	46	42	38	37
B	27	- 60	-	5	2	1	2	1	11	0	7	7	82	4.7	1.41	50	50	49	46	46	44	42	41
Bs1	60	- 90	-	4	2	1	1	1	9	0	5	5	85	5.9	1.43	50	50	48	46	45	44	40	39
	90	- 128	-	3	2	1	1	1	8	5	5	10	83	1.6	1.45	48	48	47	45	44	41	36	34
Bs2	128	- 170	-	3	2	1	1	1	7	0	10	11	82	7.7	1.39	52	52	51	49	49	47	45	43
BC	170	- 200	-	1	1	0	1	1	5	4	10	14	82	8.7	-	-	-	-	-	-	-	-	-

	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	5.2	4.2	-	1.5	0.05	5.8	1.5	0.3	0.1	7.7	-	-	13.2	16	5.2	7.7	58	-	0.02	
B	5.8	5.1	-	0.7	0.07	6.2	1.2	0.1	0.0	7.5	-	-	9.1	11	2.4	7.5	82	-	0.02	
Bs1	6.2	5.6	-	0.4	-	7.2	0.9	0.0	0.0	8.1	-	-	9.3	11	1.2	8.1	87	-	0.01	
	6.4	5.8	-	0.2	-	8.3	1.2	0.0	0.2	9.7	-	-	10.5	13	0.8	9.7	92	-	0.01	
Bs2	6.5	5.9	1.1	0.2	-	10.2	1.6	0.0	0.0	11.8	-	-	13.4	16	0.5	11.8	88	-	0.01	
BC	6.6	5.9	1.1	0.1	-	12.2	1.6	0.1	0.3	14.2	-	-	15.2	19	0.4	14.2	93	-	0.01	

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	0	0	0	2	5	0	0	0	0	3	0	0	0.2	0.3	0.0	8.5	0.5	-	-	- -
B	0	0	0	0	5	0	0	0	0	3	0	0	0.2	0.2	0.0	7.5	0.5	-	-	- -
Bs1	0	0	0	0	5	0	0	0	0	3	0	0	0.2	0.2	0.0	7.9	0.5	-	-	- -
Bs1	0	0	0	0	5	0	0	0	0	3	0	0	0.2	0.2	0.0	7.4	0.5	-	-	- -
Bs2	0	0	0	0	6	0	0	0	0	2	0	0	0.2	0.2	0.0	7.8	0.5	-	-	- -
BC	0	0	0	4	7	0	0	0	0	1	0	0	0.1	0.2	0.0	7.4	0.6	-	-	- -

Annex 1B ISIS Data Sheet CU 7

Reference soil CU 7, CUBA

Print date: 10 July 1995

FAO/UNESCO (1988) : Eutri-Haplic Ferralsol
(1974) : Orthic Ferralsol
USDA/SCS SOIL TAXONOMY (1992) : Typic Eutrustox, clayey, kaolinitic, isohyperthermic
(1975) : Tropeptic Eutrustox
LOCAL CLASSIFICATION : Ferralitico rojo tipico

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

LOCATION : Cuba Prov. Ciego de Avila Municipio y CAI Venezuela EPICA Campo 17
Latitude / Longitude : 21°40'0"N / 78°47'0"W Altitude : 25 m a.s.l.
AUTHOR(S) : Marin/Regla/Balmas. Date : July 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 : nil
Stoniness : nil
Slaking/crusting : nil
SLOPE PROCESSES Soil erosion : no

PARENT MATERIAL 1 type, texture : solid rock derived from limestone
Remarks :

EFFECTIVE SOIL DEPTH : 150 cm
WATER TABLE Kind, Depth : no watertable observed, -
DRAINAGE : well
PERMEABILITY : No slowly permeable layer observed
FLOODING Frequency : nil Run off : rapid

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 : CIEGO DE AVILA 346, 21°47' / 78°47', 26 m a.s.l
Distance to site (relevance) : CIEGO DE AVILA 346 lays 4 km SE of the site (very good)

		No. years of record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
CIEGO DE AVILA 346															
act. evapotransp.	mm	21	133	154	215	236	215	189	205	198	160	148	122	131	2110
EP Penman	mm	21	86	97	139	154	152	139	158	151	124	113	93	85	1497
relative humidity	%	21	79	76	74	72	77	82	79	82	85	85	84	81	80
precipitation	mm	21	22	31	41	47	154	227	150	173	175	144	47	12	1226
tot.glob.rad.	MJ m^{-1}	13	450.0	504.0	651.3	690.3	651.3	600.0	682.0	651.2	555.0	480.2	465.0	434.0	6814.3
T mean	°C	21	21.7	21.9	23.3	24.8	26.2	26.7	27.3	27.0	26.3	25.5	24.0	22.6	24.8
T max	°C	21	28.3	28.9	30.4	31.7	32.4	32.2	33.2	33.1	32.4	31.2	29.6	28.8	31.0
T min	°C	21	16.5	16.4	17.4	18.6	20.6	22.0	22.2	22.2	22.0	21.5	19.9	17.8	19.8
windspeed(at 2m)	m s^{-1}	21	2.9	3.4	3.9	3.5	3.0	2.5	2.8	2.6	2.1	2.5	3.2	3.1	2.9
bright sunshine	h d^{-1}	13	7.5	7.9	8.9	9.2	7.8	7.4	8.3	8.3	7.4	7.3	7.6	7.6	7.9

PROFILE DESCRIPTION :

Ap	0 - 16 cm	red (2.5YR 4.0/6.0, moist) clay; moderate medium to coarse granular; slightly sticky, slightly plastic, friable; no mottles; no cutans; common fine pores and few very fine pores; highly porous; many medium roots throughout; no inclusions; no fragments; non calcareous (10% HCL) throughout; gradual smooth boundary to
B	16 - 35 cm	dark red (2.5YR 3.0/6.0, moist) clay; strong medium to coarse subangular blocky; slightly sticky, slightly plastic, firm; no mottles; no cutans; many fine pores and few very fine pores; highly porous; common medium roots throughout; few small spherical hard ferrigenous concretions; no fragments; non calcareous (10% HCL) throughout; gradual smooth boundary to
Bs1	35 - 75 cm	red (2.5YR 4.0/6.0, moist) clay; moderate medium subangular blocky; slightly sticky, slightly plastic, very firm; no mottles; no cutans; common fine pores and few coarse pores; few fine roots throughout; frequent medium spherical hard ferrigenous concretions; no fragments; non calcareous (10% HCL) throughout; diffuse smooth boundary to
Bs2	75 - 150 cm	red (2.5YR 4.0/6.0, moist) clay; moderate medium subangular blocky; slightly sticky, slightly plastic, firm; no mottles; no cutans; common fine pores; moderately porous; few fine roots throughout; frequent medium spherical hard ferrigenous concretions; no fragments; non calcareous (10% HCL) throughout;

ADDITIONAL REMARKS

Short field description:
Very deep, well drained, red clay. Well structured, with small iron concretions.
Geology: Neogene Era. mid-higher Miocene. Guines Formation: clays, marl, limestones and dolomitic.
Geomorphology: marine plains, abrasive and accumulative abrasive, undulated and nearly plain.

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	- 16	-	1	5	7	6	5	24	5	5	11	66	-	1.13	52	51	41	34	33	30	25	22
B	16	- 35	-	1	5	7	6	4	24	4	4	8	68	-	1.31	47	46	43	38	38	35	31	30
Bs1	35	- 75	-	5	5	5	5	3	23	4	3	7	70	-	1.48	47	44	43	42	41	39	35	33
Bs2	75	- 150	-	7	7	4	4	3	26	4	4	8	67	-	1.56	45	44	43	42	41	39	35	34

	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	6.7	5.6	1.0	1.6	0.17	8.0	2.7	0.5	0.0	11.2	-	-	12.0	18	5.5	11.2	93	-	0.10	
B	7.0	6.0	1.0	1.3	0.16	8.2	2.5	0.1	0.1	10.9	-	-	11.3	17	4.6	10.9	96	-	0.09	
Bs1	7.3	6.3	0.7	0.6	0.10	6.4	1.8	0.1	0.1	8.4	-	-	8.8	13	2.2	8.4	95	-	0.07	
Bs2	7.4	6.5	0.8	0.1	-	7.2	1.3	0.0	0.2	8.7	-	-	8.8	13	0.5	8.7	99	-	0.10	

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	1	0	0	0	7	0	0	0	0	0	4	0	0.1	0.2	0.0	5.6	0.4	-	-	-	-
B	1	0	0	0	7	0	0	0	0	0	4	0	0.1	0.2	0.0	5.8	0.3	-	-	-	-
Bs1	0	0	0	0	7	0	0	0	0	0	4	0	0.2	0.2	0.0	5.6	0.4	-	-	-	-
Bs2	0	0	0	0	6	0	0	0	0	0	4	0	0.2	0.1	0.1	5.7	0.4	-	-	-	-

Annex 1C ISIS Data Sheet CU 12

Reference soil CU 12, CUBA

Print date: 10 July 1995

FAO/UNESCO (1988) : Ferralic Cambisol
(1974) : Ferralic Cambisol
USDA/SCS SOIL TAXONOMY (1992) : Oxic Dystropept, clayey, mixed, isohyperthermic
(1975) : -do-
LOCAL CLASSIFICATION : Ferralitico rojo amarillo lix.

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

LOCATION : Cuba Prov. Cienfuegos Mun. Cumanayagua EPICA Lote de Hibridacion
Latitude / Longitude : 21°55'0"N / 80°15'0"W Altitude : 1140 m a.s.l.
AUTHOR(S) : Marin/Regla/Balmas. Date : December 1991

GENERAL LANDFORM : intermontane basin Topography : mountainous
PHYSIOGRAPHIC UNIT : mountainous
SLOPE Gradient, Form : 4%, undulating, Position of site : lower slope
MICRO RELIEF Kind :
SLOPE PROCESSES Soil erosion : slight sheet
Slope stability : stable

PARENT MATERIAL 1 type, texture : residual material derived from limestone
Remarks :

EFFECTIVE SOIL DEPTH : 150 cm
WATER TABLE Kind, Depth : -, 400 cm
DRAINAGE : well
PERMEABILITY : No slowly permeable layer observed
FLOODING Frequency : nil Run off : rapid

MOISTURE CONDITIONS PROFILE : 0-160 cm moist

LAND USE : high level arable farming (sugar cane), no irrigation
VEGETATION Type : evergreen woodland Status : cut over

CLIMATE Köppen : Aw
MET. STATIONS Name, Location : TOPES DE COLLANTES, 21°55' / 80°1', 771 m a.s.l
Distance to site (relevance) : TOPES DE COLLANTES lays 13 km ESE of the site (very good)

		No. years of record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
TOPES DE COLLANTES															
EP Penman	mm	12	63	70	97	119	121	117	127	120	104	91	68	59	1161
relative humidity	%	12	86	84	82	80	84	86	85	87	89	90	90	88	89
precipitation	mm	12	60	67	67	90	294	392	179	243	303	251	93	49	2092
tot.glob.rad.	MJ m^{-1}	12	420.1	476.0	600.3	708.0	660.0	630.0	660.0	630.0	540.2	480.1	434.0	403.0	6640.7
T mean	°C	12	17.4	17.5	17.8	19.9	21.3	22.3	22.6	22.0	22.2	21.2	19.4	18.0	20.2
T max	°C	12	22.2	22.6	24.2	25.4	26.3	26.8	27.8	27.6	27.0	25.8	25.0	22.8	25.3
T min	°C	12	13.9	13.8	15.1	15.7	17.6	19.1	19.1	18.9	19.4	18.6	17.0	14.9	16.9
windspeed(at 2m)	m s^{-1}	12	1.6	1.6	1.6	1.4	1.2	1.2	1.4	1.4	1.5	1.7	1.9	1.8	1.5
bright sunshine	h d^{-1}	12	7.0	7.4	8.2	9.5	8.1	7.6	8.3	8.1	7.3	7.4	7.1	6.9	7.7

PROFILE DESCRIPTION :

Ap 0 - 21 cm strong brown (7.5YR 4.0/6.0, moist) clay loam; strong very fine granular and strong medium subangular blocky; slightly sticky, slightly plastic, firm; no mottles; no cutans; common very fine pores; moderately porous; few medium roots throughout; few small spherical soft manganiferous concretions; no fragments; few worm channels; non calcareous (10% HCL) throughout; gradual smooth boundary to

AB 21 - 48 cm strong brown (7.5YR 4.0/6.0, moist) clay loam; moderate fine subangular blocky; sticky, slightly plastic, firm; no mottles; no cutans; few medium pores and common very fine pores; moderately porous; few medium roots throughout; frequent small spherical soft manganiferous concretions; no fragments; few channels and worm channels; non calcareous (10% HCL) throughout; gradual smooth boundary to

Bs 48 - 75 cm strong brown (7.5YR 5.0/8.0, moist) clay; moderate medium subangular blocky to weak to moderate fine angular blocky; sticky, plastic, firm; no mottles; patchy thin clay and sesquioxide cutans throughout; few medium pores and common very fine pores; moderately porous; few medium roots throughout; frequent small spherical soft manganiferous nodules; no fragments; few channels; non calcareous (10% HCL) throughout; gradual smooth boundary to

PROFILE DESCRIPTION (cont'd):

Bc1 75 - 118 cm strong brown (7.5YR 5.0/8.0, moist) clay; moderate fine to medium angular blocky and moderate medium subangular blocky; sticky, plastic, very firm; no mottles; broken moderately thick clay cutans throughout; few very fine pores; moderately porous; few fine roots throughout; frequent medium spherical soft manganiferous nodules; no fragments; few channels; non calcareous (10% HCL) throughout; gradual smooth boundary to

Bc2 118 - 160 cm yellowish brown (10YR 5.0/8.0, moist) clay loam; weak to moderate medium angular blocky and weak to moderate medium subangular blocky; slightly sticky, slightly plastic, firm; no mottles; patchy thin clay cutans throughout; few very fine pores; moderately porous; no roots; very frequent medium spherical soft manganiferous nodules; no fragments; few channels; non calcareous (10% HCL);

ADDITIONAL REMARKS

Short field description:
Very deep, well drained, strong brown, clay loam. Well structured, with diffuse boundaries, porous ferromanganese concretions.
Geology: Jurasic higher, oxfordiano and tithoniano: limestones, marbles. Geomorphology: tectonic-lithological low mountain.
The monolith was taken in a small area (40 cm x 40 cm), surrounded by coffee and degraded forest.

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	21	-	5	5	3	5	6	25	38	10	49	27	9.0	1.42	44	42	38	31	30	25	21	16
AB	21	48	-	5	4	3	4	7	22	25	24	49	29	8.8	-	-	-	-	-	-	-	-	-
	25	30	-	-	-	-	-	-	-	-	-	-	-	-	1.41	39	37	34	30	29	27	20	16
	40	45	-	-	-	-	-	-	-	-	-	-	-	-	1.27	47	43	37	31	30	27	18	15
Bs	48	75	-	4	4	3	4	6	22	26	23	48	30	2.0	-	-	-	-	-	-	-	-	-
Bc1	75	90	-	3	3	3	4	6	18	28	21	50	32	0.9	-	-	-	-	-	-	-	-	-
	90	118	-	2	2	2	3	6	16	29	24	53	32	1.8	-	-	-	-	-	-	-	-	-
Bc2	118	140	-	2	3	2	4	7	17	33	24	56	26	1.5	-	-	-	-	-	-	-	-	-
	140	160	-	2	3	2	4	7	18	30	26	56	26	1.4	-	-	-	-	-	-	-	-	-

	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	4.8	4.4	-	1.0	0.17	1.0	0.3	0.3	0.0	1.6	0.9	0.7	5.7	21	3.6	2.5	28	12	0.10	
AB	4.6	4.2	-	0.8	0.14	1.2	0.3	0.3	0.0	1.8	0.7	0.5	5.3	18	2.7	2.5	34	9	0.08	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Bs	5.1	4.5	-	0.3	0.10	1.0	0.3	0.3	0.1	1.7	0.2	0.0	3.2	11	1.2	1.9	53	0	0.07	
Bc1	5.0	4.6	-	0.2	0.09	1.4	0.3	0.3	0.1	2.1	0.1	0.0	3.9	12	0.7	2.2	54	0	0.07	
	5.2	4.3	-	0.2	0.07	1.4	0.3	0.1	0.0	1.8	0.2	0.0	3.4	11	0.6	2.0	53	0	0.06	
Bc2	4.7	4.1	-	0.3	0.08	1.2	0.3	0.2	0.0	1.7	0.5	0.2	3.5	13	1.2	2.2	49	6	0.06	
	4.3	4.1	-	0.1	0.05	0.6	0.0	0.1	0.0	0.7	0.5	0.2	2.8	11	0.2	1.2	25	7	0.07	

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

Hor.	MI	VE	CH	SM	KA	HA	ML	QU	FE	GI	GO	HE
Ap	2	0	0	0	3	0	4	0	2	0	4	0
AB	2	0	0	0	3	0	4	0	2	0	4	0
AB	-	-	-	-	-	-	-	-	-	-	-	-
AB	-	-	-	-	-	-	-	-	-	-	-	-
Bs	2	0	0	0	3	0	4	0	2	0	4	0
Bc1	2	0	0	0	4	0	4	0	2	0	4	0
Bc1	2	0	0	0	4	0	4	0	2	0	4	0
Bc2	2	0	0	0	4	0	4	0	2	0	4	0
Bc2	2	0	0	0	4	0	4	0	2	0	4	0

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 1D ISIS Data Sheet CU 22

Reference soil CU 22, CUBA

Print date: 10 July 1995

FAO/UNESCO (1988)	: Ferri-Geric Ferralsol		
(1974)	: Acric Ferralsol		
USDA/SCS SOIL TAXONOMY (1992)	: Anionic Acrudox, clayey, gibbsitic, isohyperthermic		
(1975)	: Plinthic Acrorthox		
LOCAL CLASSIFICATION	: Ferritico purpura		
DIAGNOSTIC CRITERIA FAO (1988)	: ochric A, ferralic B, geric properties		
USDA/SCS (1992)	: ochric epipedon, oxic horizon		
	Soil moisture regime : udic		
	Soil temperature regime : isohyperthermic		
LOCATION	: Cuba Provincia Holguin Municipio Mayari, Pinares de Mayari		
Latitude / Longitude	: 20°33'0"N / 75°45'0"W	Altitude	: 650 m a.s.l.
AUTHOR(S)	: MARIN/REGLA/PEREZ	Date	: December 1991
GENERAL LANDFORM	: mountain	Topography	: mountainous
PHYSIOGRAPHIC UNIT	: mountain		
SLOPE Gradient, Form	: 6%, concave,	Position of site	: lower slope
MICRO RELIEF Kind	:		
SURFACE CHAR. Rock outcrop	: nil	Cracking	: nil
Stoniness	: nil		
Slaking/crusting	:		
SLOPE PROCESSES Soil erosion	: moderate gully		
PARENT MATERIAL 1 type, texture	: solid rock derived from serpentinite		
Remarks	:		
EFFECTIVE SOIL DEPTH	: 150 cm		
WATER TABLE Kind, Depth	: no watertable observed, -		
DRAINAGE	: well		
PERMEABILITY	: No slowly permeable layer observed		
FLOODING Frequency	: nil	Run off	: rapid
MOISTURE CONDITIONS PROFILE	: 0-150 cm moist		
LAND USE	: cultivated pasture (crops, see remarks)		
VEGETATION Type	: closed forest	Status	: cut over

PROFILE DESCRIPTION :

Ap 0 - 21 cm 2.5YR 2.0/4.0, moist clay loam; strong fine to medium granular; non sticky, non plastic, firm; no mottles; no cutans; common fine pores and few medium pores; highly porous; many very fine to coarse roots throughout; frequent medium spherical hard manganiferous concretions; no fragments; frequent channels and worm channels; non calcareous (10% HCL) throughout; gradual smooth boundary to

Bc1 21 - 70 cm dusky red (2.5YR 2.5/2.0, moist) clay loam; moderate medium granular to strong medium subangular blocky; non sticky, slightly plastic, firm; no mottles; no cutans; common fine pores and common medium pores; highly porous; many very fine to coarse roots throughout; frequent medium spherical hard manganiferous concretions; no fragments; non calcareous (10% HCL) throughout; diffuse smooth boundary to

Bc2 70 - 150 cm dusky red (10R 3.0/3.0, moist) clay loam; moderate medium granular to moderate medium subangular blocky; non sticky, non plastic, friable; no mottles; no cutans; many medium pores and common fine pores; highly porous; many very fine to coarse roots throughout; very frequent large spherical hard manganiferous concretions; no fragments; non calcareous (10% HCL) throughout;

ADDITIONAL REMARKS

Short field description:
Very deep, well drained, dark red, gravelly clay. Moderately structured, iron concretions and diffuse horizon boundaries.
The gravel consists of iron concretions ("mocarrreros").
Geology: serpentine, peridotite, serpentine-dune.
Geomorphology: mountain horst.
Surroundings of the site has severe erosion.

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	-	26	13	5	4	2	50	5	15	20	31	2.5	-	-	-	-	-	-	-	-	-
	20	70	-	25	12	5	3	2	46	5	11	16	38	37.1	-	-	-	-	-	-	-	-	-
Bc2	70	110	-	22	15	6	4	2	49	7	10	17	34	30.4	-	-	-	-	-	-	-	-	-
	110	150	-	23	13	5	4	2	46	7	11	19	35	28.8	-	-	-	-	-	-	-	-	-

	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	5.8	5.1	-	1.7	0.03	0.0	0.3	0.1	0.1	0.5	0.0	0.0	5.2	17	5.8	0.5	10	0	0.12	
	6.0	6.4	-	0.3	0.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	6	1.0	0.0	0	0	0.11	
Bc2	5.1	6.6	-	0.0	0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	4	0.1	0.0	0	0	0.06	
	5.6	6.6	-	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	4	0.1	0.0	0	0	0.06	

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	0	0	0	2	2	0	0	0	0	5	6	0	-	-	-	18.5	1.5	-	-	-	-
	0	0	0	2	2	0	0	0	0	4	6	0	-	-	-	19.0	1.5	-	-	-	-
Bc2	0	0	0	2	2	0	0	0	0	4	6	0	-	-	-	19.1	1.7	-	-	-	-
Bc2	0	0	0	2	2	0	0	0	0	3	6	0	-	-	-	16.1	1.5	-	-	-	-

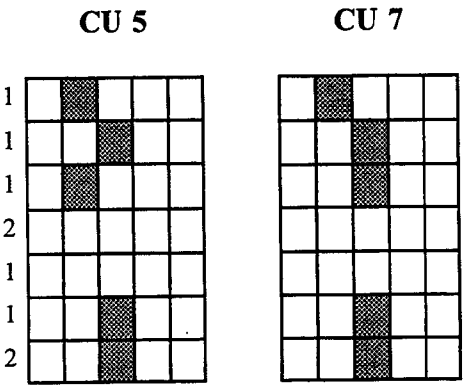
Annex 2A Evaluation of Soil/Land Qualities of CU 5 and CU 7

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		
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 2B Evaluation of Soil/Land Qualities of CU 12 and CU 22

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 12	CU 22
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 1M pH7; washed with ethanol 80% and then leached with ammonium acetate 1*M* pH7. Na determined by FES.
Exchangeable acidity and Aluminium	The sample is extracted with *1 M* KCl solution and the exchange acidity (H+Al) titrated with NaOH. Al is measured by AAS.
Carbonate	Piper's procedure. Sample is treated with dilute acidand the residual acid is titrated.
Organic carbon	Walkley-Black procedure. The sample is treated with a mixture of potassium dichromate and sulphuric acid at about 125°C. The residual dichromate is titrated with ferrous sulphate. The result expressed in % carbon (because of incomplete oxidation a correction factor of 1.3 is applied).
Total nitrogen	Micro-Kjeldahl. Digested in H_2SO_4 with Se as catalyst. Then ammonia is distilled, trapped in boric acid and titrated with standard acid.
Extractable Iron, Aluminium, Manganese and Silicon	All determinations by AAS. 1 "Free" (Fe, Al, Mn): Holmgren 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.
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.
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.

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
Unesco	United Nations Educational, Scientific and Cultural Organization

Soil Briefs of Cuba

(ISSN: 1381-6950)

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Cuba 5	Brown Calcareous Reference Soils derived from Limestone	4
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Cuba 7	Organic matter-rich Calcareous Reference Soil	1
Cuba 8	Cracking Heavy Clay Reference Soils (Vertisols)	3

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(ISSN: 1381-5571)

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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