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KENYA **SOIL SURVEY**

THE SOILS OF MUGUNA IGOKI IRRIGATION SCHEME MERU DISTRICT

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SEMI-DETAILED SOIL SURVEY REPORT NO. S26, AUGUST, 2001
KENYA SOIL SURVEY, NAIROBI

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Acknowledgements

Acknowledgements are due to the following Director, National Agricultural Research Laboratories for giving us a "go ahead", the Head Kenya Soil, Survey (KSS) through whom the request was received, CES Consulting Engineers for funding, Kenya Soil Survey Laboratories for analyzing the soils and water samples and to all those who assisted in the work execution.

1 INTRODUCTION

At the request of Mr. G. Redmer of CES Consulting Engineers through the Head Kenya Soil Survey, a semi-detailed soil investigations of Maguna Igoki Scheme, covering an area of more than 1000ha was undertaken between 5th to 20th July, 2001. Iheobjective of the survey wasto assessthe soils and water for irrigation suitabilitY.,",Two officers from Kenya Soil Survey were as~ign~dtoexe"cutethe irivestigatio~s. It is our hope that the report will provide useful information for success of the irrigation scheme.

2 THE ENVIRONMENT

2.1 Location and communication

The survey area is located 500m south of Meru town. It lies between grid coordinates (Eastings 500 to 562 and Northings 020'to 050). The elevation ranges from 1300mm to 1440m above sea level.

The area, is accessible through an all-weather road connecting Meru and Nkubu. Numerous tracks, though not marked on the base map used during field work. The survey is well served by a network of dry weather roads.

2.2 Climate

The rainfall in the area is bimodal, with peaks in April and OctoberlNovember mean annual amount of about 1300mm. Long rainy season occurs from March to May while the short rains occur between October and December. June to September generally have a water deficit.

Table 1: The annual potential evaporation (Eo) is about 1500mm giving a rainfall effectiveness rlEo) of about 87%.

Period	J	F	M	A	M	J	J	A	S	O	N	D	Totals
1970	165.8	2.0	155.0	308.0	105.0	4.1	5.1	6.9	9.7	93.5	44.5	50.8	1321.2
1971	27.3	35.0	51.9	335.3	86.9	15.5	12.5	4.2	8.4	242.0	213.0	78.0	926.3
1972	24.1	70.4	9.9	126.0	262.3	6.1	5.4	2.7	31.7	503.8	426.6	58.9	1527.9
1973	72.4	35.8	71.6	256.7	151.5	8.6	7.7	4.6	16.6	279.8	342.1	62.6	1258.5

The mean annual temperature is 18°C with an average minimum and maximum of 12°C and 24°C respectively.

2.3 Geology, geomorphology and hydrology

The soils of the area are primarily developed from Mt. Kenya basalts (Mason, 1955). The landforms recognized in the area are two: uplands with gently undulating to rolling slope ranging from 2-16% and minor valleys wti5h 5-30% slopes (undulating to hilly). In places, the valleys are deeply incised.

The survey area has two perennial rivers, Kathita on the northern and Riiji on the southern side. There are numerous springs in the area. All the rivers and streams flow from west to east. The water is suitable for irrigation.

2.4 Vegetation and present land use

Presently, the small scale holders grow coffee, maize, beans, bananas, cassava, yams, pigeon peas, sorghum, avocados, mangoes, macadamia, etc, inter-planted with graveria robusta as a source for fuel and timber. Small-scale livestock is also practiced.

3 WORKING METHODS

3.1 Office methods

Before fieldwork was undertaken relevant information concerning the natural resources of the area was collected and studied. These included geological report, soil reports and topographical maps of 1:50,000 scale. The topographic map of scale 1:50,000 was blown to a scale of 1:20,000 as base map to be used in the field.

3.2 Field methods

The survey area was reconnoitered before the actual soil investigations were commenced. A total of 50 auger-holes of observations at a depth of 102m and three profile pits at depth of 1.5m were made. Erosion cuts were also used for soil characterisation. Besides full description, the pits were sampled and taken to National Agricultural Research Laboratories (NARL) for chemical and physical property analysis.

Some of the soil characteristics observed included, physiography, slope, rockiness/stoniness, surface sealing/crusting/cracking, drainage, colour, depth, structure, mottling, drainage, ground water level, texture and vegetation. The observations were recorded on the Kenya Soil Survey routine auger-hole observation forms and profile description forms. Methods for description were based on FAO, 1977 Guidelines for profile description. Soil colour were noted by using "Munsell Colour Chart, (1975). Fertility was taken within a radius of 10-15m of each profile pit.

3.3 Laboratory

For the different treatments and analytical procedure, see Hinga *et al., 1980*

4 THE SOILS

4.1 The legend

In the soil legend, geology and geomorphology are taken into account because of their importance in soil formation and present differences in soil characteristics. The code is composed of symbols for physiography, geology and soil characteristics in that order. Slope class codes are also indicated. The following physiographic units have been indicated:

U - Uplands
V - Minor valleys

The second letter ofthe soil-mapping symbol indicates the parent rock on which the soils have been developed.

B - Basalts
X - Various parent materials

The third and sometimes forth letter indicates certain soil characteristics:

C - Soil complex
R - Red colour
B - Brown colour

1, 2 etc indicate general sub-division

TahIe 2: Key to slope classes

Slope %	Slope class code	Name of the macro-relief
0-2	A	Flat to very gently undulating
2-5	B	Gently undulating
5-8	C	Undulating
8 -16	D	Rolling
16-30	E	Hilly
> 30	F	Mountaneous

For example, mapping unit *URr1/B,* "U" is for Uplands, "B" for Basalt, "r" for red colour, "I" for subdivision of red soils and "B" is for slope class of2 - 5% referred to as "gently undulating".

4.2 Description of individual soil mapping units

Mapping Unit	**UBr_1/B**
Extent	
Location	This mapping unit is at the centre of the survey area
Parent material	Basalts
Relief	Gently undulating (slopes 2 - 5%)
Vegetation/land use	Cultivation - coffee, maize, beans, bananas
Soils in general	Well drained, very deep, dark reddish brown to very dusky red friable clay
A - horizon (surface)	
Colour	Dark reddish brown (2.5 YR 2.5/4) moist
Texture	Clay
Consistence	Friable when moist, sticky and plastic when wet
Structure	Strong, fine to medium angular and sub-angular blocky
Chemical properties	
pH-H_2O	6.4
CEC - soil	24.7 cmol/kg
Base saturation %	53
Organic carbon	1.7%
Salinity EC ds/m	non saline (0.08)
Sodicity ESP	non sodic (2)
B - horizon (subsurface)	
Colour	Dark reddish brown to very dusky red (2.5YR 2.5/4) to (2.5YR 2.5/2) moist
Texture	Clay
Consistence	Friable when moist, sticky and plastic when wet
Structure	Strong, fine to medium subangular blocky
Chemical properties	
pH-H_20	6.4 to 6.6
CEC - soil	17.9 to 25.3
Base saturation %	61
Organic carbon	0.4 to 0.5
Salinity EC ds/m	non saline (0.04 to 0.06)
Sodicity ESP	non sodic (3 to 4)
Soil classification	Rhodic NITISOLS

For the description of a representative soil profile with analytical data, see appendix I profile description No.1 08/3-1.

Mapping Unit	**UBr_2C**
Extent	ha
Location	This mapping unit is situated to the east of unit UBR1B
Relief	Undulating (slopes 5 - 8%)
Vegetation/land use	Cultivation of avocados, mangoes, maize, bananas, macadamia nuts
Soils in general	Well drained, very deep, dark reddish brown to very dusky red friable clay
A - horizon (surface)	
Colour	Dark reddish brown (2.5 YR 2.5/4) moist
Texture	Clay
Consistence	Friable when moist, sticky and plastic when wet
Structure	Moderate, very to coarse sub-angular and blocky
Chemical properties	
pH-H_20	6.2
CEC-soil	25.9cmol/kg
Base saturation %	60
Organic carbon	0.3
Salinity EC ds/m	non-saline 0.06
Sodicity ESP	non sodic
B-horizon (subsurface)	
Colour	Dark reddish brown to very dusky red (2.5YR 2.5/4) to (2.5YR 2.5/2) moist
Texture	Clay
Consistence	Friable when moist, sticky and plastic when wet
Structure	Moderate to strong, fine to medium angular and sub-angular blocky
Chemical properties	
pH-H_20	6.2 to 6.5
CEC-soil	18.3 to 19.0
Base saturation %	54 to 81
Organic carbon	0.5 to 0.9
Salinity EC ds/M	non saliine (0.4)
Sodicity ESP	non sodic
Soil classification	Rhodic NITISOLS

Mapping Unit	**UBr_3/CD**
Extent	
Location	This mapping unit is situated to the west of the survey area
Relief	Undulating to rolling (slopes 8 - 16%)
Vegetation/land use	Cultivation - coffee, maize, beans, bananas, macadamia, mangoes, pigeon peas, sorghum
Soils in general	Well drained, very deep dark reddish brown to very dusky red, in places compacts
A-horizon (surface)	
Colour	Dark reddish brown (2.5YR 2.5/4) moist
Texture	Clay
Consistence	Friable when moist, sticky and plastic when wet
B-horizon (subsurface)	
Colour	Dark reddish brown to very dusky red (2.5YR 2.5/4) to (2.5YR 2.5/2) moist
Texture	Clay
Consistence	Friable when moist, sticky and plastic when wet
Soil classification	rhodic NITISOLS

NB: Description based on auger-hole observation

Mapping Unit	**UBbIBC**
Extent	Ha
Location	Situated to the west of mapping unit UBrl/B
Parent material	Basalts
Relief	Gently undulating to undulating (slopes 2-8%)
Vegetation/land use	Cultivation - pigeon peas, coffee, maize, beans, bananas, mangoes
Soils in general	Well-drained, shallow to moderately deep, dark brown, friable clay; in places with rock out - crops/over murrum
A-horizon (surface)	
Colour	Dark brown (7.5YR %) moist
Texture	Clay
Consistence	Friable when moist, sticky and plastic when wet
Structure	Weak, very fine to medium sub-angular blocky

Chemical properties

pH-H_2O	6.1
CEC - soil	22.4
Base saturation %	59
Organic carbon	1.2
Salinity EC *ds/m*	non saline (3)
Sodicity ESP	non sodic

B-horizon (subsurface)

Colour	Dark brown (7.5YR %) moist
Texture	Clay
Consistence	Friable when moist, sticky and plastic when wet
Structure	Moderate, fine to medium sub-angular blocky

Chemical properties

pH-H_2O	6.0 to 6.1
CEC soil	22.1 to 22.4cmol/kg
Base saturation %	53 to 59
Organic carbon	1.2 to 1.2
Salinity EC *ds/M*	non saline (0.04 to 0.06)
Sodicity ESP	non-sodic (2 to 3)
Soil classification	eutric CAMBISOLS and eutric PLINTHOSOLS

Mapping Unit *VXC/CE*

Extent	Ha
Location	Situated along Kathita river (to the north) and also to the south of mapping unit UBr_2/C
Parent material	Various parent materials
Relief	Undulating to hilly (slopes 5-30%)
Vegetationlland use	Cultivation of coffee, mangoes, avocados, cassava, pawpaw, macadamia
Soils in general	Well drained to excessively drained, shallow to very deep, dark reddish brown to very dusky red, fairly rocky and stony friable

A-horizon (surface)

Colour	Dark reddish brown (2.5YR %) moist
Texture	Clay
Consistence	Friable when moist, sticky and plastic when wet

B-horizon (subsurface)

Colour	Dark reddish brown to very dusky red (2.5YR %) to (2.5YR 2.5/4) moist
Texture	Clay
Classification	rhodic NITISOLS, eutric CAMBISOLS and lithic LEPTOSOLS

NB: Description based on auger-hole observations

4.3 Soil fertility status

The fertility status were based on the data collected from the surface layers (0-30cm). The results are considered as indicative of general tendencies of the fertility levels of the soils. The results are shown in Table 2.

Table 3: Soil fertility status (O-30cm)

Soil mapping Unit Lab No.	UBrllB 1	UBr2/C 2	UBbIBC 3
pH-H2O	4.9	4.9	4.9
Name%	0.4	0.3	0.4
Kme/%	1.0	0.4	0.8
Came/%	7.3	5.8	4.5
Mgme/%	2.2	2.8	2.3
Mnme/%	0.8	1.0	0.8
P ppm (mehlich)	16	28	7
N%	0.1	0.2	0.1
C%	1.1	1.9	1.4
HPme%	0.5	0.3	0.4
EC dslM	0.1	0.01	0.1
Fe ppm	56	42.0	61
Cu ppm	8.0	3.4	0.8
Zn ppm	54	29	19

Deficiencies Underlined

As shown from the table above, soil reaction is strongly acid. Most of the plant nutrients viz: potassium, calcium, magnesium, manganese, iron, copper and zinc are adequately supplied whereas and phosphorous and nitrogen are deficient. The organic matter is moderate as shown by the % carbon.

In view ofthis:-

Apply at least 2.5 tons of farmyard manure or compost. This will improve the soil structure and moisture retention capacity

Apply NPK fertilizers to supply the deficient nutrients (N and P). Though potassium is adequate, the available fertilizers are compound in formulation

Apply at least 1000kg/ha of dolomitic limestone to raise the pH of the soil. This will also supply calcium and magnesium.

5 Quality of Irrigation Water

Table 4: Quality of irrigation water

Field Ref.	Kathita River	
Lab No.	1	2
pH	7.27	7.13
Conductivity micro mmhos	135	125
Sodium me/litre	0.70	0.78
Potassium me/litre	0.08	0.08
Calcium me/litre	Tr	Tr
Magnesium me/litre	0.73	0.92
Bicarbonates me/litre	Tr	Tr
Chlorides me/litre	0.05	0.03
Sulphates me/litre	Tr	Tr
Nitrates me/litre	3.81	6.44
Fluourides me/litre		
Sodium absorption ration	1.15	1.36

The above results indicate the pH of water is almost neutral and is within the normal range for irrigation purposes i.e (pH 6.0-8.5). The water is low salinity, low sodium water.

6 LAND SUITABILITY CLASSIFICATION FORM SPRINKLER IRRIGATION

6.1 Introduction

In land suitability classification procedure, the soils have been assessed for suitability for horticultural crops under irrigation. The procedure follows closely the FAO (1976) Framework for Land Evaluation with minor modifications to allow for the different local conditions. The classification is quantitative and is primarily on physical and chemical limitations of the soils. Five suitability classes have been identified.

Class 1: Highly suitable

Land suitable for sustained high yields of most climatically adapted crops under irrigation with minimum costs of development associated with land.

Class 2: Moderately suitable

Land of moderate productivity, or requiring moderate costs of development management due to slight to moderate limitations in land characteristics.

Class 3: Marginally suitable

Land of restricted productivity for most crops or land requiring relatively high costs for development and management because of moderate to severe limitations in land characteristics.

Class NSl: Provisionally unsuitable

Land which is considered unsuitable for sustainable irrigation pending further investigations.

Class NS2: Unsuitable

Land that is unsuitable for irrigation due to severe limitations in soils, topography or drainage for particular project.

6.2 Horticultural crop (fruits and vegetable) and their requirements

Citrus

Soils: Wide range of soils from coarse sands to fairly heavy clay soils provided no waterlogging. Well drained, medium texture, deep and fertile soils ideal for citrus, medium to low altitude crop, pH ranging from 5.0 to 6.0 gives the best results. In too acid soil, roots do not grow well and copper may become toxic. At pH above 6.0 zinc and iron fixation occurs and trees show deficiency symptoms: No sodicity or salinity

Passion fruits

Soils: Wide range of soils as for citrus. High altitude (for purple variety) and low altitude (for yellow variety) crop requires moist climate of at least 1000mm of rain. pH 5 to 6 no salinity or sodicity.

Bananas

Soils: Wide range of soils, well-aerated oils, sandy or loamy, amount of clay below 40% water table below 1 meter recommended. The crop is tolerant with a pH range of 4.5 to 8.0 although the best range is between pH 6.0 to 7.5. The soils should be free of toxic substances. Medium to low altitude crop. Rainfall of at least 1200mm and temperature of about 27°C ideal.

Pawpaw (Papaya)

Soils: Well drained well aerated, deep, permeable, fertile loamy soils, rich in organic matter, pH ranges 6.0 to 7.0 ideal. A high level of sodicity and salinity is injurious to the crop. An altitude of upto 1500m above sea level optimum temperature range between 25° to 38°C under irrigation waters 3 to 4 weeks. Wind breaks against strong winds necessary.

Mango

Soils: Like citrus, has big demand on soil. Sand or loamy, laterite or alluvial soils provided deed fertile and well drained. Ground table at a depth of 3 - 4 meters advantageous. pH between 5.5 to 7.5 ideal. At high pH values manganese, iron and zinc deficiency symptoms appear. Medium to low altitude crop. Excess of boron and chloride should be monitored.

B: Vegetables

Onion (also leeks, garlic and chivas)

Soils: Fertile, well drained, sandy loams but can grow in a wide range of soils, friable and not compact. pH range between 6.0 to 7.0, cool conditions, adequate moisture supply followed by warm conditions for maturation, harvesting and curing. Excessive nitrogen slows down bulbing.

Cabbages (also kale's Brussels sprout, cauliflower and rape)

Soils: Wide variety of soils with a cool moist climate. The ideal soils for Brassicas is rich sandy loam. Best performance altitudes above 1000 meters. pH range generally between 5.5 and above. The crop is not acid tolerant.

Okra

Soils: Any type of soil but does best on well manured loams.

Cucumber

Soils: Wide variety of soil but they do best on well manured sand loam. The crop cannot withstand water logging. pH 6.8 to 7.5. Requires warm climate, but not as hot as for melons.

Water melon, melon

Soils: Rich laom soils but grows best in fertile sand soils particularly on sandy riverbanks. Fairly drought resistant. Requires hot drier areas with plenty of sunshine. The plant cannot withstand waterlogging. pH ranges as near neutral as possible for the plant does not tolerate acidity.

Chilies

Soils: Grows best in loam soils rich in lime but can be grown on a variety of soils provided well drained no water logging. Grows from sea level to 2000 meters and above.

Egg plant (brinjals)

Soils: The crop grows best in well drained sand loams but can be grown in a wide variety of soils. Grows well upto 1000 meters.

Tomatoes

Soils: A light frees draining, fertile loam but can be grown on a variety of soils. pH ranges 5.0 to 7.0. The crop has a wide climatic tolerant.

Beans

Soils: Well-drained, moderately fertile loam with a depth of 50 - 70cm. Low tolerance to salinity. Optimal daily temperature I5-20^{p}e.

6.3 Land qualities

When evaluating the soil for suitability for horticultural crops the following land qualities were taken into consideration:

Chemical soil fertility

Drainage

Effective soil depth

Topography/slope

Chemical soil fertility

The availability of plant nutrients is pH dependent and is at its maximum within the neutral range of pH 6.0 to 7.0. With exception of micro nutrients such as iron, zinc, manganese and copper, this are readily available at pH 5.5 and below. These elements are essential for plant growth, especially fruits like citrus and mangoes that show their deficiency symptoms at pH range 6.0 _ 7.0. The soil of the area has a strong acid, 4.9 (0-30cm) and deficient in nitrogen and phosphorous. This can be rectified through soil amendments and application of the recommended fertilizers (See soil fertility status 4.4)

Drainage

Most, ifnot all of the horticultural crops need well-aerated soils for they cannot withstand waterlogging. Most of the soils in muguna Igoki are Nitisols, which are well drained. So there is no problem of waterlogging. The only compact unit in the subsoil is unit *VBr]* but upon water application, the compaction ceases.

Effective soil depth

For optimum plant growth, soil depth is important as a factor in determining the amount of moisture that can be stored in the soil. It has a direct relation to "soil moisture storage capacity". Deeper soils store more water and also allow for deepter root penetration to extract essential plant nutrients than shallow soils. Soil units *VBr), VBr2/C* and *VBr]/CD* which occupy a large area of Muguna are very deep> 120cm.

Topography/slope

Topography is extremely important for it influences the choice of irrigation method, labour requirements, irrigation efficiency, drainage requirements, erosion hazards, range of possible crops, cost of land development, possibilities of mechanization and the possible size of the field.

It is generally accepted, however, that for surface irrigation conditions are seldom favourable on slopes> 12% and smooth slopes of 0.1 to 2% are usually regarded as ideal.

Table 5: Suitability classification

Soil mapping unit	Current suitability class	Potential suitability class	Limitation
UBrl B	S2	Sl	Soil acidity and low Nand P contents
UBrz C	S3	Sl	Soil acidity, low Nand P, undulating slopes (topography) moderate soil erosion hazard
UBrl CD	NSI	Sl- S2	Topography (undulating to rolling slopes), severe soil erosion hazard, soil acidity and low Nand P
Ubb BC	NS2	NS 1 (Vegetables only)	Soil depth, rockiness, soil acidity and low Nand P
VXC CE	NS2	NS2	Topography (undulating to hilly macro-relief, severe soil erosion hazard, soil depth, soil acidity and low Nand P

7 Recommendations and Conclusions

The best area for irrigation is soil unit UBrl1B

No irrigation can be done in soil unit VXC/CE because of high hazards of soil erosion as a result of steep slopes

Gravaria robusta and Napier grass be planted in unit VXC/CE

Under whatever type of irrigation, water distribution and management has to be handled properly, particularly on soils of suitability classification "S3" with significant slopes.

Soils of units UBrIIB, *UBr2/C* and UBrJ!CD are easy to till because they are friable and porous, a marked structure stability and their consistence is not extremely hard when dry nor sticky and plastic when wet.

Addition of fertilizer and farm yard manure improves soil fertility status and structure The soils are low in phosphorus and nitrogen

Soil and water conservation personnel should be consulted for the design of anti-erosive structures, if any irrigation shall take place on soils of classification NS 1 and S3.

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Appendix 1: DESCRIPTION OF REPRESENTATIVE SOIL PROFILES WITH ANALYTICAL DATA

LABORATORY DATA OF PROFILE DESCRIPTION NO.1

Laboratory No. 101	**01**	**02**	**03**
Horizon	AP +Btl	Bh	Bt3
Depth (cm)	0-45	45-100	100-177
pH-$H_2$0 (1:2½ *v/v)*	4.8	5.4	4.9
pH-KCL			
EC *(mmho/cm)*	0.08	0.04	0.06
CaC03 (%)			
CaS04 (%)			
C(%)	1.68	0.44	0.53
N(%)			
CIN			
CEC *(mel* 1OOg)pH 8.2			
CEC *(me/lOOg)* pH 7.0	24.77	17.93	26.31
Exch. Ca (me/l OOg)	10.93	9.42	13.05
"Mg "	1.31	0.74	1.36
"K "	0.36	0.08	0.36
"Na "	0.50	0.65	0.65
Sum of cations	13.1	10.89	15.42
Base saturation % pH 8.2			
Base saturation % pH 7.0	53	61	61
ESP at pH 8.2	2.0	3.6	2.5
Texture (limited pretreatment)			
Gravel % (>2.0mm)			
Sand % (2.0 - 0.05mm)	12	8	8
Silt (0.05 - 0.002mm)	20	12	28
Clay % (0.002 - Omm)	68	80	64
Texture class	C	C	C
Fertility aspects	**0-30cm**		
General			
pH-$H_2$0 (1:1 *v/v)*	4.9		
Exch. Acidity *(mel* 1OOg)	0.50		
C%	1.08		
N%	0.12		
Remarks			

Laboratory No. 1/01

Available nutrients

Name/lOOg	0.43	Mnme/lOOg	0.82
K " "	0.95	P (ppm)	15.55
Ca " "	7.25	P-Olsen (ppm)	
Mg " "	2.15		

PROFILE DESCRIPTION NO.1

GENERAL SITE INFORMATION

Mapping Unit	UBr1IB
Soil classification	FAa 1997, rhodic NITISOLS
Agro-climatic zone	II (Sub-humid with high potential for plant growth)
Observation	108/3-1, E 538, N 039; 1440m a.s.l Meru District
Author/date	C.R.K. Njoroge and P. K. Kimani (12/07/2001)
Parent material	Basalts
Physiography	Upland
Macro-relief	Gently undulating slopes 2 - 3.5%, >200m long, straight in addition, regular
Slope at site	3 - 3.5%
Vegetation/land use	Cultivation - coffee, maize, bananas, beans
Erosion	Slight sheet
Rockiness	Nil
Surface stoniness	Nil
Surface sealing/crusting	Nil
Cracking	Nil
Drainage	Well drained

Profile description

AP 0 -17cm Dark reddish brown (2.5YR 2.5/4) moist; clay; moderate to strong, fine to medium, subangular blocky structure, slightly hard when dry, sticky and plastic when wet, many very fine and fine, many medium, few coarse pores; common biopores, 5 - 10mm wide, few krotovinas <1 Ocm wide; frequent very fine and fine, very few medium and coarse roots; clear and smooth transition to: (Sample 108/3 -la).

l746cm Dark reddish brown (2.5YR 2.5/4) moist; clay; strong, fine to medium angular and subangular blocky structures; hard when dry, friable when moist, sticky and plastic when wet, thick continuous clay cutans; many very fine to medium, few coarse pores; common worm channels; few very fine and fine; very few coarse roots; gradual and smooth transition to: (Sample 108/3 - la).

46 -lOOcm Dark reddish brown (2.5YR 2.5/4) moist; clay; strong, fine to medium angular and subangular blocky structure; slightly hard when dry, sticky and plastic when wet, thick continuous clay cutans; many very fine and fine, common medium, very few coarse pores, few worm channels, few very fine to coarse roots; diffuse and smooth transition to: (Sample 108/3 - 1b).

100 - l77cm Dark red (2.5YR 3/6) moist; clay; strong, fine and medium subangular blocky structure, friable when moist, sticky and plastic when wet; thin continuous clay cutans; many very fine and fine, common medium, very few coarse pores; few worm channels and krotovinas; very few; very fine to fine roots; (Sample 108/3 -lc)

LABORATORY DATA OF PROFILE DESCRIPTION NO.2

Laboratory No. 101	01	02	03
Horizon	AP+Bt\	Bt_2	Bt_3
Depth (em)	0-65	65-104	104-167
pH-H_20 (1:2$^1/_2$ v/v)	4.8	4.5	6.4
pH-KCL			
EC (mmho/cm)	0.06	0.04	0.04
$CaC0_3$ (%)			
CaS04 (%)			
C(%)	0.29	0.92	0.48
N(%)			
C/N			
CEC (me/lOOg) pH 8.2			
CEC (me/lOOg) pH 7.0	25.85	18.29	19.01
Exch. Ca (me/l OOg)	13.68	13.60	9.38
"Mg "	1.66	1.13	0.80
"K "	0.14	0.06	0.04
"Na "	Tr	Tr	Tr
Sum of cations	15.48	14.79	19.85
Base saturation % pH 8.2			
Base saturation % pH 7.0	60	81	54
ESP at pH 8.2			
Texture (limited pretreatment)			
Gravel % (>2.0mm)			
Sand % (2.0 - 0.05mm)	8	6	6
Silt (0.05 - 0.002mm)	26	24	8
Clay % (0.002 - Omm)	66	72	76
Texture class	C	C	C

Fertility aspects 0-30cm Laboratory No. 1/01

General

pH-H_20 (1:1 v/v)	4.8	Available nutrients			
Exch. Acidity (me/lOOg)	0.25	Name/lOOg	0.28	Mn me/lOOg	0.97
C%	1.86	K " "	0.43	P (ppm)	27.7
N%	0.18	Ca " "	5.75	P-Olsen ~m)	
		Mg " "	2.83		

Remarks

PROFILE DESCRIPTION NO.2 (0·034°N, 37·68°E)

Mapping Unit	$UBr_2$1B
Soil classification	FAO 1997, rhodic NITISOLS
Agro-climatic zone	II (Sub-h id with high potential for plant growth)
Observation	108/3-2, , 1330m a.s.l Meru District
Author/date	C.R.K. joroge an . K. Kimani (12/07/2001)
Parent material	Basalts
Physiography	Upland
Macro-relief	Gently undulating slopes 5 - 8%, >200m straight and regular
Slope at site	5 -7%
Vegetationlland use	Cultivation - avocados, maize, bananas, macadamia
Erosion	Moderate sheet
Rockiness	Nil
Surface stoniness	Nil
Surface sealing/crusting	Nil
Cracking	Nil
Drainage	Well drained

Profile description

AP 0 - 20cm Dar reddish brown (2.2YR 2.5/4) moist; clay; moderate, very fine to coarse crumbs, very fine to medium, subangular blocky structures; slightly hard when dry, friable when moist, sticky and plastic when wet, many very fine to medium, few coarse pores, common animal channels, frequent very fine and fine, very few to coarse roots; clear and smooth transition to: (Sample 108/3 - 2a).

Btl 20 - 65cm Dark reddish brown (2.5YR 2.5/4) moist; clay; moderate, strong, fine to medium angular and subangular blocky structures; hard when dry, friable when moist, thick continuous clay cutans; sticky and plastic when wet; many very fine, common medium, very few coarse, few krotovinas, 1 - 3cm wide; gradual and smooth transition to: (Sample 108/3/2b).

Bh 65 -104cm Dark reddish brown (2.5YR %) moist; clay; moderate; fine to medium angular and sub angular blocky structures; slightly hard to hard when dry, friable when moist, sticky and plastic when wet, thick continuous clay cutans; common very fine to medium, very few coarse pores; few animal channels; many very fine and fine, very few medium to coarse roots; diffuse transition to: (Sample 108/3-2c)

104-167+cm Dark reddish brown (2.5YR %) moist, moderate, fine to medium angular and subangular blocky structures; slightly hard when dry, sticky and plastic when wet; thick continuous clay cutans, common very few animal channels; few very fine and fine, very few medium to coarse roots; (Sample 108/3-2c).

LABORATORY DATA OF PROFILE DESCRIPTION NO.3

Observation No. 108/3-3 Mapping unit: UBv/BC Soil classification: eutric CAMBISOL and eutric PLINTHOSOL

Laboratory No. 101	01	02	03
Horizon	AP	Bu	BC
Depth (em)	0-19	19-39	19-65
pH-$H_2$0 (1:2$^1/_2$ v/v)	5.5	5.0	5.0
pH-KCL			
EC (mmho/em)	0.06	0.04	0.04
$CaC0_3$ (%)			
CaS04 (%)			
C(%)	1.22	1.42	1.00
N(%)			
CIN			
CEC (me/100g) pH 8.2			
CEC (me/100g) pH 7.0	22.43	22.07	22.61
Exeh. Ca (me/1 OOg)	10.60	9.05	10.56
"Mg "	1.53	1.40	1.75
"K "	0.56	0.44	0.24
"Na "	0.65	0.35	0.20
Sum of cations	13.34	11.24	12.75
Base saturation % pH 8.2			
Base saturation % pH 7.0	59	53	56
ESP at~H 8.2	2.9	1.6	0.8
Texture (limited pretreatment			
Gravel % (>2.0mm)			
Sand % (2.0 - 0.05mm)	18	16	14
Silt (0.05 - 0.002mm)	42	38	36
Clay % (0.002 - Omm)	40	46	50
Texture class	C	C	C
Fertility aspects	0-30cm		
General			
pH-$H_2$0 (1:1 v/v)	4.8		
Exeh. Acidity *lme/1* OOg)	0.40		
C%	1.42		
N%	0.13		
Remarks			

Laboratory No. 1/01

Available nutrients

Na me/100g	0.43	Mn me/100g	0.79
K " "	0.75	P (ppm)	07.2
Ca " "	4.50	P-01sen (ppm)	
Mg " "	2.49		

PROFILE DESCRIPTION NO.3

Mapping Unit	*UBbIBC*
Soil classification	FAO 1997, eutric CAMBISOLS and eutric PLINTHOSOLS
Agro-climatic zone	II (Sub-humid with high potential for plant growth)
Observation	108/3-3, E 522', N 037; 1440m a.s.l Meru District
Author/date	C.R.K. Njoroge and P. K. Kimani (12/07/2001)
Parent material	Basalts
Physiography	Upland
Macro-relief	Flat to gently undulating; slopes 0 - 3%, convex Regular slopes
Slope at site	2%
Vegetation/land use	Cultivation - coffee, pigeon peas, maize, bananas, mangoes, beans, etc.
Erosion	Very slight sheet
Rockiness	Very few rocks
Surface stoniness	Few stones
Surface sealing/crusting	Nil
Cracking	
Drainage	Well drained

Profile description

AP	0-19cm	Dark brown (7.5YR %) moist; clay; weak, very fine to medium subangular blocky structure; friable when moist, sticky and plastic when wet, many very fine and fine, common medium, few coarse pores, few termite nests; many very fine and fine roots; clear and smooth transition to: (Sample 108/3-2a).
BU	19-39cm	Dark brown (7.5YR %) moist; clay; moderate, fine to medium subangular blocky; friable when moist, sticky and plastic when wet; many very fine and fine, common medium, few coarse pores; few animal channels, few very fine and fine roots; clear and smooth transition to: (Sample 108/3-2b).
BC	30-65cm	Dark reddish brown (5YR 3/3) moist; clay; weak very fine to medium, subangular blocky structure; friable when moist, sticky and plastic when wet, many very fine and fine, medium to coarse pores, few animal channels; few fine and fine roots; (Sample 108/3-2c).
65+cm		Weathering rock