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KENYA SOIL SURVEY

DETAILED SOIL SURVEY OF THE KERIO VALLEY DEVELOPMENT AUTHORITY FARM, TOT.

(ELGEYO MARAKWET DISTRICT)

by

B. N. Ita

DETAILED SOIL SURVEY REPORT No. D40, 1986

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1. INTRODUCTION

The soil survey was carried out at the request of the Kerio Valley Development Authority with the aim of assessing the suitability of the soils for production of commonly grown field and horticultural crops under surface irrigation.

The soil survey work was done in collaboration with Messrs. F. M. Shitakha and S. Wataka from mid-October 1984 and completed by the end of the same month.

Acknowledgement is given to the staff of the K.V.D.A. farm Tot for the assistance rendered during the survey and to the staff of N.A.L. Chemistry Section for the analysis of the soil samples.

2. THE ENVIRONMENT

2.1 Location and Communication

The survey area is situated in Tot Division of Elgeyo Marakwet District, Rift Valley Province. The area is located about 3 km North East of Tot Market and is roughly intersected by longitude 35°41'E and latitude 1°13.5'N. It lies at an elevation of about 950 metres above sea level and covers about 35 ha.

The farm is accessible by a motorable track from Tot Market centre.

2.2 Climate

The survey area is located on the floor of the Kerio Valley. The climatic conditions of the area can be described using the data of Endo Tot rainfall station (88.35019) which has a rainfall record of only 4 years (1961).

2.2.1 Annual and seasonal rainfall averages (mm)

The rainfall pattern is bimodal. Long rains (April to August) have a peak in May while short rains fall in the month of November. Drier months are October, December, January, February and March. The driest month is December with 9 mm (see table 1). The average seasonal rainfall for the long rains is 468 mm (78%) and for the short rains 62 mm (10%). The rest (101 mm = 18%) is distributed over the drier months.

2.2.2 Maximum, mean and minimum temperatures

The mean annual temperature is calculated using the equation $T°C = 30.2-1.97x$ where x is altitude in thousands of feet (EAMD, 1970) to be 25°C. Mean maximum, mean minimum and absolute minimum are calculated using similar formulae to be 30°C, 19°C and 11°C respectively (see table 2).

2.2.3 Potential evaporation and evapotranspiration

Potential evaporation is estimated as 2108 mm using Woodhead's (1968) equation (Eo[mm] = 2422 - 0.358h where h is the station altitude in metres,. Evapotranspiration is estimated to be 2/3Eo = 1405mm. Both seasonal Eo and Et (2/3Eo) are shown in table 1.

2.2.4 Simple water balance

A water balance is the balance between the amount of rainfall received at a particular place and its loss by evapotranspiration (r-Et). The Et is also considered to be the crop water requirement. Table 3 shows a simple water balance for the Endo Tot rainfall station. It can be seen that with the exception of the month of May (where rainfall is in excess of crop water requirements) the rest of the year experiences a water deficit. The highest deficit is between December and March. The lowest deficit is in July and November. Therefore the rains can only sustain a crop for the month of April (assuming the available water is stored in the soil). The crops to be cultivated should be supplemented with irrigation.

Table 1. Mean monthly and annual rainfall (r), potential evaporation (Eo), evapotranspiration (2/3Eo), and r/Eo ratio of the Endo Tot rainfall station (EAMD No.88.35019, altitude 894m)

	J	F	M	A	M	J	J	A	S	O	N	D	YEAR
r (mm)	10	21	36	65	128	48	62	65	57	34	62	9	596
Eo (mm)	190	190	211	169	169	169	146	169	190	190	146	190	2108
2/3Et (mm)	127	127	141	113	113	113	97	113	127	127	97	127	1405
r/Eo (%)	5	11	17	38	76	28	42	38	30	18	42	5	28

Table 2. Temperatures (°C) for the Endo Tot Station

Mean annual temperature	25
Mean maximum temperature	30
Mean minimum temperature	19
Range	11

Table 3. Simpe water balance (mm) for the Endo Tot Station (88.35019)

Month	J	F	M	A	M	J	J	A	S	O	N	D
Rainfall r	10	21	36	65	128	48	62	65	57	34	62	9
Et	127	127	141	113	113	113	97	113	127	127	97	127
r-Et	-117	-106	-105	-48	+15	-65	-35	-48	-70	-93	-35	-118

2.3 Geology and Physiography

The area consists of colluvial material derived from banded hornblende and biotite gneisses and olivine basalts according to Siderius (1978).

The survey area is situated on a piedmont plain which extends from the foot of the Elgeyo escarpment towards the Kerio river.

The relief is flat to gently undulating (slopes 0-3%).

2.4 Present Land Use

The farm is presently used by K.V.D.A. for cultivation, about 60% of it is cropped with maize and green grams while the rest was recently cleared and bare.

The crops are rainfed while both manual and mechanised operations are employed.

2.5 Hydrology and Water Quality

2.5.1 Hydrology

The area lies between two permanent rivers namely, Kerio river arising from Keiyo escarpment and flowing in a general south-north direction 5 km east of Tot Market. It drains ultimately into Lake Turkana.

Embobut river arises from Elgeyo escarpment north-west of Tot and flows in west-east direction before joining the Kerio river.

Embobut has a tributory adjacent to Tot Market from which canals have been dug to deliver water for irrigation to the fields bordering the survey area.

2.5.2 Water Quality (for irrigation)

Near Tot market one water sample was taken from the tributory of river Embobut for analysis at the National Agricultural Laboratories (NAL).

The water was found to be of low salinity and low sodicity hazards (class C1-S1 of Richards (1954). Therefore, it is suitable for irrigation with no possibility of any hazard on both crops and soils.

Table 4. Analytical data of a water sample from tributary of river Embobut

Lab. No.	8465/84
pH	8.4
Conductivity (micro mhos/cm)	130
Sodium (me/litre)	0.22
Potassium (me/litre)	0.05
Calcium (me/litre)	0.70
Magnesium (me/litre)	0.55
Carbonates (me/litre)	Nil
Bicarbonates (me/litre)	0.98
Chlorides (me/litre)	0.27
Sulphate (me/litre)	Nil
Sodium adsorption ratio	0.3

3. WORKING METHODS

3.1 Soil Survey Methods

3.1.1 Office methods

Prior to execution of fieldwork all the relevant data of the area were collected and studied. These included topographical map sheet no. 76/3 at a scale of 1:50,000, previous soil survey and geological reports.

A base map was prepared by reducing a map of the farm drawn by K.V.D.A. at a scale of 1:1,250 to 1:2,500 using an optical pantograph. The latter map was used in the field as a base map.

After fieldwork the map was reduced from 1:2,500 to 1:5,000 and this map together with legend were forwarded to the drawing office through map correlators for final drawing.

3.1.2 Field methods

On the prepared base map transects were drawn and augerhole observations made using a grid system of an interval of 100 metres. A minimum depth of 150 cm was augered at each observation if soil conditions permitted. This depth was not realised in some places due to soil compactness.

Representative sites were selected and profile pits dug to a depth of more than 150 cm where soil conditions allowed.

A total of 35 augerhole observations were made and sampled for pH and EC field determination of a 1:2.5 (v/v) soil/water extract. Three profile pits were dug, described and sampled per horizon for chemical and physical analysis at NAL. Composite samples from 0-30 cm were taken from the vicinity of each profile pit site. All augerhole and profile pit observations, soil boundaries and slope class boundaries were plotted on the base map.

Information on site characteristics and soil properties were described according to the FAO (1977) "Guidelines for soil profile description" while soil colour (moist) was determined using "Munsell Soil Color Charts" (Munsell Color Company, 1971). Soil classification is according to the FAO/UNESCO (1974) legend.

3.2 Laboratory methods

The physical and chemical analysis of the soil samples were carried out using the methods outlined by Hinga et al. (1980). A short summary is given below:

Textural analysis was by hydrometer method. Electrical conductivity (EC), pH-H_2O and pH-KCl were measured in 1:2½ soil/water and soil/salt suspensions respectively.

The %C and %N were determined using Walkley-Black and semi-micro Kjeldahl methods respectively.

Soils were leached with 1N ammonium acetate at pH 7.0. The exchangeable cations were determined in ammonium leachates. For available nutrients (on A horizon only), soils were extracted with 1:5 0.1N HCl/0.025N H_2SO_4.

Ca, K, and Na were determined by EEL flame photometer, for P the vanadomolybdo phosphoric yellow method was used, while Mg was determined colorimetrically using thiazol yellow reagent. Mn was measured colorimetrically by use of phosphoric acid-potassium periodate for colour development.

4. THE SOILS

4.1 Previous Work

The survey area is part of the upper Kerio Valley which has been mapped at a preliminary level by Siderius (1978), who described the soils as well drained, deep, dark reddish brown, friable sandy loam over sandy clay loam. Also, well drained, deep, brown, sandy loam and dark brown sandy clay loam occur, developed on colluvium derived from gneisses rich in ferromagnesian minerals.

4.2 General Properties of the Soils

Due to the homogeneous nature of the physiography and the parent material of the survey area, variations in soil properties are rather limited.

The soils are well drained and mainly very deep, with the exception of some shallow ones in the extreme north of the farm.

Textures range from sandy clay loam to clay in the deeper soils to gravelly clay in the shallow ones. Major colours are (dark) reddish brown to dark red. The soils have a topsoil low in organic matter with a moderate subangular blocky structure, gradually changing with depth to angular blocky in the B-horizon.

In places the subsoil is slightly sodic. The soils have a high CEC and are mostly saturated. The pH ranges from 6.1 to 8.5 in the sodic subsoils.

The soil fertility is rather low with deficiencies of N and P.

4.3 Systematics and Nomenclature

The separation of mapping units has been done on the basis of physiography, parent material and soil variations in terms of characteristics such as depth, colour and texture. Each mapping unit is identified on the map by a symbol for which a code system is used (van de Weg, 1978).

(i) Physiography

Y - piedmont plain

(ii) Geology (parent material)

X - various parent materials (colluvium)

(iii) Soil depth classes

Depth class symbol	depth (cm)	Name
-	0-25	Very shallow
P	25-50	Shallow
-	50-80	Moderately deep
-	80-120	Deep
-	120-180	Very deep
-	more than 180	Extremely deep

(iv) Slope classes

Slope class symbol	slope	Name of the macrorelief
A	0-2%	flat to very gently undulating
B	2-5%	gently undulating

The numbers 1, 2 indicate different units within the same physiography/ geology grouping.

4.4 Description of the Mapping Units

Soils of the piedmont plain

(i) Mapping unit YX1

Extent : 32.0 ha (slope class A); 2.5 ha (slope class B)

Parent material : Colluvium derived from banded hornblende and biotite gneisses plus olivine basalts.

Physiography : piedmont plain

Relief, macro : flat to very gently undulating and gently undulating (0-2% and 2-3% respectively) with long, about 150m, regular slopes.

Relief, micro : few termite mounds, ½m high, 1m diameter.

Erosion : light to moderate rill wash.

Land use : cultivation of rainfed maize and green grams

Drainage condition : well drained.

Soils, general : The soils consist of well drained, very deep, dark red to dark reddish brown, friable, sandy clay loam to clay. They have an ABC equence of horizons with smooth and clear to abrupt boundaries. They are moderately to well structured.

colour : A-horizon: reddish brown to dark reddish brown (5YR 4/4-4/5 to 2.5YR 3/4 moist)

B-horizon: dark red to dark reddish brown (2.5YR 3/6-3/4 moist)

texture : sandy clay loam to clay

structure : A-horizon: moderate to strong, medium to coarse, subangular blocky.
B-horizon: weak to strong, fine to medium, angular and subangular blocky.

consistence : friable when moist, sticky and plastic when wet throughout.

Chemical properties : A-horizon: %C ranges from 0.38 to 0.71; pH-H_2O ranges from 6.3 to 6.8; pH-KCl ranges from 5.3 to 5.7; CEC soil (me/100g) ranges from 13.5 to 22.6; base saturation ranges from 69 to over 100%; ESP 2.3 to 6.1 mmho/cm.
B-horizon: pH-H_2O ranges from 6.2 to 8.5; pH-KCl from 4.8 to 7.1; CEC soil (me/100g) ranges from 14.8 to 27.7; base saturation from 75 to over 100%; ECe ranges from 2.8 to 6.5 mmho/cm, ESP ranges from 2.7 to 13.3.

Diagnostic criteria : An ochric A-horizon and a cambic B-horizon

Classification : chromic CAMBISOLS, sodic and partly saline phase.

For detailed descriptions of soil profiles with analytical data see appendix 1 profile descriptions nos. 1, 2 and 3 (observation no. 76/3-88, 76/3-89 and 76/3-90).

Mapping Unit YX2P

Extent : 0.7 ha (slope class A)

Parent material : colluvium derived from banded hornblende and biotite gneisses plus olivine basalts.

Physiography : piedmont plain

Relief, macro : flat to gently undulating (0-2%); slopes are long and regular.

Relief, micro : very few termite mounds, 30 cm high, 50 cm diameter

Erosion : moderate rain splash and rill wash

Surface stoniness : very stony

Land use : cultivation, recently cleared with no crops growing

Drainage condition : well drained.

Soils, general : well drained, shallow, dark reddish brown, gravelly clay, with an ABC horizon sequence.

colour : A-horizon: dark yellowish brown (10YR 3/4 moist)
B-horizon: dark reddish brown (5YR 3/3 moist).

texture : gravelly clay in both A and B horizons; Gravel is about 50% and deeper down there are stones.

consistence : slightly hard when dry, friable when moist, sticky and plastic when wet.

Provisional classification : eutric CAMBISOLS, petric phase

Remarks : No profile pit was dug in this mapping unit.

4.5 Soil Fertility Status

The soil fertility appraisal of the survey area is based on 3 composite topsoil (0-30cm) samples taken at the sites of representative profile pits. Due to the low number of composite topsoil samples analysed, the appraisal can only give general tendencies. The analytical data on the available nutrients are presented in table 5.

Table 5. Available nutrients (0-30 cm)

Mapping unit	YX1	YX1	YX1
Observation No.76/3-	88	89	90
Laboratory No. /84	8543	8544	8545
pH - H_2O	7.3	6.1	6.2
Na^+ (me/100g)	0.72	0.52	0.82
K^+ "	0.46	0.92	0.96
Ca^{++} "	10.2	3.0	2.8
Mg^{++} "	8.1	5.3	7.7
Mn^{++} "	0.56	0.43	0.50
P (ppm)	18	20	18
N (%)	0.09	0.13	0.11
C (%)	0.41	0.79	0.68
EC (mmhos/cm)	0.85	-	-

The soil reaction varies from slightly acid to medium alkaline. The soils are sufficiently supplied with basic plant nutrients viz Ca, Mg, K and Mn. N and P are deficient in all soils. In view of the above remarks, it is therefore recommended that phosphate and nitrogen fertilizers be applied to the soils. Also farm yard manure and or compost manure be applied to the soils to improve their fertility status and for the supply of the deficient nutrients to plants for better yields.

5. LAND SUITABILITY FOR IRRIGATED (HORTICULTURAL AND FIELD CROPS)

5.1 Introduction

The suitability was assessed following principles and concepts in the 'Framework for Land Evaluation' (FAO 1976), and the assessment was made only in physical terms.

Suitability of the Kerio Valley Development Authority farm, Tot was assessed for rainfed agriculture with additional surface irrigation for growing of cereals like maize, pulses like green grams and horticultural crops (vegetables and fruits) under a high level of management.

Here the high level of management implies proper cultural practices for each crop, viz use of improved seeds, appropriate fertilizers, chemicals for diseases and pests control, proper spacing, timely farm operations (planting, weeding and chemical applications), proper soil and water conservation measures including crop rotation and mulching.

During the suitability classification the following assumptions were made:

1. Costs of constructing canals and/or other structures for conveying water have not been considered but assumed to be repayable in time.
2. Availability of irrigation water is not limiting.

5.2 Land Qualities and their Ratings

The following land qualities were found relevant in the area and were used as the diagnostic criteria:

1. Soil moisture storage capacity (SMSC)
2. Availability of nutrients
3. Presence/hazard of sodicity

4. Presence/hazard of salinity
5. Possibilities of mechanisation

1. Soil Moisture Storage Capacity (SMSC)

The SMSC is important in irrigation for determining the frequency and the amount of water to be applied to the soil. The SMSC depends on the porosity and the depth of the soil. As no porosity data are available the SMSC is based on emperical relations with soil texture. The SMSC is assumed to be equal to the moisture content at field capacity (pF 2.0) minus the moisture content which allows unhibited plant growth (pF 3.7).

As no pF data of the survey are available the SMSC was estimated using texture and depth following a method devised by Braun and Kibe (1978). According to calculations based on texture the amount of moisture that can be stored by the soil in the survey area at 0-50 cm depth ranges from 42-56 mm, while for 100 cm depth the amount ranges from 72-112 mm. It is assumed that the maximum evapotranspiration is ± 6 mm/day. For crops with 50 cm rooting depth the soil will furnish them with moisture for 42/6 to 56/6 days = 7 to 9 days. Hence irrigation frequency would be about once a week. For crops with a rooting depth of 100 cm the soil will provide moisture for 72/6 to 112/6 days = 12 to 18 days and therefore the frequency of irrigation would be about once per two weeks on average (not taking into account additional rainfall).

The rating of SMSC was done according to Braun and van de Weg (1977) as shown in table 6.

Table 6. Soil Moisture Storage Capacity ratings

Soil moisture storage capacity in mm/100 cm depth	rating
>100	1 very high
75 - 100	2 high
50 - 75	3 moderate
25 - 50	4 low
<25	5 very low

2. Availability of Nutrients

The potential productivity of the soil is to a large extent dependent on the fertility viz, the capacity of the soil to retain and supply plant nutrients. This land quality was assessed using cation exchange capacity (CEC) (an indicator of the ability of the soil to hold nutrients), and available cations (table 7).

A high CEC is a desirable feature of a soil as this protects a higher proportion of nutrient cations from being leached and there is a close correlation between CEC of a soil and its productivity (Wrigley, 1981).

Table 7. Availability of nutrients ratings

a) Subrating CEC of the topsoil (0-30 cm)

CEC (me/100g)	rating
>16	1 very high
12-16	2 high
6-12	3 moderate
2-6	4 low
0-2	5 very low

b) Sub-rating available cations of the topsoil (0-30 cm)

Available P(ppm)	Available K(me/100g)	Available Ca(me/100g)	Available Mg(me/100g)	rating
>200	>3.5	>20	>12	1 very high
80-200	2.0-3.5	10-20	6-12	2 high
20-80	1.0-2.0	6-10	3-6	3 moderate
0-20	0.3-1.0	2-6	1-3	4 low
0-20	0-0.3	0-2	0-1	5 very low

The sum of the sub-ratings give the following final rating for availability of nutrients:

c) Final rating for the availability of nutrients

Sum of sub-ratings	final ratings
2	1 very high
3-4	2 high
5-6	3 moderate
7-8	4 low
>8	5 very low

3. Hazard of sodicity

Sodicity (alkalinity) is caused by presence of sodium on the complex and is expressed as exchangeable sodium percentage (ESP). Sodicity has indirect effects on crops through the soils like poor structure stability (dispersing), increasing rate of swelling, forming of crusts, leading to reduced water permeability and aeration conditions which are unfavourable for crop growth, as well as direct toxicity (van Alphen, 1978).

The hazard of sodicity was rated as shown in table 8. As root systems of most crops are best developed in the upper 30 cm of the soil, more weight is given to the surface soil and less severe criteria are used for the subsoil.

Table 8. Hazard of sodicity ratings

ESP (0-30 cm)	ESP (30-100 cm)	rating
<6	<6	1
6-10	6-15	2
10-15	15-40	3
15-40	>40	4
>40	>40	5

4. Hazard of salinity

Salinity is a result of the presence of soluble salts in the soil and is measured in terms of electrical conductivity of the saturated extract (ECe).

Salinity has adverse effects on plant growth by reducing the water uptake by the plant, i.e. the more salts a soil contains, the higher the osmotic pressure of the soil solution and more difficult for plant to take up water (Wrigley, 1981).

The hazard of salinity was rated as shown in table 9. For the same reasons as described under presence/hazard of sodicity more weight is given to the topsoil.

Table 9. Hazard of salinity ratings

ECe (0-30 cm)	ECe (30-120 cm)	Rating
<2	<4	1
2-4	4-8	2
4-8	8-15	3
8-15	15-30	4
>15	>30	5

5. Possibilities of mechanisation

The only land characteristic considered relevant in the survey area for this land quality is stoniness/rockiness and shallowness of the soil.

This characteristic influences the farm operations where mechanisation is involved either not allowing it to be done or reducing the efficiency of the operations. This land characteristic has been rated as shown below in table 10.

Table 10. Ratings for stoniness/rockiness/shallowness of the soil

Rating	Description
1	non-stony, non to little rocky and not shallow
2	fairly stony, fairly rocky and/or shallow
3	stony-rocky and/or shallow
4	very stony, very rocky and/or very shallow
5	exceedingly stony, and/or very rocky

The table below gives the ratings of the land qualities for all land units (soil mapping units).

Table 11. Rating of the land qualities for all land units (Soil Mapping Units)

Land units	Land qualities				
	Soil moisture storage capacity (SMSC)	Availability of nutrients	Hazard of sodicity	Hazard of salinity	Stoniness/ rockiness/ shallowness
Yx1 A	1	3	2	1	1
Yx1 B	1	3	2	1	1
Yx2P A	(4)	ND	ND	ND	4

( ) estimated; ND not determined

5.3 Land Suitability Classes and their Criteria

Land suitability classes were defined in terms of land qualities for each land utilization type (LUT). The four suitability classes used in the survey area are:-

Class S_1 Highly suitable:
Land having no significant limitations to sustained application of a given use or reduce productivity, benefits or raise inputs above unacceptable level.

Class S_2 Moderately suitable
Land having limitations which are moderately severe for sustained application of a given use or the limitations will reduce productivity or benefits.

Class S_3 Marginally suitable
Land having limitations which are severe for sustained application of a given use and will reduce productivity or benefits.

Class NS Not suitable:
Land unsuitable for sustained production due to very severe limitations.

The suitability of mapping units was obtained from the rated land qualities and crop (LUT) requirements as indicated by the suitability class-defining criteria in the conversion tables below:

Table 12. Conversion table for cereals - maize, sorghum, and millet(s)

Suitability class	Land qualities				
	Soil moisture storage capacity (SMSC)	Availability of nutrients	Hazard of sodicity	Hazard of salinity	Stoniness/ rockiness/ shallowness
S_1	3	2	1	1	1
S_2	4	3	2	2	2
S_3	5	4	3	3	3
NS	5	5	4	4	4

Table 13. Conversion table for pulses - green grams, beans, cowpeas

Suitability class	Land qualities				
	Soil moisture storage capacity (SMSC)	Availability of nutrients	Hazard of sodicity	Hazard of salinity	Stoniness/ rockiness/ shallowness
S_1	2	3	1	1	1
S_2	3	4	2	2	2
S_3	4	5	3	3	3
NS	5	5	4	4	4

Table 14. Conversion table for vegetables and moderately deep rooted fruits - bananas, pawpaws

Suitability class	Land qualities				
	Soil moisture storage capacity (SMSC)	Availability of nutrients	Hazard of sodicity	Hazard of salinity	Stoniness/ rockiness/ shallowness
S_1	2	2	1	1	1
S_2	3	3	2	2	2
S_3	4	4	3	3	3
NS	5	5	4	4	4

Table 15. Conversion table for deep rooted fruits - citrus and avocadoes

Suitability class	Land qualities				
	Soil moisture storage capacity (SMSC)	Availability of nutrients	Hazard of sodicity	Hazard of salinity	Stoniness rockiness shallowness
S_1	3	2	1	1	2
S_2	4	3	1	1	3
S_3	5	4	2	2	4
NS	5	5	3	3	5

5.4 Land suitability classification

By matching the land quality ratings of each land unit with the conversion tables, the final suitability of the land units can be found. The lowest singly rating of one of the land qualities determines the suitability class of a particular land unit. The results are shown in table 16.

Table 16. Potential land suitability for various land utilization types (LUTS)

Land unit	Land utilization type				
	Cereals (maize, sorghum, millets)	Pulses (beans, green grams, cowpeas)	Vegetables moderately deep rooted fruits, (bananas, pawpaws)	Deep rooted fruits (citrus, avocadoes)	Area in ha
$\frac{Yx1}{A}$	S_2	S_2	S_2	S_3	32.0
$\frac{Yx1}{B}$	S_2	S_2	S_2	S_3	2.5
$\frac{Yx2P}{A}$	NS	NS	NS	NS	0.7

6. CONCLUSIONS AND RECOMMENDATIONS

1. (a) The potential suitability for 34.50 ha comprising mapping unit YX1 with slope classes A and B is moderately suitable (S2) for all crops under consideration due to availability of nutrients except for citrus and avocadoes where it is considered marginally suitable (S3) due to presence of salts.

   (b) 0.70 ha consisting of mapping unit YX2p with slope class A is classified as not suitable (NS) for all crops due to stoniness/ rockiness.

2. Water for irrigation was found to be suitable

3. Soils are slightly sodic and partly slightly saline, addition of gypsum, or organic matter in form of farm yard manure may be helpful in providing a better physical condition for leaching.

4. To raise the levels of phosphorus and nitrogen appropriate fertilizers should be supplied to the soil.

5. Farm yard manure should be applied to raise the level of organic matter and also make the soils more favourable by creating good physical conditions like increasing porosity.

6. Mapping unit YX1 with slope class B(2-3%) slopes has some potential soil erosion hazard, therefore, attention should be paid to soil and water conservation measures to avoid menace of erosion after long use.

7. Field preparation should be done when the soils are neither dry nor too wet to avoid spoiling the soil structure, also workability of the soil is better at this particular time.

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APPENDIX 1

Description of representative soil profiles and analytical data.

LABORATORY DATA OF PROFILE DESCRIPTION No. 1

Observation no: 76/3-88 Mapping unit: YX1 Soil classification: chromic CAMBISOL sodic phase

Laboratory no. /84	8529	8530	8531	8532	8533	8534
Horizon	Ap	Bu1	Bu2	Bu3	BC	C
Depth(cm)	0-10	10-30	30-62	62-92	92-128	128-178
pH-H_2O(1: 2.5 v/v)	6.8	7.8	8.5	8.1	8.3	8.1
pH-KCl "	5.7	6.8	7.0	7.1	7.0	6.8
EC(mmho/cm) "	0.20	0.35	0.22	0.40	0.50	0.90
ECe (mmho/cm)						6.50
$CaSO_4$(%)						
C (%)	0.38	0.38	0.11	0.17	0.14	0.08
N (%)	0.02	0.08	-	-	-	-
C/N						
CEC(me/100g), pH 8.2	19.4	20.0	14.8	16.0	20.8	10.8
CEC " " pH 7.0						
Exch.Ca(me/100g)	17.4	16.6	32.0	35.0	34.0	17.8
" Mg "	7.0	5.6	7.0	6.4	6.0	5.7
" K "	1.36	0.78	1.16	0.82	0.84	0.66
" Na "	0.60	1.12	1.12	2.76	3.51	3.70
Sum of cations	26.4	24.1	41.3	45.0	44.4	27.9
Base sat. %, pH 8.2	100+	100+	100++	100++	100++	100++
" " %, pH 7.0						
ESP at pH 8.2	2.3	4.7	2.7	6.1	7.9	13.3
Texture (limited pretreatment)						
Gravel % (>2.0mm)						
Sand % (2.0-0.05mm)	48	38	52	40	38	48
Silt % (0.05-0.002mm)	14	20	18	22	28	32
Clay % (0.002-0mm)	38	42	30	38	34	20
Texture class	SC	C	SCL	CL	CL	L

Fertility aspects 0 - 30 cm Laboratory no. 8543 /84

General		Available nutrients			
pH-H_2O (1: 2.5 v/v)	7.3	Na/me/100g)	0.72	Mn(me/100g)	0.56
Exch. acidity (me/100g)	-	K "	0.46	P (ppm)	18
C %	0.41	Ca "	10.2	P-Olsen(ppm)	
N %	0.09	Mg "	8.1		

Remarks:

PROFILE DESCRIPTION NO. 1

General Site Information

Mapping unit	:	YX1
Soil classification	:	chromic CAMBISOL, sodic phase
Agro-climatic zone	:	VI
Observation No./date	:	76/3-88, 24/10/84
Location/altitude	:	Elgeyo Marakwet District, 1°13.5'N, 35°41'E; 950 m
Parent material	:	colluvium derived from banded hornblende and biotite gneisses plus olivine basalts
Physiography	:	piedmont plain
Relief, macro	:	gently undulating (2-3%)
Relief, micro	:	nil
Vegetation/Land use	:	nil, cultivation of maize
Erosion	:	slight rill wash
Surface stoniness/rockiness	:	<1% gravel cover
Flooding	:	nil
Groundwater level	:	(not observed) estimated to be very deep
Slope gradient	:	2-3%
Salinity/sodicity	:	slightly sodic
Surface sealing	:	<2 mm thick
Surface cracking	:	1 mm wide
Drainage class	:	well drained.

Profile description

Ap 0-10 cm : yellowish red (5YR 5/6 dry) to dark reddish brown (2.5YR 3/4 moist); sandy clay; strong medium subangular blocky; slightly hard when dry, friable when moist, sticky and plastic when wet; few large and common medium pores; common worm channels; abrupt and smooth transition to:
(sample no. 76/3-88a)

Bu1 10-30 cm : dark red (2.5YR 3/6 moist); strong medium angular blocky and strong fine subangular blocky; hard when dry, friable when moist and sticky and plastic when wet; common very fine, few fine pores; few coarse, many fine, common medium roots; common worm channels; clear and smooth transition to:
(sample no. 76/3-88b)

Bu2 30-62 cm : dark reddish brown (2,5YR 3/4 dry and moist); sandy clay loam; strong medium angular, and strong fine subangular blocky; hard when dry, friable when moist, sticky and plastic when wet; many very fine, common fine and few medium pores; many fine, few medium, few coarse roots; common worm channels; Krotovinas; ant nest; clear and smooth transition to:
(sample no. 76/3-88c)

Bu3 62-92 cm : dark red (2.5YR 3/6 moist); clay loam; weak to moderate, fine subangular blocky; hard when dry, friable when moist, sticky and plastic when wet; common very fine, few fine, few medium pores; common very fine, few coarse roots; common worm channels; Krotovinas; clear and smooth transition to:
(sample no. 76/3-88d)

BC 92-128 cm : reddish (2.5YR 4/4 moist); clay loam; weak medium angular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; common very fine, few fine, few medium roots; common worm channels; Krotovinas; gradual and smooth transition to:
(sample no. 76/3-88e)

C 128-178 cm : (auger part), yellowish red (5YR 4/6 moist); loam; slightly sticky and slightly plastic when wet;
(sample no. 76/3-88f)

LABORATORY DATA OF PROFILE DESCRIPTION No. 2

Observation no: 76/3-89 Mapping unit: YX1 Soil classification: chromic CAMBISOL sodic & saline phase

Laboratory no. /84	8535	8536	8537	8538		
Horizon	Ap	Bu1	Bu2	Bu3		
Depth(cm)	0-15	15-42	42-80	80-100+		
pH-H_2O(1: 2.5 v/v)	6.3	6.7	6.8	8.0		
pH-KCl "	5.4	5.5	5.9	6.8		
EC(mmho/cm) "	0.12	0.30	1.40	0.80		
ECe (mmho/cm)			4.00	2.80		
$CaSO_4$(%)						
C (%)	0.71	0.35	0.20	0.88		
N (%)	0.13	-	-	-		
C/N						
CEC(me/100g), pH 8.2	13.5	20.0	23.6	15.8		
CEC " " pH 7.0						
Exch.Ca(me/100g)	6.2	9.8	12.9	17.6		
" Mg "	4.2	4.8	4.1	5.6		
" K "	2.00	2.60	2.05	2.85		
" Na "	0.51	0.92	1.21	1.50		
Sum of cations	12.9	18.1	20.3	27.6		
Base sat. %, pH 8.2	96	90	86	100+		
" " %, pH 7.0						
ESP at pH 8.2	4.0	5.1	6.0	5.4		
Texture (limited pretreatment)						
Gravel % (>2.0mm)						
Sand % (2.0-0.05mm)	42	30	26	30		
Silt % (0.05-0.002mm)	18	10	14	26		
Clay % (0.002-0mm)	40	60	60	44		
Texture class	C/CL	C	C	C		

Fertility aspects 0 - 30 cm Laboratory no. 8544 /84

General		Available nutrients			
pH-H_2O (1:2.5 v/v)	6.1	Na/me/100g)	0.52	Mn(me/100g)	0.43
Exch. acidity (me/100g)	-	K "	0.92	P (ppm)	20
C %	0.79	Ca "	3.0	P-Olsen(ppm)	
N %	0.13	Mg "	5.3		

Remarks:

PROFILE DESCRIPTION NO. 2

General Site Information

Mapping unit	:	YX1
Soil classification	:	chromic CAMBISOL, saline phase and sodic phase
Agro-climatic zone	:	VI
Observation No./date	:	76/3-89, 26/10/84
Location/altitude	:	Elgeyo Marakwet District, 1°13.5'N, 35°41'E; 950 m
Parent material	:	colluvium derived from banded hornblende and biotite gneisses plus olivine basalts
Physiography	:	piedmont plain
Relief, macro	:	flat to very gently undulating (0-2%)
Relief, micro	:	nil
Vegetation/Land use	:	nil/cultivation (green grams)
Erosion	:	nil
Surface stoniness/rockiness	:	nil
Flooding	:	nil
Groundwater level	:	(not observed) estimated to be very deep
Slope gradient	:	0-2%
Salinity/sodicity	:	slight both
Surface sealing	:	1 mm
Surface cracking	:	20-50 mm
Drainage class	:	well drained.

Profile description

Ap 0-15 cm : yellowish red (5YR 5/6 dry) to reddish brown (5YR 4/4 moist); clay/clay loam; strong medium subangular blocky; very hard when dry, friable when moist, sticky and plastic when wet; common fine, very few medium pores; few worm channels, common termites; few fine roots; clear and smooth transition to:
(sample no. 76/3-89a)

Bu_1 15-42 cm : reddish brown (2.5YR 4/4 dry) to dark reddish brown (2.5YR 3/4 moist); clay; strong medium to coarse angular and subangular blocky; very hard when dry, friable when moist, sticky and plastic when wet; common fine pores; few worm channels; common termites; common fine roots; clear and smooth transition to:
(sample no. 76/3-89b)

Bu_2 42-80 cm : red (2.5YR 4/6 dry) to dark red (2.5YR 3/6 moist); clay; weak medium angular and subangular blocky; slightly hard when dry, friable when moist, sticky and plastic when wet; common termites; many fine roots; abrupt and smooth transition to:
(sample no. 76/3-89c)

Bu_3 80-100 cm+ : red (2.5YR 5/8 dry) to dark red (2.5YR 3/6 moist); clay; moderate, medium subangular blocky; slightly hard when dry, friable when moist, sticky and plastic when wet; few fine pores; few fine roots; few worm channels, common termites; Iron 5% 2 mm; carbonates
(sample no. 76/3-89d)

LABORATORY DATA OF PROFILE DESCRIPTION No. 3

Observation no: 76/3-90 Mapping unit: YX1 Soil classification: chromic CAMBISOL sodic phase

Laboratory no. /84	8539	8540	8541	8542		
Horizon	Ap	Bu_1	Bu_2	Bu_3		
Depth(cm)	0-14	14-51	51-87	87-124+		
pH-H_2O(1:2.5 v/v)	6.4	6.2	6.5	7.6		
pH-KCl "	5.3	4.8	5.5	6.9		
EC(mmho/cm) "	0.30	0.40	0.50	0.85		
ECe (mmho/cm)				5.00		
$CaSO_4$(%)						
C (%)	0.68	0.50	0.44	0.38		
N (%)	0.18	-	-	-		
C/N						
CEC(me/100g), pH 8.2	22.6	24.5	27.7	27.0		
CEC " " pH 7.0						
Exch.Ca(me/100g)	7.8	10.6	17.2	20.0		
" Mg "	4.4	4.4	4.8	5.3		
" K "	2.56	2.15	1.94	2.25		
" Na "	0.95	1.19	1.42	2.50		
Sum of cations	15.7	18.3	25.4	30.1		
Base sat. %, pH 8.2	69	75	91	100+		
" " %, pH 7.0						
ESP at pH 8.2	6.1	6.5	5.6	8.3		
Texture (limited pretreatment)						
Gravel % (>2.0mm)						
Sand % (2.0-0.05mm)	30	28	26	26		
Silt % (0.05-0.002mm)	22	18	14	14		
Clay % (0.002-0mm)	48	54	60	60		
Texture class	C	C	C	C		

Fertility aspects 0 - 30 cm Laboratory no. 8545/84

General		Available nutrients			
pH-H_2O (1:2.5 v/v)	6.2	Na/me/100g)	0.80	Mn(me/100g)	0.50
Exch. acidity (me/100g)	-	K "	0.96	P (ppm)	18
C %	0.68	Ca "	2.8	P-Olsen(ppm)	
N %	0.11	Mg "	7.7		

Remarks:

PROFILE DESCRIPTION NO. 3

General Site Information

Mapping unit	:	YX1
Soil classification	:	chromic CAMBISOL, saline-sodic phase
Agro-climatic zone	:	VI
Observation No./date	:	76/3-90, 29/10/84
Location	:	Elgeyo Marakwet District, 1°13.5'N, 35°41'E; 950 m
Parent material	:	colluvium derived from banded hornblende and biotite gneisses plus olivine basalts
Physiography	:	piedmont plain
Relief, macro	:	flat to very gently undulating (0-2%)
Relief, micro	:	nil
Vegetation/Land use	:	nil/cultivation (green grams)
Erosion	:	nil
Surface stoniness/rockiness	:	nil
Flooding	:	nil
Groundwater level	:	(not observed) estimated to be very deep
Slope gradient	:	0-2%
Salinity/sodicity	:	slight (both)
Surface sealing	:	nil
Surface cracking	:	nil
Drainage class	:	well drained.

Profile description

Ap 0-14 cm : dark brown (7.5YR 4/4 dry) to reddish brown (5YR 4/5 moist); clay; moderate, medium and coarse subangular blocky; hard when dry, friable when moist, sticky and plastic when wet; common fine pores; many very fine to fine roots; ants; clear and smooth transition to:

(sample no. 76/3-90a)

Bu_1 14-51 cm : reddish brown (5YR 4/4 dry and 5YR 4/3 moist); clay; strong, medium angular and subangular blocky; hard when dry, friable when moist, sticky and plastic when wet; very few very fine pores; few coarse, common very fine, few medium roots; ants; Iron <1% ½-1 mm; clear and smooth transition to:

(sample no. 76.3-90b)

Bu_2 51-87 cm : dark reddish brown (5YR 3/3 moist); clay; weak medium angular and subangular blocky; slightly hard when dry, friable when moist, sticky and plastic when wet; very few very fine pores; few fine to very fine, few medium and coarse roots; ants; Iron 2% ½-1 mm; clear and smooth transition to:

(sample no. 76/3-90c)

Bu_3 87-124 cm+ : dark reddish brown (5YR 3/6 moist); clay; weak medium subangular blocky; slightly hard when dry, friable when moist, sticky and plastic when wet; very few very fine pores; few fine roots; ants; Iron 1% ½-1 mm; carbonates;

(sample no. 76/3-90d)

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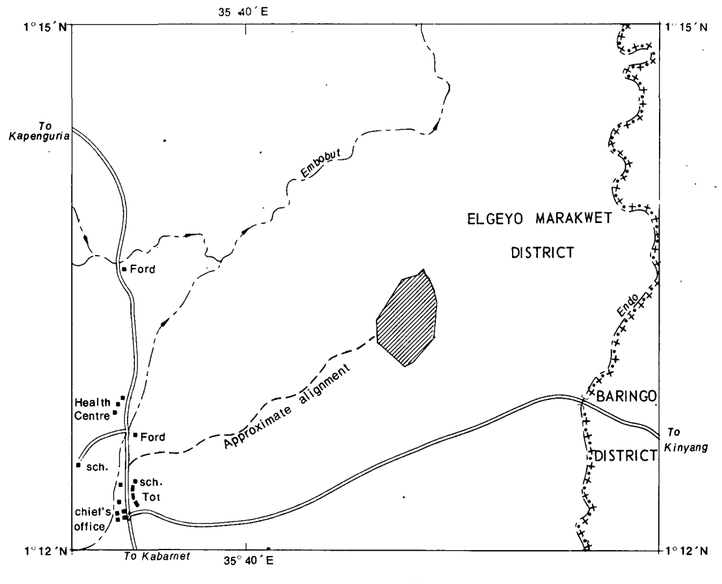
KE 1986.07

DETAILED SOIL MAP OF THE K.V.D.A. FARM, TOT

(ELGEYO–MARAKWET DISTRICT)

Appendix 2 to report No. D 40

LOCATION MAP

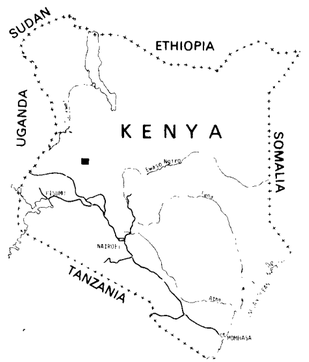


SCALE 1:50,000

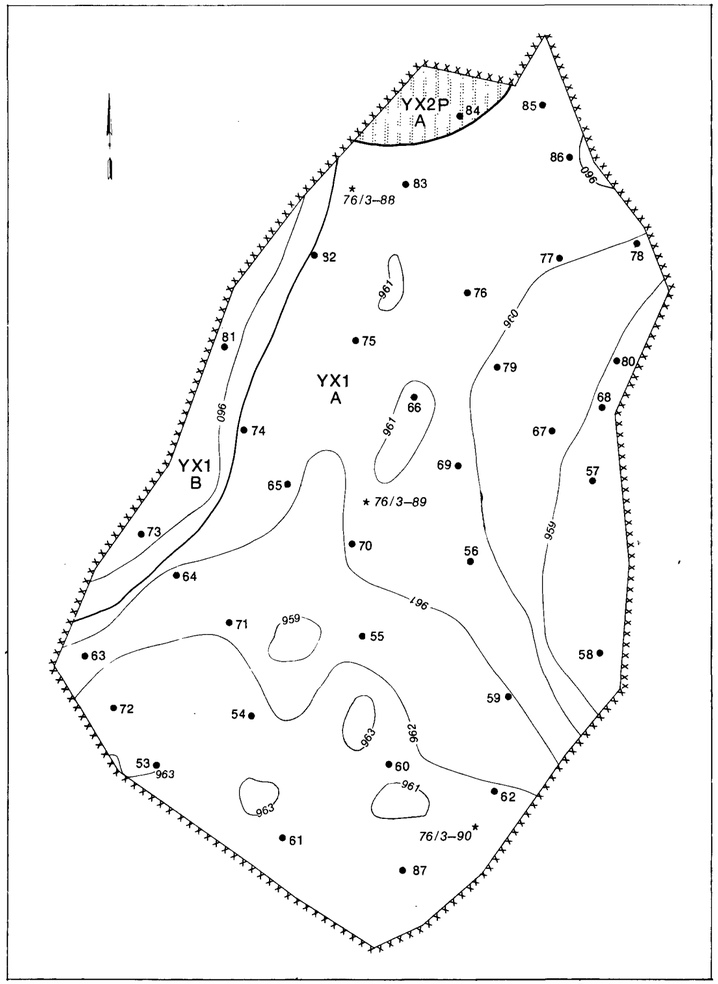
0 0·5 1 1·5 2 2·5 Km

KEY

- dry weather road
- motorable track
- river
- bridge
- building
- Sch. school
- district boundary
- survey area



■ Location of surveyed area



Base map derived from a topographical map scale 1:1,250 K.V.D.A.

SCALE 1:5,000

0 50 100 150 200 250 300m

KEY

- soil mapping code
- YX2P depth class code
- B slope class code
- soil boundary
- slope class boundary
- ●80 augerhole observation, with reference number
- ★ 76/3–90 profile pit observation, with reference number
- 1 cm² 0.25 hectares
- 962 / 961 contours V.I. 1m
- xxxxxxx survey area boundary

LEGEND

Y PIEDMONT PLAINS (slopes 0–5%)

YX Soils developed on colluvial material derived from banded hornblende and biotite gneisses, and olivine basalts

- YX1 well drained, very deep, dark red to dark reddish brown, friable, slightly sodic, calcareous, sandy clay loam to clay; in places slightly saline
  chromic CAMBISOLS, sodic and partly saline phase)
- YX2P well drained, shallow, dark reddish brown, stony and gravelly clay

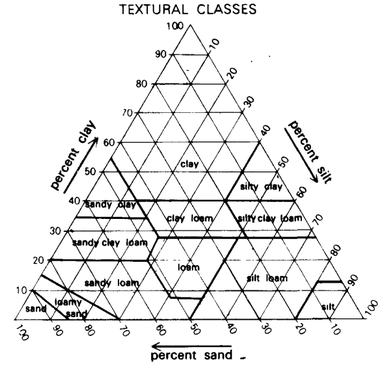
KEY TO DEPTH CLASSES

thickness soil in cm	symbol and code: over quartz	symbol and code: over murram	name
0-25			very shallow
2-50	P		shallow
50-80			moderately deep
80-120			deep
120-180			very deep
more than 120			extremely deep

KEY TO SLOPE CLASSES

slope %	slope class symbol+	name of the macrorelief
0-2	A	flat to very gently undulating
2-5	B	gently undulating

TEXTURAL CLASSES



SOIL SURVEY AND MAP PREPARATION, 1984

soil survey	S. Wataka, B.N. Ita, F.M. Shitakha
map compilation	B.N. Ita
map correlation	P.T. Gicheru and J.R. Rachilo
cartography	L.H. Mikisi

Drawing No. 85014