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The land suitability of the soils of Thai Model Village Farm, Gikindu Location, Murang'a District

By

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

SUMMARY

The Thai Model Village Farm is located in Mirira Sub-Location, Gikindu Location, Kiharu Division, Murang'a District. The farm falls in agro-climatic zone IV which is classified as semi-humid to semi-arid. The mean annual temperature ranges from 22 to 24°C. The area is characterized by two short cropping seasons with an average annual rainfall of between 980 and 1100mm. However, The area experiences a rainfall deficit in most months. The landform and geology of the area are minor valleys and alluvium (derived from Basaltic Agglomerates).

Soil drainage is a major land limitation while climate and soil fertility are minor limitations for commonly grown crops in the area. Improvement of the soil drainage conditions and application of manure at the rate of 4tons/acre and compound fertilizer (17:17:17 at 100kg/acre) are recommended management practices in order to improve land suitability of the farm.

During the time of soil survey, two soil mapping units, with 0 -1% slopes were identified. Soil mapping unit VAC1 is currently moderately suitable (S2) for maize, beans, sunflower, passion fruits, water melon, capsicum, mangoes, citrus, avocados and pawpaw due to mainly drainage, climate and soil fertility limitations. The potential suitability of these soils for most crops is considered to be highly suitable (S1) after land improvements (drainage, manuring and use of fertilizers).

The soil mapping unit VAC2 is currently marginally suitable for maize, beans, sunflower, passion fruits, water melon, mangoes, citrus and avocados due to mainly drainage, climate and soil fertility limitations. For capsicum and pawpaw, current suitability is marginally suitable to provisionally unsuitable (S3-NS1) due to severe drainage and temperature limitations. The potential suitability of these soils for most crops is considered to be highly suitable (S1) after some improvements through improvement o0f drainage, manuring and use of fertilizers. However, for citrus and pawpaw the unit is moderately suitable to highly suitable (S2-S1) due to temperature limitations.

For maize and sunflower, drought resistant varieties can be used while irrigation is recommended for high value horticultural crops in order to boost production.

1 INTRODUCTION

Following a request by the Sustainable Agricultural Community Development Project (SACDEP) through UNDP, a soil survey was carried out at the proposed Thai Model Village Farm at Gikindu Location, Murang'a District. The farm is proposed to be developed as an Agricultural Self-sufficiency Economy Demonstration Centre. The project holder is the United Nations Development Project (UNDP).

The objectives of the survey were:

i) To characterize the soils and determine their suitability for growing horticultural and other crops
ii) To evaluate the soil fertility conditions and recommend the necessary improvements and mitigation measures for the enhancement of farm production

The farm has an area of about 7.1 ha. The soil survey was carried out in November 2008.

2 ENVIRONMENTAL CONDITIONS

2.1 Location and communications

The farm is located between longitudes 34º 48' 43"and 34º 51' 42" East of Greenwich Meridian and between latitudes 1º 9' 12"and 1º 10' 2" South of the equator. The farm is about 10 Km from the Maragua-Murang'a road and the access road is about 800 m before reaching Mukuyu Market.

2.2 Geology, physiography and hydrology

2.2.1 Geology

The farm is covered by Alluvium derived from Basaltic Agglomerates, Simbara Series of tertiary volcanics (Fairburn 1966). These are recent deposits of alluvial origin formed in the post-volcanic period. The soils of the farm owe their origin more to the prevailing physical conditions of formation than to the nature of the underlying rocks.

2.2.2 Physiography

The physiograpic unit in the area consists of minor valleys which are slightly concave, flat to very gently undulating (slopes 0-1%). The altitude in the area is about 1155 meters above sea level (a.s.l.).

2.2.3 Hydrology

The minor valleys have a simple drainage system which slopes from west to east where they drain water from the surrounding uplands into a recently excavated dam.

2.3 Population

The spatial household composition and distribution of the area according to the 1999 population census are shown in Table1.

Table 1: Population in Kiharu Division, Gikindu Location and of Mirira, Kambirwa and Gathuri sub locations

Division/location/ Sub-location	Male	Female	Total	Households	Area in sq km	Density
KIHARU	**40,889**	**43,979**	**84,868**	**21,664**	**239.6**	**354**
Gikindu Location	6,562	6,896	13,458	3,106	81.1	166
Mirira Sub-location	2,378	2,595	4,973	1,149	32.5	153
Kambirwa Sub-location	2,773	2,821	5,594	1,294	18.6	301
Githuri Sub-location	1,411	1,480	2,891	663	30	96

(Source: GoK, 1999)

2.3 Climate

According to Jaetzold (2006), the rainfall in the area occurs in two rainfall seasons (bimodal). The seasonal rainfall, the mean annual rainfall and the water balance decreases from west to east (Table 2 and 3). The area to the west (e.g. Murang'a Water Supply Station) is wetter while the dryness/aridity increases eastwards beyond the survey area (e.g. Murang'a Tana River Power Station).

Table 2: Mean monthly, annual rainfall (r), potential evapotranspiration (Et) and the water balance (in mm) of Murang'a Water Supply Station at an altitude of 1310 m a.s.l.

	Jan	Feb.	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
Rainfall (r)	39	46	98	342	219	35	24	23	23	147	214	70	1280
Mean E o	195	195	195	137	156	156	137	156	176	176	137	156	1953
Mean Et	130	130	130	91	104	104	91	104	117	117	91	104	1313
r-Et	- 91	- 84	- 32	257	115	- 67	- 67	- 81	- 94	30	123	- 34	-25

Table 3: Mean monthly, annual rainfall (r), potential evapo-transpiration (Et) and the water balance (in mm) of Murang'a Tana River Power Station at an altitude of 1060 m a.s.l.

	Jan	Feb.	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
Rainfall (r)	32	32	87	207	148	21	8	14	13	89	175	64	890
Mean E o	204	204	204	143	163	163	143	163	184	184	143	163	2043
Mean Et	136	136	136	95	109	109	95	109	123	123	95	109	1375
r-Et	- 104	-104	- 117	112	39	- 88	- 87	- 95	- 110	- 34	80	- 45	553

(Calculations in Tables 2 and 3 are done according to Woodhead, 1968: Braun, 1984)

According to Jaetzold (2006), the Thai Model Village Farm in Mirira Sub-location are in the sub zone classified as LM3, s + s of the Lower Midland Cotton Zone (The farm is located about 2½

kilometers south east of Kambirwa Market). This is the Cotton Zone with two short cropping seasons. The 60% reliability of the length of cereal and legume growing period during the 1st and 2nd rainy season is between 85 and 105 days, respectively. The average annual rainfall is between 980 – 1100mm. The 66% probability of rainfall during the 1st (March – May) and the 2nd (October – February) rainy seasons is between 390 - 490mm and 270 – 320mm, respectively.

2.5 Agro climatic zones

The major aspects of climate that affect plant growth are the balance between rainfall and evaporation and temperature. With regard to rainfall, the length and intensity of the rainy and dry seasons and their variation from year to year are of particular importance (Sombroek *et al.*, 1982).

According to Sombroek *et al*. (1982), the Thai Model Village Farm falls under agro-climatic zone IV with a rainfall: evaporation (r/Eo) of 40-50 which is classified as semi-humid to semi-arid. The potential for plant growth is considered to be medium high with low risk (10-25%) of failure of an adapted maize crop (assuming that soil conditions are not limiting).

2.6 Temperature

According to Sombroek *et al.* (1982), the Thai Model Village Farm falls in temperature zone 4, with a mean annual temperature range of 22 to 24 °C which is classified as warm.

2.7 Vegetation and current land use of Thai Model Farm and the surrounding area

During the time of survey, the farm had been under fallow since the year 2007. The vegetation in the area consists of weeds, grasses and few herbs and shrubs. The livestock consists mainly of dairy cows, zebu, sheep, and goats and rabbits. Both exotic and local poultry breeds are also kept. Bee keeping is an emerging new livestock enterprise in the area.

The annual crops grown in the area (in order of importance) are: maize, beans/sunflower intercrop, pigeon peas, cowpeas, dolichos beans, Irish potatoes, butter nuts, water melons, capsicum, cassava and pumpkins. Among the perennial crops in order of importance are mangoes, passion fruits, oranges, citrus fruits, avocadoes and pawpaws.

3 METHODOLOGY

3.1 Soils mapping and soil map preparation

The available cadastral map (size A4) of the farm at a scale of 1:2,500 was enlarged to size A3 and used as a base map during the fieldwork. Reference was made to the exploratory soil map and to the geological report (and map) and to topographic map covering the area before fieldwork commenced. .

During fieldwork, both grid and some free survey methods were adopted. In the grid pattern, traverses were made about 150 m apart and on each traverse observations were at about 125 m apart. GPS coordinates were taken at all the corners of the farm. The soils were characterized using both auger hole and representative soil profile observations according to FAO (1977) guidelines for soils descriptions. During auger hole observations, the soils were examined for drainage, depth, colour, mottling, consistence and concretions. Once the soil mapping units were established, two representative soil profiles were dug in the identified soil units and then described in greater details. In the profile pits, the soil structure, clay cutans, porosity, horizon boundaries and their width and topographies were examined. Besides the above attributes, other general land attributes such as slopes, surface sealing and crusting, erosion features and micro relief, among others, were described. In all, 15 auger hole and 2 profile pit observations were made, described and soils sampled for physical and chemical laboratory analysis at the National

Agricultural Research Laboratories (NARL). From the vicinity of each profile pit, a composite soil sample was collected for fertility analysis from a depth of 0–30 cm. Besides, 8 composite soil samples were taken from one hectare (maximum) blocks for fertility analysis at NARL. After compilation and correlation, the final soil map was digitized and printed.

3.2 Laboratory methods

The laboratory methods involved air-drying and crushing soil samples before passing them through 2 mm sieve after which mechanical and chemical analysis was done following the procedures described by Hinga *et al*. (1980).

4 THE SOILS

4.1 General

On the soil map legend, the soil mapping units were sub-divided according to physiography, geology and other important soil characteristics such as color and slope. The symbols appearing on the code system are explained below.

(i) Physiography
V – Minor valleys

(ii) Geology (parent material)
A – Alluvium derived from Basaltic Agglomerates (Simbara Series)

(iii) Slope classes
A – 0 -2%, flat to very gently undulating

(iv) C – Complex
b – brown

Figure 1 below shows the soil map of Thai Model Village Farm.

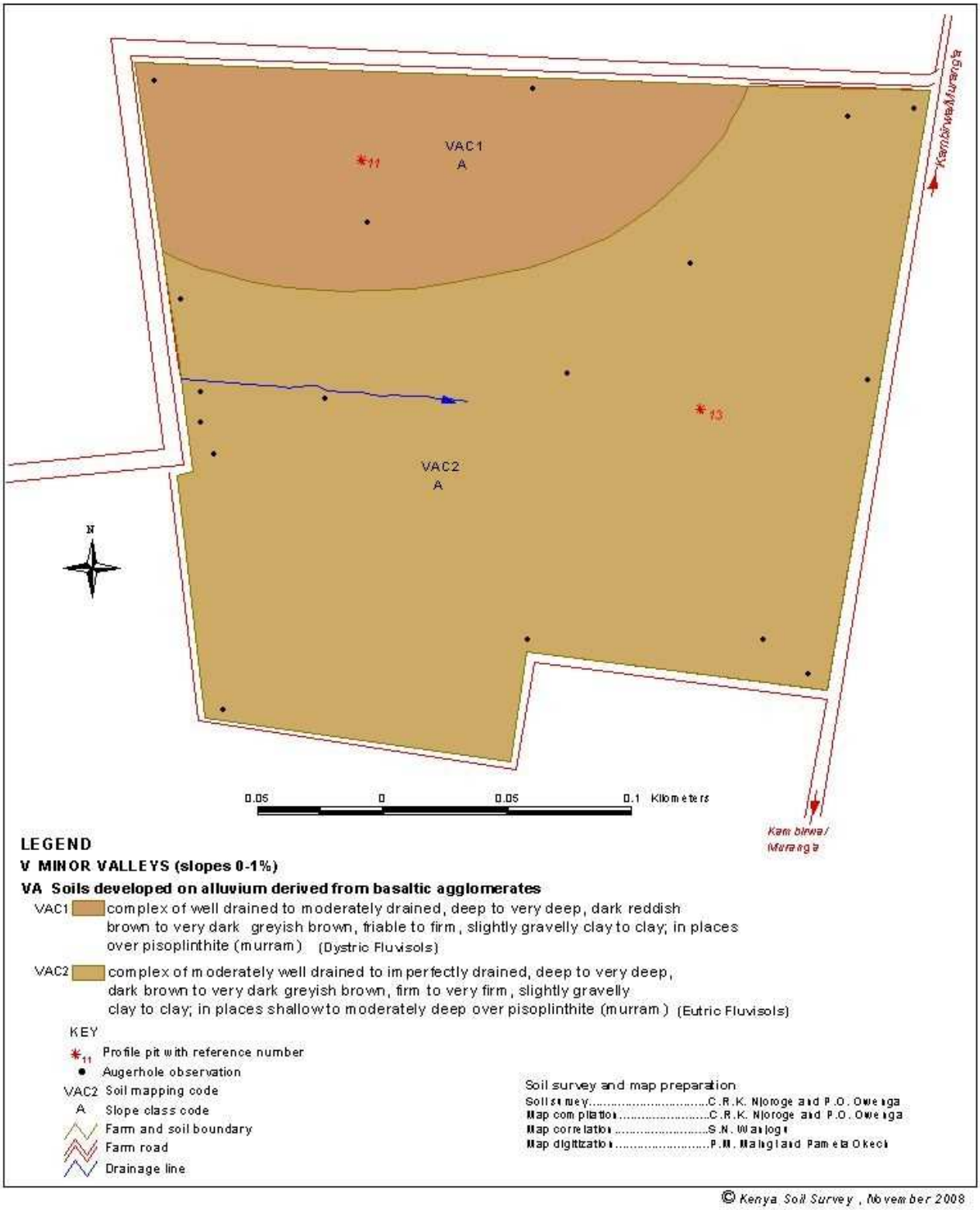

Figure 1 to report No. D81: Soil Map of Thai Model Village Farm, Gikindu Location, Murang'a District

4.2 Description of soil mapping units

The soils description follows closely the soil mapping units as described on the map legend. The soil classification used is according to FAO (1997) Soil Map of the World. Unless otherwise stated, the colour of the soil indicated is in moist state and is according to the Munsell Soil Colour Charts (1975). The minor valleys are the only landforms in the area and consist of two soil mapping units.

4.2.1 Soil mapping unit VAC1

Extent	:	1.7 ha
Parent material	:	Alluvium derived from Basalt Agglomerate (Simbara Series)
Relief	:	Flat to very gently undulating (slopes 0 -1%)
Vegetation/land use	:	Fallow since 2007 when cultivation was stopped. The vegetation of the unit consists of weeds, grasses and few herbs and shrubs. The land is used for grazing of local (unimproved) cattle, sheep and goats
Soils in general	:	This soil unit consists of a complex of well drained to moderately well drained, deep to very deep, dark reddish brown to very dark greyish brown, friable to firm, slightly gravelly clay to clay; in places over pisoplinthite (murram)

Topsoil

Colour	:	Dark reddish brown (5YR2/3-3/3) to dark brown (7.5YR3/2
Texture	:	Clay
Consistence	:	Friable when moist, sticky and plastic when wet
Structure	:	Moderate very fine and fine crumbs and sub-angular blocky structures.
pH-H_2O	:	4.8- 5.7 strongly acid to medium acid
CEC – soil me%	:	19.2-22.5
Base saturation %	:	25-44
Organic carbon %	:	0.8 - 1.48
Salinity EC ds/m	:	0.2- 0.5 (non saline)
Sodicity ESP	:	1.8 (non sodic)

Subsoil

Colour	:	Dark reddish brown (5YR3//3) to very dark greyish brown (10YR3/2)
Texture	:	Slightly gravelly clay to clay
Consistence	:	Friable to firm when moist, sticky and plastic when wet
Structure	:	Massive, breaking to weak medium angular and sub-angular blocky structures
pH – H_20	:	6.2-6.7 (slightly acid)
CEC – soil me%	:	19.9-20.1
Base saturation %	:	72-82
Organic carbon	:	0.2- 0.4
Salinity EC ds/m	:	0.2 (non saline)
Sodicity ESP	:	3.0 (non sodic)
Soil classification	:	Dystric Fluvisols

For the description of the soil profile with analytical data, see Appendix 1 profile description No. 135/1-11.

4.2.2 Soil mapping unit VAC2

Extent	:	5.4 ha
Parent material	:	Alluvium derived from Basaltic Agglomerate (Simbara Series)
Macro - relief	:	Flat to very gently undulating (slopes 0 – 0.5%)
Vegetation/land use	:	Fallow since 2007 when cultivation was stopped. The vegetation of the unit consists of weeds, grasses and few herbs and shrubs. The land is used for grazing of local (unimproved) cattle sheep and goats
Soils in general	:	The soil unit consists of a complex of moderately well drained to imperfectly drained, deep to very deep, dark brown to very dark greyish brown, firm to very firm when moist, slightly gravelly clay to clay; in places shallow to moderately deep, over pisoplinthite (murram)

Topsoil

Colour	:	Dark brown (7.5YR3/2) to very dark greyish brown (10YR3/2)
Texture	:	Clay
Consistence	:	Friable to firm when moist, sticky and plastic when wet
Structure	:	Moderate to strong very fine and fine crumbs
pH-H_2O	:	5.1-6.6 medium acid to neutral
CEC – soil me%	:	22.1
Base saturation %	:	54
Organic carbon %	:	0.8 -1.37
Salinity EC ds/m	:	0.1 (non saline)
Sodicity ESP	:	3.6 (non sodic)

Subsoil

Colour	:	Dark brown (7.5YR3/2) to very dark greyish brown (!0YR3/2)
Texture	:	Slightly gravelly clay to clay
Consistence	:	Firm to very firm when moist, sticky and plastic when wet
Structure	:	Weak, coarse prismatic primary structure, breaking to weak, medium to coarse angular blocky secondary structure
pH – H_20	:	6.1-6.3 (slightly acid)
CEC – soil	:	26.1-26.9
Base saturation %	:	53-59
Organic carbon	:	0.7- 1.1
Salinity EC ds/m	:	0.2- 0.3 (non saline)
Sodicity ESP	:	2.2- 4.2 (non sodic)
Soil classification	:	Eutric Fluvisols

For the description of the soil profile with analytical data, see Appendix 1 profile description No. 135/1-13.

5 NATURE AND PROPERTIES OF FLUVISOLS

Landon (1991) defines Fluvisols as recent alluvial soils of the floodplains with depositional rather than pedogenic profiles and have a high fertility due to high amounts of organic/humic and mineral substances as well as loamy and sandy fractions. This is true of the soils of Thai Model Village Farm. However, their low fertility is a reflection of the fertility status of the surrounding soils of the uplands which have been deposited in the farm.

6 SOIL FERTILITY EVALUATION

6.1 Introduction

The soil fertility appraisal is based on the chemical composition of 10 composite soil samples of the topsoil (0-30 cm). These soil samples were taken from around the two profile pits and from eight blocks (A, B,C,D,E,F,G, and H) of about one hectare each as shown in Table 4. Farm blocks A and B and profile pit No.135/1-11 are in soil mapping unit VAC1 while the other blocks and profile No. 135/1-13 are in soil mapping unit VAC2).

Table 4: Soil fertility conditions of the Thai Model Village Farm

	Soil Analytical Data							
Block	**135/1-A**		**135/1-B**		**135/1-C**		**135/1-D**	
Soil depth	**0 – 30 cm**		**0 – 30 cm**		**0 – 30 cm**		**0 – 30 cm**	
Fertility parameters	**value**	**class**	**value**	**class**	**value**	**class**	**value**	**class**
Soil pH	4.8	strong acid	5.0	medium acid	4.9	strong acid	5.5	medium acid
Exch. Acidity me%	0.2	adequate	0.2	adequate	o.21	adequate	-	-
Total Nitrogen %	0.12	low	0.14	low	0.10	low	0.14	low
Org. Carbon %	1.27	low	1.30	low	1.05	low	1.13	low
Phosphorus ppm	29	low	35	adequate	26	low	30	adequate
Potassium me%	0.20	low	0.20	low	0.12	low	0.20	low
Calcium me%	2.2	adequate	2.0	adequate	2.0	adequate	9.4	adequate
Magnesium me%	2.36	adequate	2.73	adequate	2.66	adequate	2.69	adequate
Manganese me%	1.13	adequate	1.10	adequate	0.90	adequate	0.93	adequate
Copper ppm	3.2	adequate	3.6	adequate	3.5	adequate	2.7	adequate
Iron ppm	44.3	adequate	62.3	adequate	70.6	adequate	48.1	adequate
Zinc ppm	2.3	low	0.9	low	0.4	low	2.2	low
Sodium me%	0.29	adequate	0.27	adequate	0.27	adequate	1.33	adequate

Block	**135/1-E**		**135/1-F**		**135/1-G**		**135/1-H**	
Soil depth	**0 – 30 cm**		**0 – 30 cm**		**0 – 30 cm**		**0 – 30 cm**	
Fertility parameters	**value**	**class**	**value**	**class**	**value**	**class**	**value**	**class**
Soil pH	5.24	medium acid	5.10	medium acid	5.34	medium acid	5.43	medium acid
Exch.Acidity me%	0.2	adequate	0.2	adequate	0.1	adequate	0.1	adequate
Total Nitrogen %	0.14	low	0.15	low	0.15	low	0.13	low
Org. Carbon %	1.13	low	1.35	moderate	1.35	moderate	1.28	low
Phosphorus ppm	25	low	28	low	25	low	22	low
Potassium me%	0.12	low	0.18	low	0.20	low	0.12	low
Calcium me%	3.0	adequate	2.0	adequate	2.0	adequate	2.0	adequate
Magnesium me%	2.14	adequate	2.60	adequate	2.76	adequate	2.08	adequate
Manganese me%	0.92	adequate	1.09	adequate	0.71	adequate	0.76	adequate
Copper ppm	3.1	adequate	3.8	adequate	3.3	adequate	2.4	adequate
Iron ppm	47.6	adequate	45.2	adequate	27.6	adequate	152	adequate
Zinc ppm	1.6	low	3.9	low	1.4	low	1.42	low
Sodium me%	0.41	adequate	0.23	adequate	0.31	adequate	0.12	adequate

Profile	**135/1-11**		**135/1-13**	
Soil depth	**0 – 30 cm**		**0 – 30 cm**	
Fertility parameters	**value**	**class**	**value**	**class**
Soil pH	5.18	medium acid	5.71	medium acid
Exch. Acidity me%	0.1	adequate	-	-
Total Nitrogen %	0.16	low	0.15	low
Org. Carbon %	1.48	moderate	1.09	low
Phosphorus ppm	29	low	34	adequate
Potassium me%	0.20	low	0.20	low
Calcium me%	2.0	adequate	2.0	adequate
Magnesium me%	2.91	adequate	2.75	adequate
Manganese me%	0.60	adequate	0.80	adequate
Copper ppm	3.2	adequate	3.3	adequate
Iron ppm	44.3	adequate	82.6	adequate
Zinc ppm	2.3	low	1.2	low
Sodium me%	0.14	adequate	0.10	adequate

6.2 Soil fertility evaluation

The soil fertility of Thai Model Village Farm is presented per soil mapping unit as shown in Table 5.

Table 5: Soil fertility status of the farm per soil mapping unit

Soil Mapping Unit	VAC1		VAC2	
Fertility results	**Value**	**Class**	**Value**	**Class**
Soil PH	4.8-5.2	strong acid to medium acid	5.1-5.7	Medium acid
Exch. Acidity (me %)	0.1-0.2	Adequate	0.1-0.2	Adequate
Total Nitrogen (%)	0.12 0.16	Low	0.10-0.16	Low
Organic Carbon (%)	1.27-1.48	Low to moderate	1.05-1.35	Low to moderate
Phoshorus (ppm)	29-35	Low to adequate	22-34	Low to adequate
Potassium (me %)	0.12-0.2	Low	0.12-0.2	Low
Calcium (me %)	2.0-3.0	Adequate	2.0-3.0	Adequate
Magnesium (me %)	2.4-2.73	Adequate	2.08 -2.76	Adequate
Manganese (me %)	1.10-2.14	Adequate	0.71-1.09	Adequate
Copper (ppm)	3.1-3.6	Adequate	2.7-3.5	Adequate
Iron (ppm)	44.3-62.3	Adequate	27.6-152	Adequate
Zinc (ppm)	0.9 – 2.3	Adequate	0.4-3.9	Low
Sodium (me %)	0.14-0.29	Adequate	0.1-1.33	Adequate

The soil reaction (pH-H_2O) of the topsoil in the farm is strong acid to medium acid (pH 4.8-5.7) This is not favourable for most crops since the pH for most commonly grown crops ranges from 5.5 – 7.0 (Landon, 1984). The exchangeable acidity (0.1-0.2) is below 0.8 and total nitrogen (0.10-0.16%) are adequate and low respectively while organic carbon (0.10-0.16%) and phosphorus (22-35 ppm) of these soils are low to moderate and low to adequate respectively. Potassium is low and all the other nutrients (Ca and all micronutrients) in the farm are adequate except Zinc in soil mapping unit VAC2. Although the soils of the farm are acidic, there is no need of liming since exchangeable acidity is far below 0.8 and calcium and magnesium are adequate.

6.3 Conditions favouring soil fertility

According to Landon (1984) some of the conditions favouring high soil fertility are:

1. Depth to limiting horizon : > 150cm
2. Texture: loam, sandy clay loam, sandy clay, clay (if structure and consistence are favourable)
3. Structure and consistence : moderate or strong, fine or medium structure; friable consistence
4. Moisture conditions : Free drainage with good moisture retention
5. Plant nutrients: high levels
6. Cations-exchange capacity: medium to high
7. Soil reaction: generally pH 5.0-8.0, but varies with crops
8. Organic matter: adequate levels

The soil properties considered not favouring high soil fertility in Thai Model Village Farm are: drainage (moderate and imperfect drainage), structure and moist consistence (massive and prismatic structures and firm consistence in the sub-soil), plant nutrients (low levels of N, P and K in most cases), pH (low for some crops) and organic matter (low to moderate).

6.4 Maintenance, replenishment and improvement of soil fertility in Thai Model Village Farm

Some form of an integrated soil fertility management approach would be ideal to restore, improve and to maintain favourable soil fertility in the farm. Most soils are moderately to imperfectly drained and there is need to improve the drainage by adopting an appropriate drainage system. In general, the soils of the farm are low in nitrogen, phosphorus, potassium and organic matter and both structure and moist consistence (of subsoil) are unfavourable. Application of 4 tons/acre of well decomposed manure or compost will not only supplement the deficient nutrients but will go a long way in improving the soil structure, consistence and water holding capacity of the soil. Acidifying fertilizers (e.g. DAP, ASN or AS) should be avoided due to their acidic reaction. To supplement nitrogen, phosphorus and potassium apply 100 kg/acre of compound N.P.K. (17:17:17) fertilizer.

7 LAND SUITABILITY FOR COMMONLY GROWN CROPS

7.1 Introduction

In this land suitability classification, the soils of Thai Model Village Farm are evaluated for growing of maize, beans, sunflower, passion fruits, water melon, capsicum, mangoes citrus, avocado and pawpaw crops which are the commonly grown crops in the area. The evaluation criterion follows closely the framework of land evaluation (FAO, 1976) but with minor modification to allow for the different local conditions. The classification is qualitative in nature and is based primarily on the physical and chemical limitations of the soils.

7.2 Land suitability classification

Five land suitability classes have been applied, thus:

Class S1: Highly suitable

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

Class S2: Moderately suitable

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

Class S3: 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 NS1: Provisionally unsuitable

Land which is considered unsuitable (or unsustainable) for crops, pending further investigations.

Class NS2: Unsuitable

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

7.3 Requirements for the commonly grown crops

The crops requirements shown in Table 6 are derived from Landon (1984), Ministry of Agriculture and Livestock Development (2003), Ngugi (1987) and Purseglove (1977):

Table 6: Requirements for commonly grown crops (maize, beans, passion fruits, water melon, capsicum, mangoes, citrus, avocado and pawpaw)

CROP	CLIMATE			SOIL				REMARKS
	Altitude (m.a.s.l.)	Rainfall	Temperature	Soil Drainage	Soil depth	Soil texture	Soil pH-H2O	
Maize *(Zea mays)*	- Altitudes ranging from sea-level to 2500m	- Average rainfall is between 600 – 900mm during the growing season	- At temperatures ranging from 21°C to 30°C. (The optimum temperatures for growth and for germination are 24°C and 18-21°C respectively)	Well aerated and drained, optimum (The crop does not tolerate water logging.	deep	-Fertile loam to silty loam	- Optimum 6-7	-Tolerates a wide variety of soils -The crop does not tolerate water logging. It is sensitive to Cu and Zn deficiency and moderately sensitive to salinity (Landon, 1984).
Beans *(Phaseolus vulgaris)*	1000-2000m Optimum	Moderate, well distributed	Cool warm climate with optimum daily temperature of 15-20^{o} C.	Grown in most soils; -Well drained and fertile	50-70+cm	sandy loam to clay ideal	5.5 – 6.0	– Has low tolerance to salinity
Sunflower *(Helianthus annuus)*	low to high elevations (0 – 2600m asl)	600-1000mm annual rainfall, evenly distributed	Grows in latitudes as far north as 50^{o} N	Deep	well drained	Grown in wide range of soils	6 – 7.5 -can tolerate acid soils	- Grown in wide range of soils - There are dwarf varieties for drier areas and giant varieties for less arid conditions
Passion fruits (P*assiflora edulis)*	Highlands (1200-2000m) for purple variety (aromatic, for export and for local market) and lowlands (<1200m) for yellow variety	<1600mm irrigation necessary for purple variety <1000mm irrigation necessary for	Moist climate purple variety (18 ^{o}C-25 ^{o}C) Yellow variety (25 ^{o}C-30 ^{o}C)	Well drained	Deep	Sand to clayey	5.5-7.0	-Grown in various soils -Deep, medium textured soils ideal -Does not tolerate sodicity or salinity

		yellow variety						
Water melon (C*itrulus lanatus)*	At altitudes of up to 1500m. Best growing areas are the lowland areas with high temperatures and relatively low rainfall, where irrigation is necessary	Best results are obtained in low to medium rainfall areas, with additional irrigation - Optimum 600mm, and 400mm considered minimum rainfall	Best under hot temperatures of 22-28 ^{o}C optimum	Well drained	-	Sandy soils most suitable (well drained heavy as well)	6.0 – 7.5	Fertile soils rich in organic mater
Capsicum (*Sweet Pepper)* -	Wide range	Medium rainfall (600-1,200mm per annum -Waterloging causes leaf shedding -Irrigate if rain < 600mm	-Tolerate wide range of climate - warm to hot ideal	Well drained		Light loamy	-Non acidic soil	
Mangoes *(Mangifera indica)*	Grows well from 0 – 1500m asl	650 – 1500mm. rainfall	20 -26 ^{o}C optimum temperature	Variable but well drained ideal	Variable but deep soils are ideal	Variable textures /structures	5.5 – 7.5 desirable	Avoid alkaline very shallow soils
Citrus (*Citrus ssp)*	Upper altitude provided no frost	900mm, well distributed. If less, supplement with free/low salinity irrigation water	Optimum 25 – 30 ^{o}C	Well drained	Deep	Light loamy	5.0 – 6.0 ideal (in too acidic soils roots do not grow well and nutrients are leached out or may become toxic e.g. copper. > ph 6.0, zinc and iron deficiency because of fixation	-fertile - does not tolerate waterlogged and saline soils
	Grows well from 0-	Not less than	Maximum	Variable provided	- (saline		Optimum pH	

Avocado (*Persea americana)* -(Optimum pH 5.5-6.5)	2100masl (depending on variety)	1,000m (if less, moderate irrigation of not more than 50mm at a time)	temperature 33 ^{o}C	well rained & deep	waterlogged soils unsuitable)		5.5-6.6h	
Pawpaw (*Carica papaya)*.	Grows best in warm areas below 1,000m.	- 1,500mm rainfall and well distributed (I, 000 minimum, If less, irrigate)	Warm to hot areas with temperatures of 22-26 ^{o}C	Well drained **note:** (waterlogged and compact soil are unfavourable)	Fairly deep		6 –6.5	

7.4 Land qualities

The land qualities/characteristics considered relevant in this land suitability classification are drainage (availability of oxygen), soil depth, soil texture, soil structure, soil pH, soil fertility, topography and workability among others. The following is an account of these parameters:

Drainage (availability of oxygen)

Most crops need well aerated soils since they cannot withstand water logging. The soils of the farm are well drained to imperfectly drained. If cultivated, drainage would be an important land improvement.

Soil depth

For optimum plant growth, soil depth is an important factor in determining the amount of water that can be stored in the soil. It has direct relation to soil moisture storage capacity. Deeper soils store more water and also allow for deeper root penetration to extract essential plant nutrients than shallow soils.

Soil fertility and soil pH

The availability of nutrients is pH dependent and is at its maximum within the neutral range of pH 6.0 to 7.0. The exceptions are micronutrients such as iron, zinc, manganese and copper, which are readily available at pH 5.5 and below. The soils of the farm are strongly acid to medium acid. Most of the plant nutrients are adequately supplied except phosphorus, nitrogen and potassium. This can be corrected through addition of organic manures and inorganic fertilizers.

Soil texture and soil structure

These are important soil characteristics related to land quality "workability" of the soils. The top-soils of Thai Model Village Farm are friable and easy to cultivate,

Topography/slope

Topography is extremely important for it influences the type of irrigation method, labour requirements, irrigation efficiency, drainage requirements, erosion hazards, range of possible crops, cost of land development and possibilities of mechanization. On sloping land, soil and water conservation measures are necessary due to high susceptibility to erosion. However, it is generally accepted that surface irrigation conditions are not favourable on slopes >12%. Slopes of 0.1 to 2% are usually regarded as ideal.

Salinity hazard

According to Wild (1989), under hot and arid conditions, soluble salts accumulate in the surface of the soils whenever the ground water comes within a few meters of the surface. The other source of salinity may be from irrigation water. Soluble salts can have two types of effects on the growing plant: specific effects due to particular ions they contain being harmful to the crop and a general effect due to the raising of the osmotic pressure of the solution around the root of the crop. Plants differ in their ability to withstand the harmful effects of salinity in the field. In Landon (1984) the USDA ratings of relative plant tolerance to salt are: high salt tolerance (e.g. kale), medium salt tolerance (e.g. maize) and low salt tolerance (e.g. beans).

Sodicity hazard

When sodium (Na) is present in the soil in significant quantities, particularly in proportion to the other cations present, it can have adverse effect, not only on many crops, but also on the physical conditions of the soil. High levels of sodium will cause dispersion of structural aggregates which may result in poor aeration of the soil.

7.5 Land suitability classification

The land suitability classification is done by comparing (matching) plant requirements (Table 6) with land qualities/characteristics of the soils of Thai Model Village Farm. Table 7 and 8 below shows the current and potential land suitability classes for maize, beans, passion fruits, water melon, capsicum, mangoes, citrus, avocado and pawpaw. Major soil limitations (with asterisks) and lesser soil limitations and possible soil improvements are also indicated in the tables. Current suitability refers to present fitness of land for a given land use (present condition) while potential suitability refers to future fitness of land after possible land improvements have been done.

Table 7: Soil mapping units, their characteristics and limitations

Soil mapping units	Soil mapping units characteristics and limitations						
	Soil drainage	**Soil depth**	**Soil texture**	**Soil pH-H2O**	**Soil consistence**	**Soil structure (sub-soil)**	**Soil limitations/ remarks**
VAC1	Well drained to moderately drained	Very deep to deep	Slightly gravelly clay to clay	4.8- 5.2 (strongly acid to medium acid)	-friable to firm when moist -sticky and plastic when wet	Weak massive , breaking to weak angular and suangular blocky structure	►Soil drainage -Soil fertility
VAC2	Moderately to imperfectly drained	Very deep to deep	Slightly gravelly clay to clay	5.1-5.7 (medium acid)	-friable to firm when moist -sticky and plastic when wet	weak very fine crumbs and weak very fine single grain structure	►Soil drainage -Soil structure -Soil texture -Soil fertility

► Major limitation

7.6 Land suitability classification

This land suitability classification was arrived at by matching the land qualities/characteristics in Table 7 with the crops requirements in Table 6. The only crops considered are those that are suited to the climatic conditions of the area.

Table 8: Land suitability classification for potential crops in the farm

Crops	Soil Mapping units	Limitations	Current suitability class	Improvements	Potential suitability	Remarks
Maize *(Zea mays)*	VAC1	►drainage - climate - soil fertility	S2	-drainage -manuring and fertilizer use use of drought resistant varieties	S1	-low tolerance to sodicity and moderately tolerant to salinity
	VAC2	►drainage - climate - soil fertility	S3	-drainage -manuring and non acidifying fertilizer use use of drought resistant varieties	S1	-low tolerance to sodicity and moderately tolerant to salinity
Beans *(Phaseolus vulgaris)*	VAC1	►drainage - climate - soil fertility	S2	-drainage manuring and non acidifying fertilizer use	S1	
	VAC2	►drainage - climate - soil fertility	S3	-drainage manuring and non acidifying fertilizer use	S1	
Sunflower *(Helianthus annuus)*	VAC1	►drainage - climate - soil fertility	S2	-drainage -manuring and fertilizer use use of drought resistant varieties	S1	
	VAC2	►drainage - climate - soil fertility	S3	-drainage -manuring and non acidifying fertilizer use use of drought resistant varieties	S1	
Passion fruits (P*assiflora edulis)*	VAC1	►drainage - climate - soil fertility	S2	-drainage -manuring and non acidifying fertilizer use irrigation	S1	
	VAC2	►drainage - climate - soil fertility	S3	-drainage -manuring and non acidifying fertilizer use irrigation	S1	
Water melon (C*itrulus lanatus)* (ref. 2003)	VAC1	►drainage - climate - soil fertility	S2	-drainage -manuring and non acidifying fertilizer use irrigation	S1	
	VAC2	►drainage - climate - soil fertility	S3	-drainage -manuring and non acidifying fertilizer use irrigation	S1	
Capsicums (*Sweet Pepper)*	VAC1	►drainage - climate - soil fertility	S2	-drainage -manuring and non acidifying fertilizer use -irrigation	S1	
	VAC2	►drainage - climate - soil fertility	S3-NS1	-drainage -manuring and non acidifying fertilizer use -irrigation	S1	
Mangoes*(Mangifera indica)*	VAC1	►drainage - climate - soil fertility	S2	-drainage -manuring and fertilizer use irrigation	S1	

	VAC2	►drainage - climate - soil fertility	S3	-drainage -manuring and fertilizer use irrigation	S1	
Citrus (*Citrus ssp)*	VAC1	►drainage - climate -soil fertility - temperature	S2	-drainage -manuring and fertilizer use -irrigation	S2-S1	
	VAC2	►drainage - climate - soil fertility - temperature	S3	-drainage -manuring and fertilizer use irrigation	S2-S1	
Avocado (*Persea americana)*	VAC1	►drainage - climate - soil fertility	S2	-drainage -manuring and fertilizer use irrigation	S1	
	VAC2	►drainage - climate - soil fertility	S3	-drainage -manuring and fertilizer use irrigation	S1	
Pawpaw (*Carica papaya)*	VAC1	►drainage - climate - soil fertility - temperature	S2	-drainage -manuring and fertilizer use irrigation	S2-S1	
	VAC2	►drainage - climate - soil fertility - temperature	NS1	-drainage -manuring and fertilizer use irrigation	S2-S1	

► Major limitation

8 CONCLUSIONS AND RECOMMENDATIONS

1. Application of 4 tons/acre of well decomposed manure or compost will not only supplement the deficient nutrients but will go a long way in improving soil structure, consistence, tilth and water holding capacity of the soil.

2. Acidifying fertilizers (e.g. DAP, ASN or AS) should be avoided due to their acidic reaction. To supplement nitrogen, phosphorus and potassium apply 100kg/acre of compound N.P.K. 17: 17:17 fertilizer.

3. Although the soils of the farm are acidic, there is no need of liming since exchangeable acidity is far below 0.8 and calcium and magnesium are adequate.

4. The subsoil has pressure faces and slickensides, a clear indication of development of cracking clays. It is recommended that it be removed in case buildings are to be constructed because it is usually unstable.

5. Adjoining the farm to the east is a nearly completed community dam. Care should be taken not to pollute the water by using un-sustainable farm management practices and overuse of agro-chemical inputs.

6. Soil mapping unit VAC1 is currently moderately suitable (S2) for maize, beans, sunflower, passion fruits, water melon, capsicum, mangoes, citrus and avocados and for pawpaw due to mainly drainage, climate and soil fertility limitations. The potential suitability of these soils for most crops is considered to be highly suitable (S1) after some improvements such as improvement of the drainage, manuring and use of fertilizers.

7. Soil mapping unit VAC2 is currently marginally suitable for maize, beans, sunflower, passion fruits, water melon, mangoes, citrus and avocados due to mainly drainage, climate and soil fertility limitations. For capsicum and pawpaw, current suitability is marginally suitable to provisionally unsuitable (S3-NS1) and provisionally unsuitable (NS1) respectively due to severe drainage and temperature limitations. The potential suitability of these soils for most crops is considered to be highly suitable (S1) after some improvements (drainage, manuring and use of fertilizers). However, for citrus and pawpaw it is moderately suitable to highly suitable (S2-S1).

8. For maize and sunflower, drought resistant varieties can be used while irrigation is recommended for high value horticultural crops in order to boost production.

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Appendix 1: Soil profile pits descriptions and their laboratory data

Soil profile pits descriptions

Profile description no. 135/1-11

Mapping unit	:	VAC1
Ecological zone	:	IV
Observation	:	135/1-11; Thai Model Village Farm, Gikindu Location, Murang'a District; 13/11/2008
Soil classification	:	Dystric Fluvisol
Geology	:	Alluvium derived from basaltic agglomerates
Physiography	:	Minor valleys
Relief and slope	:	Flat to very gently undulating, 0-2% (slope class A); straight; > 200m. long
Land use	:	Grazing of cattle, sheep and goats
Erosion	:	Nil
Effective soil depth	:	Deep
Drainage	:	Moderately well drained

Ap 0-21 cm. Dark brown (7.5YR3/2, moist), clay; moderate very fine and fine crumbs and moderate and moderate very fine and fine subangular blocky structures; friable when moist, sticky and plastic when wet; many micropores and few biopores; few animal channels and some krotovinas, 2-4 cm in diameter; many very fine, and very few fine roots; pH-H_2O 5.7; clear and smooth boundary to:

(Sample no: 135/1-11a)

BA 21-57cm Dark brown (7.5YR3/2, moist); very few fine distinct yellowish red (5YR5/8) mottles; clay; weak to moderate, fine and medium subangular blocky structure; friable moist, sticky and plastic when wet; common micropores and biopores; very few animal tubules; very few very fine and fine roots; pH- H_2O 5.7; gradual and smooth boundary to:

(Sample no. 135/1-11b)

Bt1 57-90cm. Very dark grayish brown (10.5YR3/2, moist); clay; massive breaking to weak medium angular blocky and subangular blocky structures; many continuous slickensides (pressure faces); firm when moist, sticky and plastic when wet; massive, breaking to weak angular blocky and subangular blocky structures; very few micropores; and biopores; very few very fine and fine roots; pH-H_2O 6.2; gradual and smooth boundary to:

(Sample no. 135/1-11c)

Bt2 90-34cm. Very dark grayish brown (10.5YR3/2, moist); clay; massive breaking to weak medium and coarse angular blocky and subangular blocky structures; many continuous slickensides (pressure faces); firm when moist, sticky and plastic when wet; massive, breaking to weak angular blocky and subangular blocky structures; very few microspores; and biopores; pH-H_2O 6.7

(Sample no. 135/1-11d)

Observation No: 135/1-11 Mapping unit: VAC1; Soil classification: Dystric Fluvisol

Horizon	**Ap**	**BA**	**Bt1**	**Bt2**
Depth (cm)	**0 -21**	**21- 57**	**57-90**	**90 -134**
Lab No/2008 cm)	**2399**	**2400**	**2401**	**2402**
pH-H_2O 1:2.5 suspension	5.7	5.7	6.2	6.7
EC Ms/ cm	0.2	0.5	0.2	0.2
% C	1.2	0.8	0.2	0.4
Sand %	18	16	18	22
Silt %	22	8	12	10
Clay %	60	76	70	68
Texture class	C	C	C	C
Cat.Ech.Cap (me/100g)	22.5	19.2	19.9	20.1
Ca (me/100g)	7.4	4.0	9.8	10.8
Mg	1.8	0.7	3.6	4.8
K	0.3	0.2	0.3	0.3
Na	0.4	NID*	0.6	0.6
Sum of cations	9.8	4.9	14.3	16.5
Base saturation %	44	25	72	82
ESP	1.8	-	3.0	3.0

* - Not Detected

Soil profile pits descriptions

Profile description no. 135/1-13

Mapping unit	:	VAC2
Ecological zone	:	IV
Observation	:	35/1-13; Thai Model Village Farm, Gikindu Location, Murang'a District; 13/11/2008
Soil classification	:	Eutric Fluvisol
Geology	:	Alluvium derived from basaltic agglomerates
Physiography	:	Minor valleys
Relief and slope	:	Flat to very gently undulating, 0-2% (slope class A); straight; > 200 m. long
Land use	:	Grazing of cattle, sheep and goats
Erosion	:	Nil
Effective soil depth	:	Deep
Drainage	:	Imperfectly drained

Ap 0- 20 cm. Dark brown (7.5YR3/2, moist), clay; moderate to strong very fine and fine crumbs structure; friable when moist, sticky and plastic when wet; common micropores and very few biopores; few animal channels; many very fine and few fine roots; pH-H_2O 6.6 ; clear and smooth boundary to:
(Sample no: 135/1-13a)

AB 20 –33/46cm Dark brown (7.5YR3/2, moist); weak very fine and fine subangular blocky structure; friable when moist, sticky and plastic when wet; common micropores and very few biopores; few animal channels many very fine and few fine roots; pH- H_2O 6.1; gradual and wavy boundary to:
(Sample no. 135/1-13b)

Ct 33/46- 110+cm. Very dark greyish brown (10.5YR3/2, moist); clay; weak coarse prismatic breaking to weak medium and coarse angular blocky structures; many continuous slickensides; very firm when moist, sticky and plastic when wet; very few micropores; 3-5% iron and manganese concretions, 2-5mm in diameter; very few very fine to medium roots; pH-H_2O 6.3
(Sample no. 135/1-13c)

Observation No: 135/1-13 Mapping unit: VAC2; Soil classification: Eutric Fluvisol

Horizon	**Ap**	**AB**	**Ct**
Depth (cm)	0-20	20-33/46	33/46-110+
Lab No/2008 cm)	2403	2404	2405
pH-H_2O 1:2.5 suspension	6.6	6.1	6.3
EC Ms/ cm	0.1	0.2	0.3
% C	0.8	1.1	0.7
Sand %	40	28	38
Silt %	14	16	10
Clay %	46	56	52
Texture class	C	C	C
Cat.Ech.Cap (me/100g)	22.1	26.9	26.1
Ca (me/100g)	8.9	10.0	12.2
Mg	1.9	3.34	1.5
K	0.6	0.4	0.5
Na	0.7	0.6	1.2
Sum of cations	12.0	14.3	15.4
Base saturation %	54	53	59
ESP	3.6	2.2	4.2