Soils of

Thika Horticulture Research Station

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1. Introduction

Thika Horticulture Research Station situated 3 miles North of Thika town is made up of two adjoining pieces of land, separated by the main Thika - Fort Hall road. It extends as a rectangular strip whose maximum length is about 2½ miles and maximum width about one mile. The offices are situated at the Western edge of the project areas above the slopes leading to the Thika River and lie 1½ miles from the main Thika - Fort Hall road along Bendor road. This road finds access through the office compounds and is a permanent source of dust and mud during dry and wet seasons respectively. Junior staff are accommodated at the site of offices whereas the Senior staff are housed at a site adjoining the High Level Sisal Research Station just of the Thika - Fort Hall road and East of it.

River Samuru somewhat intermittent, also dissects the Eastern portion of the project area, crossing the main road and flowing into the dam which is situated in the south east corner.

The station at an elevation of about 5000 feet comprises of about 850 acres.

The survey was requested by the Senior Horticulture Research Officer with a view to prepare a land suitability map in the light of horticultural crops. This report aims therefore to indicate soil types and to outline their suitability and methods for improvement.

The soil boundaries were drawn from aerial photographs (approximate scale 1 : 12500) enlarged 4 times and counter checked in the field. The boundaries were then transcribed to give a soil suitability map at a scale approximately 1 : 3125. Due to the lack of tracing equipment, uncontrolled nature of the photographs and flooding of the field during the investigation, the accuracy of the boundaries should be judged with caution.

The Soil Survey Unit wishes to acknowledge the cooperation of the staff of the Horticulture Research Station and the National Agricultural Laboratories.

2. PHYSIOGNOMY

Geology.

The project area lies in a belt where extensive development of volcanic material occurs. This volcanicity is associated with that of Aberdares mountains. The belt is covered by pyroclastic trachytic tuffs overlying the Simbara Agglometates following the end Tertiary period. It is inferred that this volcanic deposition generally spanned the Miocene and possibly continued into the Pliocene.

The underlying Simbara agglomerates are sub divided into 2 parts: the upper series of porphyritic Olivine basalt with agglomerates and a lower series dominantly composed of basaltic agglomerates with occasional lava flows. The series are nowhere distinct, there being a gradual passage from one to another. The basalt agglomerates are well exposed in road cuttings between Saba Saba and Thika. Many of the basalt present in the agglomerates are highly vesicular, the most characteristic is a vesicular porphyritic feldspar basalt.

The following sequence of Trachytic tuff series can be seen resting on Simbara Series in the region around Thika valley:-

Grey trachytic tuff.

Welded tuff with obsidian.

Upper Thika Building Stone.

Grits (Lake beds).

Agglomerate and hard tuff with crystals.

During the Survey, the observed subsoil rock material revealed the presence of agglomerate and hard greyish trachytic tuff with crystals, and some inclusion of obsidian. Along the course of Thika River there is a narrow band of upper Thika building stone.

In recent times geological process has been limited to soil formation and excavation of river valleys.

Soil Genesis, Landscape and Climate.

The soils of the project area are derived from volcanic deposits. The area can be considered as a region of gently undulating broad ridges. The alternating ridges and valleys as may be expected give rise to a catenary sequence of soils. The better drained and deeper soils are found on the ridge tops and on the upper and middle slopes. Whereas the shallow soils occur on the lower slopes and the poorly drained soils occur in the depressions. The poorly drained soils may have partly formed from colluvial material under conditions of poor drainage. The shallow soils on the lower slopes may be considered to be the result of the incursion of massive leterite arising from the seepage waters from higher slopes and being checked by change of slope and poor drainage at the foot slopes. The laterization process is facilitated by the deposition of sesquioxides and manganeferous materials from the seepage waters. Where the slopes are excessive as may occur on the valley sides of a deeply incised river, shallow soils may be attributed more to erosion than superficial formation of consolidated deposits. Massive loterite was commonly found to be associated with the shallow soil in the project area.

Bands of hard trachytic tuff outcrops lie exposed in the south east corner of the area, which lies to the west of Thika - Fort Hall road. The exposed rocks are presumably a result of the flood water running downslope towards the main road and causing surface wash.

The bottom lands are sometimes associated with circular mounds which are slighly better drained. The origin of these mounds has been suggested (Stephen et al) to be associated with gilgai phenomenon. Alternatively there is a school of thought which considers them to be relic termite mounds.

The better drained soils are at present under pineapple, paw-paws, citrus, bananas and other horticulture crops. Nandi setaria grass and potatoes are also grown in rotation. The shallow and stony areas support a scrub grass vegetation and poor pineapples thrive in cultivated parts. The lower lying land is seasonally waterlogged and is associated with a vegetation cover dominated by Cyperus denudatus, Sporobolus pyramidalis, Sorghastrum ri idiafolium, Botriocholoa insculpta and Dibrachionostylas haessneri.

Thika Horticultural Station may be included in the high rainfall belt (30 - 40 inches per annum). The reported average rainfall is around 34 inches. Thika Bendor Plantations which lie 2 miles North of the Horticulture Station along the Bendor road has average yearly rainfall of 35.99 inches recorded over 31 years.

The rainfall distribution pattern for the Horticulture Station can be deduced from the figures for 1960 to 1967. It appears fairly well distributed. The wettest months are March, April, May, October and November whilst the driest months are January, February, July, and August. The rainfall for 1961 and 1967 was unsually heavy.

Mean Monthly Rainfall Figures in Inches - Thika H.R. Station

Years 1960 - 67

	1960	1961	1962	1963	1964	1965	1966	1967	Mean Tep. 1967 F°
Jan.	1.01	0.48	2.36	2.21	1.51	2.04	4.67	0.0	66.1
Feb.	0.44	0.69	0.11	4.42	1.25	0.02	0.77	0.32	68.7
Mar.	4.55	3.61	2.47	3.24	1.64	1.85	6.91	3.89	70.4
Apr.	4.66	6.03	8.64	12.85	13.17	6.30	5.00	9.28	68.9
May.	6.70	0.84	7.19	13.86	1.44	3.56	3.45	21.78	67.0
Jun.	2.11	1.45	.47	0.78	1.18	0.99	0.59	1.19	65.4
Jul.	3.02	0.59	.21	0.17	0.31	0.44	0.14	1.49	63.8
Aug.	6.10	0.61	1.91	1.06	2.40	0.08	0.88	0.97	63.4
Sep.	2.98	1.19	.87	0.42	0.22	0.08	1.21	1.27	65.8
Oct.	2.76	13.90	4.09	1.06	2.23	2.41	2.16	6.47	67.7
Nov.	4.13	17.45	3.97	5.32	4.64	7.92	7.26	4.54	67.5
Dec.	1.71	6.13	3.25	6.90	3.40	2.60	0.63	0.15	67.2
Total	40.17	52.97	35.14	52.29	36.39	28.04	33.92	51.26	

The climate can be considered warm. Mean temperatures range between 63°F (July/August) and 71°F March. At these temperatures sub tropical fruits (e.g. avocados, capsicum) grow best and temperate vegetables (e.g. carrots) can be grown successfully. Short term vegetables can be grown twice a year.

Drainage System and Quality of the Waters

The drainage pattern follows the physiography of the area. During the rains the excess water drains from higher grounds to the low lying land to form seasonally waterlogged swamps. River Samuru which is intermittent traverses the eastern part of the project area and flows into the dam. The only permanent stream is river Thika which passes along the western boundary of the station.

At present the main source of irrigation water (as used by the Kenya Canners Ltd.) is that of Thika River. Water from the dam could also be pumped. There is also a large pond or water catchment formed over murram sheet in the first low lying area East of the offices. The overflow of catchment is regulated by furrows. The pond is flooded during the rains but due to high evaporation rate it dries within a month after rains cease. The station is not served by any boreholes at the moment.

Chemical composition of representative samples of these waters is given below:-

1. Pond Water
2. Dam Water
3. Thika River
4. Water from the stream (intermittent) in the lower Samuru farm.

SAMPLE	1	2	3	4
LAB. NO. (1968)	2478	2479	2480	2481
pH	6.9	6.7	7.1	6.6
E.C. x 10^6	283	103	45	100
Na m.e./litre	1.11	0.65	0.16	0.76
K m.e./litre	0.05	0.05	0.02	0.08
Ca m.e./litre	1.60	0.20	0.24	0.20
Mg m.e./litre	0.24	0.20	0.04	Nil
CO_3 m.e./litre	Nil	Nil	Nil	Nil
HCO_3 m.e./litre	3.72	1.44	1.04	1.12
Cl m.e./litre	0.88	0.90	0.62	0.96
SAR	0.3	0.3	1	0.7
R.S.C.	1.88	1.04	0.76	1.10

S.A.R. = Sodium Adsorption Ratio.
R.S.C. = Residual Sodium Carbonate.

From the analyses it can be deduced that all these waters (1,2,3 and 4) are "Low Salinity Waters" as they have conductivity values less than 250 micromhos/cm. On the basis of SAR they are also "Low Sodium" waters. The bicarbonate content from 2, 3 and 4 waters is safe, whilst that of pond water is marginal.

The waters from Thika river and the Dam are therefore safe for irrigation purposes as they are free from salinity and alkalinity hazards. The pond water has limited use because at best it can serve to irrigate only small areas and yet for only short period after the rains stop. This water could be used to irrigate the freely drained soils (1, 2, and 3) but over the years the bicarbonate accumulation will be considerable in these soils as well as in the pond, which receives seepage water deposits.

Where waters containing high concentration of bicarbonate are used there is tendency for Ca and Mg to precipitate as carbonates as the soil solution becomes more concentrated and the relative proportion of exchangeable sodium is therefore increased. Furthermore the presence of excessive bicarbonate is harmful to root development because it may inhibit the uptake of essential elements notably H_2PO_4, SO_4 and possibly nitrates.

3. SOIL DESCRIPTION AND ANALYTICAL DATA.

Methodology: 28 soils inspection pits dug to about 5 feet, were sited on the basis of apparent variation in the cultural features on the land; the factors of importance being topography, drainage and stoniness. Half of these pits were sampled according to evident distinction in soil morphology and were then analysed. Provisional soil boundaries were then drawn from aerial photographs and confirmed by ground foot inspection.

Mechanical Analysis was performed by Hydrometer (Buoyoucos G.J. 1962) method. The C.E.C. pH, exchangeable cations and available nutrients were estimated by methods based on those of Mehlich, Pinkerton, Robertson and Kempton, (Mass Analyses. Methods for soil fertility Evaluation" 1962). Conductivity assessments were not performed as there was no evident salinity problem and the slighly mild subsoil alkalinity in the poorly drained soil was thought not significant.

Abbreviations.

C.	=	Carbon
C.E.C	=	Cation Exchange Capacity
Ca	=	Calcium
K	=	Potassium
Mg	=	Magnesium
Na	=	Sodium
pH	=	Log of reciprocal of the concentration of Hydrogen.
p.p.m.	=	Parts per million
m.e.	=	Milli equivalents per cent
N	=	Nitrogen
P	=	Phosphorus
Hp	=	Exchange acidity arising from negatively charged permanent Cation Exchange Capacity sites.

SOIL 1 - Red Friable Clays (Latosolic)

These are heavily weathered heavy clays (69 - 84% clay becoming slightly heavier with depth) without mottling and gravels. Depth is more than 4 feet (120 cms); well drained and have good structure. The pH (5.3-6.2) is slightly acid increasing with depth. Organic matter content appears good (2.0 to 2.5% Carbon). The basic nutrients K, Ca, Mg and Phosphate are adequate.

These soils are encountered on ridge tops and on slope but lower down the slopes the soils merge into the shallow soils at the foot slopes, where lowering of pH and a general depletion of nutrient reserves occurs. This leads to occurrence of significant amount of Hp.

On these deep well drained soils with warm and high rainfall climate most vegetables, legumes and fruits can be grown successfully. Application of fertilizers should be assessed according to individual crop need. The soils being moderately acid liming is not recommended. Even on lower slopes where Hp values increase the benefit of liming can be obtained by normal dressing of basic phosphatic fertilizers.

On the other hand crops such as pineapples, potatoes and goosebury may suffer adversely from basic fertilizers due to increase in pH or available Calcium. These crops thrive better at low pH. The application of acid fertilizers such as ammonium sulphate and ammonium sulphate nitrate would be required to keep the pH low. Recommended Phosphate fertilizer for pineapples is double superphosphate at 150 lbs per acre placed in lines.

Soil profile 1 represents these soils. Analytical data for Profile 24, which is a similar soil is also given.

SOIL PROFILE 1.

LOCATION:	On top of ridge - North West of the project area.
ASPECT:	East - West.
SLOPE:	1^o
MICRO-RELIEF:	Slightly undulating.
PARENT MATERIAL:	Hard trachytic tuff and agglomerate.
DRAINAGE:	Good.
ROOT DEPTH:	More than 150 cms.
MAX ROOTING DEPTH:	0 - 13 cms.
PROFILE DEPTH:	150 cms.
LAND USE:	Nandi setaria grass in rotation.
ENVIRONS:	Pineapples and vegetables.
VEGETATION COVER:	90% Nandi setaria grass.

0 - 7 cms.	Dark reddish brown (2.5 YR 2/4) soft clay with fine weak subangular blocky and crumb structure. Abundant fine roots. Lower boundary clear and even.
7 - 35 cms.	Dark reddish brown (2.5 YR 3/5) friable clay with moderate medium sub angular blocky structure. Common fine roots. Has very fine few gravel carried through root crevices. Lower boundary abrupt and even.
35-75 cms.	Dark red (2.5 YR 3/6) friable clay with strong medium sub angular blocky structure. Common fine and very fine roots. Lower boundary gradual.
75 cms.	Dark red (10 R 3/6) slightly hard but friable clay with moderate to strong medium and coarse sub angular blocky structure. Roots very fine, very few.

ANALYTICAL DATA.

Pit 1 in the Western part and pit 24 in the Eastern part of project area are representative of soil 1.

PIT No.	1				24		
LAB. NO.	819	820	821	822	1276	1277	1278
DEPTH cms.	0-7	7-35	35-75	75+	0-27	27-51	51+
SAND %	12	12	12	8	19	11	14
SILT %	16	18	18	8	12	12	10
CLAY %	72	70	70	84	69	77	76
CLASS	C	C	C	C	C	C	C
pH	5.4	5.3	5.8	6.2	5.7	5.8	5.8
Na m.e.%	0.06	0.08	0.05	0.03	0.03	0.01	0.05
K m.e.%	1.16	0.96	0.46	0.90	0.46	0.26	0.13
Ca m.e.%	4.6	4.4	1.0	0.2	2.6	T r a	c e
Mg m.e.%	2.6	2.2	2.1	2.4	1.1	0.2	1.4
Mn m.e.%	0.75	0.58	0.38	0.36	0.30	0.20	0.56
P p.p.m.	56	56	17	17	14	10	12
N %	0.20				0.15		
C %	2.02				1.96		
Hp m.e.%	0.3	0.3			-	-	-
C.E.C. m.e.%	32.1	32.0	19.8	17.1			

SOIL 2. Shallow Red Clays (Latosolic)

These soils are encountered on steeper slopes (usually more than 5° slope) and are subject to erosion as well as leaching by seepage water. Normally the slopes occur on valley sides running towards the streams and associated with thick bush and grass cover, which apparently prevent drastic erosion. The soils are shallower than soil 1 but have depth of more than 2 feet (50 cms); and merge into soil 1 on ridge top. Due to difficulty in mapping small pockets of these soils, were in some areas mapped together with adjoining soils.

The texture is heavy clay (68-80% clay increasing with depth). The soils have dark reddish brown top soil (0-30 cms) which becomes redder with depth. They have a good structure and they are freely drained. Below 60 cms rounded murram concretion occur and these increase with depth. Sometimes the concretion form a compact leterite sheet. This sheet is underlain by weathering hard trachytic tuff and agglomerate.

The pH is acid (4.6 to 6.0 decreasing with depth) and the organic matter content in the top soil averages 1.5% Carbon. The basic nutrients including phosphate are generally low. The proportion of Magnesium to Calcium is high. To correct this in balance the application of lime would seem necessary.

Due to the shallowness and steep slope tree crops are not recommended on these soils. Most vegetables, short term crops and annuals would grow successfully. Terracing and ridging however, would be required to prevent soil erosion. Since Hp values are in excess of 0.5 m.e. and calcium is limiting the needs of plants (except pineapple) could be taken care of by the addition of low water soluble phosphates notably dicalcium phosphate, hyperphrophate and basic slag.

Soil Profile No. 35 is a representative of these soils.

LOCATION:	On a slope running to the stream (River Samuru) in the Eastern part of the project area.
ASPECT:	East.
SLOPE:	6°.
PARENT MATERIAL:	Hard trachytic tuff and agglomeratate.
DRAINAGE:	Fair.
MAX. ROOTING DEPTH:	0 - 12 cms.
ROOTING DEPTH:	140 cms.
SOIL DEPTH:	More than 140 cms.
LAND USE:	Previously grazed.
ENVIRONS:	Maize.
VEGETATION COVER:	100% grass and shrubs.

0 - 13 cms.	Dark reddish brown (2.5 YR 3/4) friable clay with weak fine and medium sub angular blocky structure breaking into crubs, abundant fi e roots. Lower boundary clear and even.
13 - 70 cms.	Dark red (2.5 YR 3/6) friable clay with moderate medium sub angular blocky structure. Common fine roots and occasional medium roots towards the horizon base. Lower boundary clear and gradual.
70 cms.	This is a layer of loose manganeferous gravel increasing with depth. Common fine roots. At 130 cms rock sheet encountered.

Analytical Data.

PIT NO.	35		
LAB. NO.(1968)	2249	2250	2251
DEPTH in cms.	0-13	13-70	70+
GRAVELS %			57.5
SAND %	14	10	24
SILT %	16	10	12
CLAY %	70	80	64
pH	5.5	5.3	5.0
Na m.e.%	0.16	0.07	0.05
K m.e. %	0.54	0.39	0.50
Ca m.e. %	1.6	0.2	Trace
Mg m.e. %	2.7	2.6	2.7
Mn m.e. %	0.86	0.36	0.48
P p.p.m.	5	4	8
N %	0.17		
C %	1.44		
Hp m.e. %	0.2	0.7	1.9

SOIL 3 - Shallow Gravelly Soils Overlying a Leterite Horizon.

These occur mainly on lower slopes. They are affected by seepage water deposits. Manganeferous gravel is abundantly present throughout the profile. Gravel concentration increases with depth to form a compact leterite sheet below 2 feet. The soils immediately above the swamp tend to be very shallow with massive leterite almost to the surface and are therefore mapped as very shallow soils.

There is no apparent root impedence on these soils but with depth the rooting clearly becomes very poor.

The gravel concentration varies considerably from top soil (0-30 cms) to sub soil. It is 5 to 63% in the top soil and in the subsoil 15-74%. Analysis of the separate less than 2 m.m., reveals a light clay to sandy clay texture (top soil sand 28-50% and clay 52-38%; the subsoil sand 26 to 54% and clay 58 to 40%). The colour of the topsoil matrix is dark reddish brown (5YR 3/2) with strong brown to red (7.5 YR 5/8 to 2.5 YR 4/8) coatings of iron. In contrast the subsoil is dark reddish brown to yellowish red (5 YR 3/4 to 4/6) with red, brown and black coatings.

The pH of these soils is slightly acid (pH 5.5 to 6.0). The organic matter content appears good (2.6 to 3% Carbon). The basic nutrient K, Ca, Mg and Mn are adequate. Available phosphorus seems marginal. The C.E.C. is low averaging 20 m.e. % for topsoil and falling gradually with depth.

These soils being gravelly and stony and overlying compact gravel sheet, deep rooting crops (more than 3 feet) should be avoided. Although tree crops are grown on these soils at present, the density of rooting system was not normal. The presence of gravels lowers the nutrient and moisture holding capacity of these soils. Cultivation is also impeded where pockets of compact gravel are encountered in the surface horizon. Even pineapples which tolerate gravelly soils were seen to be very poor in areas with these pockets of compact murram. The soils would require frequent irrigation and different crops may be grown under varied moisture regimes. Mulching especially for pineapples would be essential. Frequent light applications of fertilizers may be appropriate on these soils.

SOIL PROFILE NO. 15.

LOCATION:	In the Citrus plantation above swamp and furrow in Western part of the project area.
ASPECT:	East-West.
SLOPE:	2°.
MICRO-RELIEF:	Undulating.
PARENT MATERIAL:	Hard Trachytic tuff and Agglomerate.
DRAINAGE:	Freely drained but impeded below.
ROOT DEPTH:	Effectivelly 90 cms.
MAXIMUM ROOTING DENSITY:	0-11 cms.
SOIL DEPTH:	More than 90 cms.
LAND USE:	Citrus and pineapples.
ENVIRONS:	Pineapples: Vegetation cover 60%.

0 - 9 cms.	Dark reddish brown clay (5 YR 3/2) crumbly with loose gravel and strong brown (7.5 YR 5/8) and red (2.5YR 4/8) iron coatings; abundant fine roots. Lower boundary diffuse.
9 - 24 cms.	Dark reddish brown (5 YR 3/4) clay with loose to compact gravel, and red and strong brown coatings. Common fine roots. Lower boundary diffuse.
24 - 48 cms.	Dark reddish brown to yellowish red (5 YR 3/4 to 4/6) clay, rather compact gravel with few to common fine roots. Below 48 cms massive murram.

Analytical Data.

SOIL PIT NO.	15		
LAB. NO.	2070	2071	2072
DEPTH cms.	0-9	9-24	24-48
SAND %	28	22	26
SILT %	20	18	16
CLAY %	52	60	58
GRAVELS %	63	73.8	73.4
pH	5.7	5.7	5.7
Na m.e.%	0.32	0.18	0.27
K m.e. %	0.78	0.44	0.48
Ca m.e.%	5.6	2.8	1.2
Mg m.e. %	2.6	2.3	2.0
Mn m.e. %	0.79	0.94	1.24
P p.p.m.	30	16	14
N %	0.26		
C %	3.08		
Hp	-		-
C.E.C. m.e.%	20.4	18	17.6

SOIL 4. - Exposed rock Outcrops and very Shallow Soil

Hard trachytic tuff and agglomerate rock outcrops are seen on the West side of the portion of the main road cutting the project area. The rocks are also exposed in places where the land is under the inluence of continued surface wash. Narrow bands of these rocks or laterite underlain by hard trachytic rock also occur on lower steep slopes running into the main streams. The portions of land immediately adjoining the swamps are also made up of very shallow soils with compact laterite underlain by rock sheet.

Because of stoniness and topographic position these soils are unsuitable for horticulture.

SOIL 5: - Seasonally Waterlogged Low lying Soils.

These are soils with impeded drainage. They exhibit wide range of colours between very dark grey to greyish brown being greyer at the top and browner at the bottom. The soils are heavy clay and have slightly lighter topsoil (40-70% clay) than subsoil (60-84% clay). Rust in root channels and common faint to distinct mottle occur. The soils are sometimes underlain by weathering rock sheet and may either be gravelly or contain calcium concretions. These soils become deeper as the main body of the aerial extent of the soil is penetrated.

The pH of these soils is slightly acid in the topsoil and mildly alkaline in the subsoil. There appears slight sodium accumulation at the bottom but no salinity or alkalinity is evident. The organic matter content is high (2.5 - 3.5% carbon) and appears to be well incorporated into the mineral matter. The soils are generally calcareous. Magnesium and Manganese are rather high but potassium is low. Available phosphate is marginal and probably exists in an unavailable form.

Because of seasonal waterlogging these soils will require drainage layout to counteract flooding and improve permeability. Even then the horticultural crops may not be suited for these soils. At present the soils seem to support thrieving Eucalyptus; these trees appear to provide the best use for the soils.

Soil Profile 6 is Typical of these soils.

SOIL PROFILE NO. 6

LOCATION:	In a depression in the Western part of the project area. Close to the furrow, below the banana and paw-paw plantation.
CRACKING:	Slight.
ASPECT:	East-West.
MICRO-RELIEF:	Undulating.
DRAINAGE:	Imperfectly drained.
UNDERLYING ROCK:	Trachytic tuff and agglomerate.
ROOTING DEPTH:	Effectivelly 110 cms.
MAX. ROOTING DENSITY:	0-8 cms.
SOIL DEPTH:	125 cms.
LAND USE:	Nil.
VEGETATION COVER:	100% grass and weeds. Sorgastrum rigidifolium, Cyperus denudatus. Sporobolus pyramidalis. Botriochloa insculpta.
0 - 8 cms.	Black to very dark brown (7.5 YR 3/1) very hard clay with medium granular and crumb structure. Few rust mottles in root channels. Abundant fine roots. Lower boundary abrupt and even.
8 - 48 cms.	Very grey (10 YR 3/0) extremely hard clay with strong coarse blocky structure compounded into medium prisms. Frequent reddish yellow mottles (7.5 YR 7/6) and faint clay faces. Few fine calcium concretions. Common fine roots. Lower boundary diffuse and even.
48 - 95 cms.	Very dark greyish brown (10 YR 3/2) very hard clay with moderate medium blocky structure. Faint abundant yellowish brown (10 YR 5/6) mottles. Few fine iron concretions and occasional fine calcium concretions. Few fine roots.

95 - 112 cms. Very dark grey (10 YR 4/0) Clay with moderate weak Blocky structure. Mottles very rare and few fine iron concretions. Very few fine roots. Below 112 cms there is a horizon of weathered rock with few calcium concretions giving a white speckled appearance. Rock at 125 cms.

Analytical Data.

PIT NO.	6			
LAB NO.	830	831	832	833
DEPTH cms.	0-8	8-48	48-95	95-112
GRAVEL %	-	-	-	-
SAND %	20	14	12	10
SILT %	16	12	16	14
CLAY %	64	74	72	76
pH	5.4	5.9	6.9	7.2
Na m.e.%	0.54	1.22	1.81	2.20
K m.e. %	0.68	0.38	0.34	0.34
Ca m.e. %	12.8	11.6	10.8	16.4
Mg m.e. %	3.4	3.1	2.1	2.9
P p.p.m.	16	20	23	31
N. %	0.34			
C %	3.48			
Hp m.e.%	0.3			
C.E.C. m.e.%	46.8	45.0	46.8	48.0

SOIL 6. Permanently Waterlogged or Peaty Swamps

These are dark grey to dark brown acid clay with abundand prominent rust mottles in the profile. Common distinct rust mottles in root channels also occurs in the surface layer. These soils are encountered as narrow bands along the main stream banks and are permanently waterlogged. These narrow bands of water-logged soil merge into papyrus swamp.

Due to their limited distribution and poor drainage, these soils do not require any further consideration.

4. PEDOLOGICAL FACTORS OF SIGNIFICANCE TO THE HORTICULTURAL CROPS (SOIL DEPTH, DRAINAGE AND ACIDITY)

The soils which are considered best suited for horticultural crops should be deep, well drained and with good natural structure and adequate nutrient reserves. The trees and long term crops because of their extensive deep rooting system require soils which are at least 4 feet (120 cms) deep whereas annual and short term crops require at least 2 feet (60 cms) depth of soil. On soil 1 therefore most horticulture crops, including tree crops can be grown successfully. The annual crops could also be grown on the shallow soil 2, but would require terracing to prevent erosion.

Shallow stony soils and shallow soils over gravel or murram sheet have only limited suitability. Soil 3 is affected by significant amount of gravel throughout the profile. The presence of these gravels reduces the nutrient and moisture holding capcity, whereas the presence of stones close to the surface makes cultivation and root development difficulty. Whilst other horticultural crops will not do well on gravelly soils pineapples thrive on these soils provided there are no thick sheets of unbroken murram. Soil 3 therefore is suitable for pineapple.

Areas of laterite sheet and rock outcrops are clearly unsuitable for development.

The poorly drained soils are also of limited suitability as they require soil ammendments. They would necessitate drainage layout to improve permeability and guard against seasonal flooding. Poor drainage inhibits rooting and ironicically causes droughting in dry seasons, Root respiration may be reduced and hence retard nutrient uptake, Some nutrients may also be rendered either unavailable or excessive to the plant. Drainage layout costs a lot of money and also requires continual maintenance. Often the drained soils harbour couch or other stoleniferous grasses there -by adding to the expenses.

In one area the seasonally waterlogged soils were seen to support healthy Eucalyptus. Perhaps the seasonally waterlogged soil 5 could be used for these trees.

Very acid or alkaline soils are not favourable for horticulture. Ideal pH range is 5 to 7.3 Soils strongly leached by seepage water and those receiving free Alluminium and iron tend to be more acid and kaolinitic. They have poor reserves of potassium and calcium and may render Phosphate unavailable to plants. This phosphate fixation may inhibit response to phosphatic fertilizers. Frequent light applications may be necessary on these soils. Soil 2 is subject to leaching and the subsoil is generally below pH 5. The lower slopes of soil 1 merging into the shallow soils at the foot slopes are also subject to leaching by seepage water. These soils will require application of basic fertilizers or calculated amount of lime depending upon the crops to be grown.

FERTILITY OF THE SOILS

The best indicator of soil fertility is the yield and the quality of crops grown. Since plant species vary widely in their nutritional requirements different levels of soil fertility may be needed to meet plant requirements. Factors to be taken into account when assessing nutritional requirements include soil, climate and cultural practices. Careful consideration for ideal soil features for individual crops is necessary. For instance the acidity in soil should not be in excess of the acid root tolerance of a given plant and that the delivery of Calcium and Magnesium should meet the plant requirement. Harmful levels of certain elements for instance sodium should also be given due consideration.

As no data between fertilizer treatments and yield on various plots could be obtained, no direct correlation could be applied between different soils of the station. Furthermore the experiments were not conducted on any soil distiction. Some inferences however, can be made on the nutritional aspects pertaining to the various soils of the station.

Organic matter. The application of organic matter is important as it not only provides nutrients but also preserves soil moisture and improves the soil structure. Very often the failure to grow vegetables and fruits successfully is due to insufficient organic matter. On the other hand excessive organic matter in the soil as may occur in long cultivated and heavily manured vegetable gardens may lead to toxic effects. Proper corrective measure for such conditions is perhaps suitable crop rotation.

Considering the existing pattern of the soil types, soil 3 being gravelly and stony is subject to low moisture holding capacity and would certainly benefit from heavier doses of organic matter to preserve the moisture. Soil 2 is subject to leaching and would necessitate more frequent applications of manure. The general recommendation for soil 1, as advocated by the horticultural handbook is 20 tons of manure/acre.

Nitrogen: Nitrogen stimulates growth but in excessive amounts the juice quality of some crops (of the pineapple) may fall. This is due to delayed maturity. But crops such as maize, carrots betroot, cauliflower and celery amongst others require higher amounts of nitrogen. Calcium ammonium nitrate (C.A.N. 20.5% N) may be recommended for soils 2 and 3 with pH below 5 and Ammonium sulphate or ammonium sulphate nitrate for soils with pH above 5 (eg. soil 1) C.A.N. is best for tomatoes as it also reduces Blossom End Rot, but it should be avoided for pineapples as they suffer from to much calcium.

Phosphate. Stimulates rooting tillering and general growth. Superphosphate application meets the requirements in most cases. But where Hp (Hydrogen due to permanent negative charge) is high relatively water insoluble basic phosphates, (hyperphosphate, Kemphos and basic slag) may be used. This is because Hp enhances the release of phosphate as well as Cations, notably calcium which helps to control excess acidity. On soils 2 and 3 and on soil 1 (at lower slopes) merging into the shallow soils, basic phosphates could be tried. Optimum results may be obtained by using mixtures of superphosphate and cheaper less soluble mineral phosphate to respectively give a young plant a good start and to provide continuing supply of available phosphate.

<u>Liming</u>. This may (dependent on the acid tolerance of the crop to be grown) only be applied in quantities necessary to neutralise the Hp. When calcium plus Magnesium in relation to permanent negative charge is high, soils with low cation exchange capacity, in the tropics on application of lime tend to induce hydrolysis to form stable bicarbonate and alumino trihydroxide. This leads to unfavourable root environment thus inhibiting the uptake of important plant nutrients such as phosphate and sulphate. On soil 2 and 1 at lower slopes merging into the shallow soils the need for lime may be taken care of by application of basic phosphate fertilizers.

<u>Potash</u> is essential for growth processes. However there appears not much need for it on these soils. Most vegetables such as carrots, cabbage, betroot, melon, spinach and onions amongst others may however benefit from its application. Muriate of potash (KCl) and potassium sulphate may be tried.

6. SUMMARY OF SOIL TYPES AND MAP LEGEND.

SOIL 1. Red friable Clay (Latosolic)
Suitable for both tree and annual crops
Approximate acreage:250 acres

SOIL 2. Shallow red clays (Latosolic)
Suitability limited to annual crops but would require terracing.
Approximately 65 acres.

SOIL 3. Shallow gravelly and Stony soils.
Suitability limited - Suitable for pineapples.
Approximately 90 acres.

SOIL 4. Rock Outcrops and very Shallow soils.
Unsuitable.
Approximately 150 acres.

SOIL 5. Seasonally waterlogged low lying Swamps.
Unsuitable
Approximately 80 acres.

SOIL 6. Permanently Waterlogged, prominently mottled swamps including papyrus swamp and streams
Unsuitable.
Approximately 40 acres.

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SOIL SURVEY UNIT.

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SOILS OF

THIKA HORTICULTURE RESEARCH STATION

SCALE 1:3125

MAP SYMBOL	SOIL UNIT	DESCRIPTION
1	1	Red friable Clays(Latosolic)
2	2	Shallow red Clays(Latosolic)
3	3	Shallow gravelly and Stony Soils
4	4	Rock outcrops and very shallow soils
5	5	Seasonally waterlogged soils
6	6	Permanently waterlogged swamps

Drawn and Produced by V. Da Costa