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KENYA SOIL SURVEY

SOIL RESOURCES OF THE MAU NAROK AREA, NAROK DISTRICT

A preliminary investigation

by

J.P. Mbuvi and E.B. Njeru

SITE EVALUATION REPORT
No.29 March, 1977

Kenya Soil Survey
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CONTENTS.

1. Introduction

At the request of the Development Planning Division of the Ministry of Agriculture a site evaluation was carried out for potential wheat production land in Mau Narok area. The area they requested to be studied was to include Kisiriri Olkirikirai, Oloropil, Olchoro, Enabelbel, Sakutiek, Konjonga, Enusetia, Enusupukia, Iloamati Loibeti and Nairagai Ngare. It was also emphasised that the site evaluation should be carried out in virgin land; so as to allow for a start in a special wheat growing project to be financed by IBRD.

Preliminary photo interpretation of the requested area was carried out in February, 1976, using aerial photographs scale 1:50,000 of 1967 (Survey of Kenya). The photographs were not very useful since most of the land use has greatly changed since these photos were taken. Another drawback was that the topographical maps for the area completely lacked any contours or form lines. A number of the tracks and roads as appearing in the topographical maps have changed their position or have altogether disappeared, while some minor ones have been upgraded to major roads. This factor made orientation in the area very difficult.

The first fieldwork was carried out in early March 1976 (one week). The senior author visited the area only to find that any land that could be used for wheat growing was already grown with wheat. Following this, the KSS decided to carry out an extended site evaluation covering a bigger area (297,600 ha) with the intention to find out what was the overall potential of the area, for either large scale wheat growing or expansion and improvement (see fig. 1). This map was compiled from whole or parts of sheet nos: 132/2; 147/1; 133/3; 133/1; 132/4; 146/2. Further aerial photo interpretation was done to include those areas which were newly added to the originally chosen area. The same problems were encountered with the aerial photos and the topographical maps as already mentioned above. Two trips were then made: 2 weeks in May 17th - 28th (Messrs. Mbuvi, Njeru and Kinyanjui) and 1 week in Oct. 12th - 17th (Messrs. Mbuvi and Mwangi).

During these two trips 23 representative profile pits were described and sampled for laboratory analysis at N.A.L. In addition to this, 18 augerholes which were only described. To get an overall picture of the fertility status of the area; 8 compound samples (0-30 cm) were collected for fertility analysis (Mehlich). In a later stage, two short trips were made in the company of Messrs. Sombroek and Van de Weg to discuss matters of land form descriptions, soil classification and soil erosion hazards.

2. Environmental conditions

2.1. Location and Communication

The area forms part of Narok District stretched from slightly south of Mau Narok town (0° 38' E 1° 08' E latitude and 35° 47' 36° 13' E longitude, see fig. 1). Narok town in the south is the district headquarters with some limited facilities while Nairagie Ngare is a divisional headquarters for Mau Division. Recently because of new settlement more villages have sprung up with a few shops.

The new Nairobi-Narok road is tarmaced up to Narok town only. The road from Narok to Nakuru through Njoro is an all weather road although it is not tarmaced. The other access road to the area is from Naivasha through Sakutiek. This road is impassable during the rains and is also difficult for travel during the dry season because of the heavy dust. Lately a number of tracks have been upgraded and are now being worked to all weather roads which is necessary for wheat transportation. The few roads that exist run on the ridges only, joining each other at major roads outside the survey area.

2.2. Geology, Geomorphology, Altitude and Drainage

The area is underlain by "undifferentiated pyroclastic materials" consisting mainly of poorly consolidated volcanic tuffs and volcanic ashes (Wright, 1967, Thomson and Dodson, 1963). Tuffs are widespread in the area and are frequently altered into clay in the upper Mau area. In many parts these tuffs are overlain by volcanic ashes resting on tuffs. The ash layer is thick in the east but is thinning out westwards.The ashes can be divided into two groups. The young ashes which were subaerially deposited are poorly bedded and widespread. The older ashes which accumulated as waterlain sediments are soft, laminated and "cross-bedded". They are mainly found in the Seyabei and Uaso Ngiro river valleys. South of Narok town occur thick calcite concretions which give rise to the formation of calcareous soils.

The southern most part of the area consists of a plain "(Loita plains)" Units PP1 and PP2 were formed by deposition of subaerial volcanic ashes and later slightly dissected by shallow water courses. The central part of the area consists of foot-ridges (" the lower Mau" unit, RP1 to RP6). It extends from Narok town northwards to Enabelbel and Alchoro. The lower Mau consists mainly of series of convex topped ridges with deep erosional features induced by surface runoff; the volcanic rocks, consisting mainly of volcanic ashes and tuffs, are easily erodable due to the soft nature of the rocks. The eastern fringe of the area consists of fault-stepped terraces (unit LP4), separated by scarps lowering to the floor of the Rift Valley.

Four major geomorphic surfaces were identified in the area:-

1. H. Hills and minor scarps
2. L. Plateaus
3. R Foot ridges
4. P Plains

The hills of the Rift-Valley are a result of the uplifting activities which form the Mau escarpment. They are not well defined, but form a kind of ridges in succession with the "Mau escarpment" as the highest peak. They are faulted in many places, thus forming ridges with different directions. These hills form the base from where the gullies to the ridges originate.

The plateau in the northern part of the sheet seems to be geomorphologically of older age than any of the other units with the least dissection and is the most stable also.

The ridges have no specific direction and are deeply dissected by waterways. In most cases, the gully sides are very steep and mass movement activities seem to have occurred in the past and is now being referred to as erosional activities.

The plains in the southern part of the survey area are less dissected but here also it appears to be some erosion activity taking place, though at a slow rate (this could be due to overgrazing in the area which is prevailing there).

The elevation of the surveyed area rises from the Loita plains in the south towards the Mau plateau in the north. The Loita plains slope gently southwards from an altitude of 1900 m at Narok town. The plains are fringed in the north by the lower Mau which extends from Mau Narok to Enabelbel and Olchoro with a corresponding rise in altitude from 1900m to 2400m. In the north the lower Mau rises rather abruptly towards the Mau plateau. The plateau varies in altitude between 2400m and 2700m with the Mau range attaining a maximum height of 3,000m. The height of the range decreases towards the south east and grades into the footridges before it reaches Nairagie Ngare.

The drainage is controlled by the Mau escarpment with deeply incised gullies starting from the escarpment and joining in their lower courses, the Uaso Ng'iro which is the principal river draining the area. Although in the topographical maps the area shown to have numerous rivers, the only permanent rivers are Engare Narok and Engare Siapei which are tributaries of the Uaso Ng'iro. These two tributaries drain the north-eastern part of the area. Most of what would be called streams are ephemeral, flowing only during the rainy season.

2.3. Climate

The climatic conditions of the study area are strongly influenced by altitude. The mean annual rainfall increases with altitude from about 700mm in Narok in the south to approximately 1200 mm in the Upper Mau. (EAMD, 1972). The annual potential evaporation (Eo) takes the opposite trend decreasing with increase of altitude from approximately 1700 mm in the south (Mau Narok) to about 1400 mm in the Upper Mau (Woodhead 1968). The major climatic zones tranversed from the South to the North are semi arid zone, sub-humid zone and humid zone, (Glover, 1966).

The average annual rainfall recorded at Narok is 735 mm which is typical of the lower Mau area (see table 1 and fig. 2). The sub-humid zone is represented by Mau Narok (Lutyen farm Met. Station) while the humid zone is reflected in Mau Narok (Holmes slack farm and Lukia Forest stations).

The monthly rainfall distribution pattern varies greatly for the three zones (see fig. 2) In the semi arid zone the rainfall has clearly monomodal pattern with a clearly pronounced dry season in the months of June to November. The onset of the rains is not very clearly pronounced as it may start anytime beginning November to January, thus making the planting time uncertain.

The sub-humid zone has two rainfall peaks, March-May and July-September, when the average monthly rainfall is above 100 mm. June has a monthly rainfall of 80 mm. This is one of the cold months in the area with a low Eo, thus it cannot be regarded as a dry month. What could be regarded as the dry season for this region is October-February but even then the monthly rainfall is above 40 mm.

In the humid zone there is no pronounced dry season as such. Three rainfall peaks occur in this zone the highest between March and May with a low ebb in June and then another peak between July and August, then a low ebb in September again, then the third peak in October-November, with low recordings in December-February. Agro-climatologically the above implies that in the sub-humid and humid zones one can grow two crops per year while it is only possible to grow only one crop per year in the semi arid zone.

Lack of more equipped meteorological stations prevent more elaborate climatic information for the area both for rainfall distribution, probability and determination of evapotranspiration. The annual evaporation (Eo) from open water is however, altitude dependent and can be estimated on a regional scale using the equation of weighted regression when large differences in altitude is the major climatic modification factor.

$$Eo = 2422 - 0.358\,h$$

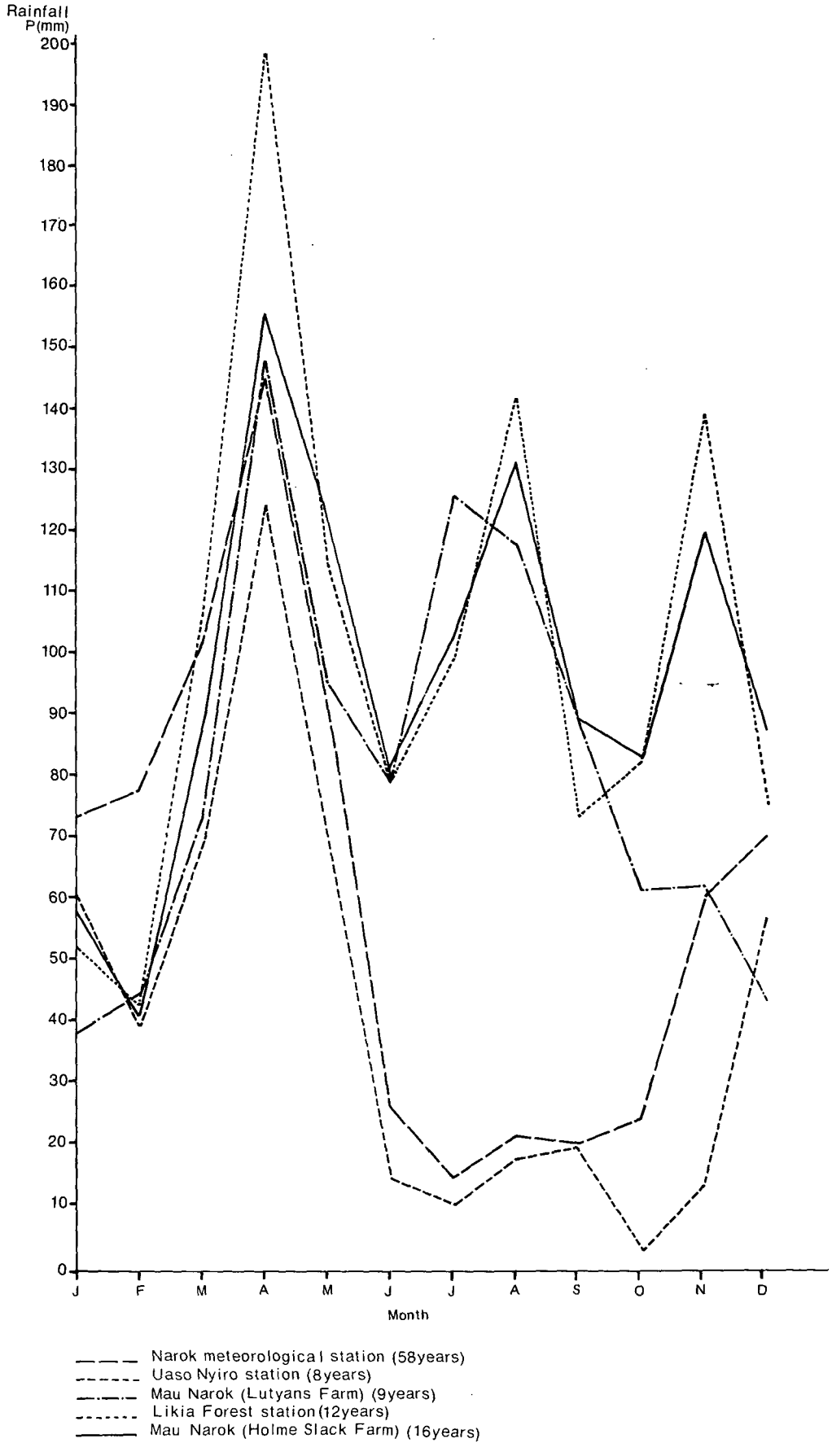
Where Eo = annual evaporation in mm per year.
h = altitude in m.

Table 1.

Mean monthly rainfall in mm (EAMD 1972)

Station	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Year	No.of years
Elementaita Longotia farm	45	41	57	137	110	83	118	158	99	69	73	60	1049	19
Mau Narok (Holmes slack farm)	60	52	89	155	123	83	103	132	90	84	121	88	1180	16
Likia forest station	53	44	106	198	115	80	100	143	74	83	139	76	1211	12
Mau Narok (Lutyens farm)	39	45	74	147	93	80	126	118	89	62	63	44	980	9
Narok met. station	74	78	102	145	94	27	15	22	21	25	61	71	735	58
Uaso Ngiro	62	40	70	125	71	15	11	18	20	3	14	57	506	8

Fig. 2 **Rainfall distribution at various station in Mau Narok area**



Drawing No. 77002

Using the above equation it is found that the annual evaporation being a function of altitude decreases proportionally with the increase of altitude from lower Mau to Upper Mau. The equation is only to be accepted as an approximation of the truth since accurate measurements of the annual evaporation are apt to be a little different (Woodhead 1973).

2.4. Vegetation, land use and population

The pattern of vegetation and land use follows the zonation in altitude. Climate determines, the distribution of the major climax species. The description below follows a gradient from the high range (upper Mau) to the Loita Plains (after Trump 1972).

(1) Bamboo Forest: Occurs around 2400m. The ecological zone is indicated as 11. Extensive forest of the bamboo; Arundineria alpina, are the dominant features of the landscape. Pockets of Erica arborea, Stoebe Kilimandscharica and Artremisia afra may occur in shallow exposed slopes. Land use is limited by low temperatures.

(2) Montane Grassland: In the high mountain range, ecological zone 11 includes a number of plants of the moorland flora. Erica arbota, Stoebe Kilimandscharica, and Artemisia afra are common. In valley bottoms; Lobellia gibberoa is common. Grasses include Themeda triandra, Pennisetum clandestinum, Digitaaria scolarum etc.

(3) Forest: Occurs on the Mau Range and the lower altitudes. The ecological zone is indicated as 11. Extensive forests occur frequently interrupted by forest glades and grassland. The characteristic trees are Juniperus procera, Podocarpus milandjianus, Olea hochstetteri, Cassipourea malosana and Nuxia congesta. Due to burning, cutting and more frequently, clearing for arable cropping, the extent of the forest area is rapidly decreasing.

(4) Forest derived vegetation: These are secondary types which are indicated here because their potential is rather variable. Only relic species have enabled identification of original forest type. Ecological zone 11.

(i) Tarconanthus Evergreen and Semi-Evergreen bushland: Quite similar to the "Climax" Evergreen bushland but differing in the presence of forest species amidst the Tarchonanthus camphoratus bushland.

(ii) Acacia woodland and wooded grassland: Fire is the main cause for the evolution of this type. Acacia lahai woodland and wooded grassland is characteristic. Grasses include Pennisetum clandestinum and Cynodon dactylon

(iii) Grassland: This is the ultimate objective of the pastoral people in the area. The type is dominated by Themeda triandra. Where fire is absent, Pennisetum schimperi and Pennisetum catabasis are dominant.

(5) Evergreen and semi-deciduous bushland: The annual rainfall is between 500-600 mm. Characteristic plants include: Tarchonanthus camphoratus, Olea africana, Acokanthera friesiorum, Euphobia condelabrum, Rhus natalensis and Boscia angustifolia.

(6) Evergreen bushland derived grasslands: Found on the Loita Plains. These are fire induced. Boscia angustifolia is the common woody plant. Grasses include Themeda triandra, Pennisetum mezianum, Pennisetum schimperi, Sporobolus discosporus etc. Under conditions of heavy utilization Pennisetum schimperi and Harpachne schimperi become dominant.

At present, the major crops grown in the area are wheat and barley, with the hectarege of the former one having increased greatly in the past few years. At the moment there is practically no more room for the expansion of these two crops. Other crops grown on the higher parts include potatoes, peas, onions and cabbages. Trees are being cut down for charcoal burning in areas where otherwise they should not be cut. This is something that should strongly be discouraged with immediate effect if we are still to have the few streams in the area flowing in both the sub humid and humid zones.

Sheep rearing is a major occupation at the higher altitude while nomadic herding dominates in the semi arid zone.

The population for the area in question is approximately 27,218 people according to a 1969 census; (Ministry for Finance and Planning 1970).

The break down of the population by division is as follows:-

Ildamat	2,541
Melili	12,654
Mau	12,023

The majority of the population are Masai but other tribes have started migrating to the area from other parts of the country. Most of the recent immigrants lease land from the indigenous people for a short period while others have already started to settle there.

3. The soils

3.1. Previous work

According to the (Gethin Jones and Scott) soil map of Kenya (Survey of Kenya, 1970), three major soil groupings are found in the survey area: Dark-brown loams (Ando-like soils), Brown calcareous loan (chestnut soils) and Dark brown loams.

The FAO/Unesco soil map of the World recognizes two soil units Chromic Cambisol and Mollic Andosols.

3.2. General properties of the soils.

The various mapping units which are described below were largely delineated based on aerial photo interpretation at scale 1:50,000; field work which followed was to check the various units and to verify the soil boundaries as do occur on the map. The field work was carried out using 1:50,000 maps which were later reduced to 1:100,00 and compiled to form the present map (fig.1). The legend in the map provides a short description of the physiography, soils and land use of the mapping units.

Most of the soils are deep and well developed. They have clay to clay loam textures, dark greyish brown to black colours, a rather organic matter-rich topsoil and a friable consistence, crumby structure on the top soil. The subsoil in general have a subangular blocky structure. In general these soils have a bulk density below 1, no surface sealing, and have a rather rapid infiltration rate and low susceptibility to sheet erosion. On the steep slopes there is however gully erosion activity and land slide hazard if the land is left bare. The clay fraction consists of amorphorus material with traces of feldspars with no crystalline components as revealed by xray analysis. There is very high amounts of F_2O_3% in the clay mineralogy. The base saturation is very high except for mapping units LP1 which is below 50%. More details can be found in the description of the mapping units themselves.

In general the soils in the survey area are polygenetic. In the following technical descriptions one will see that the various mapping units are rather similar if they occur in the same geomorphic level under the same climatic conditions. Thus the soil forming process in this area seems to have been very much determined by altitude and climate. The profile description of the various soils together with laboratory data are presented in the appendix.

3.3. Description of the soil mapping units.

3.3.1. Soils of the hills and minor scarps

Unit HP1 Area 6227 ha.

This unit, which has a high relief intensity covers mainly the "Mau escarpment". The escarpment has a narrow flat top with steep slopes on either side.

The soils in this unit are well drained and deep. The texture of the topsoil (A horizon) is loam and the colour ranges from black (10YR 2.5/1*) to very dark grey (10YR 3/1). The structure ranges from massive to crumby. There is 50-60 cm slightly acid humic topsoil with an average organic matter content of C% 2.4. The subsoil (B_3 or C horizon) has a very dark greyish brown (10YR 3/2) colour and a sandy clay loam texture. The structure is massive to subangular blocky.

Where the A horizon is underlain by a C horizon then the C is a soft ash deposit.

On the flat tops small plots of potatoes, onions, peas and cabbages are a common feature. Most of the slopes are still forested. (For complete profile description, see profile 133/3-11).

Unit HP2 Area 39260 ha

This unit occurs alongside and south of unit HP1. It is more dissected than unit HP1 with numerous peaks and a high relief intensity. The soils are well drained and deep. The texture of the topsoil is loam and the colour is very dark grey (10YR 3/1), with a crumby structure. There is 50-60 cm slightly acid humic topsoil with an average organic matter of C% 4.5. The subsoil (B_3 or B_2 horizon) has colour ranges from olive (5Y/3) to dark brown (7.5YR 3/2). The texture varies from loamy sand (B_3) to clay loam with glassy material for B_2 horizon The structure is massive to subangular.

Where the A horizon is underlain by a B1 and B3 without B_2 horizon then the B_3 is mainly composed of ash layer but more developed than the C horizon in HP1. In the event that the A horizon is underlain by a B1, B2 and B3 horizons then the C horizon is composed mainly of weathering tuff and not soft ashes.

Clearing of small plots in this unit has just started (for complete profile description see pit 133/3-3).

* unless otherwise stated the colours shown are moist.

3.3.2. Soils of the Plateaus

Unit LP1 Area 33170 ha

The general terrain in this unit is very gently undulating though the gully sides may have slopes up to 15%. The soils are deep and well drained. The texture of the topsoil is loam to sandy clay loam and the colour is dark reddish brown (5YR 3/2). The structure is crumby to granular. There is 20-50 cm slightly acid humic topsoil with an average organic matter of C% 2.6. The subsoil (B horizon), has a dark brown to reddish brown colour (10YR 4/3 and 5YR4/3). The texture is sandy clay to clay and massive to subangular blocky structure. The C horizon in the average starts at 130 cm which is composed of weathering tuff.

The area is extensively cultivated with wheat and rape in the very gently undulating parts. It is difficult to estimate the actual cultivated area but it is thought to be approximately half the total area shown above though it may be slightly less than that. The other half is grassland (for complete profile description see pit 132/2-3).

Unit LP2 Area 21807 ha

This unit is in general gently undulating with some parts rolling. The major soils in this unit are deep and well drained. The texture of the topsoil is clay loam to sandy clay loam and the colour is black (5YR 2.5/1). The structure is massive to subangular blocky, with a 30-60 cm of acid humic topsoil with an average organic matter of C% 3.0 %. The subsoil (B horizon) has a dark brown colour (7.5YR 3/2). The texture is clay loam to clay and massive to subangular blocky structure.

Generally the C horizon starts between 90-120 cm depth. This horizon is mainly composed of weathering tuff. In this unit there is negligeable portion of moderately deep soil with the C horizon starting at 50 cm.

There is a small inclusion of flat valley bottoms which are imperfectly drained. These valley bottoms are so narrow that they are of no practical importance.

The major crop in this unit is wheat and barley. Again, here, it is difficult to estimate the hectarage under cultivation, although it is estimated that slightly more than half the area is cultivated. Sheep are also kept in the area but in small numbers. (For complete profile description see pit no. 132/2-5).

Unit LP3 Area 6373 ha

The area is undulating to rolling but lacking deep gullies. The major soils are deep and well drained. The texture of the topsoil is sandy clay loam to loam and the colour is very dark grey to very dark greyish brown (10YR 3/1 and 10YR 3/2). The structure is crumby with 30-40 cm of acid humic topsoil with an average organic matter c% 2.7. The subsoil has a very dark greyish brown colour (10YR 3/2). The texture is clay loam to loam and massive to subangular blocky structure.

There are several small depression like inclusions in this unit which were not separated at this mapping scale. Except for one small depression near Nairagie Ngare, which is very shallow and poorly drained, the rest have soils similar to the major soil types in this unit.

The major crop in this unit is wheat and maize. It is estimated that roughly half the area is cultivated with wheat and maize having equal shares in the cultivated portion. (For complete profile description see pit no. 147/1-6).

Unit LP4 Area 6333 ha

The unit occurs in two relatively small areas which are step faulted and consequently "terraced". They are very gently undulating but have some very deep gullies. The major soils are deep and well drained. The texture of the top soil is silt clay loam to loam and the colour is black to very dark grey (10YR 2.5/1 and 10YR 3/1). The structure is crumby with 50-60 cm of humic topsoil with an average organic matter of C% 2.5. The subsoil has a very greyish brown colour (10YR 3/2). The texture is loam to clay and massive to subangular blocky structure.

The major crop in this unit is wheat. It is estimated that at least 75% of this unit is under cultivation. (For complete profile description see pit no. 133/3-10).

3.3.3. Soils of the Footridges

Unit RP1 Area 19490 ha

This unit is in general undulating, with an irregular pattern of very deep gullies. The major soils in this unit are deep and well drained. The texture of the topsoil is clay loam to clay and the colour is black (5YR 2.5/1). The structure is massive to granular with 30-50 cm of slightly acid humic topsoil with an average organic matter of C% 3.0. The subsoil has a dark reddish brown colour (5YR 3/3). The texture is sandy clay to clay loam and a porous massive structure.

The C horizon starts at 130 cm and is composed of weathering tuff.

The ridges in this unit are rather irregular and narrow, thus not permitting extensive cultivation. There are small patches grown with wheat, potatoes, maize, onions and peas. (For complete profile description see pit no. 132/4-6).

Unit RP2 Area 30270 ha

The general terrain form in this unit is undulating with some parts rolling. The pattern of gullies is denser than in RP1. The gullies are also very deeply incised ($\pm$ 80-100 m) with gully slopes of over 18%. The soils are deep and well drained. The texture of the topsoil is sandy clay loam and the colour is black to very dark grey (5YR 2.5/1 and 10YR 3/1). The structure is massive to crumby with 40-50 cm of acid humic topsoil with an average organic matter of C% 3.2. The subsoil has a dark reddish brown colour (5YR 3/2). The texture is clay and a massive to subangular blocky structure.

The C horizon generally starts at 120 cm and is mainly composed of weathering tuff.

The ridge tops with undulating slopes are cultivated with wheat and the more steeper parts are normally left for sheep grazing. The cultivated area in this unit is estimated to be 25% of the total area. (For complete profile description see pit no. 133/3-17)

Unit RP3 Area 16040 ha

The area is in general gently undulating with steep gully slopes. The gullies are in irregular patterns separated by narrow ridges. The major soils of this unit are deep and well drained. The texture of the topsoil is clay loam and the colour is very dark grey (10YR 3/1). The structure is crumby with 30-50 cm of acid humic topsoil with an average organic matter of C% 2.0. The subsoil has a very dark grayish brown colour (10YR 3/2). The texture is clay and a porous massive to subangular blocky structure.

The C horizon starts at 120 cm and is mainly composed of weathering tuff. A small portion of this unit has shallow soils with tuff exposed to the surface.

The area under cultivation is estimated to be roughly 12.5% of the total area while the remaining part is under forest (for complete profile description see pit no. 132/4-7).

Unit RP4 Area 28983

This unit has an undulating topography with deeply incised ± 30-40 m gullies with slopes of 7-12%. The major soils of this unit are moderately deep and well drained. The texture of the topsoil is clay loam and the colour is very dark grey (10YR 3/1). The structure is crumby with 20-30 cm of slightly acid humic topsoil with an average organic matter of C% 3.2. The subsoil has a dark greyish brown colour (10YR 3/2). The texture is clay loam to sandy clay loam and a massive structure.

In the examined pit, the weathering tuff was found at 70 cm but in other augerings in this unit no weathering tuff was hit at 120 cm depth.

All the area with undulating topography is already cultivated with wheat which is estimated to be 25% of the total area (for complete profile description see pit no. 132/4-8).

Unit RP5 Area 11263 ha

The terrain in this unit is very gently undulating to undulating. The major soils are moderately deep and well drained. The texture of the topsoil is clay and the colour is very dark grey to very dark greyish brown (10YR 3/1 and 10YR 3/2). The structure is massive to subangular blocky with an average organic matter of C% 1.1. The subsoil has a dark brown colour (10YR 3/3). The texture is clay loam to sandy clay loam and a porous massive to subangular blocky structure.

There are a few places with shallow soils and rock outcrops, which have not been separated because of the mapping scale.

There is no cultivation in this unit. Ranching is the major occupation here (for complete profile description see pit no. (146/2-5).

Unit RP6 Area 33437 ha

This unit is gently undulating to undulating with deep and well drained soils. The texture of the topsoil is clay and the colour is very dark greyish brown (10YR 3/2). The structure is massive to crumby with an average organic matter of C% 1.7. The subsoil has a dark reddish brown to dark greyish brown colour (5YR 3/2 and 10YR 3/2). The texture is sandy clay loam and a porous massive structure.

There are a few places in this unit with shallow soils and rock outcrops, which have not been separated because of the mapping scale.

The area is used for grazing purposes only, although of late some clearing has been done for cultivation purposes (for complete profile description see pit no. 147/1-7).

3.3.4. Soils of the Plains

Unit PP1 Area 32507 ha

This unit is situated in the northern fringe of the Loita plains. The general terrain is flat to very gently undulating. The major soils in this unit are moderately deep and well drained. The texture of the topsoil is clay to clay loam and the colour is dark brown to very dark brown (7.5YR 3/2 and 7.5YR 2.5/2). The structure is massive to subangular blocky, with an average organic matter of C% 1.5. The subsoil has a dark brown colour (7.5YR 3/2). The texture is clay loam to sandy clay loam and a massive to subangular blocky structure.

This area is only used for grazing purposes (for complete profile description see pit no. 146/2-4).

Unit PP2 Area 12440 ha

The area borders the "Lower Mau" and forms the north-eastern part of the Loita plains. The terrain is flat to very gently undulating. The major soils are moderately deep to deep and well drained. The texture of the topsoil is clay loam and the colour is dark brown (7.5YR 3/2). The structure is porous massive to crumby with an average organic matter of C% 2.0. The subsoil has a dark reddish brown colour (5YR 3/2). The texture is clay loam to sandy clay loam and a porous massive to massive structure.

There are a few scattered patches of wheat in this unit which were started recently, otherwise the main occupation is ranching. (For complete profile description see pit no. 147/1-3).

4. Chemical Soil Fertility

Considering the relatively few samples analysed (1-2 profiles) per soil mapping unit, the interpretation of the chemical data in terms of soil fertility must be done with due care. It should further be pointed out that the productivity within a certain area is only partly based on soil fertility. Physical factors, both from the soil and the landscape play a part as well (e.g. rainfall, temperature, drainage conditions, slopes etc.)

The soils of the area are largely derived from volcanic ash and tuffs, as is evident from their generally low bulk density. The X-ray report indicates amorphous material with only traces of feldspars and illite and/or kaolinite. Although the clay fraction is amorphous, there is little evidence of the presence of allophanic material, which is notorious for its phosphate-fixing properties at low organic matter status of the soil. The soils show relatively low variable charge values and the specific allophane test with NaF is negative.

An important feature of the soil fertility aspect in this area is the organic matter (OM) content. Apart from unit PP1, RP6 and RP5, which show rather low carbon percentages, the soils have in general medium to medium high organic matter contents which may often extend to a depth of 70 cm or more. The lower carbon content of the first three units mentioned may perhaps be ascribed to a more intensive land use (exploitation), combined with a drier climate, which results in a decrease of organic matter content.

The soil fertility assessment has been done on the basis of such chemical data as: OM, pH, cation exchange capacity and exchangeable bases, the levels of Ca, Mg, K, P, Mn and 1% EDTA extractable Cu, Zn, Fe, Mn.

Copper deficiencies have been reported in the Narok area in wheat and maize. To what extent other crops or the natural vegetation are adversely affected is not known. The copper extraction values determined in the soil of the various mapping units are generally low and copper deficiencies are possible to exist or to develop with the introduction of certain crops.

In the fertility appraisal given below, this negative quality has not been taken into account and adjustments may be necessary depending on the crops to be grown and information becoming available regarding adverse effects on vegetation. A tentative rating system for soil fertility is presented in a summarized form in table 2, in which I denotes excellent and V denotes very poor fertility.

As may be seen from table 2, the level of soil fertility appears generally to be medium to high, with often only slight differences showing, which is the reason for expressions for rating such as I/II and II/III. The phosphorus content of many units are medium to low. However, considering the high O.M. status of the soils it is thought that a steady supply is ensured through mineralization.

The role of organic matter in supplying plant nutrients has been duly stressed in the foregoing. Its maintenance is therefore of primary importance. Overgrazing and soil erosion

may alter the favourable fertility aspects completely in a relatively short time.

Table 2.

Soil fertility assessment

Unit	pH	Base status	O.M. content	P-content	Rating
PP1	6-6.5	high	mod.low to low	mod.low	III
PP2	6.0	high	high to 100cm.	high	I/II
RP6	6.8	high	med.to med.low	med.	II/III
RP5	6.3	medium	low	med.to low	III
RP4	6.2	high	high; 70cm	high	I
RP3	5.1	medium	high to med.50cm	med.to low	II/III
RP2	5.5	medium	high; 50cm	med.to low	II/III
RP1	6.2	high	high to med.80cm	med.	II
LP4	5.5-6	high	high to med.80cm	low	II/III
LP3	6.0	med/high	high; 75cm	high	II
LP2	5.5	medium	high; 60cm	med	II
LP1	5.8	med/med.low	high to med.50cm	low	II/III
HP2	6.4	high	high;60-120cm	low	II
HP1	6.5	high	high; 60cm	med.	I/II

5. Soil erosion aspects

Much has been said and written in the past (Glover, et al, 1966) on the hazard of soil digeneration by accelerated erosion once the protective forest or bushland vegetation has been removed. Indeed there are parts of the cleared and cultivated land where signs of erosion are apparent. It is mainly in the form of landslides minor scarps of 10-50 m long and 1-4 m height (mass movement). It was however observed during the field work that such land slides are largely a thing of the past; they apparently did occur during (if not before) the time that forest vegetation was still present - as exemplified by sites where slided land still contained stumps of trees. Apparently the rain soaked open ashy subsoil is liable to massive displacement, especially if it overlies abruptly the more massive and consolidated tuffs.

It is however true that nomadic grazing in the southern mapping units tends to cause local gully erosion at the sites of the minor scarps that originated from the landslides. The impression prevails that areas under wheat seem to present no increased hazard of mass-movement, if not less; contrary to many areas elsewhere in the country.

Sheet erosion is nowhere in the area a serious hazard, even on rather steep slopes, because of the high permeability and stability of the thick humic topsoils. On steep slopes gully-erosion may however set-in, because of the lower stability of the subsoil. This can be prevented under wheat/barley growing and small-holders mixed cropping by contour-ploughing and the establishment of bench terraces. These measures are already carried out locally in the case of wheat/barley, but should be enforced also in the case of small-holders cultivation. It will however be difficult to effect in the case of nomadic grazing by the Masai cattle, sheep and goats. This would be particularly so when the scarsity of the available grazing land would lead to further overgrazing.

In this connection, the temporary reversion of well maintained wheat/barley land into fenced and controlled grazing (as may be necessary anyhow because of the prevalence of wild oat infestation) may in fact be beneficial.

In the mapping units with lower rainfall and higher evaporation (units PP1 and PP2) the overgrazing has resulted in a wind erosion hazard, the seriousness of which can not yet be assessed.

Notwithstanding the above, signalled relatively favourable situation as regards erosion hazards, the many very steep slopes directly along the water courses should be left under forest - or reaforested. The topsoils there tend to be relatively shallow and purely mechanical soil movement - whether induced by run off, cultivation or trampling, will clog the watercourses, with a subsequent negative effect on the overall hydrological characteristics of the area.

6. Land suitability

6.1. Climatic aspects

Detailed information concerning the assessment of the present situation in the study area and the possibilities for improved agricultural output is still lacking. Unfortunately there are very few well equipped meteorological stations with long recordings, thus important parameters like climatic variables, the balance between rainfall and evaporation on an annual and in particular on seasonal basis could not be studied. As stated elsewhere in this report there is a good correlation between altitude, potential evaporation and average annual rainfall. The rainfall decreases southwards with the decrease in altitude. From the available data it can be pointed out that most of the area under consideration falls within ecological zones II and III except for the area south of Olchoro and Ololopil which is in ecological zone IV.

6.2. Soils

From the soils point of view both physical and chemical the area under consideration is quite favourable. The soils are quite rich chemically with high amount of organic carbon and plant nutrients although a few trace elements may be in short supply. The present natural fertility is enough to support a healthy crop without any major inputs (for more details see chapter 4). The soils are easy to work and have high infiltration rates, thus absorbing all the water that reaches the ground.

As it is to be expected from the above information most of the farming activities are concentrated on ecological zones II and III while ranching is the main occupation in ecological zone IV. The major commercial crops in the area are wheat and rape. Subsistance crops grown in the area are potatoes, cabbages, peas, onions and maize. The urge for opening up new land should not be allowed to surpass the physical limitations. It should however be pointed out that the present system of farming which seems to lay emphasis on mono-culture practices should be changed to avoid depletion of plant nutrients. Cultivation on steep slopes should be highly discouraged as this will definitely lead to serious soil erosion hazards. The very steep slopes should be planted with trees for water-catchment purposes while the less steep ones should be planted with grass for grazing purposes.

7. Conclusions and recommendations

(a) The study area as such offers no room for expansion of new land for wheat growing as was the original purpose of the request for the study.

(b) The present monocultural system of farming should be discouraged and a more systematic rotation system adapted in its place, to prevent the depletion of plant nutrients from the soils.

(c) Though erosion hazards in the area are relatively small because of the favourable topsoil characteristics measures should be instituted to prevent further development. This can be achieved through terracing and strip cropping.

(d) Grazing on steep slopes should be strictly controlled to avoid erosion hazard. The number of animals should be limited according to the carrying capacity of each given area.

(e) Care must be taken to avoid further destruction of the existing forests which would otherwise lead to undesirable effects in the steep gully slopes, especially on the hilly units (HP1 and HP2)

(f) It is advised that the forest/bush on the gully slopes should be left intact to prevent any further development of the gullies and to act as water catchment areas (particularly for units RP1, RP2, RP3, RP4, RP5, RP6 and LP4)

(g) The area south of Olchoro and Oloropil should best be left for ranching purposes as the chances for crop failure due to limited moisture supply are pretty high for any commercial cropping.

(h) It should be stressed that new aerial photographs of the area and new topographical maps are required for any more comprehensive field work.

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LABORATORY DATA SHEET - SOIL PROFILE NO.133/3-11

horizon	A1	A3	C	IIA1b	A3b	B2b
Depth in cm	0-30	30-60	60-90	90-110	110-135	135-150
Sand %	48	43	44	49	51	59
Silt %	36	36	44	26	16	12
Clay %	16	21	12	25	33	29
Texture class	L	L	L	SCL	SC	SCL
Dispersed clay %	8	8	12	8	12	12
Flocculation index	50	61	0	68	64	62
pH-H_2O (1:1)	6.6	6.5	6.4	6.4	6.2	6.2
pH-KCl (1:1)	6.0	5.7	5.5	5.4	5.4	5.4
EC in mmho's/cm	0.24	0.10	0.05	0.10	0.10	0.08
C%	2.69	2.22	0.33	2.49	3.14	1.78
N%	0.24	0.20	0.23	0.20	0.11	0.23
C/N	11.2					7.7
CEC (NH_4OAc, pH7.0) me%	22	24	5.6	22	24	21.0
Exch. Ca me%	14.2	14.4	3.0	15.0	15.8	10.3
" Mg "	3.9	4.2	0.65	3.0	4.2	4.1
" K "	2.3	1.9	0.6	2.3	1.8	1.3
" Na "	0.4	0.4	0.2	0.5	0.5	0.5
Sum of cations me%	20.8	20.9	4.4	20.8	22.3	16.2
Base saturation pH 7.0 % CEC v	94.5	87.6	78.5	94.5 29	92.9	77.1
Bulk density	0.83					
Clay mineralogy:						
SiO_2/Al_2O_3						2.1
SiO_2/R_2O_3						1.3
Fe_2O_3%						20.9
X-ray report: B_{2_3}	Amorphous material. No crystalline material.					
Fertility aspects:						
Available Ca me%	19.8	14.8				
" Mg "	3.6	3.7				
" K "	1.76	1.16				
" Na "	0.34	0.26				
" Mn "	0.55	0.52				
" P ppm	25	22				

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9. Appendix

Profile descriptions

Unit HP1 observ. No. 133/3-11

Soil classification: nollic andosol
Geological formation: ashes and soft tuff
Local petrography: ashes
Physiography: hilly (scarp)
Relief - meso: undulating to hilly
- meso and micro: nil
Vegetation/land use: forest - small holder cultivation
Erosion: nil
Surface stoniness: nil
Slope gradient: 6-18%
Salanity/alkalinity: nil
Surface sealing: nil
Drainage class: well drained

Horizon designation	Depth in cm	Description
A1	0-30	black (10YR 2.5/1 moist), loam; massive breaking to weak fine crumby structure; friable when moist, slightly sticky and slightly plastic when wet; diffuse smooth boundary;
A3	30-60	very dark gray (10YR 3/1 moist), loam; massive falling apart to weak fine subangular blocky structure; friable when moist, slightly sticky and slightly plastic when wet; clear wavy boundary;
B3(c)	60-90	very dark grayish brown (2.5YR 3/2 moist), loam; massive; friable when moist, non sticky and non plastic when wet; clear wavy boundary;
II A1b	90-110	black (10YR 2.5/1 moist), sandy clay loam; massive falling apart to weak fine to medium subangular blocky structure; friable when moist, sticky and plastic when wet; diffuse wavy boundary;
II A3b	110-135	black (2.5YR 2.5/0 moist), sandy clay, massive falling apart to weak fine to medium subangular blocky structure; friable when moist, sticky and plastic when wet; clear wavy boundary;
II B2b	135-150+	dark brown (10YR 3/3 moist), sandy clay loam; porous massive falling apart to weak fine to medium subangular blocky structure; friable when moist, sticky and plastic when wet

LABORATORY DATA SHEET - SOIL PROFILE NO: 133/3-3

horizon	A1	B1	B3	IIB1	IIB2
Depth in cm	0-33	33-50	50-74	74-109	109-150
Sand %	38	40	40	22	26
Silt %	46	44	40	50	40
Clay %	16	16	20	28	34
Texture class	L	L	L	L	CL
Dispersed clay %	16	14	12	18	16
Flocculation index	0	13	40	36	53
pH-H_2O (1:1)	6.6	6.3	5.8	5.2	5.2
pH-KCl (1:1)	5.8	5.4	4.8	4.2	4.1
EC in mmho's/cm	0.30	0.21	0.14	0.10	0.08
C %	4.96	2.29	1.18	2.09	2.15
N %	0.58				
C/N	8.5				
CEC (NH_4OAc,pH7.0)me%	38.0	16.0	11.2	15.1	18.0
Exch. Ca me%	19.6	8.1	3.7	3.8	2.2
" Mg "	10.0	3.6	1.6	1.7	1.2
" K "	2.3	2.3	2.8	2.7	2.7
" Na "	0.2	0.1	0.2	0.3	0.8
Sum of cations me%	32.1	14.1	8.3	8.5	6.9
Base sat. % at pH 7.0	84	88	74	56	38
Bulk density	0.75		0.83		
Clay mineralogy:					
SiO_2/Al_2O_3		3.0		2.9	
SiO_2/R_2O_3		1.4		1.5	
Fe_2O_3%		23.8		29.5	
X-ray report: B_1	Amorphous material; no crystalline material				
IIB_1	Amorphous material; no crystalline material				
Fertility aspects:					
Available Ca me%	31.0				
" Mg "	8.0				
" K "	2.70				
" Na "	0.36				
" Mn "	0.24				
" P ppm	13.				
1% EDTA extract:					
Cu ppm.	0.4				
Zn	15.0				
Mn	90				
Fe	225				
CECv %		35			37

Unit HP2 observ. No. 133/3-3

Soil classification: mollic andosol
Geological formation: ashes, soft tuff
Local petrography: ashes
Physiography: hilly
Relief macro: rolling to hilly
Relief meso-micro: nil
Vegetation/land use: forest/small holder cultivation
Erosion: nil
Surface stoniness: nil
Slope gradient: 3-12%
Salinity/Alkalinity: nil
Surface sealing: nil
Drainage class: well drained

Horizon designation	Depth in cm	Description
A1	0-33	black (7.5YR 2.5/1 moist), loam; massive falling apart to medium very fine to fine crumby structure; friable when moist, non sticky and non plastic when wet; diffuse wavy boundary;
B1	33-50	very dark gray (10YR 3/1 moist); loam; massive; friable when moist, non sticky and plastic when wet; clear wavy boundary;
B3	50-74	olive (5Y 4/3 moist), loam ;porous massive; loose when moist, non sticky and non plastic when wet; clear wavy boundary;
IIB1	74-109	black (7.5YR 2.5/0 moist), loam; massive falling apart to medium, medium to coarse subangular blocky structure; friable when moist, non sticky and non plastic when wet; clear wavy boundary;
IIB2	109-150+	very dark gray (10YR 3/1), clay loam; massive falling apart to medium, medium to coarse subangular blocky structure; friable when moist, non sticky and non plastic when wet.

LABORATORY DATA SHEET - SOIL PROFILE NO. 132/2-3

horizon	A	B1	B21	B22
Depth in cm	0-20	20-50	50-85	85-130
Sand %	68	52	48	32
Silt %	12	16	12	12
Clay %	20	32	40	56
Texture class	SCL	SCL	SC	C
Dispersed clay %	16	20	6	8
Flocculation index	20	38	85	86
pH-H_2O (1:1)	5.8	5.3	5.2	5.3
pH-KCl (1:1)	4.7	4.4	4.7	4.5
EC in mmho's/cm	0.13	0.08	0.08	0.07
C %	2.59	2.09	1.12	0.73
N %	0.29			
C/N	8.9			
CEC (NH_4OAc, pH7.0) me%	23	18	14	15
Exch. Ca me%	6.0	3.9	3.6	3.4
" Mg "	3.8	3.0	2.2	2.0
" K "	1.1	0.9	1.16	1.6
" Na "	0.5	0.3	0.3	0.5
Sum of cations me%	11.4	8.1	7.3	7.5
Base sat. % at pH7.0	49.5	45.0	52.1	50.0
% CECv				5
Bulk density		0.94		
Clay mineralogy:				
SiO_2/Al_2O_3		2.9	2.2	2.0
SiO_2/R_2O_3		1.4	1.2	1.2
Fe_2O_3%		32.4	33.1	34.6

X-ray report: B1, B21 — generally amorphous with some traces of illite and kaolinite which are poorly crystallized.

Fertility aspects:

Available Ca	me%	4.3
" Mg	"	3.2
" K	"	0.68
" Na	"	trace
" Mn	"	1.38
P	ppm	6

L plateau
O

Unit LP1 observ. 132/2-3

Soil classification:	humic andosol
Geological formation:	soft tuff
Local petrography:	tuff
Physiography:	plateau
Relief macro:	gently undulating to undulating
Relief meso & micro:	nil
Vegetation/land use:	open grassland; wheat growing
Erosion:	nil
Surface stoniness:	nil
Slope gradient:	2-4%
Salinity/Alkalinity:	nil
Surface sealing:	nil
Drainage:	well drained

Horizon designation	Depth in cm	Description
A1	0-20	dark reddish brown (5YR 3/2 moist), sandy clay loam; weak fine granular structure; friable when moist, sticky and plastic when wet; gradual wavy boundary;
B1	20-50	reddish brown (5YR 4/4 moist), sandy clay loam; porous massive; friable when moist, sticky and plastic when wet; diffuse smooth boundary;
B21	50-85	dark reddish brown (5YR 3/4 moist), sandy clay; weak, fine to medium subangular blocky structure; friable when moist, sticky and plastic when wet; gradual wavy boundary;
B22	85-130	reddish brown (5YR 4/4 moist), clay; massive falling apart to weak, medium subangular blocky structure; firm when moist, sticky and plastic when wet;

Remarks - Below 130 cm weathering soft tuff. = C

LABORATORY DATA SHEET - SOIL PROFILE NO. 132/2-5

horizon	A1	A3	B2
Depth in cm	0-30	30-60	60-125
Sand %	20	36	40
Silt %	44	24	20
Clay %	36	40	40
Texture class	CL	C	CL
Dispersed clay %	16	20	24
Flocculation index	56	50	40
pH-H_2O (1:1)	5.3	5.7	5.8
pH-KCl	4.6	4.8	4.6
EC in mmho's/cm	0.16	0.11	0.10
C %	3.47	2.26	0.47
N %	0.32		
C/N	10.8		
CEC (NH_4OAc, pH7.0) me%	27	23	22
Exch. Ca me%	9.8	10.8	5.4
" Mg "	4.0	3.2	2.8
" K "	1.8	1.3	1.5
" Na "	0.4	0.3	0.3
Sum of cations me%	16.0	15.6	10.0
Base sat. % at pH 7.0	59.2	67.8	45.4
% CECv		35	
Bulk density	1.1		
Clay mineralogy:			
SiO_2/Al_2O_3			2.8
SiO_2/R_2O_3			1.5
Fe_2O_3%			31.0
X-ray report: B2	The sample is generally anorphous except some traces of illite and feldspars.		
Fertility aspects:			
Available Ca me%	8.2	8.4	
" Mg "	2.4	3.3	
" K "	1.46	0.86	
" Na "	0.30	1.10	
" Mn "	1.35	1.12	
P ppm	34	5	

Unit LP2 observ. 132/2-5

Soil classification:	nollic andosol
Geological formation:	soft tuff
Local petrography	soft tuff
Physiography:	plateau
Relief - macro:	gently undulating to undulating
Relief - meso-micro:	nil
Vegetation/land use:	grassland/wheat growing
Erosion:	nil
Surface stoniness:	nil
Slope gradient:	2-4%
Salinity/alkalinity:	nil
Surface sealing:	nil
Drainage:	well drained

Horizon designation	Depth in cm	Description
A1	0-30	black (10YR 2.5/1 moist), clay loam; massive falling apart to weak fine subangular blocky structure; friable when moist, sticky and plastic when wet; diffuse smooth boundary;
A3	30-60	very dark greyish brown (10YR 3/2 moist), clay; massive falling apart to weak very fine to fine subangular blocky structure; friable when moist, sticky and plastic when wet; gradual smooth boundary;
B2 (BW1 60-90, BW2 90-120)	60-120	dark brown (7.5YR 4/4 moist), clay loam; medium fine to medium subangular blocky structure; friable when moist, sticky and plastic when wet

Remarks - Below 120 cm weathering soft tuff

LABORATORY DATA SHEET - SOIL PROFILE NO: 147/1-6

horizon	A1	A3	B1	B2	B3	IIB2	IIB3
Depth in cm	0-20	20-40	40-64	64-85	85-97	97-109	109-150
Sand %	54	30	30	38	36	28	20
Silt %	22	46	44	42	42	36	40
Clay %	24	24	26	20	22	36	40
Texture class	SCL	L	L	L	L	CL	C
Dispersed clay %	22	20	20	8	16	28	24
Flocculation index	8	17	23	60	23	44	40
pH-H_2O (1:1)	6.3	6.4	6.6	6.3	6.0	5.7	5.6
pH-KCl (1:1)	5.7	5.9	5.9	5.2	4.8	4.6	4.4
EC in mmho's/cm	0.13	0.11	0.10	0.12	0.10	0.11	0.10
C %	3.22	2.07	1.94	1.13	1.13	1.16	1.01
N %	0.60						
C/N	5.3						
CEC(NH_4OAc, pH7.0) me%	24.5	21.5	20.8	13.5	8.5	16.4	17.0
Exch. Ca me%	16.0	15.5	10.0	6.5	4.1	8.4	7.3
" Mg "	3.1	2.4	6.7	1.6	0.7	1.2	1.4
" K "	1.2	0.9	1.2	2.1	1.3	1.3	1.0
" Na "	0.2	0.1	0.4	0.4	0.3	0.4	0.6
Sum of cations me%	20.5	18.9	18.3	10.6	6.4	11.3	10.3
Base sat. % at pH7.0	84.0	88.0	88.0	79.0	75.0	69	61
CECv %				25			
Clay mineralogy:							
SiO_2/Al_2O_3				2.9		7.9	
SiO_2/R_2O_3				1.5		1.0	
Fe_2O_3 %				23.8		27.4	

X-ray report: B2 Amorphous material, traces of feldspars. No crystalline material.

IIB_2 Amorphous material. No crystalline material.

Fertility aspects:

Available Ca	me%	25.0	17.4
" Mg	"	3.4	3.4
" K	"	1.64	1.36
" Na	"	0.32	0.23
" Mn	"	0.60	0.55
P	ppm	34	15
1% EDTA extract			
Cu	ppm	1.2	1.2
Zn		8.0	6.0
Mn		146	54
Fe		195	180

Unit LP3 observ. 147/1-6

Soil classification: mollic andosol
Geological formation: ashes, soft tuff
Local petrography: ashes
Physiography: plateau
Relief - macro: flat to gently undulating
Relief meso-micro: nil
Vegetation/land use: bushland; maize and wheat growing
Surface stoniness: nil
Slope gradient: 2-4%
Salinity/Alkalinity: nil
Surface sealing: nil
Drainage: well drained

Horizon designation	Depth in cm	Description
A1	0-20	very dark grey (10YR 3/1 moist), sandy clay loam; massive; friable when moist; non sticky and non plastic when wet; diffuse wavy boundary
A3	20-40	very dark grey (10YR 3/1 moist), loam; weak fine subangular blocky structure; friable when moist, non sticky and non plastic when wet; diffuse wavy boundary;
B1	40-64	very dark grey (10YR 3/1 moist), loam massive falling apart to weak fine subangular blocky structure; friable when moist, slightly sticky and plastic when wet; diffuse wavy boundary;
B2	64-85	very dark greyish brown (10YR 3/2) loam; massive; friable when moist, non sticky and non plastic when wet; clear wavy boundary;
B3	85-97	dark greyish brown (10YR 4/2 moist), loam; massive; loose when moist, non sticky and non plastic when wet; diffuse wavy boundary.
II B2	97-109	very dark grey (10YR 3/1 moist), clay loam; massive falling apart to weak fine to medium subangular blocky structure; friable when moist, slightly sticky and plastic when wet; clear wavy boundary;
II B3	109-150+	dark yellowish brown (10YR 4/4 moist), clay; porous massive; friable when moist, slightly sticky and plastic when wet

LABORATORY DATA SHEET - SOIL PROFILE NO. 133/3-10.

horizon	A1	A3	B1	B21	B22
Depth in cm	0-34	34-62	62-96	96-120	120-140
Sand %	38	26	28	20	20
Silt %	42	46	24	52	40
Clay %	20	28	48	28	40
Texture class	L	CL	CL	L	C
pH-H_2O (1:1)	5.5	5.7	6.0	6.2	6.5
pH-KCl (1:1)	4.9	5.0	5.2	5.4	5.4
EC in mmho's/cm	0.13	0.10	0.13	0.16	0.18
C %	3.26	2.29	2.15	1.56	0.68
N %	0.34				
C/N	9.5				
CEC (NH_4OAc, pH7.0) me%	21.0	20.0	22.0	18.5	14.6
Exch. Ca me%	12.4	12.0	13.5	11.2	8.5
" Mg "	3.4	2.9	3.3	3.0	2.7
" K "	1.7	1.7	2.3	2.5	1.9
" Na "	0.2	0.3	0.5	0.8	0.8
Sum of cations me%	17.7	16.9	19.6	17.5	13.9
Base sat. % at pH 7.0	84	85	87	95	95
CECv %				25	
Clay mineralogy:					
SiO_2/Al_2O_3				1.6	
SiO_2/R_2O_3				0.9	
Fe_2O_3%				29.5	
X-ray report: B21	Amorphous material. No crystalline material				
Fertility aspects:					
Available Ca me%	10.6	9.8			
" Mg "	4.0	2.8			
" K "	1.46	1.46			
" Na "	0.20	0.36			
" Mn "	0.64	0.34			
P ppm	9	8			
1% EDTA extract					
Cu ppm.	1.2				
Zn	4.5				
Mn	135				
Fe	240				

Unit LP4 observ. 133/3-10

Soil classification:	nollic andosol
Geological formation:	soft tuff
Local petrography:	soft tuff
Physiography:	plateau
Relief - macro:	gently undulating
Relief meso-micro:	nil
Vegetation/land use:	forest and wheat growing
Erosion:	nil
Surface stoniness:	nil
slope gradient:	3-5%
Salinity/alkalinity:	nil
Surface sealing:	nil
Drainage:	well drained

Horizon designation	Depth in cm	Description
A1	0-34	black (10YR 2.5/1 moist), loam; strong very fine to fine crumby structure; friable when moist, non sticky and non plastic when wet; diffuse smooth boundary;
A3	34-62	black (10YR 2.5/1 moist), clay loam; strong, medium crumby structure; friable when moist, non sticky and non plastic when wet; diffuse smooth boundary;
B1	62-96	very dark greyish brown (2.5Y 3/2 moist), clay loam; massive; loose when moist, non sticky and non plastic when wet; clear smooth boundary;
B21	96-120	very dark grey (10YR 3/1 moist), loam; porous massive; friable when moist, slightly sticky and plastic when wet; clear smooth boundary;
B22	120-140	dark yellowish brown (10YR 4/3 moist) clay massive falling apart to weak very fine to fine crumby structure; friable when moist slightly sticky and plastic when wet

LABORATORY DATA SHEET - SOIL PROFILE NO. 132/4-6.

horizon	A1	A3	B21	B22	B3
Depth in cm	0-25	25-55	55-80	80-110	110-130
Sand %	32	22	40	52	50
Silt %	32	38	16	8	22
Clay %	36	40	44	40	28
Texture class	CL	CL/C	C	SC	SCL
Dispersed clay %	12	12	8	8	12
Flocculation index	55	70	82	80	57
pH-H_2O (1:1)	6.3	5.7	4.9	4.9	5.0
pH-KCl (1:1)	4.6	4.9	4.2	4.0	4.2
EC in mmho's/cm	0.18	0.11	0.08	0.07	0.06
C %	2.30	2.27	1.51	0.79	0.49
N %	0.38				
C/N	6.05				
CEC (NH_4OAc, pH7.0) me%	26	16	16	16	11.0
Exch. Ca me%	15.3	9.2	3.4	3.2	2.4
" Mg "	5.0	3.6	3.0	1.8	1.3
" K "	1.3	0.8	0.5	0.7	0.7
" Na "	0.4	0.2	0.3	0.3	0.2
Sum of cations me%	22.0	13.8	7.2	6.0	4.6
Base sat. % at pH 7.0	84.6	86.2	45.0	37.5	41.8
% CECv				28	
Bulk density	0.93			1.01	
Clay mineralogy:					
SiO_2/Al_2O_3			2.0	2.9	3.0
SiO_2/R_2O_3			1.0	1.5	1.6

X-ray report: B2, B22, B 3) Amorphous with traces of feldspars. Generally amorphous with traces of feldspars and traces of illite.

Fertility aspects:

Available Ca me%	18.2	5.2
" Mg "	3.6	2.8
" K "	0.96	0.66
" Na "	0.34	0.18
" Mn "	0.82	0.85
P ppm	25	15

R1

Unit RP1 observ. 132/4-6

Soil classification:	mollic andosol
Geological formation:	soft tuff
Local petrography:	soft tuff
Physiography:	foot ridges
Relief - macro:	undulating
Relief - meso-micro:	nil
Vegetation/land use:	forest/small holder cultivation
Erosion:	nil
Surface stoniness:	nil
Slope gradient:	5-7%
Salinity/Alkalinity:	nil
Surface sealing:	nil
Drainage:	well drained

Horizon designation	Depth in cm	Description
A1	0-25	black (5YR 2.5/1 moist), clay loam; massive, medium very fine granular structure; friable when moist, sticky and slightly plastic when wet; diffuse smooth boundary;
A3	25-55	black (5YR 2.5/1 moist), clay loam/ clay; massive, medium very fine to fine crumby structure; friable when wet; clear smooth boundary;
B21	55-80	dark reddish brown (5YR 3/2 moist), clay; porous massive falling apart to weak fine subangular blocky structure; friable when moist, sticky and plastic when wet; diffuse smooth boundary;
B22	80-110	dark reddish brown (5YR 3/3 moist), sandy clay; porous massive; very friable when moist, sticky and plastic when wet; diffuse smooth boundary;
B3	110-130	dark reddish brown (5YR 3/3 moist), sandy clay loam; porous massive; friable when moist, sticky and plastic when wet

LABORATORY DATA SHEET - SOIL PROFILE NO. 133/3-1

horizon	A1	A3	B1	B2
Depth in cm	0-25	25-48	48-66	66-125
Sand %	49	51	23	39
Silt %	26	20	32	20
Clay %	25	29	45	41
Texture class	SCL	SCL	C	C
Dispersed clay %	24	20	24	20
Flocculation index	4	34	47	51
pH-H_2O (1:1)	5.5	6.1	6.3	6.6
pH-KCl	5.0	5.3	5.5	5.5
EC in mmho's/cm	0.17	0.14	0.13	0.21
C %	4.21	2.85	0.37	0.32
N %	0.39			
C/N	10.8			
CEC (NH_4OAc; pH7.0) me%	28	26	24	21
Exch: Ca me%	13.4	12.0	12.4	9.4
" Mg "	4.2	4.1	3.8	3.4
" K "	1.2	1.2	1.8	4.3
" Na "	0.3	0.4	0.4	0.7
Sum of cations me%	19.1	17.7	18.4	17.8
Base sat. % at pH 7.0	68.2	68.0	76.6	84.7
% CECv			23	
Bulk density				1.02
Clay mineralogy:				
SiO_2/Al_2O_3			2.0	2.4
SiO_2/R_2O_3			1.1	1.2
Fe_2O_3%			32.4	33.1

X-ray report: B_1 Amorphous material. No peaks formed by the major clay minerals.

B_2 Generally amorphous material traces of feldspars. No crystalline material.

Fertility aspects:

Available Ca	me%	16.2
" Mg	"	3.4
" K	"	0.82
" Na	"	0.24
" Mn	"	0.75
P	ppm	16

RP2

Unit RP2 observ. 133/3-17

Soil classification:	mollic andosol
Geological formation:	soft tuff
Local petrography:	soft tuff
Physiography:	foot ridges
Relief - macro:	undulating to rolling
Relief - meso, micro:	nil
Vegetation/land use:	wheat growing
Erosion:	nil
Surface stoniness:	nil
Slope gradient:	5-10%
Salinity/Alkalinity:	nil
Surface sealing:	nil
Drainage:	well drained

Horizon designation	Depth in cm	Description
Ap	0-25	black (5YR 2.5/1 moist), sandy clay loam; medium fine crumby; friable when moist, slightly sticky and slightly plastic when wet; gradual smooth boundary;
A3	25-48	black (5YR 2.5/1 moist), sandy clay loam; weak fine crumby structure; friable when moist, sticky and plastic when wet; diffuse smooth boundary;
B1	48-66	very dark gray (5YR 3/1 moist), clay; massive falling apart to weak fine to medium subangular blocky structure; friable when moist, sticky and plastic when wet; clear smooth boundary;
B2	66-125	dark reddish brown (5YR 3/2 moist), clay; massive falling apart to weak medium subangular blocky structure; friable when moist, sticky and plastic when wet.

Remarks - the weathering tuff starts at 125 cm

LABORATORY DATA SHEET - SOIL PROFILE NO. 132/1-7.

horizon	A1	A3	B1	B21	B22
Depth in cm	0-30	30-50	50-70	70-89	89-120
Sand %	48	40	40	20	36
Silt %	12	18	14	28	20
Clay %	40	42	46	52	44
Texture class	CL	C	C	C	C
Dispersed clay %	12	16	20	20	21
Flocculation index	70	62	57	61	34
pH-H_2O (1:1)	5.1	5.4	5.6	5.8	6.0
pH-KCl (1:1)	4.4	4.4	4.5	4.8	4.9
EC in mmho's/cm	0.11	0.12	0.13	0.15	0.19
C %	2.28	1.63	0.86	1.22	0.93
N %	0.19	0.37	1.22		
C/N	12				
CEC (NH_4OAc, pH7.0) me%	14	15	18	24	21
Exch. Ca me%	6.4	8.2	9.6	10.8	10.7
" Mg "	3.2	2.6	2.5	3.1	3.4
" K "	1.2	0.7	0.9	1.1	1.6
" Na "	0.4	0.6	0.5	0.6	0.7
Sum of cations me%	11.2	12.1	13.5	15.6	16.4
Base sat. % at pH 7.0	80.0	80.6	75.0	65.0	78.0
% CECv				5	
Bulk density	1.02				0.97
Clay mineralogy:					
SiO_2/Al_2O_3			3.3	2.4	2.2
SiO_2/R_2O_3			1.8	1.3	1.2
Fe_2O_3%			26.6	25.9	26.6

X-ray report: B1, B21, B22) Generally amorphous with traces of feldspar. No crystalline material.

Fertility aspects:

Available Ca	me%	5.4	7.3
" Mg	"	2.1	2.4
" K	"	0.84	0.42
" Na	"	0.26	0.52
" Mn	"	0.82	0.85
P	ppm	14	16

Unit RP3 observ. 132/4-7

Soil classification:	nollic andosol
Geological formation:	soft tuff
Local petrography:	soft tuff
Physiography:	foot ridges
Relief - macro:	gently undulating to undulating
Relief - meso-micro:	nil
Vegetation/land use:	bushland/wheat growing
Erosion:	nil
Surface stoniness:	nil
Slope gradient:	3-6%
Salinity/alkalinity:	nil
Surface sealing:	nil
Drainage:	well drained

Horizon designation	Depth in cm	Description
A1	0-30	very dark gray (10YR 3/1 moist), clay loam; weak very fine to fine crumby structure; friable when moist, sticky and plastic when wet; diffuse smooth boundary;
A3	30-50	black (10YR 2.5/1 moist), clay; medium fine crumby structure; friable when moist, sticky and plastic when wet; diffuse smooth boundary;
B1	50-70	very dark grayish brown (10YR 3/2 moist), clay; porous massive falling apart to weak fine subangular blocky structure; very friable when moist, sticky and plastic when wet; diffuse smooth boundary;
B21	70-89	very dark grayish brown (10YR 3/2 moist), clay; porous massive falling apart to weak medium subangular blocky structure; friable when moist, sticky and plastic when wet; diffuse smooth boundary;
B22	89-120	very dark grayish brown (10YR 3/2 moist), clay; porous massive falling apart to weak fine subangular blocky structure; friable when moist, sticky and plastic when wet; clear wavy boundary;
C	120-150	mostly composed of weathering tuff

LABORATORY DATA SHEET - SOIL PROFILE NO. 132/4-8

horizon	A1	B2
Depth in cm	0-30	30-70
Sand %	43	49
Silt %	26	22
Clay %	31	29
Texture class	CL	SCL
Dispersed clay %	16	18
Flocculation index	48	37
pH-H_2O (1:1)	6.2	6.6
pH-KCl (1:1)	5.4	5.7
EC in mmho's/cm	0.20	0.13
C %	3.18	2.65
N %	0.39	
C/N	8.1	
CEC (NH_4OAc, pH 7.0) me%	31	24
Exch. Ca me%	19.0	13.0
" Mg "	4.2	2.0
" K "	2.7	1.8
" Na "	0.4	0.4
Sum of cations me%	26.3	17.2
Base sat. % at pH 7.0	84.8	71.6
Bulk density		0.81
Clay mineralogy:		
SiO_2/Al_2O_3		2.6
SiO_2/R_2O_3		1.6
Fe_2O_3%		32.0
X-ray report: B_2	Amorphous material, traces of feldspar. No crystalline material.	
Fertility aspects:		
Available Ca me%	21.0	
" Mg "	3.4	
" K "	2.00	
" Na "	0.40	
" Mn "	0.65	
P ppm	90	

Unit RP4 observ. 132/4-8

Soil classification:	mollic andosol
Geological formation:	soft tuff
Local petrography:	soft tuff
Physiography:	foot ridges
Relief - macro:	flat to undulating
Relief - meso-micro:	nil
Vegetation/land use:	bushland/wheat growing
Erosion:	nil
Surface stoniness:	nil
Slope gradient:	1-7%
Salinity/alkalinity:	nil
Surface sealing:	nil
Drainage:	well drained

Horizon designation	Depth in cm	Description
A1	0-30	black (10YR 2.5/1 moist), clay loam; medium crumby structure; friable when moist, sticky and plastic when wet; diffuse wavy boundary;
B1	30-70	dark brown (10YR 3/3 moist), sandy clay loam; light brown, few fine faint mottles; massive; friable when moist, sticky and plastic when wet

Remarks - below 70 cm there is a thick horizon indurated with weathering tuff which has polygonal structure which has some patchy parts of free line

LABORATORY DATA SHEET - SOIL PROFILE NO. 146/2-5.

horizon	A (A)	B2 (Bw2)	B3 (BC)
Depth in cm	0-37	37-60	60-82
Sand %	28	24	48
Silt %	32	38	16
Clay %	40	38	36
Texture class	C	CL	SC
Dispersed clay %	16	12	8
Flocculation index	60	68	77
pH-H_2O (1:1)	6.3	5.2	5.2
pH-KCl	5.1	3.7	3.6
EC in mmho's/cm	0.15	0.10	0.16
C %	1.07	0.53	0.44
N %	0.07	0.14	0.23
C/N	15.2		
CEC (NH_4OAc, pH 7.0) me%	14	18	17
Exch. Ca me%	6.8	2.8	3.8
" Mg "	3.8	1.6	1.5
" K "	1.5	1.7	1.3
" Na "	0.4	0.9	1.1
Sum of cations "	12.5	7.0	7.7
Base sat. % at pH 7.0	89.2	38.8	45.2
Bulk density	1.00	1.07	
Clay mineralogy:			
SiO_2/Al_2O_3		3.7	4.7
SiO_2/R_2O_3		2.1	2.3
Fe_2O_3 %		22.3	19.4
X-ray report: B2, B3	Entirely amorphous, traces of feldspars. No crystalline material.		
Fertility aspects:			
Available Ca me%	4.4		
" Mg "	2.6		
" K "	1.58		
" Na "	0.30		
" Mn "	0.70		
P ppm	16		

RS

Unit RP5 observ. 146/2-5

Soil classification:	mollic andosol
Geological formation:	soft tuff
Local petrography:	soft tuff
Physiography:	foot ridges
Relief macro:	gently undulating to undulating
Relief - meso-micro:	nil
Vegetation/land use:	bushland
Erosion:	nil
Surface stoniness:	nil
Slope gradient:	3-6%
Salinity/alkalinity:	nil
Surface sealing:	nil
Drainage:	well drained

Horizon designation	Depth in cm	Description
A1 RP	0-37	very dark grayish brown (10YR 3/2 moist), clay; massive falling apart to weak fine subangular blocky structure; very friable when moist, slightly sticky and plastic when wet; slightly calcerous; clear wavy boundary;
B2 RP	37-60	dark brown (10YR 3/3 moist), clay loam; weak very fine to fine crumby to weak fine subangular blocky structure; friable when moist, sticky and plastic when wet; slightly calcerous; diffuse wavy boundary;
B3 RP	60-82	dark brown (10YR 3/3 moist) sandy clay; few medium many mottles; porous massive falling apart to weak fine subangular blocky structure; friable when moist, sticky and plastic when wet; abrupt wavy boundary
IIR C	82+	composed of weathering tuff.

LABORATORY DATA SHEET - SOIL PROFILE NO. 147/1-7.

horizon	A1	A3	B1	B2
Depth in cm	0-33	33-62	62-74	74-100
Sand %	42	51	51	59
Silt %	16	16	28	8
Clay %	41	33	21	33
Texture class	C	SCL	SCL	SCL
Dispersed clay %	20	16	8	8
Flocculation index	51	52	62	46
pH-H_2O (1:1)	6.8	7.2	7.6	7.8
pH-KCl (1:1)	5.7	6.1	6.5	6.8
EC in mmho's/cm	0.26	0.21	0.23	0.35
C %	1.69	1.12	0.50	0.74
N %	0.40			
C/N	4.2			
CEC (NH_4OAc, pH7.0) me%	26	22	20	20.5
Exch. Ca me%	17.0	15.6	12.6	13.7
" Mg "	4.5	2.4	2.8	2.6
" K "	3.3	3.0	3.0	3.6
" Na "	0.4	0.6	0.6	0.6
Sum of cations me%	25.2	21.6	19.0	20.5
Base sat. % at pH 7.0	96.2	98.1	95.0	100
Bulk density	0.82			
Clay mineralogy:				
SiO_2/Al_2O_3			2.4	3.0
SiO_2/R_2O_3			1.4	1.7
Fe_2O_3%			25.9	20.6

X-ray report: B1 Entirely amorphous traces of feldspars. No crystalline material.

Fertility aspects:		
Available Ca me%	14.8	11.0
" Mg "	3.0	2.1
" K "	2.30	2.30
" Na "	0.30	0.31
" Mn "	0.55	0.58
P ppm	34	22

RP6

Unit RP6 observ. 147/1-7

Soil classification:	mollic andosol
Geological formation:	soft tuff
Local petrography:	soft tuff
Physiography:	foot ridges
Relief - macro:	gently undulating to undulating
Relief - meso-micro:	nil
Vegetation/land use:	bushland
Erosion:	nil
Surface stoniness:	nil
Slope gradient:	3-6%
Salinity/alkalinity:	nil
Surface sealing:	nil
Drainage:	well drained

Horizon designation	Depth in cm	Description
A1	0-33	dark brown (5YR 2.5/1 moist), clay; massive falling apart to medium fine crumby structure; friable when moist, sticky and plastic when wet; gradual smooth boundary;
A3	33-62	dark reddish brown (5YR 3/2 moist), sandy clay loam; porous massive; friable when moist, sticky and plastic when wet; diffuse smooth boundary;
B1	62-74	dark brown (7.5YR 3/2 moist) sandy clay loam; porous massive; friable when moist, slightly sticky and slightly plastic when wet; diffuse smooth boundary;
B2	74-100	dark reddish brown (5YR 3/2 moist), sandy clay loam; porous massive; friable when moist, sticky and plastic when wet

Remarks - the weathering tuff starts at 100 cm.

Unit PP1 observ. 146/2-4

Soil classification:	mollic andosol
Geological formation:	soft tuff
Local petrography:	soft tuff
Physiography:	plain
Relief - macro:	flat to very gently undulating
Relief - meso-micro:	nil
Vegetation/land use:	open bushland
Erosion:	nil
Surface stoniness:	nil
Slope gradient:	1-3%
Salinity/alkalinity:	nil
Surface sealing:	1-2 mm weak
Drainage:	well drained

Horizon designation	Depth in cm	Description
A1	0-20	dark brown (7.5YR 3/2 moist), clay loam; massive falling apart to weak very fine to fine subangular blocky structure; friable when moist, sticky and plastic when wet; slightly calcerous; clear smooth boundary;
B21	20-60	dark brown (7.5YR 3/2 moist) sandy clay; massive falling apart to weak very fine crumby structure; friable when moist, sticky and plastic when wet; slightly calcerous; diffuse smooth boundary;
II B22	60-90	dark brown (7.5YR 3/2 moist), clay loam; massive falling apart to weak fine to medium subangular blocky structure; firm when moist, sticky and plastic when wet; moderately calcerous, diffuse smooth boundary;
II B3	90-145	horizon composed of concreatinonary mass of weathering tuff- calcerous
II C	145-170	horizon composed of weathering tuff which feels loose when moist and grit when wet as if containing sand grains.

P1

LABORATORY DATA SHEET - SOIL PROFILE NO: 146/2-4.

horizon	A (A)	B21 (Bw1)	B22 (Bw2)	B3 (BC)	C (C)
Depth in cm	0-20	20-60	60-90	90-145	145-170
Sand %	24	47	24	32	32
Silt %	36	12	36	28	24
Clay %	40	41	40	40	44
Texture class	CL	SC	CL	CL	CL
Dispersed clay %	16	20	12	16	16
Flocculation index	60	52	70	60	86
pH-H_2O (1:1)	6.5	6.4	6.5	7.0	7.7
pH-KCl (1:1)	5.2	5.0	5.3	5.7	6.5
EC in mmho's/cm	0.15	0.16	0.19	0.30	0.40
C %	1.18	0.74	0.62	0.38	0.18
N %	0.16	0.14	0.17	0.23	0.23
C/N	7.3				
CEC (NH_4OAc, pH7.0) me%	20	20	22	26	27
Exch. Ca me%	11.6	11.1	13.2	14.8	16.0
" Mg "	3.0	4.0	3.8	4.6	4.4
" K "	2.9	2.6	3.1	4.7	5.0
" Na "	0.5	0.4	0.5	0.8	0.9
Sum of cations me%	18.0	18.1	20.6	24.9	26.3
Base sat. % at pH 7.0	90.0	90.5	93.6	95.7	97.4
% CECv				5	
Clay mineralogy:					
SiO_2/Al_2O_3		3.2	3.3	3.2	
SiO_2/R_2O_3		2.0	1.8	1.7	
Fe_2O_3%		17.3	21.6	21.6	

X-ray report: B21, B22, B3) Entirely amorphous, with traces of feldspars; no crystalline material.

Fertility aspects:

Available Ca	me%	6.4
" Mg	"	3.0
" K	"	2.0
" Na	"	0.20
" Mn	"	0.72
P	ppm	20

Unit PP2 - observ. 147/1-3

Soil classification:	nollic andosol
Geological formation:	soft tuff
Local petrography:	soft tuff
Physiography:	plain
Relief - macro:	flat
Relief - meso-micro:	nil
Vegetation/land use:	open grassland
Erosion:	nil
Surface stoniness:	nil
Slope gradient:	1-2%
Salinity/alkalinity:	nil
Surface sealing:	1-2 mm weak
Drainage:	well drained

Horizon designation	Depth in cm	Description
A1	0-30	dark brown (7.5YR 3/2 moist), clay loam; porous massive falling apart to weak very fine crumby structure; friable when moist, sticky and plastic when wet; diffuse smooth boundary;
A3	30-60	dark brown (7.5YR 3/2 moist), clay loam; porous massive, friable when moist, sticky and plastic when wet; slightly calcerous; diffuse wavy boundary;
B2	60-80	dark reddish brown (5YR 3/2 moist), clay loam; porous massive; friable when moist, sticky and plastic when wet; slightly calcerous; clear wavy boundary;
C1	80-98	dark reddish brown (5YR 3/2 moist), clay loam; massive, loose when moist, sticky and plastic when wet; slightly calcerous; abrupt wavy boundary
II C2	98-117	dark brown (10YR 3/3 moist), sandy clay loam; massive; loose when moist, sticky and plastic when wet; slightly calcerous;
II C3	117-150	weathering tuff

P2

LABORATORY DATA SHEET - SOIL PROFILE NO: 147/1-3.

horizon	A1	BW1 A3	B2	BW2 C1	C IIC2
Depth in cm	0-30	30-60	60-80	80-98	98-117
Sand %	32	24	40	39	54
Silt %	28	38	26	28	16
Clay %	40	40	34	33	29
Texture class	CL	CL	CL	CL	SCL
Dispersed clay %	8	8	6	4	8
Flocculation index	80	80	81	87	75
pH-H_2O (1:1)	6.1	6.4	6.3	7.0	7.2
pH-KCl	5.2	5.4	5.7	5.9	6.1
EC in mmho's/cm	0.13	0.15	0.18	0.21	0.25
C %	2.34	1.58	1.12	0.95	0.65
CEC (NH_4OAc, pH7.0) me%	26	24	26	27	28
Exch. Ca me%	13.5	14.8	15.4	17.6	16.8
" Mg "	5.3	4.5	4.6	4.7	4.9
" K "	3.2	4.0	4.2	3.4	3.4
" Na "	0.4	0.4	0.5	0.5	0.6
Sum of cations me%	22.4	23.7	24.7	25.8	25.7
Base sat. % at pH 7.0	86.1	97.7	95.0	95.5	91.7
% CECv				35	
Bulk density		0.90			
Clay mineralogy:					
SiO_2/Al_2O_3			2.1	2.9	2.1
SiO_2/R_2O_3			1.3	1.6	1.3
Fe_2O_3 %			21.6	22.3	23.8

X-ray report: B1, B21, B22) Amorphous material / No crystalline material detected.

Fertility aspects:

Available Ca	me%	15.2	14.8
" Mg	"	4.3	3.9
" K	"	2.70	2.10
" Na	"	0.28	0.36
" Mn	"	0.88	0.55
P	ppm	284	324