SOIL SURVEY AT MAHENENE RESEARCH STATION

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ABSTRACT

A detailed soil survey of the 33 ha cultivated land on Mahenene Research Station in the Omusati region, was completed by staff of the Namibian Ministry of Agriculture, Water and Rural Development in November 1997. The survey procedure was based on the grid method, entailing 123 augerings and 4 soil profile descriptions. The final map scale is 1:2 500. Only one main soil type, a ferralic arenosol, was identified. It was further divided into three soil mapping units, which were described.

This article briefly describes the location of the survey area, methods used, geology, preliminary agro-ecological zones, land forms, as well as the soil units. The limitations for agriculture are summarised.

INTRODUCTION

A detailed soil survey of part of Mahenene Research Station was executed in November 1997 by H. Mouton and J. Kutuahupira, under the auspices of the Agro-ecological Zoning (AEZ) Programme of the Ministry of Agriculture, Water and Rural Development (MAWRD). Soil mapping at Mahenene Research Station was done both to collect soil data for future applications such as land evaluation, and for practical training. The agricultural research technicians were given the opportunity to apply theoretical and practical knowledge gained through in-service training in soil survey and land evaluation procedures.

BACKGROUND

Location

Mahenene Research Station is located along the main road between Ombalantu and Ruacana in the Omusati region of northern Namibia. It's average co-ordinates are 17° 26" S and 14° 47" E (Figure 1). The size of the farm is approximately 140 hectares of which 33 hectares are cultivated land. The survey covered only the cultivated land, due to time constraints and the possibility of land mines on certain parts of the farm, as it had previously been used as a military base.

Agro-ecological Classification

On the Preliminary Agro-Ecological Zones Map of Namibia (MAWRD, 1997), Mahenene Research Station belongs to the Kal 9-4 zone: Kalahari Sands Plateau, Oshana flood system, having an average growing period of 61-90 days, with a very short dependable growing period (Figure 2).

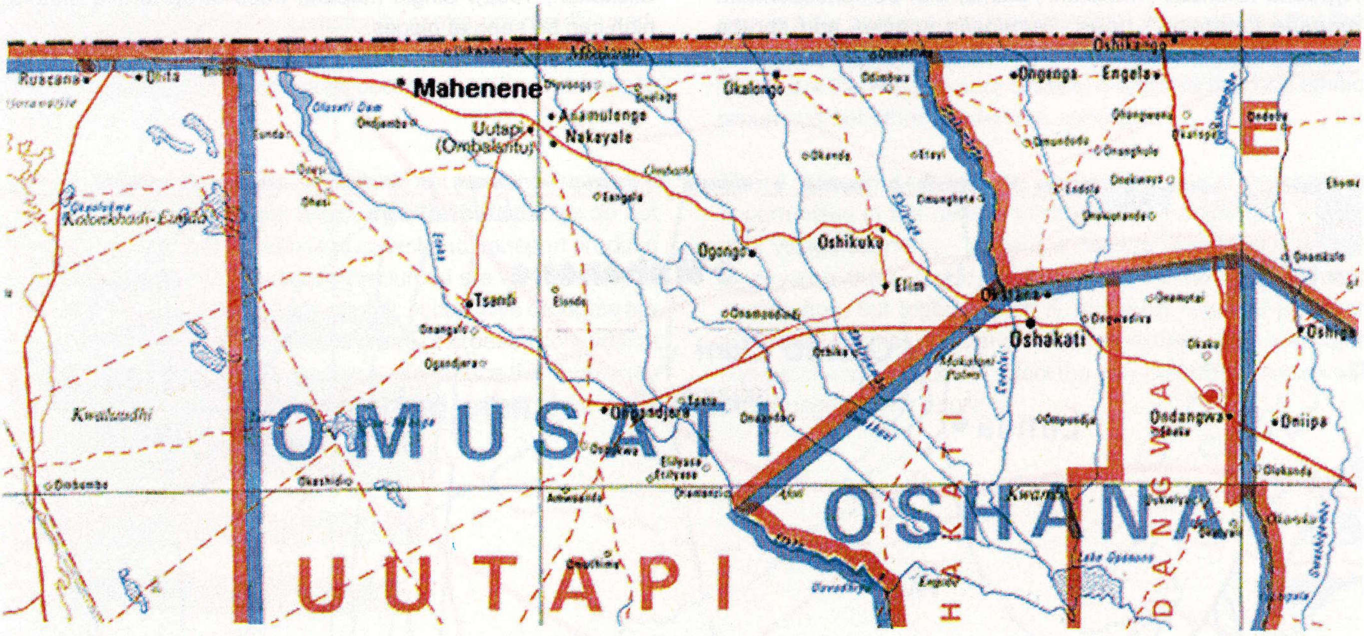

Figure 1. Location map of Mahenene Research Station in northern Namibia (Surveyor General, 1994).

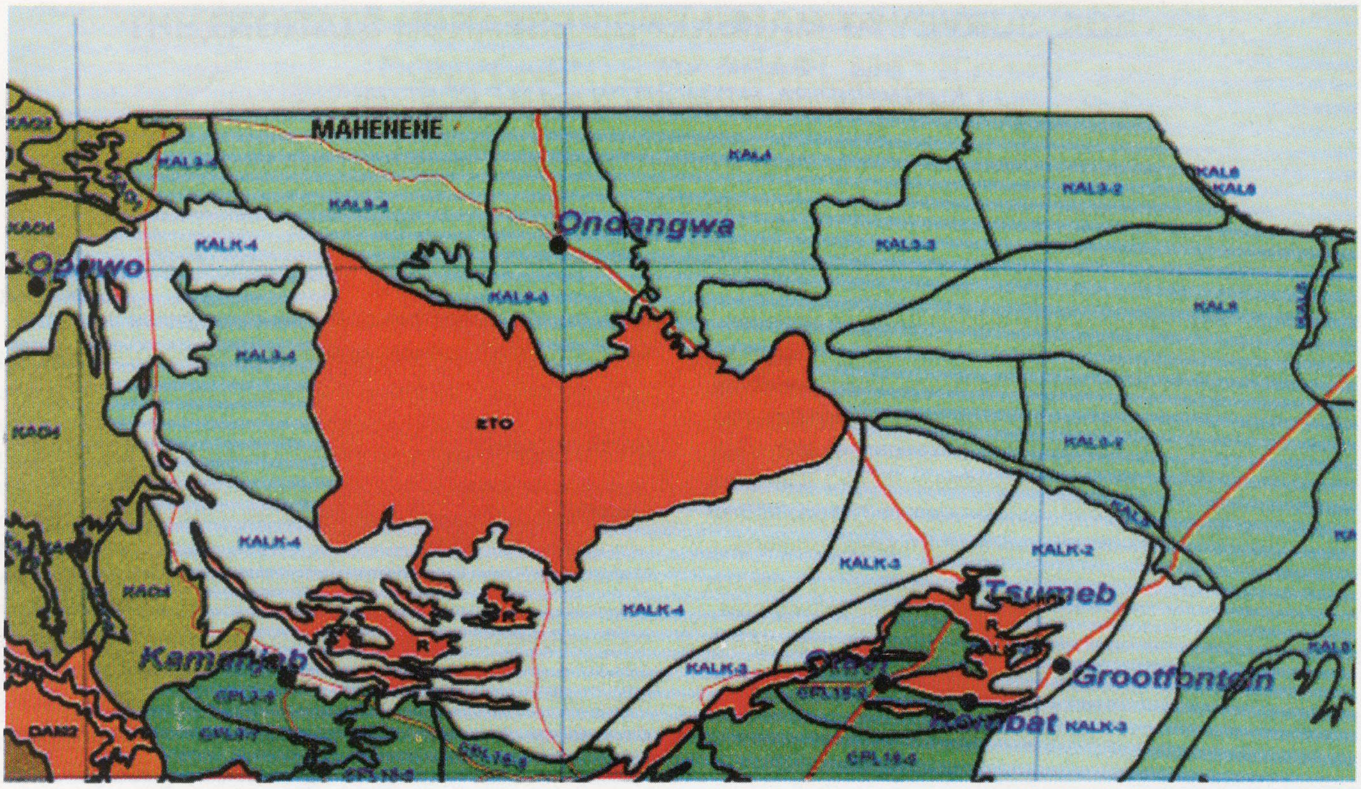

Figure 2. Location of Mahenene Research Station on the Agro-ecological Zones map of Namibia (Ministry of Agriculture, Water & Rural Development,1997).

Vegetation

The vegetation comprises a mosaic of mopane woodland and wooded grassland (Erkkila & Siiskonen, 1992), characterised by open grassy drainage channels ('oshanas') lined by *Hypaena ventricos* ('makalani') palms, with *Colophospermum mopane* ('mopane') trees, *Terminalia* species and shrubs dominating at higher elevations. *Acacia* species, *Adansonia digitata* ('baobab') and *Commiphora* species are common. The dominant tree species is *Colophospermum mopane*, which is greatly influenced by farming and grazing. Mopane woodlands are transformed into shrubland and pasture lands (Erkkila & Siiskonen, 1992). Single mopane trees of up to five meters high can be seen at places.

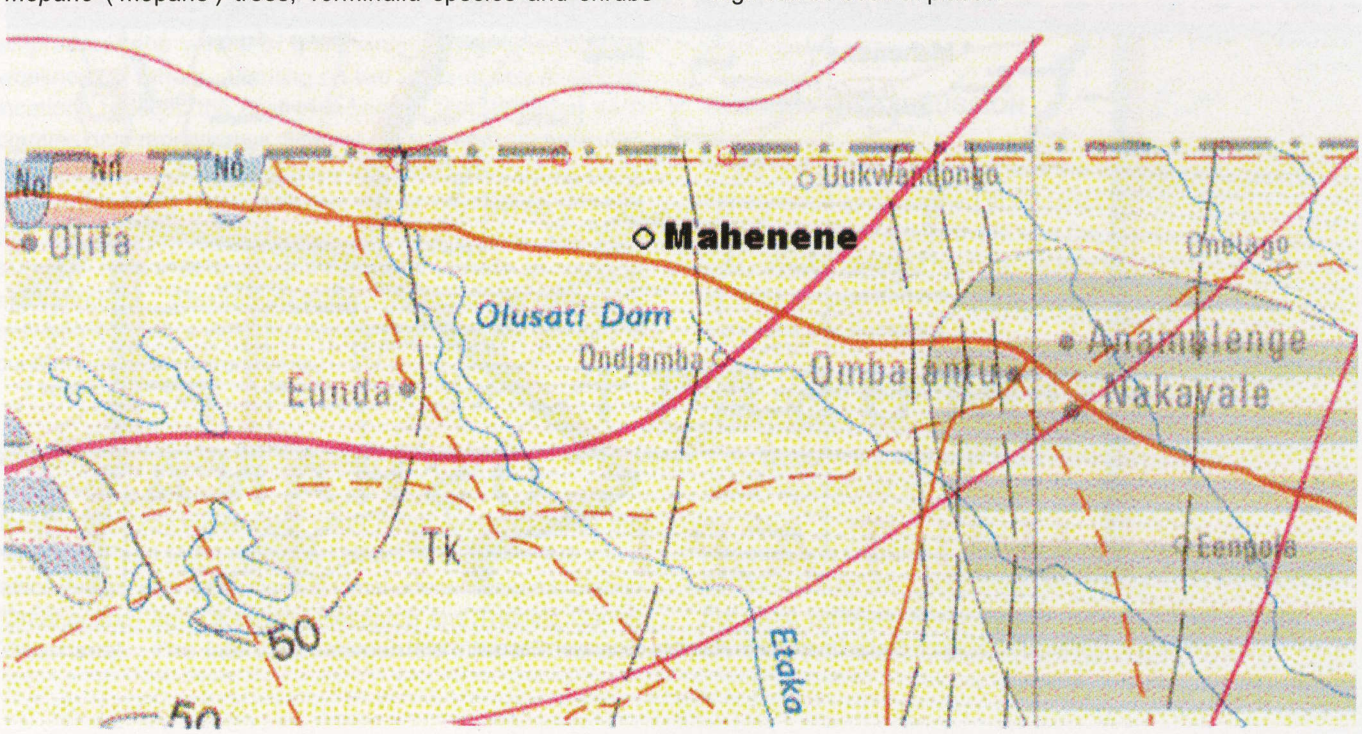

Figure 3. The position of Mahenene indicated on a part of the Geological Map of Namibia (Geological Survey, 1980).

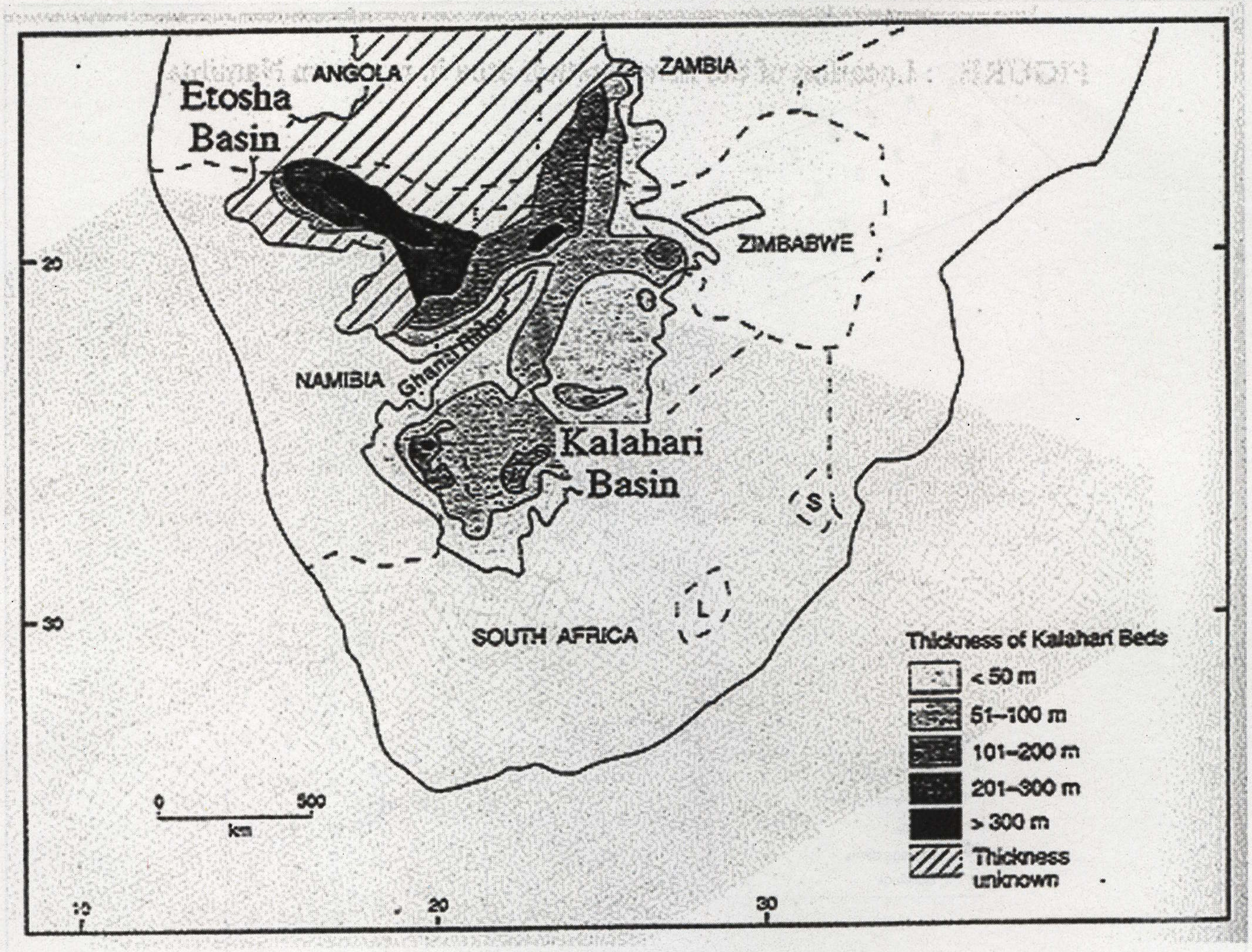

Figure 4. Distribution and thickness of the Kalahari Group sediments in southern Africa, constructed largely from borehole data (after Thomas, 1988).

Geology

The geological substrata is the Kalahari Group, composed of sand, calcrete and gravels - Tk and Tn on the 1: 1 000 000 Geological Map of Namibia (Geological Survey, 1980) (Figure 3).

In the Tertiary to Quaternary Kalahari Sequence, six major lithological components can be identified within the Kalahari group:

- conglomerate and gravels,
- marl (i.e. Grootfontein area),
- sandstone, mainly secondary duricrusts,
- alluvium and lacustrine deposits (swamps and pans),
- Kalahari sand, and
- duricrusts.

At Mahenene a mantle of sand completely hides underlying rocks. Sand is composed of quarts. The colour of the sand is commonly red, though in fact it is frequently ochreous and surface layers are sometimes bleached, particularly when the sand has been re-worked in water.

The precise origin of Kalahari sands is not known, but they probably originate from Karoo or Stormberg sandstone sediments. The term Kalahari sand is not applied to a homogeneous deposit, but to one which varies markedly in colour, composition, thickness and age. In northern Namibia, 200-300m of sand lie uninterrupted on lower Kalahari gravels and marl, or directly on Karoo rocks (Figure 4).

METHODOLOGY

Soil augerings, to a maximum depth of 100cm, were made according to the grid method, using a 50m grid. At each of the 123 augering sites, all horizons were described according to FAO terminology (FAO, 1990) in terms of texture, colour, presence of carbonates and surface characteristics such as erosion, surface sealing and hardpan formation (Figure 5). Samples were taken from some augerings. Texture was estimated with the ‘finger-test method’. Soil colour of dry and moist samples was described by comparison to colour chips in the Revised Standard Soil Colour Charts (Eijkelkamp, 1993).

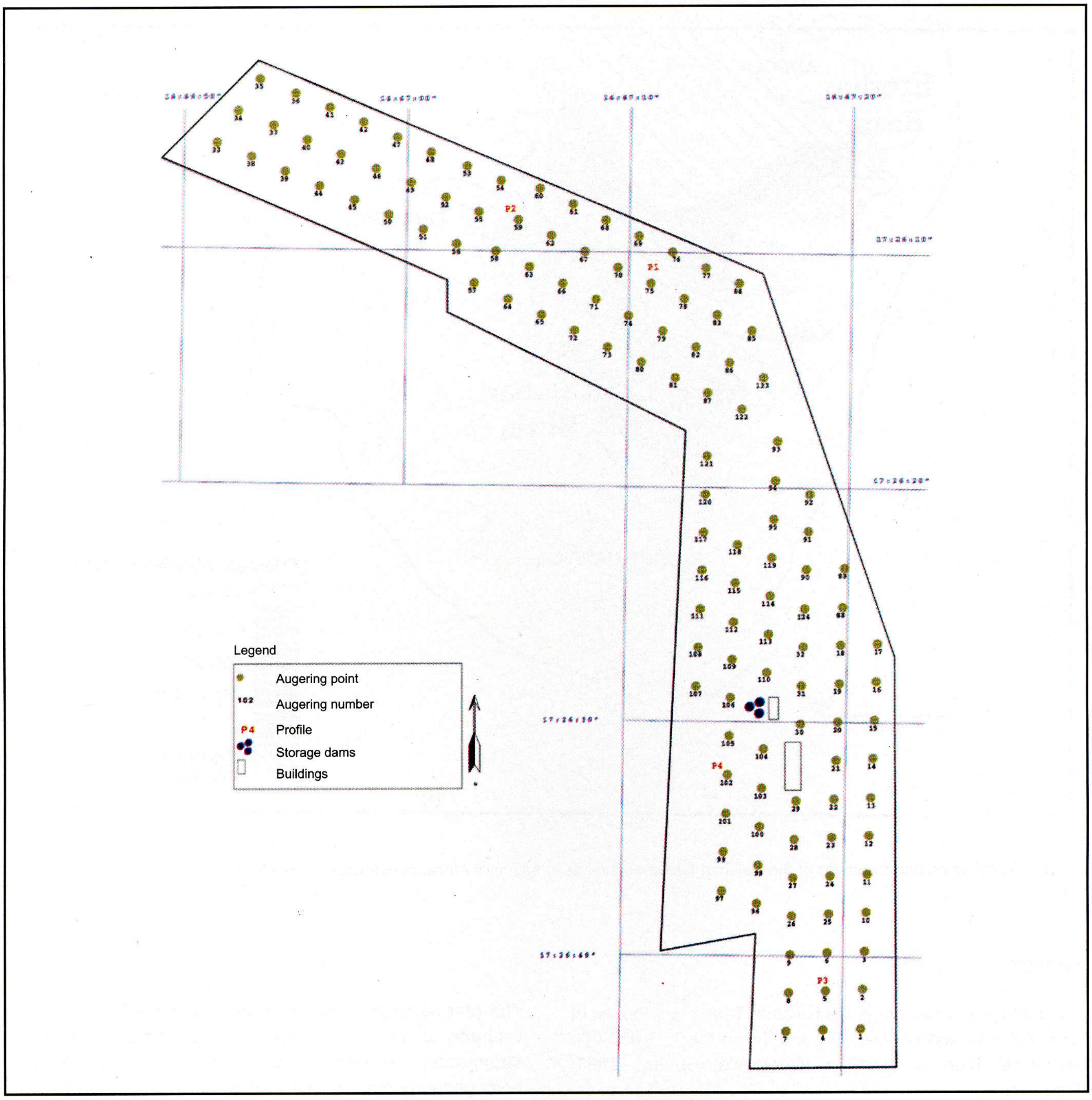

Figure 5. Location of Soil Augerings and Soil Profiles on Mahenene Research Station.

The presence of calcium carbonates was established by treating dry soil with 10% hydrochloric acid and observing the effervescence.

Four profiles pits were dug at representative sites and described in accordance with the FAO Guidelines for Soil Description (FAO, 1990) (Figure 5). Samples were collected from each horizon for physical and chemical analyses. The depth of profile pits ranged between 135cm and 175cm.

Laboratory analyses were done by the Agriculture Laboratory of MAWRD. Sixty-two samples were tested for pH (KCl), pH (H_2O), available phosphorus (Ohlsen method), exchangeable potassium, calcium, magnesium, sodium, cation exchange capacity, base saturation, electrical conductivity, particle size distribution (texture, according to the Bouyoucos method) and organic carbon.

Soils were classified using the soil classification system for Etosha/Northern Namibia (Beugler-Bell *et al.*, 1993) based on the updated FAO-UNESCO Legend of the World Soil Map (FAO-UNESCO, 1990). The final map produced is at detailed level, drawn at a scale of 1:2 500.

RESULTS

Soil Mapping Units

All the soils are Ferralic Arenosols. They can be subdivided into three soil mapping units by the colour of the B-horizons, indicating differences in intensity and duration of pedogenesis in relation to landscape position (Buch *et al.*, 1994) (Figure 6).

Deep reddish brown sandy soil [R1,s,H-h]

Rhodi Ferralic Arenosol (FAO, 1990; Beugler-Bell *et al.*, 1993)

Due to the intensive colouring, the soil is classified as a Rhodi Ferralic Arenosol. The soil texture is medium sand throughout the profile, with smaller amounts of fine sand in the topsoil. This soil occurs at higher elevation. When this soil is cultivated and ploughed, it develops a strong hardpan or ploughpan at shallow depth.

- The Ap1 horizon has a loose structure. Its thickness is 2-15 cm and its texture is sandy to loamy sand. Moist soil colour is brown (7.5YR 4/4 [2]) to dull reddish brown (5YR 4/3 [3], 5YR 4/4 [3], 2.5YR 4.4 [3]). This horizon is non calcareous with slight to very slight surface crusting.

- The Ap2 H-h reaches a depth of 20-50 cm. Texture is sandy to loamy sand. Moist soil colour is dull reddish brown (5YR 4/4 [3], 2.5YR 4/4 [3]) to reddish brown (5YR 4/6 [4]), occasionally with a slight to strong hardpan; non calcareous.

- The Bw horizon starts at a depth of 25-50 cm and has a sandy to loamy sand texture. Moist soil colour is dull reddish brown (2.5YR 4/4 [3]) to reddish brown (2.5YR 4/6 [5], 2.5YR 4/8 [5]); non calcareous.

Yellowish red sandy soil [YR1,s,H-h]

Chromi Ferralic Arenosol (FAO, 1990; Beugler-Bell *et al.*, 1993)

This soil is similar to the reddish brown (2.5YR) soil described above, but it shows less intensive red colouring. The B-horizon is reddish brown, with a hue of 5YR and chroma of 6 or more. This soil occurs at a lower position in the landscape than the reddish brown soil.

- The Ap1 horizon can be up to 35 cm deep at some places. Texture is sandy to loamy sand. Moist colour is brown (7.5YR 4/3 [6], 7.5YR 4/4 [2]) or dull reddish brown (5YR 4/4 [3]). This horizon has a loose structure with a very slight and sometimes no crust; non calcareous.

- The Ap2 reaches a depth of 20-50 cm. Texture is sandy to loamy sand. Moist colour is brown (7.5YR 4/3 [6], 7.5YR 4/4 [2]) or dull reddish brown[3] (5YR 4/3 [3], 5YR 4/4 [3]) to sometimes reddish brown (5YR 4/6 [4]), with a slight to strong hardpan; non calcareous.

- The Bw horizon starts at a depth of 25-50 cm. Texture is sandy to loamy sand. Moist soil colour is reddish brown (5YR 4/6 [4], 5YR 4/8 [4]); non calcareous.

Brown sandy soil [B1,s,H-h]

Xanthi Ferralic Arenosol (FAO, 1990; Beugler-Bell *et al.*, 1993)

- The Ap1 horizon is 1-12 cm thick. Texture is sandy to loamy sand. Moist soil colour is brown (10YR 4/4 [7], 7.5YR 4/3 [6], 7.5YR 4/4 [2]) to dark brown (7.5YR 3/3 [6]), sometimes dull reddish brown (5YR 4/4 [3]); non calcareous.

- The Ap2 reaches a depth of 25-50 cm. Texture is sandy to sandy loam. Moist soil colour is brown (7.5YR 4/3 [6], 7.5YR 4/4 [2]) to dull reddish brown (5YR 4/4 [3]); non calcareous.

- The Bw starts at a depth of 25-60 cm. Texture is sandy to loamy sand and sometimes silty clay loam. Moist soil colour is brown (5YR 4/4 [3], 5YR 4/6 [4], 7.5YR 4/4 [2], 7.5YR 4/6 [6]); non calcareous.

Analytical Results (MAWRD Agriculture Laboratory, 1998)

All the soils have low organic matter content and are slightly acidic. With one exception, all are low in soluble salts. Surface horizons are uniformly sandy in texture, while B and C horizons tend to be loamy sands in texture, with evidence of carbonate accumulation in some C horizons. The sand fraction is quite coarse. It is estimated that the maximum amount of available water storage will be about 60-70 mm/m in the surface 0-25 cm and 100-110 mm/m in the 25-100 cm zone. This will give an overal value of 80-90 mm/m in the surface meter. Most surface samples have medium to high levels of available phosphorus, probably as a result of fertilizer applications in the past. Surface samples have low cation exchange capacities, normally in the 2-5 meq/100g range. In the subsurface CEC rises normally to 6-10 meq/100g, due to higher amounts of clay at those depths. Most soils are 100% or >100% base saturated. A few samples show evidence of exchangeable acidity from the difference between pH in water and pH in potassium chloride, combined with base saturation values in the 40-75% range. There is considerable variability in the total amounts of exchangeable cations and their relative proportions. All combinations of low/high calcium, magnesium and potassium seem to exist. A few samples have moderate amounts of sodium.

[2] Munsell Soil Colour: dark brown
[3] Munsell Soil Colour: reddish brown
[4] Munsell Soil Colour: yellowish red
[5] Munsell Soil Colour: red
[6] Munsell Soil Colour: none
[7] Munsell Soil Colour: dark yellowish brown

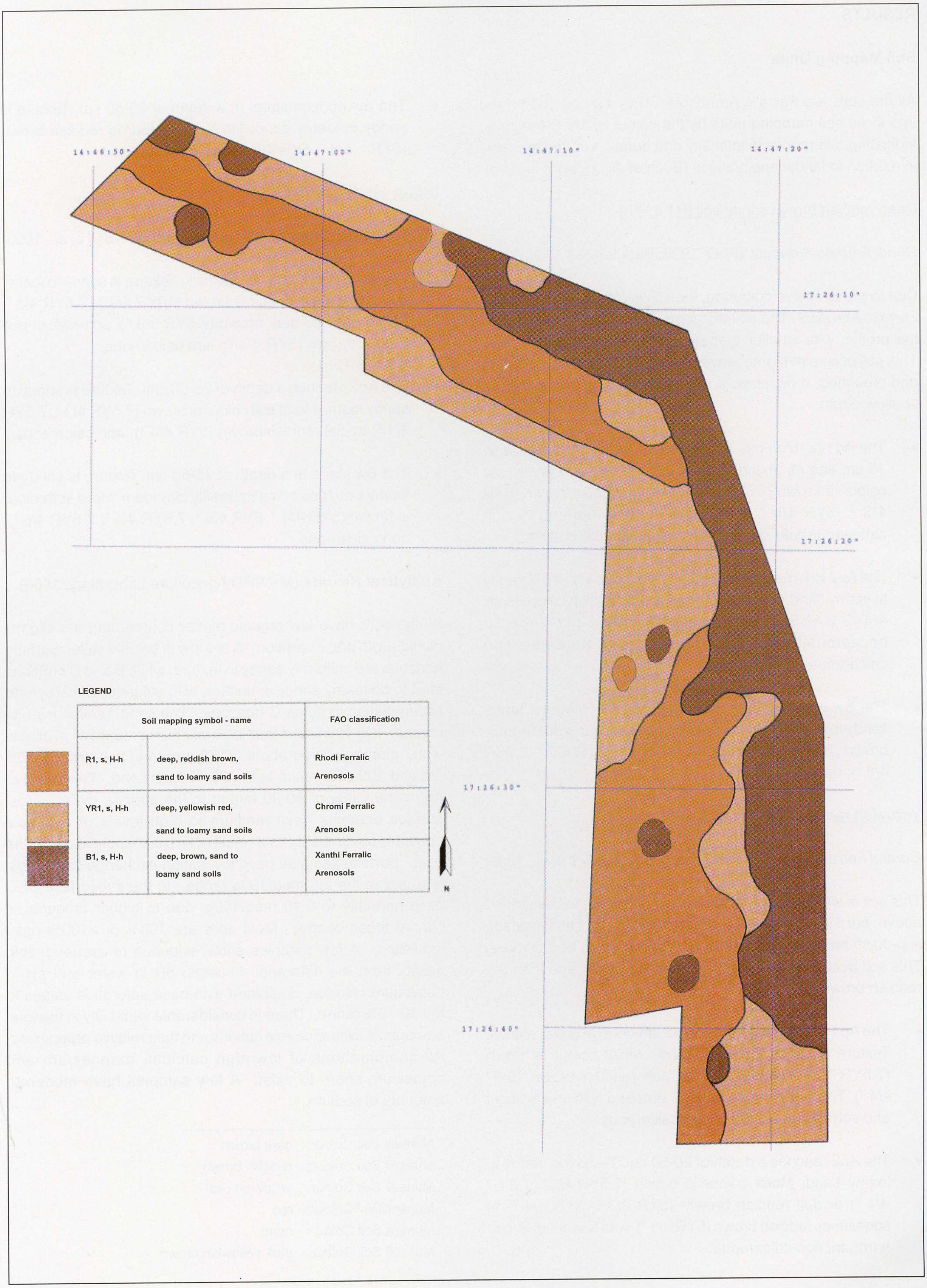

Figure 6. Detailed Soil Map of Mahenene Research Station (Uutapi district, Omusati Region).

INTERPRETATION

Field observations and laboratory analyses (MAWRD Agriculture Laboratory, 1998) indicate the following situations at Mahenene Research Station:

- Climatic suitability for crops and pastures is restricted by the year to year fluctuations of rainfall, reducing productivity.
- The low nutrient retention capacity, in terms of cation exchange capacity, of predominantly sandy topsoil strongly decreases productivity of grasses and crops.
- The general concentrations of calcium, magnesium and phosphorus do not indicate an immediate need for fertilization in these elements, though magnesium is sometime quite low deeper in the profile.
- Potassium is at low enough levels in some samples to warrant application of potassium fertilizer.
- The low organic matter content mean that only small amounts of nitrogen will be made available for crop growth each year. Under good rainfall conditions high response to nitrogen fertilization can be expected.
- The surface pH is acceptable for the growth of most crop plants. Slight acidity may improve the availability of micronutrients (which were not analysed for). The pH increases with depth due to the presence of calcium carbonate. This may be expected to reduce the availability of many plant nutrients, but may improve the availability of phosphorus.
- Excessive internal drainage and low water holding capacity, resulting from the sandy texture and low organic matter content, limit plant available water in upper horizons. These characteristics will severely limit crop production under the normally low and erratic rainfall conditions of the area.
- Rainfed production will be limited to drought tolerant crops such as millet and sorghum, that have a capacity for efficient use of available soil moisture. Productivity and range of crops can be increased markedly with irrigation.
- In agricultural lands hardpans have formed as a result of ploughing. This limits root distribution and, consequently, the soil volume that can be explored for nutrients and water.

For pearl millet and cowpeas, all three soil mapping units are only marginally suitable. All three soil types are moderately to marginally suitable for sorghum.

RECOMMENDATIONS

- It is recommended that crop residues should be left on the land. This practice will increase the organic matter content of the topsoil, return some nutrients to the soil, diminish wind erosion, diminish crust formation through raindrop impact, help to lower soil temperature and create a better living environment for beneficial soil microbes.
- Low organic matter content may be improved by the application of manure. It is recommended that cattle be kept on a layer of straw or crop residues when they are concentrated at certain sites. This will produce an effective manure, which can be used to improve topsoil fertility on agricultural lands.
- Inorganic fertilizers will have to be applied to raise the nitrogen and potassium levels, as both these nutrients are in short supply. Phosphorus, calcium and magnesium do not seem to be deficient at the moment, but have to be monitored in future. Nitrogen applications should be distributed in small portions throughout the rainy season, according to the needs of the specific crops.
- Ripping of the hardpan, or sub-soiling, during the dry season, is required. This will improve rooting depth and soil moisture storage.

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