SOIL RECONNAISSANCE SURVEY

PROPOSED DEVELOPMENT SCHEME

LINYANTI

EASTERN CAPRIVI/SWA-NAMIBIA

REP.SCH. IV - 01 - 88

15/3/2 - 01 - 88

M.B. SCHNEIDER

SENIOR AGRICULTURAL RESEARCHER

DEPARTMENT OF AGRICULTURE AND NATURE CONSERVATION

WINDHOEK

1988

SOIL RECONNAISSANCE SURVEY

PROPOSED DEVELOPMENT SCHEME

LINYANTI

EASTERN CAPRIVI/SWA-NAMIBIA

REP.SCH. IV - 01 - 88

15/3/2 - 01 - 88

M.B. SCHNEIDER

SENIOR AGRICULTURAL RESEARCHER

DEPARTMENT OF AGRICULTURE AND NATURE CONSERVATION

WINDHOEK

1988

Content:

1. INTRODUCTION

A soil reconnaissance survey was carried out at Linyanti, 83 km south west of Katima Mulilo in the Eastern Caprivi Strip (see annexure I)
The survey area (less than 60ha), which has been selected for a proposed irrigation and settlement scheme by the Administration for Caprivians, is situated 2km east of Linyanti Village, close to the gravel road linking Katima Mulilo with Kongola Bridge.
Field work (soil mapping, soil profile description and soil sampling) took place during the period November 16th to November 27th, 1987, mainly to obtain information on the existing soil forms, soil series and the main physical soil characteristics. Soil profiles were described to identify the main soil forms. 20 soil samples were collected and analysed in terms of their physical and chemical composition and properties (i.e. phosphorus, potassium, calcium, magnesium, copper, zinc, manganese, boron, pH, resistance and texture). The analytical results as well as the necessary fertilizer recommendations are attached as annexure II to this report.
In addition the particle size distribution of all samples was determined and the textural class was identified. A fertilizer recommendation for maize based on the analytical results of all soil samples is also included in this report. A detailed geographical location map of the survey area, as well as the relevant soil map are attached to this report as annexure I.
Climatic data and detailed information on the vegetation of the survey area is available from previous reports and is therefore not dealt with in the present version.

2. SURVEY AREA

2.1 Description and location

The proposed settlement and irrigation scheme which was surveyed is located app. 80km south west of Katima Mulilo, situated approximately 2km north east of Linyanti Village and 1,5 - 2,0 km from the Linyanti River. The area lies between 18° 00' + 18° 05' latitude and 24° 00' and 24° 05' longitude (see annexure I) close to the Linyanti flood plain at an average altitude of 930m above sea-level.

2.2 Physiography

Geologically the survey area belongs to the Kalahari System (COOKE, 1964). The Kwando/Mashi/Linyanti and Chobe flood plains (including the Molapo drainage systems in the Easter Caprivi) are confined by a number of extensive parallel north-east trending faults (JONES, 1962). The entire region lies within an area of continuing earthquake activity. The faults control the imponding not only of the Zambesi swamps but also parts of the Linyanti and Chobe rivers. Tonal contrasts along these rifted grabens suggest a profound influence of this phenomenon on the distribution of soils and vegetation not only in the survey area.

The regional distribution of morphologically different soils in the survey area are mainly the result of the depositional history associated with the imponding of the Zambesi River and its tributaries.

Down warping of the Zambesi River at Katima Mulilo deranged the flow of the river system, thus causing periodic flooding (during high peak flow periods) of the former aeolian landscape.
Deposition of river transported silt and clay on sand between higher lying sand ridges is the major factor influencing the soil pattern of the area investigated.
The sand, which may primarily be of Pliocene age and which was redistributed during the Pleistocene age (Quarternary), covers the area in several meters of reddish-brown to greyish sand of the so called Kalahari type. Only several hundreds of meters below the sand, original rock formations can be found. A forest of large trees grows in the deep sands, whereas the vegetation of the different molapos is almost restricted to shrubs and grass.
The deposition of silt and clay was followed by a drier period characterized by the colluvial downslope movement of the sand and the associated covering of parts of the deposited clay and silt along various river fringes.
This lead to a major levelling of the whole landscape in the eastern Caprivi. The present geomorphological appearance is therefore one of an almost flat sandy plain with a complex distribution of round and elongated slight depressions with clayey bottomlands. In some areas the clayfilled former interdune regions have been incised subsequently and filled with sand during teh colluvial levelling of the Caprivi. In contrast, before the structural changes, the region was probably slightly undulating with broad dunes and a very uniform distribution of soils and vegetation (HARMSE & NEL, 1987).

The result of these phenomenas associated with the faulting, flexural movements, colluviation and subsequent soil formation, is a recurrent catenary sequence of soils as being investigated also at Linyanti.

3. MAIZE REQUIREMENTS

3.1 Moisture requirements

Best production is obtained in areas having rainfall between 600 and 1 000 mm of rain, though irrigated maize in warm, sunny areas produces highest yields with more than 1 000 mm of water.

Maize uses about half it's seasonal intake of water during the five weeks after maximum leaf area is produced, which is at about tasseling stage. Moisture supply must be adequate at this time. Correct time of planting will, on average, ensure that the crop does not suffer from moisture stress at flowering. A study of rainfall porbabilities of a locality and cultivar characteristics will enable selection of planting dates for that locality and the cultivar best suited to it.

Moisture is used more efficiently when the nutritional requirements of the crop are adequately balanced.

It has been estimated that about 92 000 litres of effective rainfall are needed to produce 100 kg of maize grain. 92 000 litres is equivalent to about 10,7 mm of rain. Effective rain fall is that part of the total rainfall effectively used in crop production.
It includes.

- the moisture transpired by the crop
- the moisture used by the crop in manufacturing foods,
- the moisture retained in the crop,

but excludes

- runoff
- drainage
- moisture used by weeds
- moisture retained in the soil

3.2 Soil requirements

Maize may be grown on almost any soil type provided

- there is an adequate supply of moisture
- there is a balanced supply of nutrients for the crop needs
- the soil acidity is not too low, or acid saturation should not be more than 0,25%
- the soil is not continually waterlogged during the growing season
- erosion is not a problem and can be controlled

Maximum production is obtained from fertile, well drained, aerated, deep loams and sandy loams having an abundance of readily available soil nutrients, and moisture being not limiting.

In climates that tend to droughtiness as in the Caprivi, soils that hold their moisture, are on average higher yielding than well drained soils that dry out rapidly.

Soils that are not recommended for maize production are
- shallow clay pan soils
- shallow soil on rock

For grain yields in excess of 4 00 kg/ha under dryland production, a minimum soil depth of 60 cm is recommended.

3.3 Irrigation of sandy soils

In irrigation development projects involving sandy soils the irrigation method must be considered very carefully.
In general surface irrigation methods are not the most suitable for sandy soils whether by basin, border or furrow. The high permeability and the low water storage

capacity make it very difficult to apply the correct amounts of water. Irrigation of sandy soils may lead to water wastage by deep percolation and low irrigation efficiencies of less than 50 per cent. Moreover the yield of crops may also be affected by bad uniform application. The lowest parts of fields often do not receive enough water to meet their requirements whereas the upper parts are generally over-irrigated. Nutrients are carried away and micro-elements are frequently lacking. Usually under normal conditions, surface irrigation methods are not recommended for sandy soils.

Sandy soils have a low pore space and a high infiltration rate. The consequences of these two features on irrigation systems and methods are of great importance. The low pore space is responsible for a low water holding capacity. Consequently the frequency of irrigation and labour requirements are highly independent of the irrigation method used. Labour requirements can be reduced but the initial cost of equipment is then considerably increased. The high infiltration rates make surface irrigation very difficult and an important objective is to avoid losses when applying water to the fields. The adaptation of surface irrigation, when possible, requires higher investment costs for increased length and size of canals, canal lining, large number of small plots and eventually special on-farm equipment.
On the other hand high infiltration rates have little influence on sprinkler irrigation. This method can therefore be considered as the best for sandy soils. It will lead to acceptable efficiencies if properly designed and managed. Drip irrigation is a promising method but its cost is still quite high. In any case irrigation of sandy soils requires a good deal of knowledge and skill. Guidance should be provided to farmers by a well organized irrigation education programme.

4. SURVEY METHODS

4.1 Mapping scale

Topographical maps used for mapping in the field were at a scale of 1:250.000. The final soil map, however, accompanying this report (see Annexure I) is drawn at a scale of 1:5000, using the 1:50 000 scale orthophoto maps as an additional information source. The maps representing the survey area are No.: 17 1/2 22 Kwando and 1724 Katima Mulilo at a scale of 1:250.000. Additional information sources were made available through the SWA Territory Forces.

4.2 Profile description

Various soil profile pits were dug to describe and classify the range of soils occurring in the survey area using the South African Binomial System (MACVICAR et.al., 1977). On the basis of profile descriptions and augering, two main soil forms (Clovelly-and Vilafontes Soil Forms) were encountered and the soil map, including the legend, were modified accordingly (see Annexure I).

Root development was limited to the topsoil (approximately 30 - 35 cm). At that level, the soil is dark-grey throughout owing to the damp conditions, in contrast with the much lighter hue of the subsoil. This contrast held true for the adjacent veld as well, according to profile holes dug there, confirming that the roots of grass, in particular, were confined to the topsoil layer.

Soil texture consists mostly of fine sand - probably blown there by the wind, although some of it may be alluvium from the adjacent Linyanti River.
Initially, the intention was to distinguish between soil-types in terms of differences in colour and texture. Laboratory tests, however, proved such differences to be of secondary importance. In respect of the moisture-retention capacity of the soil, smaller variations in value occur.
Details of test hole No. 156 may be used as a general profile description of the area:

Topsoil (0 - 35 cm):	grey-brown (5YR-4/2) fine sand, moderately soft (in dry conditions), structureless, good root distribution, changing sharply to -
Subsoil (35 - 70+ cm)	pale yellow-brown (10YR-5/4) fine sand, soft (in damp conditions), structureless, hardly any roots, isolated old, larger root channels, a few pieces of charcoal (probably old, burnt-out roots of trees or shrubs), no signs of drainage having been disturbed (e.g. reduction stains).

(Colour differences usually occur as a grey-black topsoil in the vicinity of test hole No. 169 and a dull reddish-brown soil profile in the area surrounding test holes No.'s 170 and 171.)

5. SOILS

5.1 Sandy soils

The aridity of the climate in the Caprivi is responsible for the slow chemical weathering and soil formation of the sandy soil body. The sparse vegetation cover coupled with high soil temperature is the cause of the low organic matter content and biological activity in the soil. Carbonates, gypsum and salts may be present at some level depending on the penetration depth and intensity of rainfall. Generally, all sandy soils are weakly developed.

Calcification and gypsification are the main soil forming processes. Under strong winds which promote sand and dust storms, the upper layer is either blown off or buried under aeolian deposits depending on the topography. Sandy soils are generally poor in plant nutrients and the nutrients applied to these soils are lost because of irrigation water. Fertilization of these soils is therefore a necessary practice. Sandy soils with sand and loamy sand texture deserve special considerations since they have a larger percentage of sand fractions that adversely affect their agricultural potentialities. Sands being noncoherent and structureless are erodible. Although they have a high specific gravity and low total porosity, their pores are large and contribute to good aeration, rapid drainage and low water holding capacity. The low specific surface area of sand is a main factor affecting their low surface activity and explains dissimilarities from clays in their physical behaviour.

Sandy soils are often described as droughty. Their low available water range, high infiltration rate and rapid redistribution affect their irrigation practices and agricultural potentialities. The water transmitting properties of sands encourage upward water movement when they are wet and discourage it when they are dry.

5.2 Previous surveys

Very few and small soil surveys have been carried out in the Caprivi in the past. However, detailed soil surveys for small scale irrigation purposes did not permit the inclusion of results from these surveys due to the shortage of detailed analytical data related to the survey area. Detailed agro-climatic data and general information on the vegetation in the Caprivi however is available through reports by the Administration for Caprivians at Katima Mulilo and through the Department of Agriculture and Nature Conservation in Windhoek (Soil Science Section).

5.3 Soil types and main characteristics

During the soil survey two main soil forms were identified and subdivided into different soil series. Owing to the homogenity of the aeolian sand in the survey area, the whole region is pedologically homogeneous and most soil series occur fairly extensively (compare soil map). The series are mostly the sandy series within each form and differ mainly in colour. More than 80% of the analysed soils contain sands in amounts up to 90%. The humus content determined in the topsoils from the different sites is quite low and the percentages are always less than 3%. The soil reaction of the analysed samples appeared to be between 5,0 and 8,7 (i.e. moderate acid to moderate alkaline). The rainfall is sufficient for dry cultivation (under drip irrigation systems experimental orchards could be set up also for subtropical fruit trees), but run off during heavy thunderstorms and the lack of humus makes the shortage of water in high sandy soils worse than the actual shortage of rainfall. Dry periods are very common between the first rains and they can cause difficulties even though the question of drought is reduced. Thus there are opportunities for farmers to organize more reliable water supplies through irrigation from water available at the nearby Linyanti River.

The soil developed on the described parent material were identified as those series belonging to the Clovelly-and Vilafontes Soil Forms. They are the dominating group of soils also found in other areas of the Eastern Caprivi.

5.4 Analytical data

20 Soil samples have been collected from the survey area which is proposed to become utilized. Each sample (No.'s: 151 - 156 and 158 - 171) has been collected from a different site and the precise location is indicated on the soil map (see annexure I).

Analytical data includes results on: Phosphorus and potassium (in mg/kg; method: Citric Acid), calcium and magnesium (in mg/kg; method: Eksteen), exchangeable zinc, Copper, Manganese and Boron (in mg/kg; method: EDTA), pH in KCl, resistance and texture class. The results are attached as annexure II to this report.

It is obvious that the sandy soil with low clay content is also consistently poorly buffered and has a poor cationic status as well. Potassium (K) and phosphorus are low, and the supply of K and P requires special attention for successful crop farming.

Most of the pH values are close to neutral and indicate no built up of salt in the subsoil. Overirrigation is thus not necessary.

The analytical data reveal that sound management, in respect of crop nutrition and irrigation, is of particular importance. To this end, a centre pivot irrigation system is decidedly an efficient means of achieving success. The possibility of planting on ridges, as an alternative to deep tillage as a means of promoting root development and to improve crop growth and yield, is well worth investigating.

With regard to the proposed citrus orchard, micro-irrigation should be used.

5.5 Soil fertility

Restrictions on agricultural production due to soil nutrient deficiencies are removed simply by applying appropriate fertilizers. The easiest way to increase production in most countries is to increase the general use of fertilizers. The problem that arises is that the cost of using fertilizers is never negligible and may be considerable, or even prohibitive, relative to the economic resources of farmers. In general it is not economical to attempt to eliminate deficiencies and maximise production in the short term by massive applications of fertilizers. Rather, lesser, economic rates of fertilizer application have to be chosen with due allowance for the costs involved, the value of the crops, expected responses, risks, other demands on capital resources, and so on. In other words, fertilizer rates have to be chosen primarily for the economic benefit of farmers, the elimination of deficiencies and the maximisation of production following in the long term from the resulting progressive build-up of soil fertility by fertilizer residues.

5.6 Soil acidity and trace element deficiencies

None of the samples has a lime deficiency.

Some soil samples have pH values larger than 6.0 and together with the sandy texture and manganese content of less than 5 ppm, may cause manganese deficiency symptoms in maize. Foliar feeding with manganese may thus be necessary.

Almost all the soils have a zinc deficiency and the application of a zinc-containing fertilizer before planting or sowing is recommended.

There are some soils with deficiencies in copper and/or boron. Where results have been underlined, fertilization with these elements before planting is necessary.

Fertilizing

All the soils have a low phosphorus content and high concentrations should be applied. Most soils also need a potassium supplement.

The necessary fertilizers can be applied before sowing or planting.

Under irrigation it would furthermore be desirable to apply 250,200 and 100 kg KAN per HA AT 2, 5 AND 7 weeks after germination.

5.7 Fertilizer requirements

According to the soil analysis (see annexure II), fertilizer recommendations have been worked out to increase the levels of phosphorus (superphosphate 10,5%), and potassium (potassium chloride 50% K) as well as the general application of nitrogen (LAN 28).
Based on all analysis which represent an area of app. 60 ha the following amounts of fertilizer are required (minimum yield target: 6 t/ha):

Prices (ex factory KYNOCH-RSA -02/1988):

1. 60 t supers (10,5%) (bandplacing may reduce total amount — Rand 376.00 per ton (22.560, -R)
2. 4,5 t potassium chloride, — Rand 452.00 per ton (2034, - R)
3. 39 t LAN 28, — Rand 370.00 per ton (14.430, - R)
4. Micronutrient mixtures:
   - 1,5 t Zinc sulfate ($ZnSO_4$), to be worked in before planting,
   - 250 kg Solubor to be worked in once before planting through the irrigation system or when applying herbicides

5. Rand 150. -/200.- per ha (x 60 ha: 12.000. - Rand) as initial costs for the control of pests, diseases and weeds in maize (personal communication: BAYER Chemicals-Windhoek, Mr. Rohwer).

Prices for mixtures as mentioned under 4 (ex factory RSA - 02/1988):

- Zinc sulfate Rand 0,97 per kg (1455, - R)
- Solubor Rand 3,90 per kg (975, - R)

Total (initial) amount necessary for fertilizers per 60 ha:

R41,454,-

6. REFERENCES

COOKE, H.B.S. (1964): The pleistocene environment in Southern Africa. Ecological studies in Southern Africa by Davis, D. et.al. p. 1-23.

VON M. HARMSE, H.J. (1987): Preliminary notes on geomorphological and associated processes in Eastern Caprivi. - Abstracts 14th Congress Soil Science Society of South Africa, p. 93.

JONES, M.T. (1962): Reports on a photogeological study of the area between the Okavango Swamps and the South West Africa border. - Unpublished report, Botswana Geol. Surv., Lobatse.

MACVICAR, C.N., DE VILLIERS, J.M., LOXTON, R.F., VERSTER, E., LAMBRECHTS, J.J.N., MERRYWEATHER, F.R., LE ROUX, J., VAN ROOYEN, T.H., & VON M. HARMSE, H.J. (1977): Soil Classification - A Binomial System for South Africa. - Dep. of Agriculture Technical Services; Science Bulletin 390.