**Humisphere**

# SOIL RECONNAISSANCE MISSION TO 3 ESTATES IN TANZANIA

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## 1. INTRODUCTION

By order of FORM International, Hattem, The Netherlands, a mission to Tanzania was carried out in order to investigate the soil suitability for growing teak in 3 estates in Tanzania where at present sisal is grown. It concerns Kwamdulu and Kwaruguru estates near Korogwe and Kilimangwido estate near Pangani. The mission was carried out together with Paul Hol and Mans Vroom of FORM International, from 9 to 15 September 2012.

## 2. SOIL INFORMATION OBTAINED

The following reports were obtained from the International Soil Reference and Information Centre (ISRIC);

- Soils of Kwamdulu Estate and their potential for hybrid sisal cultivation. National Soil Service Mlingano, Tanzania (1988).
- Soils of Mwera Estate and their potential for hybrid sisal cultivation. National Soil Service, Mlingano, Tanzania (1988).
- The potential for hybrid sisal cultivation of four Amboni estates in Tanga region. National Soil Service, Mlingano, Tanzania (1988).
- Hartemink, Alfred E, (1995). Soil fertility decline under sisal cultivation in Tanzania. ISRIC Technical paper no 28.
- Soil map of Korogwe district
- Soil map of Handeni district

From the reports of Kwamdulu and Mwera estates the soil map 1:20.000 were missing. The soil map of Kwamdulu was however found in the office of the estate. A copy of the soil map of Mwera estate was obtained from Mlingano Institute.

During the mission Mr. Joseph Mbogoni and Mr. Godson Urassa from the Mlingano Institute have been consulted. According Mr. Mbogoni Kwamdulu and Kwaruguru estates are part of the same soil unit of the recently updated soil map of East Tanzania which is part of the project to produce a map with agro-ecological zones of Tanzania. Mr Mbogoni supplied additional information about this soil unit.

A paper copy of the soil map of Mwera estate and digital copies of some district soil maps were supplied by Mlingano Institute.

## 3. SOILS OF KWAMDULU ESTATE

### 3.1 Soils

The upland soils of Kwamdulu estate are very deep (rootable depth more than 150 cm, usually more than 200 cm), well drained, red ferralitic clays derived from gneiss rock. In the valleys soils are imperfectly and poorly drained alluvial and colluvial sandy clays.

During the field inspection no shallow soils have been observed in Kwamdulu, neither spots with iron/manganese nodules. However the soil report mentions that on some of the steep slopes (slopes over 10%) the soils have locally ironstone close to the surface. Ironstones have a gravelly character.

The red upland soils have favourable physical properties, but a very low fertility status. Their pH is usually 5 -6 at the surface and 4,5 – 5 in the subsoil. Plant nutrients like phosphate and calcium are very low; potassium is extremely low.

Soils of hill crests

The soils on the hill crests (map unit C1/W) are very strongly acid (pH 4,5 – 5,0), have a very low effective capacity to retain nutrients and are extremely low in calcium, potassium, phosphate and other nutrients. These soils have high (toxic) aluminum saturation values and are in the suitability rating classified as unsuitable for sisal, covering 19% of the area. In spite of that it has been observed in the field that are planted with sisal. It is unknown whether lime has been applied on these hillcrests.

During the survey in 1988 12 sites in this unit have been sampled and analyzed for toxic aluminum. In 8 out of 12 sites the aluminum saturation rates turned out to be too high in the subsoil (30 – 50 cm depth). The present suitability for sisal is supposed to be better; probably moderately suitable.

### 3.2 Soil suitability

Soil suitability for sisal

According the Kwamdulu soil report 53% of the area is suitable for sisal, 4% is moderately suitable, 7% marginally suitable and 36% unsuitable. As unsuitable are classified the soils in the imperfectly and poorly drained valley bottoms and the soils of the hill crests. The latter make out 19% of the total area, but at least parts of this unit will be suitable, making the total suitable area for sisal about 66%.

Soil suitability for teak

Both sisal and teak require well drained, deep soils. Roughly suitability criteria are similar. It is still in discussion what the effect of the very low pH will have on the growth of teak, and whether teak can stand toxic aluminum. However in Kwamdulu estate and in Ghana reasonable growth rates have been observed on similar soils.

In general it is assumed that teak will grow on a wide range of soil pH's (pH water), pH 5,0 to pH 8,0 , with an optimum range between pH 6,5 and pH 7,5

**Soil suitability for sisal and teak in Kwamdulu estate**

| **Suitability** | **soils** | **% of area** |
|---|---|---|
| suitable | Red soils on slopes<br>Red soils on crests (partly) | 57<br>7 |
| **Total suitable** | | **64** |
| unsuitable | Red soils on crests with toxic aluminum<br>Soils with impeded drainage | 12<br>24 |
| **Total unsuitable** | | **36** |

### 3.3 Soil fertility management recommendations

The mineral parts of the upland soils of Kwamdulu are extremely poor and acidic, and have a very low capacity to retain nutrients. The organic matter in the soils has a high capacity to retain moisture and nutrients. Good management of organic matter is therefore of utmost importance to maintain fertility and moisture holding capacity and to prevent erosion! Burning should be avoided and all organic sisal waste should be returned to the field and incorporated in the soil.

Potassium and phosphate levels in the soil are extremely low. When fertilizer is applied these two elements should be applied first of all. Nitrogen fertilizer will only be effective if levels of potassium and phosphate are satisfactory. When one or more nutrients are missing plants will have troubles with the uptake of other nutrients.

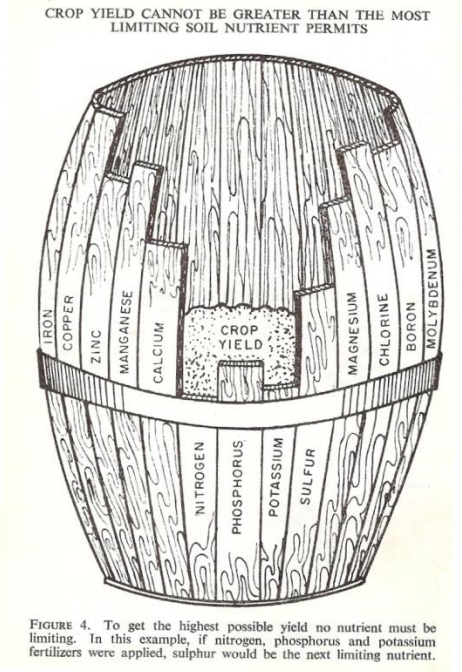

FIGURE 4. To get the highest possible yield no nutrient must be limiting. In this example, if nitrogen, phosphorus and potassium fertilizers were applied, sulphur would be the next limiting nutrient.

Source: FAO Fertilizer Programme (1978). Fertilizers and their use.

## 4. SOILS OF KWARUGURU ESTATE

### 4.1 Soils

A field inspection of Kwaruguru estate has been carried out. It confirmed the statement of Mr. Mbogoni that Kwamdulu and Kwaruguru estates are situated within the same soil- and physiographic unit.

Deep red soils have been observed in road cuttings and in auger hole observations. These soils are similar to those of Kwamdulu estate.

Deep red soils in Kwaruguru estate.

In Kwaruguru estate a pilot teak plantation is situated on a slope of 7 to 8%. Here two soil augerings have been made, one just above the plantation (augering 1) and one just down slope the plantation (augering 2). Both augerings showed uniform deep red soils more than 150 cm deep, without any obstruction to roots, which are representative for the suitable areas of the estate. The teak plantation showed a reasonable growth of the trees: the growth of teak is 15 $m^3$/ha year (source: FORM International) .

Teak plantation in Kwaruguru estate.

A salinity measurement was made in water from a borehole (about 10m depth). The water turned out to be very highly saline (EC 2,7 mS/cm), and cannot be used for irrigation. The origin of the salinity is not known. At present the water from the borehole is used for the sisal factory (Corona). It is recommended to investigate the impact of the saline water on the environment.

### 4.2 Soil suitability for teak and sisal

Because no soil survey has been carried out in Kwaruguru estate, detailed suitability data are not available. But because soils and landscape of Kwaruguru belong to the same soil unit as Kwamdulu estate, it is a fair assumption that the percentage of suitable area for sisal and teak will be almost similar to that of Kwamdulu estate.

**Assumed soil suitability for sisal and teak in Kwaruguru estate**

| **Suitability** | **soils** | **% of area** |
|---|---|---|
| suitable | Red soils on slopes<br>Red soils on crests (partly) | 57<br>7 |
| **Total suitable** | | **64** |
| unsuitable | Red soils on crests with toxic aluminum<br>Soils with impeded drainage | 12<br>24 |
| **Total unsuitable** | | **36** |

According the farm manager the sisal production of this estate is higher than in Kwamdulu. It is unknown whether soil/climate factors attribute to the higher production or management practices.

### 4.3 Soil fertility management recommendations

As the soils in Kwaruguru are similar to those of Kwamdulu, the same recommendations apply to Kwaruguru. Please see section 3.3.

## 5. SOILS OF KILIMANGWIDO ESTATE

### 5.1 Soils

In Kilimangwido estate a soil survey has never been carried out. However, in the neighbouring Mwera estate, which has a similar position near the coastline, a detailed soil survey has been carried out in 1988. From the survey report of that estate valuable data could be obtained.

During the field visit a quick reconnaissance has been carried out and 5 augerhole observations were made in order to identify the soil types.

Three different units of the Mwera soil map have been identified:

Map unit Rvd/W : Well drained red sandy clay loams with more than 200 cm effective soil depth.

Map unit Rd/W : Well drained red sandy clay loams with 50 to 200 cm effective soil depth.

Map unit Bs/W : Well drained dark grayish brown calcareous sandy clay with an effective soil depth of 80 to 100 cm and a pH of 7,2 to 7,8 over soft powdery lime.

As no estate soil map is available, it is difficult to judge percentage of the area of each map unit; it is assumed that the soil pattern is almost similar to that of Mwera estate. During the reconnaissance visit the emphasis was on well drained soil as imperfectly and poorly drained soils are not suitable for teak.

In general the soils of Kilimangwido are less acid and have a much better soil fertility status than the soils of Kwamdulu and Kwaruguru; the organic matter content and base saturation are higher and toxic aluminum is not reported. However, Kilimangwido soils are also very low in phosphate and potassium.

Some soils are developed in old uplifted coral reefs, resulting in presence of limestone, high pH, and high levels of calcium. Limestone from coral reef is still visible in a quarry where material for road construction has been taken out.

### 5.2 Soil suitability for sisal and teak

Regarding soil suitability it is a fair assumption that the soil pattern is almost similar to that of Mwera estate. Based on this assumption the following estimate of the suitable area for sisal can be made.

**Estimated soil suitability for sisal in Kilimangwido estate**

| **Suitability** | **soils** | **% of area** |
|---|---|---|
| suitable | Well drained red and black soils on slopes and crests | 66 |
| **Total suitable** | | **66** |
| unsuitable | Soils with impeded drainage<br>shallow soils | 29<br>5 |
| **Total unsuitable** | | **34** |

The soil suitability for teak might slightly differ from the suitability for sisal. Regarding the suitability for sisal in Mwera estate an area of 10% of the total surface with somewhat excessively drained, shallow black soil is included which is only moderately suitable for sisal; this area will be unsuitable for teak. This results in the following estimated soil suitability for teak.

**Estimated soil suitability for teak in Kilimangwido estate**

| **Suitability** | **soils** | **% of area** |
|---|---|---|
| suitable | Well drained red and black soils on slopes and crests | 56 |
| **Total suitable** | | **56** |
| unsuitable | Soils with impeded drainage<br>shallow soils | 29<br>15 |
| **Total unsuitable** | | **44** |

**Please note that the above mentioned figures are estimates, and that the real suitable area can only be calculated from a soil map of Kilimangwido estate; such a soil map has still to be made!**

Rainfall data of Kilimangwido estate show that rainfall is higher than in Kwamdulu and Kwaruguru estates.

### 5.3 Soil fertility management recommendations

Especially in the red soils maintenance of a good level of organic matter is very important. Burning should be avoided and organic waste from sisal should be returned to the field before planting.

Present levels of potassium are low to very low; phosphate levels are low. All soils are expected to respond to nitrogen fertilizers. However, nitrogen should not be applied without additional potash and phosphate fertilizers (see also 3.3).

**ANNEX AUGER HOLE OBSERVATIONS**

**Augering Nr. 1** location: S 5° 28.696 E 38° 31.796

Kwaruguru estate, upper slope of teak plantation.

Date: 11-09-2012

Author: J.H.M. Scholten

| | | |
|---|---|---|
| 0 – 30 cm | dark reddish brown (2,5YR 3/3) | clay loam |
| 30 – 160 cm | dark red (10R 3/6) | clay |
| Remarks: | slope: 8% to the South | |

**Augering Nr. 2** location: S 5° 28.803 E 38° 31.747

Kwaruguru estate, down slope of teak plantation

Date: 11-09-2012

Author: J.H.M. Scholten

| | | |
|---|---|---|
| 0 – 20 cm | dark reddish brown (2,5YR 3/3) | clay loam |
| 20 - 30 cm | very dark reddish brown (2,5YR 2/4) | clay loam |
| 30 – 120+ | dark reddish brown (2,5YR 3/6) | clay |
| Remarks: | slope 7% to the South | |

**Augering Nr. 3** location: S 5° 27.049 E 38° 56.125

Kilimangwido estate, Block nr. 23A

Date: 12-09-2012

Author: J.H.M. Scholten

| | | |
|---|---|---|
| 0 – 20 cm | dark reddish brown (5YR 3/3) | clay loam |
| 20 - 30 cm | very dark reddish brown (5YR 2/4) | clay loam |
| 30 – 50 cm | reddish brown (5YR 4/6) | clay |
| 50 – 120 cm | reddish brown (2,5YR 4/6) | clay |

Remarks: slope 7% to SE; Mwera soil map unit Rvd/W

**Augering Nr. 4** location: S 5° 28.077 E 38° 55.326

Kilimangwido estate, block nr. 30

Date: 12-09-2012

Author: J.H.M. Scholten

| | | | |
|---|---|---|---|
| 0 – 20 cm | brownish black (10YR 2/3) | clay | very friable, granular structure |
| 20 - 40 cm | brownish black (10YR 2/3) | clay | idem, with pieces of sea shells and lime stone |
| 40 – 60 cm | dark reddish brown (5YR 3/4) | clay | |
| 60 – 80 cm | dark reddish brown (5YR 3/3) | clay | |
| 80+ cm | pieces of limestone, impossible to continue augering | | |
| Remarks: | slope 3,5% to S; Leucena bush; Mwera soil map unit Bs/W. | | |

**Augering Nr. 5** location: S 5° 28.084 E 38° 54.616

Kilimangwido estate, block nr. 12

Date: 12-09-2012

Author: J.H.M. Scholten

| | | | |
|---|---|---|---|
| 0 – 30 cm | black (10YR 2/1) | clay | friable moist, hard when dry |
| 30 - 40 cm | brownish black (10YR 2/2) | clay | |
| 40 – 50 cm | dark brown (10YR 3/3) | clay | |
| 50 – 90 cm | brown (10YR 4/4) | clay | |
| 90+ cm | pieces of limestone, impossible to continue augering. | | |
| Remarks: | slope 5% to SW; Mwera soil map unit Bs/W. | | |

**Augering Nr. 6** location: S 5° 27.541 E 38° 54.501

Kilimangwido estate, block nr. 14

Date: 12-09-2012

Author: J.H.M. Scholten

| | | | |
|---|---|---|---|
| 0 – 20 cm | very dark reddish brown (5YR 2/3) | clay loam | |
| 20 - 30 cm | very dark reddish brown (5YR 2/4) | clay | |
| 30 – 40 cm | dark reddish brown (2,5YR 3/4) | clay | |
| 40 – 110+ cm | very dark reddish brown (2,5YR 2/4) | clay | firm |

Remarks: on nearly flat hill crest; dwellings, bananas, maize.

**Augering Nr. 7** location: S 5° 28.610 E 38° 52.571

Kilimangwido estate, block nr. 4

Date: 12-09-2012

Author: J.H.M. Scholten

| | | |
|---|---|---|
| 0 – 20 cm | brownish black (10YR 2/2) | clay |
| 20 - 30 cm | dark brown (10YR 3/4) | clay |
| 30 – 80+ | dark reddish brown (5YR 3/4) | clay |

Remarks: slope 1% to S; scattered trees, grazing, Masai people; surface looks like black clay soil, but is a deep red soil; Mwera soil map unit Rd/W.