# Present situation of the Citrus Greening disease in Tanzania and proposal for control strategies.

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PRESENT SITUATION OF THE CITRUS GREENING DISEASE IN TANZANIA AND PROPOSAL FOR CONTROL STRATEGIES.
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ABSTRACT - The prevalence of Citrus Greening Disease CGD in Tanzania is classified into four zones. Zone A located in the highlands above 1 200 m of elevation is characterized by a high degree of greening infection and a dense population of *Trioza erytreae*, the African vector. Zone B (800 to 1 200 m) experiences fairly high populations of vector but moderate symptoms of greening. Zone C (500 to 800 m) is intermediate with very light infection and relatively small vector populations. Finally in zone D (below 400 m) there is no natural spread of the disease and the vector is absent. This gradient is resulting from the temperature sensitivity of the greening pathogen on the one hand, and from increasing vector mortality under warm and dry conditions on the other hand.
While nurseries and foundation stock orchards should be exclusively established in zone D, citriculture can still develop in zone C and even to some extend in zone B if appropriate cropping techniques are used.

LE GREENING DES AGRUMES EN TANZANIE.
SITUATION PRESENTE ET STRATEGIES D'INTERVENTION.
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RESUME - La prévalence de la maladie du greening en Tanzanie a été observée selon quatre types de situations différentes. Dans la zone A des Hauts Plateaux située au-dessus de 1 200 m d'altitude, les symptômes de la maladie sont très sévères et les populations de *Trioza erytreae*, le vecteur africain, toujours élevées. La zone B située entre 800 et 1 200 m héberge des populations de vecteurs assez élevées mais les symptômes de la maladie sont moins sévères. La zone C qui correspond à la tranche altitudinale 500-800 m ne connaît que des infestations sporadiques et généralement peu importantes de vecteurs, les symptômes de greening y sont en général bénins. Enfin la zone D située en-dessous de 400 m est indemne à la fois de vecteur et de greening. Le gradient observé résulte de la sensibilité de l'organisme pathogène du greening (souche africaine) aux fortes températures et de l'importante mortalité observée sur les oeufs et les larves du vecteur lorsqu'augmente le degré de siccité de l'air.
Les pépinières et les parcs à bois doivent exclusivement être situés en zone D, mais l'agrumiculture reste possible encore en zone C, voire en zone B moyennant certaines précautions phytosanitaires.

## INTRODUCTION

Citrus Greening disease (CGD) is a major hindrance for the citriculture in Africa and Asia. Originally, the name of the disease is refering to the lack of colour break when fruits reach maturity.

The disease was described under various local names such as Yellow Branching Disease, Citrus Decline, Leaf mottling, Citrus Vein Phloem Degeneration, Huanglungbin.

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Greening was first considered as a viral infection. But the causal agent was later identified as a phloem restricted intra cellular bacterium organism (Laflèche and Bové, 1970 ; Garnier and Bové, 1978 ; Garnier *et al.*, 1984).

Two strains of Greening associated with two different vectors (both psyllids) are distinguished : the AFRICAN GREENING and the ASIAN GREENING.

The two types of greening organism are not adapted to the same range of temperature (Bové *et al.*, 1974) while the two vectors have different ecological characteristics. This has resulted in different geographical distributions of the disease.

Recent evidence was obtained of the presence of the disease in Tanzania, where the vector *Trioza erytreae*

(Del Guercio) is widely observed in the highland areas of Morogoro (Grisoni, 1988) and Arusha. The Greening disease was successfully transmitted by graft inoculation from Tanzanian contaminated citrus to indicator plants, and these plants tested positive to electron microscope examination (Swai *et al.*, 1991). Therefore TANZANIA is not an exception for the greening occurence in the region since the disease has already been described from RWANDA, BURUNDI, MALAWI (Aubert *et al.*, 1988) and KENYA (Seif and Whittle, 1984), four surrounding countries of TANZANIA.

## SYMPTOMATOLOGY OF THE DISEASE

The symptoms of greening disease found in Tanzania are similar to those described in various other countries on oranges, mandarins, and tangelos (Aubert, 1987). Affected leaves exhibit mottling, yellowing with eventual zinc and manganese deficiences. Leaf yellowing is typically interveinal. At an early stage of infection in mature orchards, only scattered young twigs are affected but the yellowing will extend soon to entire branches in sectorial infection. Off-season flowering and leaf shedding will follow.

Affected branches bear few fruits that are usually underdevelopped, lopsided and may start to colour partially from the peduncle. Fruits often drop prematurely ; sugar and juice content are reduced. In seedy varieties, seed abortion occurs.

If the tree is severely infected, it will show sparse chlorotic foliage, dieback of branches and heavy fruit drop.

To some extend Citrus Greening symptoms can be confused with poor nutritional status of the tree.

## PATHOGEN PARTICULARITY AND CHARACTERISTICS OF THE DISEASE

The African strain of Greening Disease is «TEMPERATURE SENSITIVE» and symptoms will appear only if day and night temperature are below 25°C and 20°C respectively.

This characteristic is restricting the development of the disease and the expression of the symptoms to highlands situations in TANZANIA.

Two parameters may be used to assess the incidence of the disease :

1) The number of degrees-hours per year during which temperature is above 30°C (DM/30) : when the DM/30 reaches 1,500 hours, the symptoms of greening are greatly reduced. At a DM/30 of 200 hours they generally show up.

2) The number of days per year when the maximum temperature remains below 25.50°C (Nb/25.5). If the Nb/25.5 is less than 50 days/year, the symptoms are reduced or non existent.

A survey on citrus greening was carried out in one of the most important citrus producing area of Tanzania and covering an altitudinal transect along the slopes of Uluguru mountains between Matombo, Morogoro and Langali. The main results are summarized in Table 1.

According to the daily temperature data of Morogoro (SUA campus, 550 m a.s.l), the number of days below 25.5°C was the following for the last six years :

| | |
|---|---|
| 1984 : 12 days | 1987 : 7 days |
| 1985 : 3 days | 1988 : 1 day |
| 1986 : 9 days | 1989 : 9 days |

These figures are far below the 50 days threshold, meaning that the symptoms cannot be observed in such conditions. But at a slightly higher elevation (Msikitini and Langali) where cooler temperatures are experienced, severe greening is undoubtedly affecting local citrus.

A general view of the citrus orchards established near the Uluguru mountains in the suroundings of Morogoro appears on Figure 1.

## VECTOR PREVALENCE

African Greening is transmitted by *Trioza erytreae* the psyllid feeding on Rutaceous plants. Man can also transmit the disease through vegetative propagation with infected budwood.

The feeding activity of *T. erytreae* is detrimental to citrus not only for the sap depletion, but also because of the nesting of nymphs that results in the galling or curling of leaves, as well as honeydew secretion and subsequent development of sooty mould (Figure 2).

**TABLE 1 - Greening situation on an altitudinal transect along the slopes of Uluguru mountains.**

| Location | Altitude (m.a.s.l.) * | Presence of vector galls ** | Disease symptoms |
|---|---|---|---|
| Matombo | 200-400 | none | none |
| Morogoro | 500-600 | few | not clear |
| Mskitini | 800 | many | faint |
| Langali | 1 200 | many | yes |

* - Meters above sea level.
** - Leaf galls induced by *T. erytreae*.

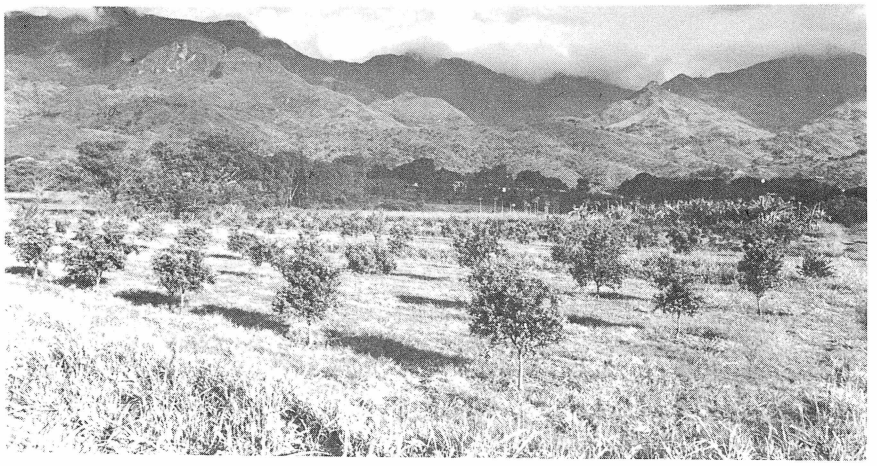


**Figure 1** - Orchard of the SOKOINE Agricultural University (Morogoro) with Uluguru mountains in the background. The dark area (Da) shows the forest gallery near kikundi stream.

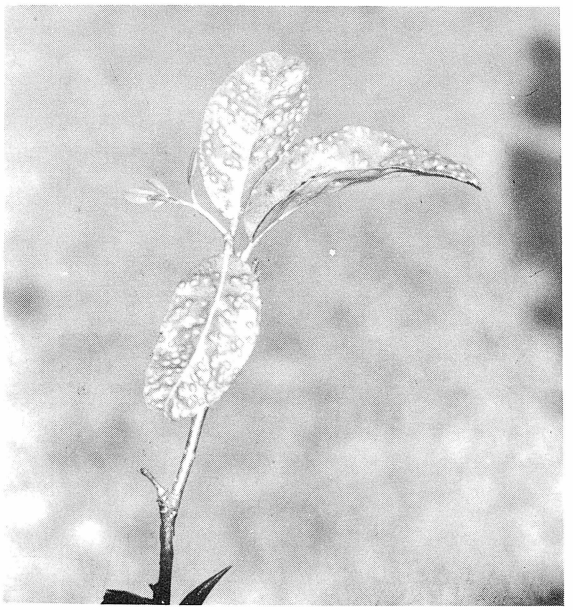

**Figure 2** - Damage of *T. erytreae* on a Rough lemon seedling.

Moreover and by far, the greatest damage induced by *T. erytreae* is the transmission of the Citrus Greening Disease.

Eggs and young nymphs (mostly first instars) of *Trioza erytreae* are extremely vulnerable to dessiccation and to high temperature (over 25°C). Combining air humidity and temperature factor, one can calculate the air evaporating power (or maximum saturation deficit) at midday and evaluate the probability of mortality of the eggs and nymphs :

$$MSD = SVP \times \frac{100 - RH}{100} \text{ (in mbars)}$$

MSD : Maximum Saturation Deficit (mbars)
SVP : Saturated Vapour Pressure (depends directly on Temperature, data available on tables) (mbars).
RH : Relative Humidity (%)
(ALL DATA TAKEN AT MIDDAY/3 pm).

Field experiments showed that beyond MSD of 45 mbars, 100% mortality of eggs and first instar nymphs succumb ; 35 mbars induced an average of 70% mortality while at 15 mbars only 10% of organism died (Green and Catling, 1971).

The vector population.

A study of the climatic conditions of the Horticulture Unit in Morogoro (SUA) shows that although the humidity levels are not optimal for the development of *Trioza erytreae*, they do not preclude psyllid outbreaks. Clearly, with a maximum air saturation deficit of 20 millibars, the upsurges of psyllids are minimal, but the cycle of the insect may be carried over the different seasons of the year. The period of the year covering the months between April and August would be the most favourable for the development of the vector.

Data for the years 1984 to 1988 are given in Table 2.

Psyllids symptoms are observed at SUA Horticulture Unit almost all the year around, provided there is a flushing on citrus plants. Yet the psyllid attacks remain at a low level, although more gall symptoms are observed on citrus located close to the KIKUNDI stream (cf. Figure 1).

Besides the general climatic conditions prevailing at SUA, it is suggested that some topoclimatic factors would be involved :

- Proximity of the Uluguru mountains (vector reservoir).
- Regular winds blowing down from these mountains.
- Micro-climatic conditions due to higher humidity near the forest ecosystem of the KIKUNDI stream.

Parasites constitute the second factor likely to limit the psyllid population. The observation at SUA showed a diversity of fauna associated with psyllids but the rate of parasitized nymphs is not exceeding 40% (GRISONI, 1988).

Observations on CGD and its vector will continue in Morogoro area as well as in other parts of the country.

TABLE 2 - Meteorological data with maximum saturation deficit (MSD) at Morogoro (SUA Campus, 570 m).

| | J | F | M | A | M | J | JL | A | S | O | N | D | Total or means |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1984 | | | | | | | | | | | | | |
| T. max | 30.4 | 31.0 | 31.5 | 29.5 | 27.9 | 27.2 | 26.9 | 27.3 | 30.3 | 31.7 | 29.7 | 31.7 | 29.5 |
| T. min | 20.9 | 20.6 | 20.2 | 20.2 | 18.5 | 15.9 | 16.8 | 15.9 | 15.9 | 17.9 | 20.1 | 21.0 | 18.6 |
| Rainfall | 186.1 | 101.4 | 110.8 | 297.6 | 63.3 | 22.9 | 5.9 | 4.1 | 5.6 | 30.5 | 127.4 | 56.2 | 1 011.8 |
| R.H. (3 pm) | 60 | 51 | 57 | 67 | 63 | 57 | 57 | 51 | 41 | 41 | 57 | 57 | 55.1 |
| MSD/mb | 17.4 | 22 | 19.9 | 15.2 | 13.9 | 15.5 | 15.2 | 17.8 | 25.4 | 26.2 | 17.9 | 20.1 | 18.8 |
| 1985 | | | | | | | | | | | | | |
| T. max | 32.9 | 30.9 | 32.6 | 29.6 | 28.8 | 28.1 | 27.7 | 28.2 | 30.3 | 31.3 | 31.5 | 32.8 | 30.3 |
| T. min | 21.0 | 20.8 | 20.3 | 20.3 | 18.2 | 15.2 | 15.2 | 14.1 | 16.6 | 17.8 | 19.6 | 21.3 | 18.3 |
| Rainfall | 10.0 | 158.7 | 107.1 | 135.1 | 108.3 | 1.3 | 16.7 | 9.6 | 0.8 | 13.7 | 58.3 | 43.3 | 663.7 |
| R.H. (3 pm) | 51 | 59 | 55 | 70 | 63 | 53 | 51 | 45 | 40 | 45 | 47 | 49 | 52.4 |
| MSD/mb | 24.5 | 18.3 | 22.1 | 12.5 | 14.7 | 17.5 | 18.2 | 21.0 | 25.9 | 25.2 | 24.5 | 25.3 | 20.0 |
| 1986 | | | | | | | | | | | | | |
| T. max | 31.3 | 33.7 | 31.5 | 30.1 | 28.3 | 27.8 | 27.4 | 28.5 | 29.7 | 32.0 | 31.5 | 30.8 | 30.2 |
| T. min | 20.8 | 20.7 | 20.7 | 20.2 | 19.6 | 15.3 | 14.2 | 15.4 | 16.4 | 18.9 | 20.5 | 21.5 | 18.6 |
| Rainfall | 134.6 | 70.1 | 155.5 | 142.7 | 157.7 | 11.4 | 2.3 | 6.9 | 1.2 | 37.6 | 157.7 | 156.2 | 1 051.9 |
| R.H. (3 pm) | 59 | 46 | 65 | 68 | 70 | 57 | 50 | 46 | 43 | 45 | 55 | 65 | 55.7 |
| MSD/mb | 18.7 | 28.2 | 16.2 | 13.6 | 11.5 | 16.1 | 18.5 | 21.0 | 23.8 | 26.2 | 20.8 | 15.5 | 19.1 |
| 1987 | | | | | | | | | | | | | |
| T. max | 30.3 | 32.1 | 32.3 | 30.5 | 28.9 | 28.4 | 28.1 | 28.8 | 30.5 | 31.5 | 32.4 | 33.8 | 30.6 |
| T. min | 20.9 | 21.1 | 21.6 | 21.0 | 19.2 | 15.3 | 15.7 | 17.2 | 17.7 | 19.1 | 20.4 | 22.1 | 19.3 |
| Rainfall | 52.5 | 74.9 | 65.7 | 108.2 | 132.7 | - | 4.0 | 8.5 | - | 43.8 | 36.0 | 28.9 | 555.2 |
| R.H. (3 pm) | 61 | 54 | 57 | 66 | 69 | 54 | 53 | 47 | 43 | 46 | 48 | 46 | 53.7 |
| MSD/mb | 16.8 | 22.0 | 20.8 | 14.8 | 12.3 | 17.8 | 17.9 | 20.1 | 23.1 | 25.0 | 25.3 | 28.4 | 20.4 |
| 1988 | | | | | | | | | | | | | |
| T. max | 33.7 | 33.0 | 32.4 | 30.5 | 29.7 | 28.7 | 28.8 | 28.9 | 29.7 | 32.2 | 31.8 | 31.5 | 30.9 |
| T. min | 22.3 | 22.2 | 21.8 | 21.3 | 18.5 | 18.5 | 16.6 | 16.3 | 17.8 | 18.8 | 20.6 | 21.1 | 19.7 |
| Rainfall | 93.7 | 33.7 | 191.9 | 87.1 | 12.7 | 44.8 | - | 17.6 | 33.4 | 27.5 | 51.7 | 170.1 | 764.2 |
| R.H. (3 pm) | 47 | 49 | 53 | 63 | 89 | 55 | 50 | 46 | 45 | 40 | 75 | 54 | 55.5 |
| MSD/mb | 27.7 | 25.7 | 22.9 | 16.2 | 4.6 | 17.7 | 19.8 | 21.5 | 22.9 | 28.9 | 11.8 | 21.3 | 20.1 |
| MEAN of MSD/mb | 21.0 | 23.2 | 20.4 | 14.5 | 11.4 | 16.9 | 17.9 | 20.3 | 24.2 | 26.3 | 20.1 | 22.1 | 19.9 |

Morogoro (SUA campus) can be considered as the boundary of CGD vector territory where the disease seldom develops even on psyllid visited citrus plants. A major problem remains for citrus nurseries if these are later planted in such a risk area.

## CONTROL OF THE CITRUS GREENING DISEASE

### Risk area.

It has been shown that the disease is limited to the humid altitudinal areas. Temperatures below 26°C are favourable for both the vector and the disease development. While waiting for a better knowledge on CGD incidence in Tanzania, it is proposed - in a first attempt - to distinguish 3 zones :

- HIGH RISK AREAS include cool and humid climate located above 800-1 000 meters such as Uluguru and Usambara mountains, Southern Highlands, Kilimandjaro and Arusha regions ;
- LOW RISK AREA are limited to humid climate located between 500 to 800 m and dryer climates above 800 m such as Morogoro and Dodoma, respectively ;
- ZERO RISK AREA covers any area below 500 m such as coastal zone, Tanga, Dar es Salam, Matombo, Zanzibar ...

Better classification, is being obtained by a national survey for adjusting the altitudinal criteria according to the latitude and any other relevant climatic data.

Interestingly the two major citrus production areas of Tanzania (Tanga and Matombo) are located in zero risk area.

Citrus production and propagation should be recommended according to the criteria of table 3.

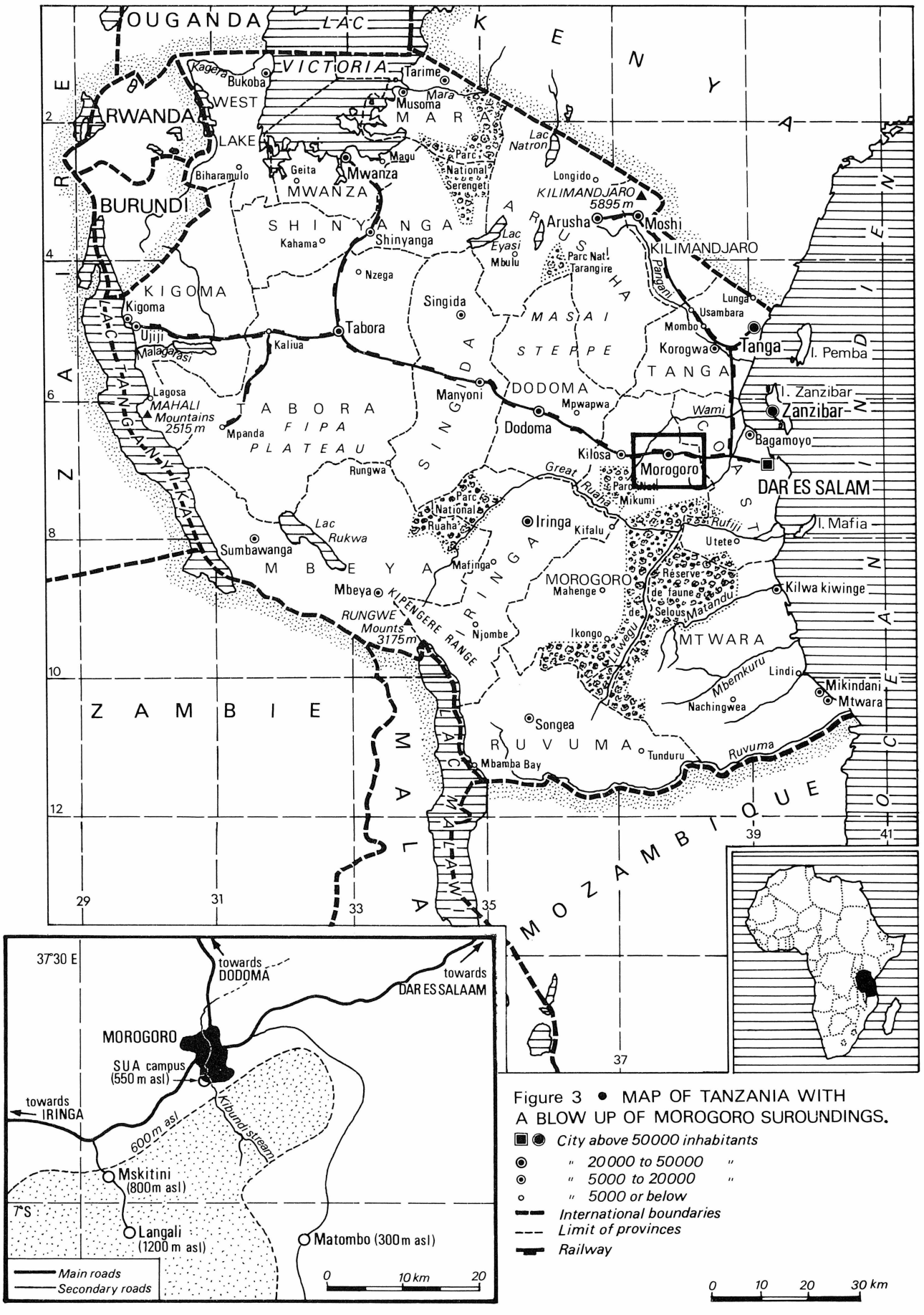
OUGANDA
LAC VICTORIA
K E N Y A
R W A N D A
WEST LAKE
Kagera
Bukoba
Tarime
Musoma
Mara
M A R A
Lac Natron
Parc National Serengeti
Magu
Geita
Mwanza
MWANZA
Biharamulo
BURUNDI
Longido
KILIMANDJARO 5895 m
Arusha
Moshi
KILIMANDJARO
S H I N Y A N G A
Kahama
Shinyanga
Lac Eyasi
Mbulu
Parc Nat! Tarangire
Pangani
Lunga
Usambara
Mombo
Korogwa
Tanga
I. Pemba
K I G O M A
Kigoma
Singida
M A S A I
S T E P P E
T A N G A
Ujiji
Malagarasi
Tabora
Kaliua
Nzega
Lagosa
MAHALI Mountains 2515 m
Manyoni
DODOMA
Mpwapwa
Wami
I. Zanzibar
Zanzibar
Dodoma
Bagamoyo
Kilosa
Morogoro
DAR ES SALAM
Rungwa
Great Ruaha
Parc National Mikumi
Iringa
Kifalu
Rufiji
I. Mafia
Lac Rukwa
Ruaha
Utete
Sumbawanga
M B E Y A
Mafinga
MOROGORO
Mahenge
Réserve de faune de Selous
Matandu
Kilwa kiwinge
Mbeya
KIPENGERE RANGE
RUNGWE Mounts 3175 m
Njombe
Ikongo
Luwegu
MTWARA
Lindi
Mbemkuru
Mikindani
Mtwara
Nachingwea
Z A M B I E
Songea
R U V U M A
Tunduru
Ruvuma
Mbamba Bay
M O Z A M B I Q U E
37°30 E
towards DODOMA
towards DAR ES SALAAM
MOROGORO
SUA campus (550 m asl)
towards IRINGA
600 m asl
Kibundi stream
Mskitini (800m asl)
7°S
Langali (1200 m asl)
Matombo (300 m asl)
Main roads
Secondary roads
0 10 km 20
Figure 3 • MAP OF TANZANIA WITH A BLOW UP OF MOROGORO SUROUNDINGS.
City above 50000 inhabitants
" 20000 to 50000 "
" 5000 to 20000 "
" 5000 or below
International boundaries
Limit of provinces
Railway
0 10 20 30 km

TABLE 3 - Recommendations for the management of foundation blocks and nurseries in Tanzania.

| Risk area | Citrus production | Nursery for local release | Nursery for transfert to other areas | Mother tree orchard (germplasm) |
|---|---|---|---|---|
| High | no * | no | no | no |
| Low | yes ** | yes ** | no | no |
| Zero | yes | yes | yes | yes |

* - Unless for home production with citrus psyllid control.
** - With the control of citrus psyllids.

## NURSERY REGULATIONS

Budwood should only be taken from vigourous growing, high producing, healthy trees from greening free areas (zero risk). In low risk areas, a strict control of psyllids with insecticides (dimethoate, diazinon, endosulfan, ...) should be practiced from the stage of young rootstock seedlings up to the release of the trees.

An efficient broad insecticide/acaricide/nematicide that can be used - IN NURSERIES ONLY - is aldicarbe.

## ORCHARDS PRACTICES

### Psyllid control.

When there is a risk of *Trioza erytreae* attack, strict control of the insect should be obtained. This is necessary during flushing periods if the temperature and the humidity conditions are favouring psyllid outbreaks.

Yellow Saturn traps together with the follow up of climatic parameters of temperatures, relative humidity and tree flushing can be used as a warning system to determine the accurate time of first spraying.

For efficient psyllid control, sprayings should be repeated every 7-10 days as long as young leaves will appear.

### Disease control.

Although infested trees could be treated with antibiotics, this technique is not allowed, nor commercially feasible in TANZANIA.

The first policy to adopt is to ensure a very good nutritional and water status to the trees. If only a few branches presumably contaminated appear in a otherwise healthy orchard, they must be pruned off immediately. Severely infected trees not producing marketable fruits should be uprooted, and thorough eradication has to be enforced in producing zones.

Young nursery trees showing generalised symptoms should be replaced immediatly as they will never bear fruits.

## CONCLUSIONS AND GENERAL RECOMMENDATIONS

The African citrus greening disease CGD is occuring in Tanzania. A national survey could gather all relevant information on CGD and come up with a more accurate map showing the different risk areas of the country.

This would assist extension officers in advising properly citrus farmers.

One has to be very careful while dealing with citrus material imports. As a matter of fact, the Middle East and Asia should be completely prohibited areas for avoiding accidental importation of vector/strain of the Asian Citrus Greening into Tanzania, since they would easy establish in the coastal area of the countrv.

Also a good policy should be finalised at national level for limiting the propagation of the disease in Tanzania. Strict control of nurseries through registered disease free certification scheme is essential for reducing the spread of CGD. Healthy mother tree orchards are a prerequisite for developing citrus production in Tanzania, since CGD is graft-transmissible.

The banning of transport of nursery trees or budding material from contaminated to healthy areas must be enforced.

Finally, extension service officers should be warned that if a pest or a disease like CGD is threatening citrus production in a given area alternative fruit crops should be prefered for concentrating citrus production in disease-free sectors.

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**EL GREENING DE LOS CITRICOS EN TANZANIA. SITUACION PRESENTE Y ESTRATEGIAS DE INTERVENCION.**

**G. EVERS y M. GRISONI.**

*Fruits,* Mar.-Apr. 1991, vol. 46, n° 2, p. 171-177.

RESUMEN - La presencia de la enfermedad del greening en Tanzania fué observada de acuerdo a cuatro situaciones diferentes. En la zona A de los altiplanos situada arriba de 1 200 m de altitud, los síntomas de la enfermedad son muy severos y las poblaciones de *Trioza erytreae*, el vector africano, son siempre elevadas. La zona B situada entre 800 y 1 200 m tiene poblaciones de vectores bastante elevadas pero los síntomas de la enfermedad son menos severos. La zona C que corresponde al rango altitudinal 500-800 m solo presenta infestaciones esporadicas de vectores, generalmente poco importantes, los síntomas de greening son en general benignos. Finalmente la zona D situada abajo de 400 m esta indemne al mismo tiempo al vector y al greening. El gradiente observado es el resultado de la sensibilidad del organismo patógeno del greening (cepa africana) a las fuertes temperaturas y de la importante mortalidad del vector luego que aumenta el grado de desecación del aire.
Viveros y lotes productores de esquejes deben exclusivamente estar situados en zona D, pero la citricultura es posible aun en zona C, incluso en zona B mediante algunas precausiones fitosanitarias.