# CITRUS DISEASES : PROBLEMS AND PROSPECTS

by M. I. DOSSA & G. M. LALLMAHOMED *

*Ministry of Agriculture, Fisheries and Natural Resources*

RÉSUMÉ

Les maladies principales des agrumes ainsi que leurs symptômes, méthodes de transmission et techniques de lutte en usage, sont décrites. Des recommendations générales ayant trait à la propagation des agrumes sont aussi presentées.

SUMMARY

Main diseases of citrus are discussed, symptoms described and control measures outlined. General recommendations for the development of a citrus industry are mentioned.

## Introduction

Mauritius relies heavily on the importation of citrus fruits to meet its local requirements. This is clearly reflected in the table below :

*Importation of citrus fruits for past four years* †

| Year | Weight (tonnes) | C.I.F. value (Million Rs) |
|---|---|---|
| 1979 ... ... ... ... ... | 2 297.4 | 8.3 |
| 1980 ... ... ... ... ... | 1 805.1 | 9.8 |
| 1981 ... ... ... ... ... | 1 743.3 | 11.9 |
| 1982 ... ... ... ... ... | 1 658.3 | 10.5 |

† Source : Ann. Report Customs & Excise Department.

Attempts to set up citrus orchards in the past have ended in disaster mainly due to plant diseases. The first inventory of citrus plants at the Royal Botanical Gardens of Pamplemousses was published in 1775 (AUBERT, 1982). Serious attempts at citriculture were recorded as from 1917 when 30 acres were planted in lime (*Citrus aurantifolia* Swing). From 1924 to 1933 various varieties of citrus spp. were grown at Abercrombie and Barkly Experimental Stations. Unfortunately the plants succumbed probably to canker, tristeza or greening. In fact from 1945-1962 only seedlings of lime, pommelo and mandarines were sold to the public (JULIEN, 1970) Innumerable introductions of budwood at various times in the past from places as varied as Trinidad, South Africa or U.S.A. had contributed much in the intro-

* Scientific Officer (Plant Pathology) & Temporary Principal Agricultural Officer (crops) respectively

duction of most of the diseases that currently infect our citrus trees. In 1967, Dr. S. Moreira surveyed conditions of citriculture in Mauritius and confirmed the existence of tristeza. The presence of greening, psorosis, exocortis and bud-union crease was established for the first time. In 1975, Vogel of the *Institut Français de Recherces Fruitières Outre-mer* (IFAC) found at Richelieu a severe strain of tristeza on Rangpur lime introduced from Taiwan. He reported for the first time the presence of stubborn disease of citrus introduced with budwood of Washington Navel orange from Morocco. In 1981, Dr. Bové recommended the use of indexed citrus material for plant propagation, an indexation programme and the biological control of the psylla vectors of greening.

## Diseases

The most important diseases in Mauritius are citrus canker (bacterial), gummosis (fungal), exocortis (viroid), tristeza and seedling yellows (viral), and greening (bacteria-like). Symptoms of these will be described and appropriate methods of control outlined.

### Citrus canker

This disease has been known to occur in Mauritius for more than 50 years. It causes canker like symptoms on leaves, twigs, thorns, older limbs and fruits (Fig. 1). On fruits these appear like spongy eruptions, often crater like on the rind, with a glazed oily margin. Affected fruits may even fall off prematurely. Infection takes place readily within a temperature range of between 20-30°C and is related to the density and maturity of the stomata, being heaviest during their development (HAYWARD & WATERSTON, 1964). Prolongued wet weather is the most important factor in the spread of the disease which is enhanced when leaves are damaged by strong winds or by the thorns. With high infection, the branches become defoliated and die back resulting in a weak, stunted unproductive plant. The bacteria is reported to survive in infected leaves for six months (HAYWARD & WATERSTON, 1964).

Most citrus varieties are susceptible to the disease but limes (Mexican, Rangpur limes), rough lemon, grapefruit and some sweet orange varieties are very susceptible. Some sweet orange varieties, mandarin, shaddock (*pamplemousses*) appear to be less susceptible. In Mauritius, *Xanthomonas citri* was severe on Eureka Lemon whereas Bearss lime was free of canker, suggesting that the bacterial strain in Mauritius is different from those recorded in Réunion (AUBERT, personal communication).

A satisfactory measure of control can be achieved by weekly sprays of a combination of Dithane M45 (1 g/litre) and copper oxychloride (3 g/litre). Suitable wind breaks (e.g. acacia hedges *Leucaena glauca*) are essential to reduce wind damage and subsequent bacterial spread.

### Seedling yellows virus

Although this virus is sometimes listed as a strain of Tristeza (PRICE, 1970) it is more appropriate to consider it as a separate entity that occurs with tristeza. All isolates that cause seedling yellows consist of two components, one of them being tristeza. Isolates of tristeza separated from seedling yellows are referred to as seedling-yellows tristeza to distinguish them from naturally occuring tristeza which is free from seedling yellows. Seedling yellows causes a stunting and

chlorosis of seedlings of sour orange, Eureka lemon and grapefruit. Leaves of severely affected plants are small, greenish yellow in colour and remain undeveloped (KLOTZ, *et al*, 1972). In fact, often citrus trees become infected after transplant and later recover and carry only the tristeza component. Thus, symptoms would be rare in fields where seedling yellows has existed for a long time except in young seedling trees. Since all root-stock/scion combinations susceptible to tristeza are also susceptible to seedling yellows it is imperative to use a tolerant rootstock. There are reports of cross protection with avirulent seedling yellows strains.

## Tristeza

Tristeza which occurs in most regions of the world where citrus is grown has been the cause of epiphytotics which resulted in the loss of around 20 million citrus trees grafted on sour orange rootstocks in Argentina, Brazil and California in the early 1930's. It is believed that tristeza disease has been present in Mauritius for more than a century, since the citrus plants and the vector, the black aphid, (*Toxoptera citricidus*) were introduced together (MOREIRA, 1967). Tristeza caused the complete failure of several citrus varieties on sour orange rootstock in the past and prompted the use of Rough Lemon as a rootstock in Mauritius. Tristeza is principally a disease of sweet oranges and other varieties when grown on sour orange (*Citrus aurantium* L.) rootstocks. It is also of common occurrence on grapefruit, lime and calamondin.

The most typical symptom on leaves consists of vein clearing on acid lime. Young leaves remain small and become cup or canoe shaped. Stems are pitted under the bark (Fig. 2) and plants may remain stunted. Defoliation of trees and dieback are not uncommon. However, the degree of vein clearing, stem-pitting and stunting varies with different strains of tristeza virus (CHILDS, 1968). Sweet orange on sour orange rootstock may either die suddenly or develop a characteristic honeycombing below the union on the sour orange rootstock. Fruits can be smaller in size.

In Mauritius the disease is particularly severe on Limon Rodrigues (Mexican lime) and on several grapefruit varieties i.e. Marsh Seedless, Duncan, Leonard, Jadoo. However, the latter produced abundantly even in the presence of severe stem pitting throughout the trunk and branches. In 1967, Moreira introduced the rootstock Rangpur lime because of its tolerance to tristeza. However, a highly virulent strain from Taiwan was found to be the causal agent of severe pitting in this rootstock. It is worthwhile to point out that a less severe strain also occurs in Mauritius.

The disease is transmitted by several aphids (*Toxoptera citricidus, Aphis gossypii, T. aurantii*) which occur locally but *T. citricidus* is the most efficient vector. The virus is acquired and transmitted in a few seconds feeding. The virus is graft transmissible.

The only practical control is the use of disease free budwood (from mother plants that have been indexed for the presence of virus diseases) and tolerant rootstocks such as citrange Carrizo. The rootstocks should be kept free of insect infestation especially *Toxoptera* spp. The control of the insect vestors by suitable insecticide has a very limited value in controlling the field spread of the disease because of the rapidity with which the virus is acquired and transmitted. The use of cross protection by mild strains of the virus could offer possible protection and it necessitates further experimentation.

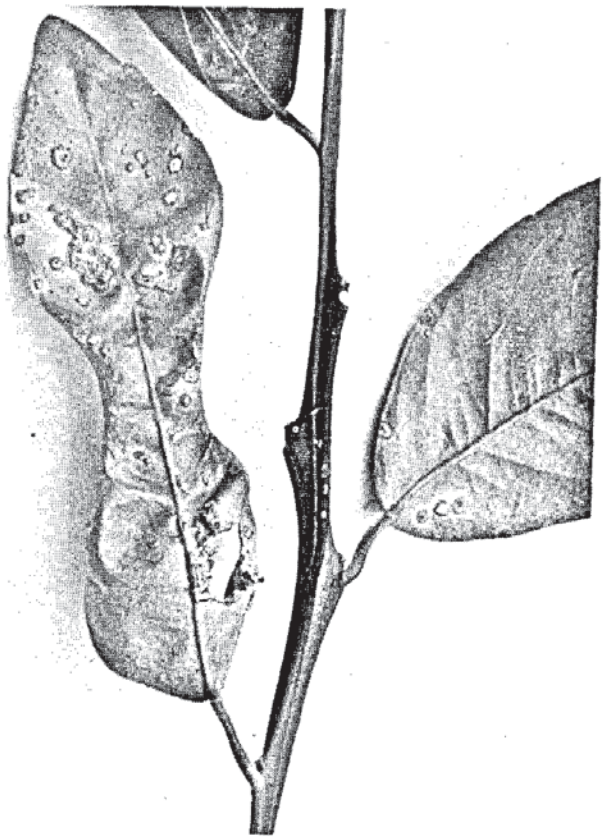

Fig. 1. Symptoms of citrus canker on leaves and twig.

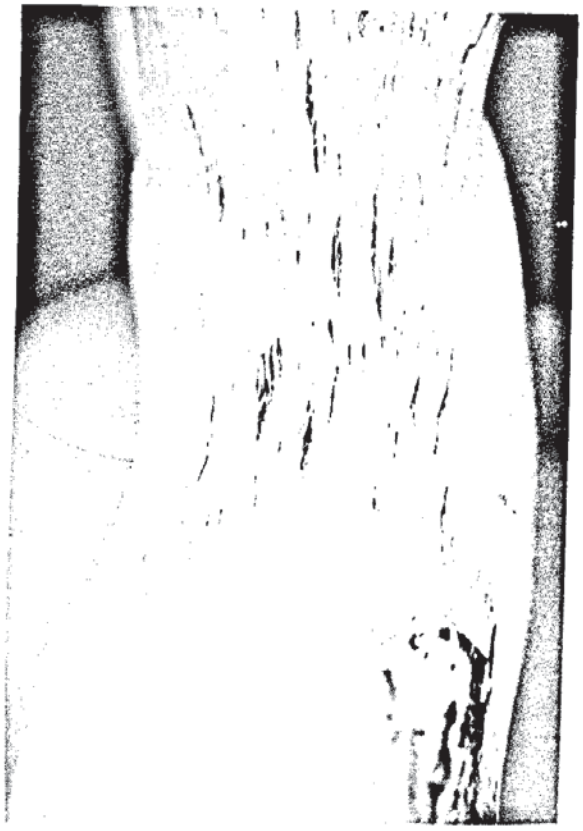

Fig. 2. Severe stem pitting on a susceptible scion grafted on a tolerant rootstock.

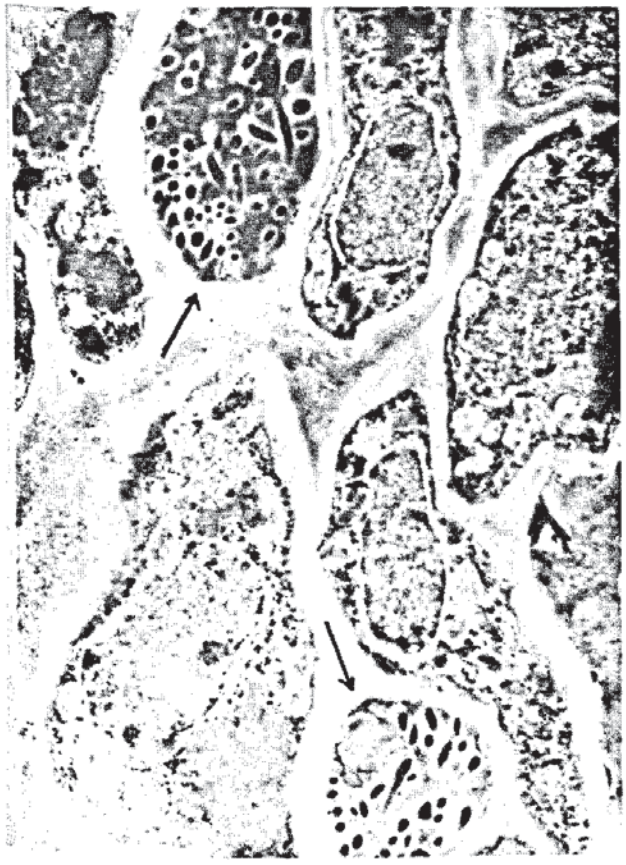

Fig. 3. Greening organisms in infected citrus tissue.

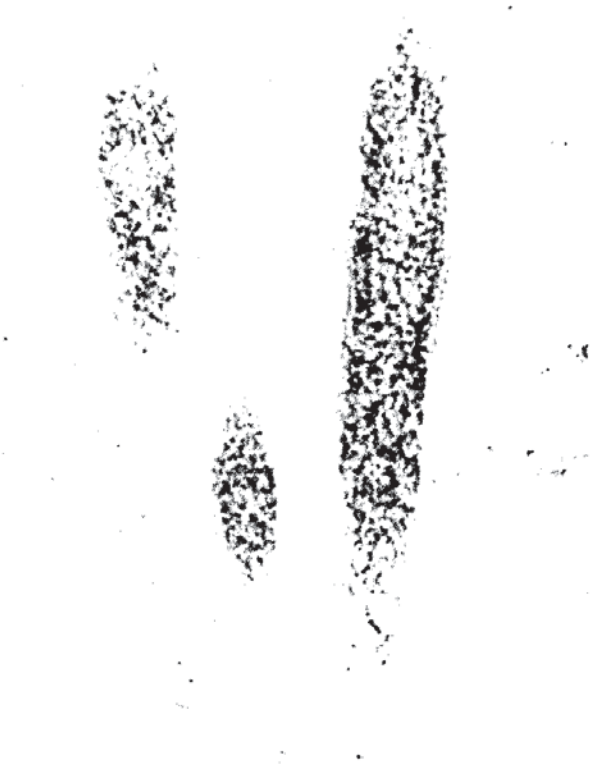

Fig. 4. Electron micrograph of organism responsible for greening.

Fig. 5. Leaf symptoms of greening disease. The two leaves on the left are healthy controls.

Fig. 6. Symptoms of greening on mandarine var. Poeten.

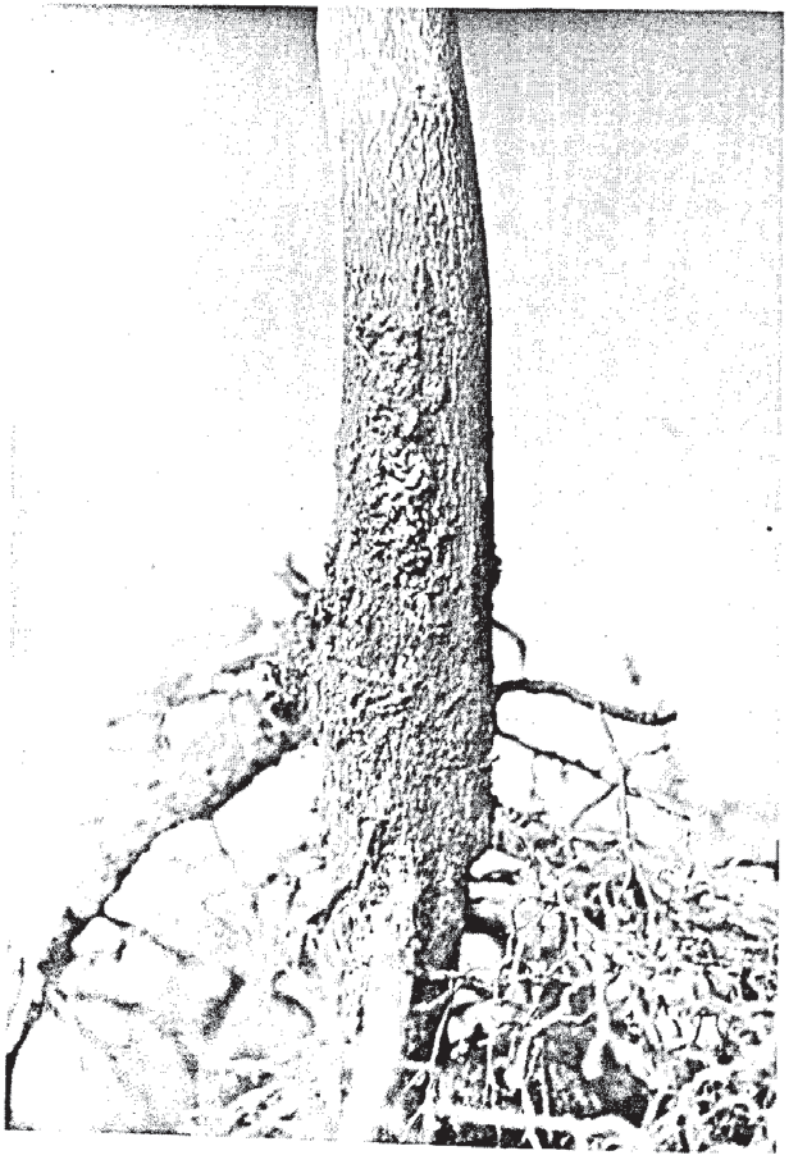

Fig 7. Gum exudation caused by *Phytophthora* spp.

## Greening

Greening disease, the cause of stunting, foliar chlorosis and decline of *Citrus* spp. has been known in South Africa since 1929 although it probably originated in China. The disease was first thought to be caused by malnutrition, rather than by a transmissible virus until the finding of Lafleche and Bové that the disease is caused by a mycoplasma like organism (LAFLECHE & BOVÉ, 1970). In this context, greening affected material sent to Japan for electronmicroscopy revealed the presence of mycoplasma like organisms in phloem cell tissue of affected citrus spp. (Figs. 3 and 4). Subsequent work (GARNIER & BOVÉ, 1977) has shown that it would be more scientifically accurate to label the causal organism as a bacteria like organism. Similar diseases have been described under different names, such as, " die back " in India, " Leaf mottling " in the Phillipines, " Yellow Shoot " in China and " Likubin " in Taiwan.

Moreira identified the disease for the first time in Mauritius in 1967 where it remains an important limiting factor in citrus production. As far as is known, Réunion and Mauritius are the only places where both vectors of greening, *Trioza erytreae* (Del guericio) and *Diaphorina citri* Kuw coexist (CATLING, 1970).

No species of citrus have been described as immune. Symptoms of greening disease differ according to the variety attacked. Generally, on sweet oranges, the disease causes considerable stunting, leaf and fruit drop and twig dieback depending largely on the extent of attack. The disease either occurs throughout the tree, or may be confined to a few branches of the tree where affected parts show a variety of chlorotic leaf symptoms of which a blotching mottle (Fig. 5) is a diagnostic feature (MC CLEAN & SCHWARZ, 1970). Chlorotic leaf patterns produced within greening affected trees vary according the age of the leaves and the flushing period. Fully matured leaves show a leaf mottle caused by an irregular discoloration following the course of the midrib and larger veins. The yellowing spreads laterally away from the veins to a greater or lesser extent producing a generalized mottle. New growth often produces short twings bearing narrow upright leaves, which are either quite yellow or yellow with some dark spots. As the leaves nature they turn green with their veins marked as a darker green network (MC CLEAN & OBERHOLZER, 1965). Severely diseased trees are stunted, unthrifty, usually sparsely foliated (Fig. 6) and produce poor crops of predominantly greened, worthless fruit. Fruits are usually smaller than normal and often lop-sided and may drop prematurely. The side of the fruits away from direct sunlight tends to stay abnormally green and to develop more slowly than the exposed side. The quality of greened fruits is poor, they usually have a bitter unpleasant taste. Affected plants usually have poorly developed root systems, with relatively few fibrous roots (OBERHOLZER, *et al*, 1965).

SONIASSY and LALLMOHAMED (1972) were the first here to try to confirm the presence of greening by chromatographic determination of gentisoyl glucoside. Although there are other reports that the presence of the fluorescent marker, gentisoyl glucoside in greening affected plants can be used for indexation purposes, the authors have not found it possible to establish a correlation between symptoms of the disease and the presence of the marker substance (DOSSA & MUNGUR, 1982). It was possible to index for the presence of the disease on sweet orange indicator seedlings when symptoms developed after three months (unpublished).

Greening responds very well to injections of tetracycline hydrochloride and (unlike mycoplasmas) to penicillin (AUBERT, *et al*, 1980). SCHWARZ and VAN VUUREN (1971) have succeeded in reducing the incidence of fruit greening by about 50% by injecting a 500 ppm or 750 ppm tetracycline hydrochloride (hostacycline) into the trunks of severely greened sweet orange trees. Trees were injected by the method originally described by SCHREIBER (1969). In Mauritius, the authors have used a similar system with modifications proposed by SCHWARZ (personal communication) and found that a dose of 300 ppm of tetracycline hydrochloride is sufficient for the suppression of symptom expression in three year old citrus plants (DOSSA & MUNGUR, 1981).

Fruits containing antibiotics at harvest may be harmful. Fortunately, it has been shown that when antibiotics are injected during flush periods, no residues could be detected in the fruits one month after injection (MOLL, 1972). Experiments are under way to determine the rate of breakdown of antibiotics under local conditions.

Shoots free of greening can also be obtained after infected budsticks are immersed for 25 minutes in a solution of 100 ppm of tetracycline hydrochloride (MARTINEZ, *et al*, 1970).

Although the use of antibiotics appear attractive, yet they do not constitute an ideal solution. This is because antibiotics merely afford a remission to the disease and are not a cure. By far the most important control measure is the control of the psylla vectors. Biological control of one of the vectors, (*T. erytreae*) initiated in 1977 appears to have had a promising effect (AUBERT, 1982). Although much remains to be done in this field, it would appear that work which started earlier on biological control in Réunion Island has yielded positive results (AUBERT, *et al*, 1980).

## Exocortis

Exocortis is a viroid disease, primarily of citrus trees grown on rootstocks of trifoliate oranges, citranges and Rangpur lime. Characteristic symptoms are vertical cracking and scaling of the bark at the base of the rootstock usually associated with a pronounced stunting. Symptoms on upper portions of the plant include leaf and stem epinasty, cracking and callousing of underside of mid-veins, yellow blotches and cracks on shoots. Varieties attacked are trifoliate oranges, citranges, Rangpur lime, mandarin and sweet limes. The disease is also readily transmitted to healthy plants by budding knives or other mechnical means. The viroid is reported to survive on steel knife blades for at least 8 days.

Since the disease is transmitted only through the propagation of infected budwood, only seed and budwood from disease-free sources should be used for propagation. A 1% solution of sodium hypochlorite is recommended for inactivating the viroid.

## Gummosis (*Phytophthora* spp.)

Gummosis is mainly a disease of the rootstock portion of the grafted citrus plant but it can also occur on certain species on their own roots e.g. Cleopatra mandarin. It causes a foot rot associated with bark splitting and gum exudation of the trunk at or near soil level. The roots of the affected plant are weakened by the fungus and the whole plant can be shaken off easily by holding the main trunk. With severe attacks, the plant wilts and dies off slowly. The disease is more prevalent

on deep, heavy, waterlogged soils. Susceptibility to the disease varies according to the rootstock used. Susceptible varieties are Rodrigues lime, Cleopatra mandarin, Rough lemon and the sweet oranges. Varieties which are known to exhibit good tolerance or resistance are *Poncirus trifoliata*, Sunki mandarin, Troyer citrange, Carrizo citrange and *Citrus volkameriana*.

Control of the disease lies in the use of resistant rootstocks. Apart from choosing the right soil type, deep planting is not encouraged, grafts should be made at knee height to prevent the fungus from reaching the scion portion of the plant. Fungicide Aliette (aluminium tris-ethyl phosphonate) is known to be effective against *Phytophthora* spp. on citrus. It possessess both upward and downward systemic activity and can be used preventively as a foliar spray especially during flush periods or curatively as a paint.

## Conclusion

Conditions in Mauritius are suitable for the development of a proper citrus industry provided, among other things, that technical constraints at production level are overcome. The most important diseases of citrus are canker, greening and tristeza. Bacterial canker can be prevented to a significant degree by repeated sprayings of an appropriate fungicide coupled with proper agronomic practice. The battle with greening is half won with the introduction of biological control of the vectors of the disease and tetracycline treatment. Control of tristeza is now feasible through use of tolerant rootstocks.

It would be preposterous to assume that all our major disease problems have been solved. The success of citriculture would depend upon sustained efforts at research level e.g. rootstocks trials should be continued, mother plants indexed for freedom from virus and viroid diseases for propagation of healthy budwood. Most of all, the success of citriculture would depend on consolidated efforts of different Divisions of the Ministry.

## Acknowledgements

The authors would like to express their gratitude to Dr. Matsui of Nagoya University and Dr. T. Miyakawa of Tokushima Horticultural Experiment Station for the electron-micrographs, to Mr. N. Teeluck of the Extension Services of the Ministry of Agriculture for photographs and to Mr. N. Sobun for assistance.

## References

AUBERT, A., BOVÉ, J. M., and ETIENNE, J. (1980). La lutte contre la maladie du "Greening" des agrumes à l'île de La Réunion. Résultats et perspectives. *Fruits*, 35 (10) : 605-623.

AUBERT, B. (1982). *Situation de l'agrimiculture mauricienne*. Rapport de visite. Août 1982.

CATLING, H. D. (1970). Distribution of the psyllid vectors of citrus greening disease with notes on the biology and bionomics of *Diaphorina citri*. *FAO Plant Prot. Bull.* 18 : 8-15.

CHILDS, J. F. L. (Ed.) (1968). *Indexation procedures for 15 virus diseases of citrus trees*. Washington D. C. : USDA Agric. Handbook 333.

DOSSA, M. I. & MUNGUR, R. (1981). *Ann. Rept. Min. Agric. & Nat. Res.* (in press).

DOSSA, M. I. and MUNGUR, R., (1982). *Ann. Rept. Min. Agric. Nat. Res. Env.* (in press).

GARNIER, M. and BOVÉ, J. M. (1977). Structure trilamellaire des deux membranes qui entourent les organismes procartyotes associé à la maladie du " Greening " des agrumes. *Fruits*, 32 (12) : 749-752.

HAYWARD, A. C. & WATERSTON, J. M. (1964). *Xanthomonas citri*. CMI Descriptions of pathogenic fungi and bacteria, No. 11.

JULIEN, H. (1970). History of horticulture in Mauritius. *Rev. Agric. Sucr. Ile Maurice*, 49 : 194-205.

KLOTZ, L. J., CALAVAN, E. C., and WEATHERS, L. G. (1972). *Virus and virus like diseases of citrus*. Circ. 559, Calif. Agric. Exp. Sta. Ext. Service

LAFLÈCHE, D., and BOVÉ, J. M. (1970). Structures de type mycoplasme dans les feuilles d'orangers atteints de la maladie du " greening ". *Compt. Rend. Acad. Sci. Ser. D.*, 270 : 1915-1917.

MARTINEZ, A. L., NORA, D. M. and ARMEDILLA, A. L., (1970). Suppression of symptoms of citrus greening disease in the Philipines by treatment with tetracycline antibiotics. *Plant Disease Reptr.* 54 : 1007-1009.

MC CLEAN, A. P. D., and OBERHOLZER, P. J. C. (1965). Greening disease of the sweet orange. Evidence that it is caused by a transmissible virus. *S. Afr. J. Agric. Sci.* 8 : 253-276.

MC CLEAN, A. P. D., and SCHWARZ, R. E. (1970). Greening or blotchy mottle disease of citrus. *Phytophylactica*, 2 : 177-194.

MOLL, J. N. (1972). Fluorometric determination of antibiotic residues in trees injected with tetracycline hydrochloride. *In Proc. 6th Conf. I.O.C.V.* : 198-201.

MOREIRA, S. (1967). *Citriculture in Mauritius*. Report FAO/UNDP PL : SF/22/R. Rome.

OBERHOLZER, P. C. J., VON STANDEN, D. F. A. & BASSON, W. J. (1965). Greening disease of sweet orange in South Africa : 213-219. In *Proc. 3rd Conf. International Organization of Citrus Virologists (I.O.C.V.), Univ. Florida Press, Gainesville*. W. C. Price (Ed.).

PRICE, W. C. (1970). Citrus tristeza virus. GMI/AAB. Descriptions of plant viruses, No. 33.

SCHREIBER, L. R. (1969). A method for the injection of chemicals into trees. *Plant Disease Reptr.* 53 : 764-765.

SCHWARZ, R. E. and VAN VUUREN, S. P. (1971). Decrease in fruit greening of sweet orange by trunk injections of tetracyclines. *Plant Disease Reptr.* 55 : 747-750.

SONIASSY, N. and LALLMAHOMED, G. M. (1972). Confirmation of the greening disease in Mauritius by identification of the marker substance gentisoyl glucose. *Rev. Agric. Sucr. Ile Maurice*, 51 : 198-200.