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COMMITTEE ON COMMODITY PROBLEMS

INTERGOVERNMENTAL GROUP ON CITRUS FRUIT

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REVIEW OF CURRENT CITRUS PHYTOSANITARY PROBLEMS AND CONTROL POLICIES EMPLOYED

I. INTRODUCTION

1. The Uruguay Round Agreement on Agriculture (URA) established a rules based system regarding the application of Sanitary and Phytosanitary Measures.[1]

2. Phytosanitary procedures have been defined by the International Plant Protection Committee (IPPC) to mitigate the pest risk associated with the movement of citrus and other commodities. Briefly, there are three measures commonly used to address sanitary and phytosanitary concerns:

a) Disease-free zones and regions of low risk. IPPC has issued guidelines to help countries achieve disease-free or pest-free recognition. The exporting country must have a good infrastructure because the surveys are lengthy and expensive, and the importing country needs assurance that the declared regions will remain disease-free/pest-free.

b) Increased vigilance at ports of entry. The ability to intercept disease/pest at ports of entry calls for resources from the importing country. If a disease/pest is found, the product must either be treated if possible depending on the problem, or re-exported to another country having less stringent requirements, or destroyed, all of which result in increased cost to the exporting country.

c) Use of pre-clearance programmes where the product being exported is inspected and treated in the exporting country before being exported.

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[1] Please see CCP: CI 98/7 "Sanitary and phytosanitary measures, citrus industry and trade, September 1998, www.fao.org/unfao/bodies/ccp/citrus/98/98-7e.htm

3. The goal of an importing country is to have sufficient phytosanitary measures in effect to prevent entry and to prevent the establishment of quarantine pathogens/pests. In the IPPC draft of 27 July 2000, a systems approach was proposed and defined as the integration of different pest risk management measures, including at least two independent procedures that individually reduce pest risk, which may be combined with other measures that cumulatively result in meeting the appropriate level of protection defined by the importing country. At least two of the measures must have an independent effect on reducing the risk of pest introduction. The systems approach resembles an integrated pest management approach to minimize the threat of quarantine diseases and pests. The management strategies can begin with pre-plant procedures, such as selection of planting material and the use of certification programmes, and includes surveys for pests and application of treatments through the year, and include procedures at the harvest, post-harvest handling, storage, shipping and distribution stages.

II. FACTORS TO CONSIDER FOR PRIORITIZATION OF EXOTIC PATHOGENS/PESTS

4. In reality it is difficult for a country having a citrus industry to recognize and prioritize the exotic pathogens/pests which pose a severe danger to that country’s industry. Several factors need to be considered before prioritization: introduction, establishment, potential economic impact, spread, ease of detection, and control.

Introduction	Existence of pathogen/pest in the exporting country
	Existence of pathogen/pest in the area where produce originates
	Nature of the inoculum (spores, plant tissue, etc.)
	Method of entry to the importing country (wind, tourist traffic, citrus commerce)
	Likelihood that the pathogen/pest will be found at the point of entry
	Availability of methods of diagnosis at point of entry
Establishment	Climatic similarities between exporting and importing countries
	Penetration of product in rural areas (vs. urban)
	Availability of alternative hosts in importing country
	Survival of inoculum in imported products (days, months, years)
	Time lag between pathogen infection and identification of disease
Spread	Method of transmission (vector, wind, etc.)
	Existence of vectors in the importing country
	Host preferences of the vector and presence of preferred vectors in the importing country
	Efficiency of pathogen transmission by the vector
	Persistence of pathogen in vector
	Possibility of pathogen being transovarially passed to insect progeny
	Existence of natural enemies/pathogens of the vector in importing country
	Likelihood of pathogen being spread by debris, of equipment, or on fruit
	Likelihood of spores being spread by wind
	Adequacy of conditions for spore germination

	Likelihood of pathogen being spread by movement of nursery material
	Existence of certification programmes for freedom from pathogen for budwood source trees
	Citrus variety(ies) affected by the pathogen (sweet orange, grapefruit, mandarin, lime)
Detection	Availability of accurate, timely and reliable detection methods of the pathogen/pest
	Possibility of using detection methods at ports of entry
	Suitability of detection methods for large scale usage
	Cost of diagnosis
	Availability of accurate information on the life cycle of the pathogen/pest to enable effective testing
	If the pest is an insect, have methods been developed to enable accurate monitoring for presence and/or population?
Control	Control measures applied in the exporting country
	Possibility of applying control measures of exporting countries in importing countries, and cost of the control
	Existence of control measures for the pathogen/pest in the importing country
	Possibility of pathogen/pest control by chemical application or the use of budwood certification programmes
	Availability of resistant or tolerant citrus varieties in the importing country
	Availability of breeding programmes of resistant or tolerant varieties in the importing country
	Likelihood of developing genetic resistance to the pathogen and length of time required to achieve it

III. EXAMPLES OF EMERGING DISEASES OF CITRUS WHICH INTERFERE WITH TRADE AND LIMIT PRODUCTION

A. HUANGLONGBIN (HLB)

5. Huanglongbin (HLB), synonyms: citrus greening, yellow shoot, likubin, leaf mottling and vein-phloem degeneration, is caused by systemic phloem-inhabiting bacterium, *Candidatus* Liberobacter. There are two forms of HLB, each form has a similar host range but they differ in the temperature under which they express strongest symptoms. The African form, *Cadidatus* L. africanus causes symptoms under cool conditions while the Asian form, *Candidatus* L. asiaticus causes symptoms under warm conditions. the Asian forms, in general, express stronger symptoms than African forms. The HLB bacterium infects nearly all citrus species, cultivars and hybrids and some citrus relatives. Sweet orange, mandarin and mandarin hybrids are most susceptible; lemons, grapefruit and pomelos are moderately affected; and Mexican lime, trifoliate orange, citranges and citrumelos are more tolerant, often expressing foliar symptoms but little twig dieback. Australian citrus dieback (ACD) may be a disease similar to HLB.

6. Symptoms of Asian HLB are leaf chlorosis. The early symptoms usually appear only on one sector or branch of the tree. The chlorosis spreads, often resembling a zinc deficiency symptom. Twig dieback occurs, and the affected trees decline to a non-productive state. Fruit is small, lopsided, with the basal end often remaining green, and the seeds are usually aborted. The fruit has a bitter taste. The symptoms of the African form of HLB are similar except they are

expressed during cooler weather, and a blotchy mottle symptom is common on the leaves, especially young flush leaves grown under cool temperature.

7. HLB is graft transmissible. The distribution of the HLB bacterium within an infected tree can be irregular so not all buds will contain the bacterium or transmit the disease. The more phloem tissue that is included in the inoculum, the greater the probability of graft transmission when transmitting by grafting.

8. HLB bacteria are transmitted by psyllids; *Trioza erytreae* occurs in Africa, Yemen and islands in the Indian Ocean. This vector is associated with the African form of HLB. *Diaphorina citri*, commonly called the Asian citrus psyllids, is better adapted to warm humid climates and occurs in Asia, the Indian Subcontinent, Saudi Arabia, Reunion, Mauritius, South America and more recently several Caribbean islands, areas in Central America and Florida. Both psyllids have been shown to transmit either form of HLB, Asian or Africa. The bacterium is transmitted in a persistent manner with a latent period occurring after the psyllid acquires the bacterium before the insect is able to transmit; the bacterium multiplies in the psyllid vector. Because of the latent period, most psyllids capable of transmitting HLB are either late-stage nymphs or adults. The psyllids remain capable of transmitting HLB for the duration of their life once the bacterium has been acquired. Citrus species is the primary host for feeding of both psyllid species. The psyllids prefer to feed on young flush tissue. Hosts which are vigorous and always flushing, such as lemon, lime and *M. paniculata* are ideal hosts to look at for presence of psyllids.

9. The quickest and most reliable method for detection and diagnosis of HLB is by PCR using symptomatic tissue as the source. Biological indexing is often difficult because severe strains of citrus tristeza virus (CTV) occur in most areas where HLB occurs, and the symptoms of CTV can mask the presence of HLB. Cool greenhouse conditions, 24-27ºC, are required for symptom development of African forms of HLB, while warm conditions, 30-37ºC, are required for symptom development of Asian forms of HLB. Asymmetric growth of young leaves, especially on greenhouse indicator plants, is indicative of presence of HLB, in addition to a blotchy mottle leaf symptom for African forms and zinc deficiency-like symptoms for Asian forms. Grapefruit and lemon plants are good indicator plants, showing good symptoms under greenhouse conditions. Mandarin indicator plants may be useful if severe strains of CTV are present as the mandarins are tolerant of CTV and most of the symptoms being expressed are due to HLB. Other methods of assay which have been reported are use of transmission electron microscopy, a method not useful for a large number of samples, and assays for presence of gentisic acid, a method which is not as accurate and sensitive as PCR but it does not require elaborate equipment.

10. The best control for HLB is exclusion. Because of the similarity of the symptoms of HLB and other decline disease such as citrus blight and CTV, it may take awhile before HLB infections are noticed as being due to a new disease, thus making establishment of this exotic disease more likely. In areas where HLB has been established, management to reduce losses include propagation of HLB-free trees for planting, reduction of the psyllids populations by removing species which continually flush, application of insecticides when threshold population levels are attained, and by pruning symptomatic sectors from the trees. The use of parasites to control the psyllids population has been successful in Reunion and some other areas. Before the development of shoot tip grafting methods to eliminate graft transmissible pathogens, budwood was treated at an elevated temperature, up to 60ºC, for a few minutes for therapy, before propagating.

11. HLB is one of the most destructive diseases of citrus. Once established, the management of the disease to achieve continued production of citrus is difficult and expensive. When the psyllid vector is present and under ideal climatic conditions, HLB can rapidly decimate productive citrus plantings. If trees are infected while young, they often have no fruit production.

POLICY IMPLICATIONS FOR GREENING

Greening – Implementation of control measures in several countries

Economic importance

Greening has been reported in some 29 countries of Asia and Africa. Losses due to greening are not easy to assess, as sometimes only sectors of a tree are affected and losses are small, but in other cases entire trees are infected and crop loss is total. Severe economic losses have been reported in India, the Philippines, where some seven million trees were affected, reducing the planted area by over 60 percent, and in Thailand, Taiwan Province of China, where the disease destroyed some three million trees, while groves in Indonesia and Saudi Arabia have been abandoned, declined or disappeared entirely.

Responses and policies in a few countries

Control of citrus greening can be achieved by such integrated measures as eradicating infected plant material, introducing clean nursery seedlings and eliminating the insect vectors. Treating affected trees with injections of antibiotics alleviates the symptoms, but does not cure the diseased plants. Prompt elimination of diseased trees is strongly advised.

It is of primary importance to propagate and plant pathogen-free seedlings derived from foundation stock obtained by heat therapy, shoot-tip grafting, health indexing, or nucellar lines. In South Africa a system of internal quarantine prohibits the movement of trees from the greening-affected areas to other parts of the country. In addition, vector control is emphasized in South Africa, combined with removal of infected trees and branches. Trees with 50-70 percent greening fruit symptoms are removed, while removal of branches is recommended for lower infection levels. Injection with PMT (N-pyrrolidinomethyltetracycline) is recommended only for trees over 10 years old with more than 40 percent greening. China employs a similar system. Clearly, integrated control will be the most effective.

In Reunion a combination of introducing parasites, treating trees with antibiotics and raising new trees free of infection has had success, and in India the use of insecticides, injections of tetracycline hydrochloride, thermotherapy of budwood and the use of tolerant rootstocks has reduced losses. In China, where the use of antibiotics has not yet been widely adopted, a combination of quarantine, propagation of healthy plants, thermotherapy and shoot-tip grafting of infected budwood, removal of diseased trees, especially in areas of low psylla incidence and the use of insecticides is recommended. In foundation blocks in the Philippines a combination of tolerant varieties, eradication of diseased trees, replanting with healthy plants, and spraying against psylla showed that citrus production is still feasible in greening areas.

Policy implications

Technical know-how and information are the key to solving a disease problem. However, when it comes to extending technology to producers and keeping an integrated control programme moving, other resources should be taken into consideration. First of all, enough qualified manpower to do the job in an organized and coordinated way is needed. Skilled manpower is particularly needed for the production of pathogen-free seedlings, the monitoring of vectors, the early detection and destruction of infected plants, and the release of natural enemies.

In addition, government policies should support the control programme with adequate funding, and with pertinent regulations. These laws are indispensable for the regulatory control of pests. They enforce the destruction of inoculum sources (diseased plants and vectors) and establish a certification system for pathogen-free planting materials. Money certainly cannot solve every problem, but money makes it much easier to solve a problem.

Finally, not only does the control technology and information need to be integrated and managed but also the manpower, the budget and the regulations, so that they reinforce each other.

As exclusion of infected graft material is the best course of action to present introduction, strict phytosanitary measures at the border are important.

A concern for those countries that have so far escaped the ravages of greening is how to avoid it. For Brazil the danger is probably greatest because the vector, *D. citri*, is already present. If it should enter, the rest of South America and subsequently North America would be threatened. The northward migration of the citrus tristeza aphid vector *Toxoptera citricidus* illustrates the danger. The presence of the vectors and the disease in Pakistan and the Arabian peninsula poses a similar danger for Mediterranean countries. The danger is real that the Asian vector, *D. citri*, may move either from Arabia or from Reunion and Mauritius, via Madagascar, to the African mainland, and become established in conjunction with the existing African form. Citrus in the hotter, drier areas would then also be threatened.

B. CITRUS VARIEGATED CHLOROSIS (CVC)

12. The symptoms of CVC usually begin with a zinc deficiency-like chlorosis appearing on one sector of the trees. The leaves develop a gummy raised lesion on their underneath side with a corresponding yellow chlorosis appearing on the upper surface of the leaf. As the symptoms spread, the new leaves are small and tend to point upward, twig dieback occurs, the fruit size is greatly reduced, and the fruit has a hard rind. The sugar content of the fruit is higher than in non-affected fruit, and the fruit ripen earlier. Once infected with CVC a tree is rendered non-productive in three years. Once infected, the trees have reduced growth. Younger trees are more susceptible to CVC than trees which are ten years of age or older. Symptom expression and incidence of CVC appear to be greater in warmer climates. All sweet orange varieties are susceptible to CVC. Lemons, limes, mandarins, mandarin hybrids such as Murcott and Sunburst, kumquats, trifoliate orange and grapefruit usually do not show symptoms of CVC but allow some multiplication of the bacterium.

13. The CVC bacterium is transmitted by several species of sharpshooters which are common in Brazilian citrus areas. The efficiency varies among species. Ultrastructure studies have shown that the bacterium may attach to the inside of the stylet, pump organ (cybarium) and pre-cybarium of the sharpshooter. The sharpshooter loses the ability to transmit *X. fastidiosa* whenever a molt occurs. Once an adult acquires *X. fastidiosa,* they retain the ability to transmit for life. At least 11 species of sharpshooter have been identified to transmit CVC in Brazil. The most important vectors in Brazil are *Acrogonia terminalis, Dilobopterus costalimai,* and *Oncometopia fascialis*, other common vectors present are *Sonesimia grossa, Hortensia similis, Ferrariana* sp. and *Molomea* sp. The glassy winged sharpshooter, *Homoladisca coagulate*, present in the southeast United States and now in California has been shown to be capable of transmitting CVC.

14. Diagnosis of CVC in the field can be confused with other decline diseases of citrus. CVC infected trees will take up water by the syringe injection test while blight infected trees do not. Diagnostic field symptoms are the small fruit having high sugar content, the gummy lesion on the underside of the leaves, and the small, pointy leaves at the top of the tree. Laboratory detection methods include serological assays, culturing the bacterium, microscopy and PCR. The problem with most of these detection methods is that it is difficult to differentiate between the CVC strain and other strains of *X. fastidiosa*. PCR methods have been reported which allow specific detection of the CVC strain.

15. For areas without CVC, exclusion is the best control. Use of citrus budwood certification programmes are helpful. Management of CVC in Brazil is by propagation of disease-free planting material, use of insecticidal sprays to reduce vector populations, and pruning of early symptoms from the trees on a regular basis. In the longer term, genetic engineering approaches are being used to develop resistance to CVC in sweet orange.

POLICY WITH REGARD TO CITRUS VARIEGATED CHLOROSIS (CVC) IN BRAZIL CASE STUDY

Cost of compliance: economic importance of healthy nursery trees production

In Brazil, every year, millions of trees are eradicated due to Citrus Variegated Chlorosis (CVC), citrus canker and other diseases and pests. A good quantity of these plants did not even produce oranges and the reason is simple: they already arrived at the grove with one disease or another, i.e., they were already contaminated when they left the nursery. It is known that the best way to prevent nursery trees contamination is the construction of greenhouses. The technology employed in the construction of a greenhouse greatly increases nursery tree prices. However, of all the expenses incurred by the citrus producer, from planting until the end of the grove useful life, the price of this nursery tree will represent only two percent of its expenses.

At the same time that the production of disease-free nursery trees is becoming urgent, but the quantity of existing propagating material does not meet demand. There is a need for 15 million healthy budded trees a year in Brazil. At present, budded tree production is of approximately five million.

Response of FUNDECITRUS

The reformulation of the Brazilian national Stock Plant Registration Programme and the Production of Certified Nursery Tree together are expected to increase the supply of healthy budded trees.

FUNDECITRUS is offering technical support to nursery owners since 1997. The first step was to perform a survey of the quantity of nurseries and greenhouses existing in the citriculture region and the plant protection conditions in which the nursery trees were being produced. A survey performed in 1998 identified 998 nurseries. This survey served as a basis for a series of information steps and technical support, such as lectures and training as well as a service to provide guidance to the citrus grower.

FUNDECITRUS also performs monthly inspections in nurseries. During those visits, FUNDECITRUS technicians strongly recommend to the nursery owners to adopt measures to control pests and diseases, such as the use of greenhouses and the application of pesticides on a regular and methodical basis. These actions form part of the technological package offered to fight Citrus Variegated Chlorosis, citrus canker and other pests and diseases that attack citriculture.

On 27 January 1998, the São Paulo State Agriculture Department published strict rules for nursery tree production, and it will issue a quality certificate for nursery owners who invest in technology.

To this point, CVC has been limited to Brazil. However, the following quotation from Dr Chester Roistacher, Secretary of the International Organization of Citrus Virology (IOCV) is interesting in terms of policy formulation by other citrus producing countries: “I feel that we live in a fools paradise if we believe that our citrus industry is immune to getting any of these diseases and if we persist in the belief that it can’t happen to us. It truly can! Sadly, we do have the technology to detect and eliminate these diseases in our propagative budwood. The major problem is political! How to convince the authorities of what lies ahead if they do not properly fund. I firmly believe that for each dollar invested in a programme of certification, one thousand dollars can be earned or saved by preventing these or other diseases from eating away at our citrus industries”. Dr Roistacher is making a plea for a proactive public-private effort to confront these problems which impact so strongly on citrus industries.

C. CITRUS LEPROSIS (CILV)

16. Citrus leprosis (CiLV), caused by an uncharacterized rhabdo-like virus, has become of increased importance in Brazil and other areas in South America. The bullet-shaped CiLV virions are about 100-110 by 30 mm in size and are not enveloped. The virus is not systemic in the sense that they become systemically distributed throughout the plant, rather the virus particles appear slowly at the edge of the feeding sites of the mite vector. Virions are usually found in the nuclei of infected cells. Inclusion bodies present in the cytoplasm of infected cells appear as viroplasms and

do not contain virions. Variation in the size and shape of virions and differences in the properties of the viroplasm have caused speculation that more than one virus may cause the symptoms commonly associated with CiLV. Toxins secreted by the mite vector may cause some damage also, but leprosis lesions appear to be distinct, contain virions, and are different from the spots caused by mite feeding.

17. CiLV is transmitted by mite vectors of the genus *Brevipalpus*, commonly called flat mites or false spider mites, with *B. phoenicis* reported to be the most efficient; *B. californicus* and *B. obovatus* have also been associated with field spread.

18. CiLV infects all varieties of sweet orange, and has been reported on lemon and mandarin, grapefruit is reported to be tolerant of CiLV.

19. CiLV first occurs as lesions on leaves, fruit and twigs. The occurrence of CiLV on fruit results in premature fruit drop. The centre of the lesions becomes necrotic as they mature. The lesions on twigs gradually enlarge and girdle the twig, resulting in twig dieback. CiLV will kill trees if the mites are not controlled.

20. Zonate chlorosis produces leaf lesions similar to CiLV, but the necrotic area in the centre of the lesion does not develop. The relationship between CiLV and zonate chlorosis has not been studied.

21. Diagnosis of CiLV is by observation of the typical symptoms in the field. Transmission electron microscopy (TEM) to visualize the bullet-like virions is the only method of confirmation presently available. There are no serological or nucleic acid-based assays available at the present time to enable large scale assays or surveys.

22. The control of CiLV is by the application of miticides and pruning infected branches from trees. The major production cost of citrus in Brazil at the present is miticide applications. Current research in Venezuela suggests that CiLV may be passaged through nurseries with leaf lesions developing after the budlings have been planted into the field.

23. Prior to 1925, leprosis had a negative impact on citrus production in Florida. Then about 1926 the incidence of leprosis in Florida drastically declined, with the decline coinciding with the introduction of sulphur as an effective miticide for controlling citrus rust mite. The last time leprosis was reported in Florida was in the mid-1960s.

24. In Venezuela, leprosis was not a problem until about 1990 when it increased in prevalence, perhaps coinciding with the abandoning of many groves on sour orange rootstock which died from citrus tristeza virus. **Export restrictions were placed on shipment of fresh fruit from Venezuela by neighbouring countries illustrate the potential economic impact of this disease**. CiLV has been found in one location in the northern area of Panama, apparently following importation of budwood from Brazil. Recently the presence of CiLV in Guatemala has been confirmed by TEM. There are unconfirmed reports of CiLV in Honduras.

D. CITRUS BLACK SPOT

25. Citrus black spot, caused by *Guignardia citricarpa* (synonym: *Criptosporiopsis citri* Johnston & Fuller), is one of the more important fungal diseases of citrus. The disease occurs in subtropical climates with summer rains in South America, Asia, Africa and Australia. It causes spots on fruit that make the fruit unacceptable for fresh market and causes premature fruit drop.

26. Black spot is favoured by warm, wet climates. The primary source of infection is ascospores produced on dead leaves on the ground, these spores are released when the tissue is wet. Fruit is susceptible to infection for 4-5 months following fruit set. The typical black spot develops when the fruit nears maturity, but the infection occurs long before the development of the black spot. At least four types of lesions have been described. Type A and D lesions are the

most conspicuous and the type of spot associated with black spot disease, the other lesions are described as a speckled blotch and freckle spot.

27. Lemons and late maturing sweet oranges are the most susceptible to black spot. All citrus cultivars can be infected with the disease. Older trees are more susceptible than younger trees.

28. Black spot may be identified in the field by the typical symptoms on the fruit. The fungus can be cultured from infected tissue, but differentiation between non-pathogenic and pathogenic isolates requires a pathogenicity test. Fungicides can provide effective control and be used as a protectant to prevent infection, however timing of applications is important and up to five applications may be needed to protect fruit during their susceptibility period. Care needs to be given to manage fungicides to prevent tolerance of the fungus against the fungicides. Reduction of dead leaves from beneath trees is beneficial to reduce inoculum. Long distance spread of black spot is by movement of infected nursery material. While concern is expressed over the introduction of black spot into new areas by movement of fruit, this would not be likely unless extreme measures were taken to initiate an infection.

E. CITRUS CANKER

29. Citrus canker is a bacterial disease caused by *Xanthomonas axonopodis* pv. *citri*, [synonyms: *Pseudomonas citri*, *Xanthomonas*, *Xanthomonas campestris* pv. Several pathotypes of citrus canker have been described. The most destructive pathotype is the “A” type or Asian citrus canker; grapefruit, acid lime, trifoliate orange are highly susceptible to canker “A”, sweet orange, sour orange and lemon are moderately susceptible, and mandarins are least susceptible. Other pathotypes are “B” which infects mostly lemon, acid lime, sour orange and pomelo; “C” which infects primarily acid lime; and the “bacterial leaf spot disease” caused by *Xanthomonas campestris* pv. *aurantifolii*, which produces leaf spots primarily on trifoliate plants in nurseries.

30. Citrus canker is primarily a leaf spotting disease, causing lesions on leaves, stems and fruit. The lesions begin as small chlorotic spots that enlarge to become lesions with necrotic centres surrounded by a chlorotic halo. Older lesions often have a corky appearance. The size of the lesion depends on the age of tissue when the lesion begins and susceptibility of the cultivar. When canker lesions are prevalent, leaf abscission, fruit drop and twig dieback occur.

31. Citrus canker is spread long distances by movement of infected plants or tissue, or on infested equipment. Local tree to tree spread is by wind blown rain. New infections occur only in young tissue and require free moisture and stomatal penetration. The leaf mines caused by the citrus leafminer, *Phyllocnistis citrella* Stainton, provide excellent avenues of entry and movement in the leaf for citrus canker bacteria and make control more difficult. Year to year survival is in twig and branch lesions. Recent research shows that new infections of citrus canker can occur at 607 metres from the nearest source on inoculum during severe thunderstorms.

Methods for detection of citrus canker

32. Leaf lesions are easier to visualize than twig and limb lesions, but it is difficult to identify infected trees having only a few leaves having lesions. The corky appearance of the lesions surrounded with a chlorotic halo allow for field diagnosis, but conformation must be made using a laboratory method. A variety of detection methods are available: serology assays, fatty acid analysis, bacteriophage typing, DNA analysis and PCR.

Control of citrus canker

33. Exclusion and eradication are the primary control measures for citrus canker in areas where it is not endemic. The success of eradication depends on the size of the infestation and the willingness of homeowners/growers to cooperate. Resources must be available for an extended time to survey and remove infected trees. In Florida over US$200 million has been spent on the citrus canker eradication campaign over the past six years. Citrus canker has been introduced into Florida three times in the past 100 years, and successfully eradicated two times. In areas where

citrus canker is endemic, management is done by changing cultural practices to reduce the severity of the disease. Windbreaks are utilized to reduce wind speed, ground cover reduces wind blown sand and debris which would be leaves and provide an entry site for the bacterium, and the use of copper sprays when tissue is at a susceptible stage are examples of cultural practices.

POLICY WITH REGARD TO CITRUS CANKER

Florida case study – Implementation of control measures

Citrus canker was first described after it was discovered in the United States in the Gulf States in 1915. The Gulf States outbreak is believed to have resulted from a shipment of infected nursery stock from Asia. The disease was reportedly eliminated in the Gulf States through nursery and orchard inspections, quarantines and the on-site burning of infected trees.

Citrus canker was found in 13 locations in Florida from 1985 to 1992. Through extensive inspection and tree removal, eradication was believed to have been achieved. The disease re-emerged in commercial plantations in Manatee County, Florida, in June 1997, where eradication efforts had previously taken place. The age of the oldest lesions found indicated the disease had been in the area for about 1 to 1.5 years. This outbreak has largely been suppressed by destruction of several hundred hectares (acres) of infected commercial citrus plantations.

A new and extensive outbreak was discovered in urban Miami, Florida, in 1995. The Miami outbreak infected residential properties. Since its first discovery in September 1995, it has expanded. The oldest lesions in the Miami area indicated that the disease was present in that area for about two to three years prior to its discovery. Severe tropical weather patterns have affected Miami in the past several years including hurricanes, tropical storms, tornadoes and numerous rainstorms associated with high winds. These have spread the infestation locally and greatly exacerbated the epidemic.

Impact

Citrus canker is a costly disease. **The most serious consequence of citrus canker infestations is the impact on commerce resulting from restrictions to interstate and international transport and sale of fruit originating from infested areas**. In the United States millions of dollars per year are spent on eradication and hundreds of personnel are dedicated to the eradication and control programme. In spite of this considerable effort, the disease continues to spread in the Miami, Florida, area.

Implementation of disease management

Exclusion: the first line of defence against canker is exclusion. Canker still does not exist in some parts of Florida although climatic conditions are favourable. This is probably because of rigid restrictions on the importation into those areas of propagating material and fruit from areas with canker.

Eradication: once introduced into an area, elimination of inoculum by removal and destruction of infected and exposed trees is the most accepted practice. To accomplish this, trees are uprooted and burned. In urban areas, trees are cut down and chipped, and the refuse is disposed of in a landfill.

Because the disease is spread locally by wind and rain, the reduction of wind is one approach to management. Vegetation is allowed to grow between rows of trees to reduce injury from wind-blown soil. Windbreaks are planted to reduce wind speeds.

Policy implications

Strict US phytosanitary controls on imports of plants and plant tissue presents a barrier to canker introduction. Implementation of this policy limits trade in these materials. Fruit imports suffer to the extent that they require close inspection, treatment and possibly quarantine, all of which add costs which are likely to be at least in part passed back to the original exporter.

IV. RECOMMENDATIONS

34. **Placed in the context of expanding world trade in citrus, a systems approach involving regulations, enforcement of phytosanitary measures in a transparent and open manner and allocation of adequate financial resources by public and private sectors becomes the preferred manner for confronting these disease issues**.

35. **A continuing commitment must be made by the exporting country to protect their citrus industry's place in the global marketplace. Importing countries must use their resources to maintain exclusion whenever possible and/or to secure pre-export clearance for the protection of their citrus industry. The pathogens and vectors which could carry the pathogen have no respect for country borders. Thus measures which improve the phytosanitary status of even a few members of a group of trading partners in a region benefits all trading partners**.

A. FUNDAMENTAL POLICY ELEMENTS – A REGIONAL APPROACH

36. At the very fundamental level, disease control begins with planting healthy, disease-free plants. Mandatory citrus certification programmes provide a basic foundation within each country for the control of all graft transmissible diseases and help in limiting the spread of pathogens. However, it is difficult for developing countries having small citrus industries to find the resources needed for implementing and sustaining a citrus certification programme. Regional facilities covering several developing countries can reduce the expense of maintaining in-country certification programmes and training of phytosanitary personnel. Regional clean stock programmes could also provide the expertise and central location for the training needed for in-country certification and quarantine personnel. Additionally, a regional facility could serve as a back up repository to re-supply material to in-country certification programmes in case of disasters, such as hurricanes.

37. The need for training is a recurring concern: training of personnel working in the certification programmes, training of inspectors at ports of entry, training for inspectors who are conducting surveys for the maintenance of pathogen-free zones or pre-entry clearance. Also, since plant inspectors often are "eyes" already in the right place to see new pathogens, they should be familiar with all the diseases which are potential threat, not just one or two high priority diseases. Accurate and reliable diagnose of specific quarantine pathogens is a recurring concern. Most of these concerns could be addressed by using regional centres for laboratory indexing and maintenance of clean citrus germplasm, which could be supplied to in-country certification programmes.

V. CONCLUSION

38. The tools for dealing with transborder disease problems are available, if not perfect. Public contributions at national, regional and local levels are needed to complement private efforts. Good science has to be supported by adequate finance, regulatory authority and enforcement. The WTO SPS agreements offer the citrus trade new opportunities to confront trade problems arising from phytosanitary concerns. As the case studies included here demonstrate, effective systems approaches employing many different techniques can attack the problems at source, potentially avoiding the spread of the disease internationally, thus avoiding trade issues. However, vigilance and attention to the ever increasing disease threats in the global citrus industry must be maintained at a high level if trade is to expand and developing citrus producers are to benefit from trade expansion.