



Ministry of  
Agriculture &  
Fisheries



Food and Agriculture  
Organization  
of the United Nations

**TRAINING MANUAL**  
for  
**MANAGEMENT OF CITRUS GREENING**  
**(HUANGLONGBING)**  
and its  
**INSECT VECTOR THE ASIAN CITRUS PSYLLID**  
**(Diaphorina citri)**  
**IN JAMAICA**

Prepared under  
*The Citrus Greening FAO TCP Project*

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# *Contents*

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Introduction.....	4
The Causal Agent.....	6
The Vector- The Asian Citrus Psyllid (ACP).....	6
How Do Psyllids Spread Greening Bacteria.....	9
How Do We Identify the Disease.....	9
How to monitor for the Psyllid Vector .....	18
Area-Wide Integrated Management .....	21
Management Clusters:	
A Regional Approach to Implementation .....	23
Vector control in conventional plantings.....	25
Vector control in organic and Global GAP certified plantings .....	27
Vector Control in abandoned, unmanaged groves backyard citrus and Murraya hedges.....	28
Nutrient Management .....	29
Data Logging and Record Keeping.....	32
References.....	26
Appendix 1 .....	36
Appendix 2.....	40
Appendix 3.....	42

# Foreword

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The Jamaican citrus industry is currently valued at approximately J\$4billion, with some 8,903 hectares under production by over 5,200 farmers. But, over the past few years, production areas and production levels have been trending downwards, to the extent that, according to industry players, the 2010 output represented an approximately 36% decline over the corresponding output in 1999. Chief among the several factors impacting on the decline was an outbreak of the citrus Tristeza virus (CTV) but the disease has been effectively controlled with replanting on resistant rootstocks and a certification programme remains in effect. With confirmation of the dreaded citrus greening disease in Jamaica in October 2009, the sustainability of the industry has been further endangered and a focused, multi-pronged, management approach is necessary due to the nature and spread of the disease. Development of a manual with focus on an Area-wide Integrated Management System (AIMS) programme is very appropriate at this time and will auger well for the successful redevelopment of the industry.

This manual was prepared with support by the FAO Technical Cooperation Project, “Assistance to Manage Citrus Greening in Jamaica”, with active participation by the project’s Technical Working Group drawn from the Ministry of Agriculture and Fisheries’ Departments and Agencies as well as key private sector partners. It provides detailed information on the disease, its symptoms and vector and outlines specific strategies for implementation of the AIMS programme which include biological and chemical control, nutrition management, cultural best practices and cluster management. It is targeted at extension and technical officers, residential and commercial citrus growers and other critical stakeholders who will play an integral role in the implementation of the national management programme.

It is hoped that the information provided will be used as an indispensable tool towards sustainable management of the disease and revival of the industry.

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# *Acknowledgements*

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The efforts of many persons are represented in this publication and without their support and input this product could not have been possible. The Ministry of Agriculture and Fisheries Research and Development Division acknowledges with gratitude the sterling contribution of all.

There were a number of stages that came into play in the process of producing the finished work. The initial draft was a compilation of specific sections submitted by each of the following and thanks is extended to each of them.

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Special thanks to Dr. Lisa Myers Morgan, Senior Research Director, Montpelier Research Station, National Project Coordinator who after reviewing and editing the draft reformatted it to produce a less voluminous second draft. She also incorporated the comments received from the various consultants and produced the final draft.

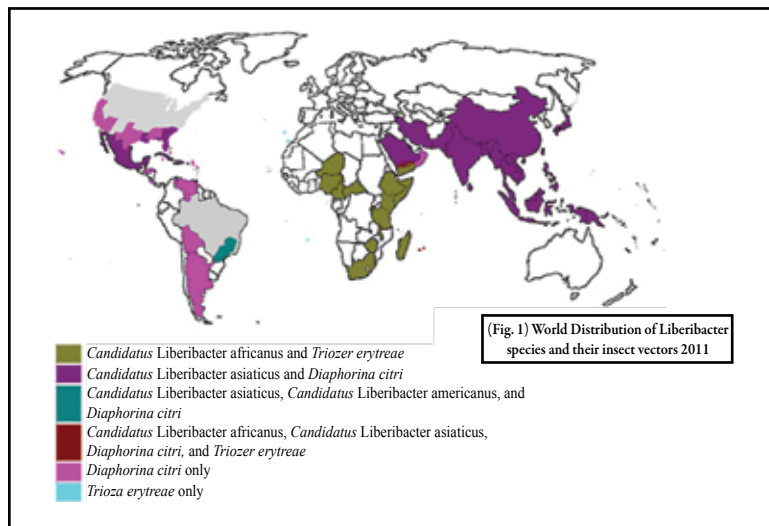
Appreciation is extended to the project consultants – Dr. Philip Stansly - Pest Management, Mr. Paul Mears - Crop Protection Technical Assistant and Dr. Florence Young - National Research Assistant and Dr. Vyjavanthi Lopez - FAOSLC who provided comments on the final draft document.

We are also indeed grateful to the Food and Agriculture Organization of the United Nations as sponsor.

# Introduction

**H**uanglongbing (HLB), also known as citrus greening is a destructive disease of citrus. The disease causes a reduction in the production level as well as the quality of fruits produced, eventually the whole tree declines, resulting in death. All citrus varieties are susceptible. HLB has been present for many centuries on the Asian continent and subsequently in Africa. It was detected in the Americas in the year 2004 in the state of Sao Paulo, Brazil. In 2005 its presence was detected in Florida, USA (Fig 1.). In July 2009 the disease was reported in Jamaica. In the Caribbean the disease has also been reported in Cuba, the Dominican Republic and Puerto Rico.

HLB is caused by a bacterium *Liberibacter* species which invades the food-conducting vessels of the citrus plant. The bacterium is transmitted from tree to tree by insect vectors called citrus psyllids. Psyllids are the only natural way for greening to spread from tree to tree. The Asian citrus psyllid (ACP), *Diaphorina citri* Kuwayma is the vector of the bacterium in Jamaica. Its presence was detected earlier in Jamaica in 2003. The current worldwide distribution of the bacterium and its insect vectors are shown below in fig 1.



# The Causal Agent

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There are three known forms of HLB the Asian, African and American forms (Bove' 2006 ). Evidence suggests that these are caused by at least three strains of bacteria, belonging to the genus *Candidatus Liberibacter*. The Asian form is associated with *Candidatus Liberibacter asiaticus*, the African form with *Candidatus Liberibacter africanus* and the American with *Candidatus Liberibacter americanus* ( Bove 2006).

The Asian and American strains are transmitted by the Asian citrus psyllid *Diaphorina citri* and the African strain by the citrus psyllid *Trioza erytreae*. The Asian and American strains have been reported in the Americas along with their psyllid vector *Diaphorina citri*.

## The Vector-

### The Asian Citrus Psyllid (ACP)

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#### Eggs

- Eggs are oval shaped and 0.3 mm (0.01 inch) long.
- Eggs are yellow or orange in colour.
- ACP eggs are laid singly or in small clusters mainly on the tips of growing shoots and in the crevices of the tiny, unfolded flush (feather flush) and also in small cracks on stems or on leaves damaged by adult feeding.



#### Nymphs

- Nymphs are less than 0.3 mm (<0.01 inch) long when they first emerge and go through five instars) before becoming an adult.
- They are orange in colour and lay flat on the plant surface. External wing pads are visible on the later (3rd -5th) instars (stages)



- Nymphs initially feed near birth site but may move around the same shoot as they get older.
- Psyllids possess piercing-sucking mouth parts which are used to remove plant sap
- Nymphs excrete a large quantity of sugary liquid (honey dew). A curly tube with a bulb at the end (waxy tubule) is used by the nymph to direct the honey dew away from its body which is typical of ACP nymphs and can be used for identification.
- The optimal temperature range for egg and nymphal development is 25°C (77°F) to 27.7°C (82°F). Temperatures below 10°C (50°F) and over 33°C (92°F) appear to be unfavourable for development.



## Adult Psyllids

- Adults of ACP are brown in colour and 3 – 4 mm (0.1 to 0.2 inch) in size, with a pointed front end, red eyes and short antennae.
- The abdomen may be greenish, yellow or orange Both males and females possess wings which have a mottled brown band around the outer edge of the forewing except where a clear strip breaks up the pattern.
- Adults are known to be fast-moving jumpers and are able to fly distances up to 2.5 km if aided by wind.
- Adults (like nymphs) have piercing sucking mouthparts which inject toxic saliva in to the host plant when feeding begins.
- Their bodies are normally set at a slant angle (45°) to the plant leaf or stem during feeding. They feed with their head down almost touching the leaf and its tail end in the air.



- They are often found on new flush as well as on the upper or lower leaf surface or along the plant stem. The complete life cycle of ACP ranges from 15 to 47 days depending on temperature. Adults may survive up to two months during cool weather.



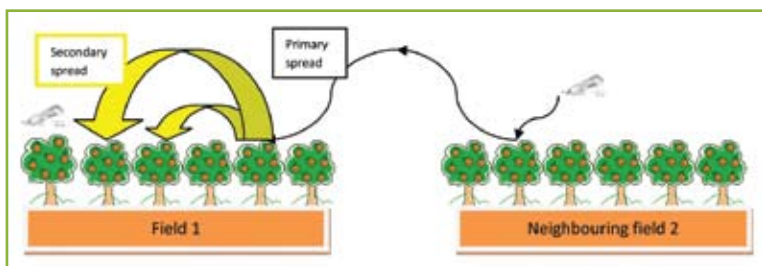
## Feeding Damage

- Large numbers of ACP feeding on newly formed citrus leaves can cause deformation of leaves and shoots and even death of young flush.
- Honeydew produced by both nymphs and adults promotes the growth of sooty mould which covers the leaves and reduces photosynthesis. Ants may also be present as they are attracted by sugary sweet honeydew.
- Injection of salivary toxins during feeding stops terminal elongation and causes malformation of leaves and shoots. Young trees are more susceptible to this damage as the young flush is a large part of the canopy when compared to mature trees where the flush is a small portion of the entire canopy. (Cardwell *et al.*,2006).

# *How Do Psyllids Spread Greening Bacteria*

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- Psyllids, primarily nymphs, feed on infected trees and become infected themselves
- Adults then move to a different tree to continue feeding
- The infected psyllid may now transmit the bacteria to the new tree during the process of feeding



## *How Do We Identify the Disease*

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### **Field Symptoms**

- The most challenging part in the field identification of citrus greening is the similarities between HLB and other citrus diseases such as Citrus tristeza virus, and nutrient deficiency problems and other disorders.
- Symptoms can be found any time of year but are most visible from September through March.
- Symptoms are more easily seen in shade or on overcast days

- The disease affects all parts of the canopy, leaves, twigs and fruit
- As the disease progresses, whole tree decline will occur

*The most common foliar symptoms of greening include:*



Figure 8 Blotchy Mottle

## Blotchy Mottle

- Best diagnostic symptom of greening
- Blotchy mottling patterns on the leaves are asymmetrical using the mid-rib as a central line.
- With nutrient-deficient plants and other disorders, the patterns seen would be symmetrical (i.e. almost exact replicas of each half using the mid-rib as a mirror). HLB plants will usually show these nutrient deficiency symptoms in addition to blotchy mottle but these are not definitive symptoms of the disease.
- Blotchy mottle can be found on young or mature leaves anywhere in the tree canopy

Vein corking



Figure 9 Vein corking

- Vein corking and yellow veins by themselves are not diagnostic for greening
- However if present look also for blotchy mottle symptoms in tree canopy
- Pronounced/prominent mid-vein, 'corky' mid-veins/under-rib, interveinal chlorosis, bright yellow shoots amongst a green canopy

Yellow Veins



Figure 10 Yellow veins

*Most Common fruit symptoms: symptoms may appear on the outside or inside the fruit*



*Outside*

- Lopsided shape
- Oblong shape
- Reduced size in fruits,
- Inversion of colour formation on fruit (yellowing of fruit from top down on orange colour varieties of citrus)
- Fruit drop

*Inside*

- Fruits with aborted seeds
- Curvature of the columella or central core
- Yellow stain beneath the calyx button
- Bitter tasting

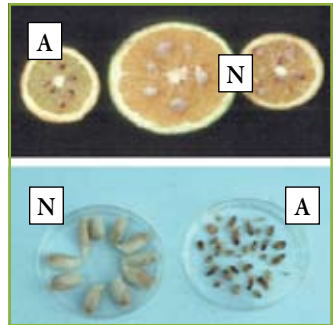
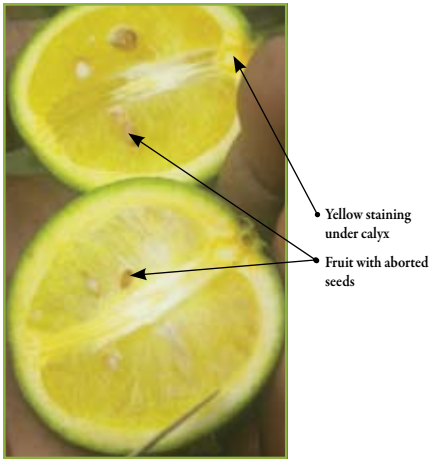


(Fig. 12 a-c ) Note the curvature of the columella in three varieties of citrus.



Some varieties, such as sour orange are more tolerant, i.e. the symptoms are not as severe, than on other varieties.

HLB symptomatic fruit usually drop before they are mature so that symptomatic fruit on the tree is immature and naturally bitter or sour.



(Fig. 13) Normal seeds (N) and aborted seeds (A)

Although a number of these symptoms can be confused with deficiencies and disorders, characteristically, one branch or part of the tree usually shows the symptoms first which then spread to the entire canopy, while for deficiencies and disorders are usually more uniform within the canopy and among trees.

## Whole tree symptoms

- Yellow shoots with upright narrow leaves that may have blotchy mottle and yellow veins
- Shoot die back
- Stunting
- Off season bloom
- Overall yellow appearance
- Fruit drop



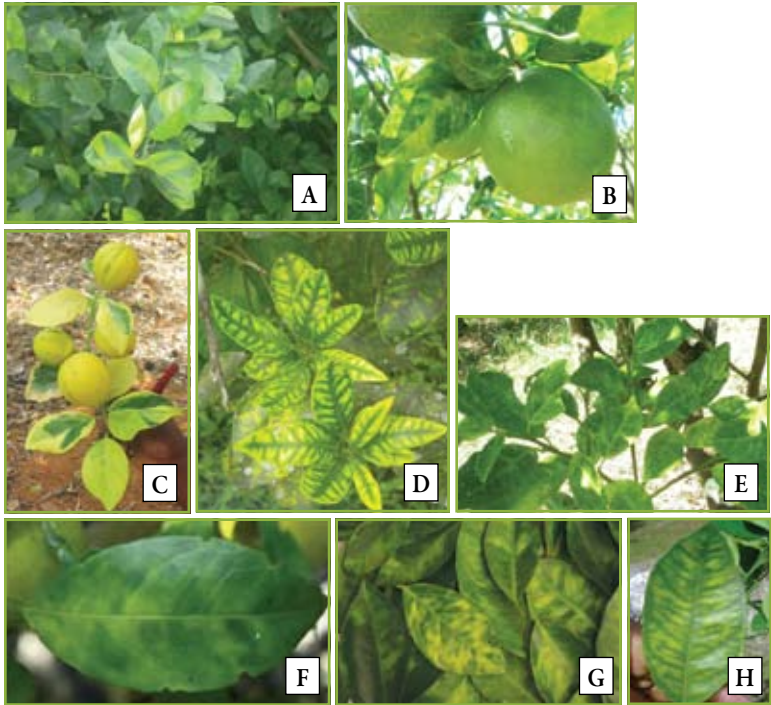
(Fig. 14) Distinct, bright yellow shoots amongst green canopies



Premature leaf fall in this citrus grove has left many trees denuded. Severity of the symptoms increases the longer the trees are infected as well as climate changes or other stress factors. This field also experienced drought due to lack of steady rainfall for over a year.

# TEST 1

Can you tell which picture is showing diagnostic symptoms of HLB and which are not?



*When trying to identify leaf symptoms ask these questions*

1. Is there any insect damage?
2. Are the symptoms on both the front and back of the leaf?
3. Is the pattern different on the right and left half of the leaf?
4. Is the branch broken or damaged?
5. Is there root damage or root rot?

If you have answered yes to 2 and 3 it is highly likely that greening is present



### *Differences between HLB and other problems*

HLB produces leaves with diffuse asymmetric mottle, which is observed in the form of irregular patches of light green or yellow in contrast with the normal green colour of the leaf.





The pen test is a simple test to determine if the pattern is the same on both sides of the leaf



- Draw two circles on opposite halves of the leaf
  - Is the pattern the same in both circles
  - Different patterns indicate potential greening if other problems have been ruled out
- **Nutrient deficiency:** often associated with advanced stages of the disease will appear on leaves showing a symmetrical pattern on opposite sides of leaf veins while blotchy mottle symptoms appear with no pattern and is not symmetrical.

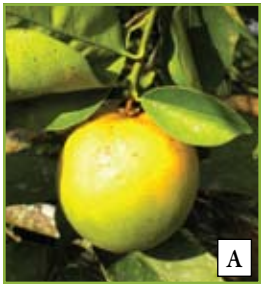
Description of nutrient deficiency/disease symptoms	Figures
<p><b>Zinc deficiency:</b> Leaves have an interveinal yellow mottle, which is symmetrical with respect to the central vein. When the deficiency is severe, the leaves are small, narrow and chlorotic. This can also occur with HLB</p>	
<p><b>Manganese deficiency:</b> Is very similar to zinc deficiency, but the coloration is less contrasting, between light green and dark green. The symptoms appear in the young leaves of the plant</p>	



Description of nutrient deficiency/disease symptoms	Figures
<p><b>Magnesium deficiency:</b> Produces an inverted V of the color green on both sides of the central vein, that contrasts with the yellow of the rest of the leaf. The mature leaves of the plant are affected</p>	
<p><b>Iron deficiency:</b> Appears in the young leaves where the leaves are light green, to almost pale with the veins an intense green colour</p>	
<p><b>Gummosis:</b> Leaves are chlorotic with pronounced yellow veins. In this case one is able to observe the trunk, where the exudation of gum can be seen</p>	
<p><b>Greasy spot disease:</b> Is caused by a fungus and dark brown spots are associated with this disease</p>	

# Test 2

Can you tell which pictures are showing citrus greening symptoms and which are not?



# *How to Monitor for the Psyllid Vector*

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Monitoring the vector is key to the management of citrus greening. The adult psyllid which is responsible for the spread of the pathogen is the stage being targeted. There are two simple methods i.e. tap sampling and flush inspection. Both should be used regularly for the quick, easy and effective evaluation of this pest.

## **Best time to monitor**

The monitoring of the adult psyllid population is a year round activity. The frequency will depend on the stage of the tree.

- Once a month during December to March on mature trees
- Young growing trees and mature trees during the growing season: fortnightly
- Within one week after insecticide applications

## **Visual inspection of flush for nymphs**

- The adult female psyllid after 2 weeks of feeding on emerging shoots begins laying eggs in young unexpanded leaves or “feather flush.”
- The presence of yellow-orange eggs and nymphs on young flush indicates that adult psyllids are present and reproducing.
- Leaf distortion caused by adult or nymphal feeding is often the first indication of psyllid activity, this sign remains as the leaves mature.
- Spirals of honeydew contained in curly tubes of white wax secreted by nymphs are often seen on young shoots.
- It is difficult to accurately count the number of eggs or nymphs in the field. For this reason, a simple presence/absence assessment of young shoots is recommended.
- A ratio of infested shoots to number of shoots observed is useful information. However, proper interpretation requires an estimate of flush density in the block because a high percentage of infested shoots when flush is sparse may be of lesser concern than a moderate level of infestation with high flush density.
- At each location, 10 young shoots, each containing “feather flush” should be

examined with a hand lens to determine if they are infested with psyllids. The search is terminated if 10 young shoots cannot be found after examining 20 trees. Monitor 10 locations per block.

## Stem Tap Sampling Method

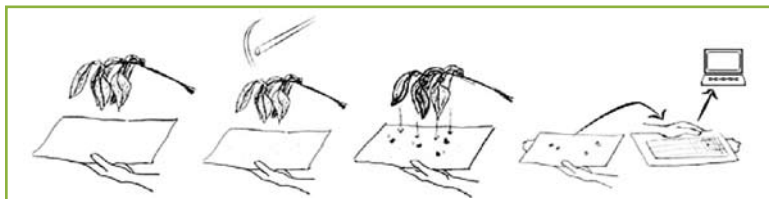
This is a quick method to use at any stage or age of the citrus crop. The method works with dry or wet foliage and is reliable for scouting purposes. Beneficial and other pests can also be counted. It is recommended that 10 tap samples be taken at each location, 10 locations per block.

### *Materials required:*

- A laminated sheet of letter size or a smooth white surface such as a clipboard. (The slippery surface impedes the psyllid from taking flight but some may take off before being counted, usually if numbers are high)
- A piece of half inch PVC pipe about a foot and a half long with which to strike the branch.
- Data sheets

### *Methodology (Fig. 19)*

- The sheet or board is placed about, one foot or 30cm below a leaf branch
- The branch is struck three times with the pipe.
- At each location, 10 tap samplings from 10 different trees are to be sampled (Only one tap sample per tree is required). Repeat this at five locations around the edge of the block and five in the interior for a total of 100 taps.
- The number of psyllids falling unto the sheet are counted and recorded.
- Make notes of other pests or natural enemies such as ladybird beetles and spiders that fall on the sheet.



(Fig.19) Stepwise illustration for taking a tap sample for ACP

## Sticky Traps



Yellow sticky cards are attractive to adult psyllids and can complement tree scouting for nymphs and eggs. Note that the use of sticky traps and other monitoring devices only provides evidence of infestation but cannot provide information about the actual incidence of the disease in the field.

Yellow sticky traps are used to monitor flying adult psyllids. Sticky traps have been used to monitor field populations. However its major disadvantage is that it also traps some beneficial insects. They can also be expensive and the results will be delayed for 1 or 2 weeks depending on how long the traps were left in the field. This means that the time the traps are ready to be collected, a new generation of psyllid may have already emerged

Yellow sticky traps can be made from yellow poster card cut 7"x9" and hung from the tree or placed on post 1 to 1.5 meters from the ground. Traps should be exposed to sunlight when placed.

## Placing of traps

It is recommended that 10 traps and 20 traps be placed in blocks <10 acres and > 10 acres respectively. Traps are to be placed around the border of the orchard. In



the case of 20 traps, 5 traps on each of four sides and in the case of 10 traps minimum of two on each side of the orchard. Traps will be monitored by Ministry personnel and advisory given to management areas regarding timing of pesticide interventions

# *Area-Wide Integrated Management*

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A major component of the comprehensive management programme being proposed is control of the spread of the disease through what is known as an area-wide integrated management system (AIMS) which requires the cooperation of the citrus growers and the residents living around groves. The first phase of this programme will be implemented under the FAO TCP project in the parishes of St. Catherine and Clarendon. The programme involves the formation of management clusters among citrus farmers and residents in these two major growing areas through which specific management tactics are to be applied, guided by a network involving personnel from the Ministry of Agriculture & Fisheries and other key agencies.

## **The Concept of Area-Wide Integrated Management Systems / A.I.M.S.**

Integrated pest management has been the dominant thrust of pest control over the last 30 years with the objective of reducing pesticide use. However traditional Integrated Pest Management is a localized strategy, with localized short term objectives, which are achieved by remedial interventions, generally based on insecticides to maintain local pest populations below economic injury levels. As pest insects from neighbouring populations keep moving into the treated areas, the effectiveness of these uncoordinated and reactive farm-by-farm, orchard-by-orchard controls is therefore at best temporary, resulting in the frequent need to reapply and eventual over-reliance and overuse of pesticides.

The concept of Area-wide Integrated Pest Management is more than just extending local strategies to large areas. Area-wide management has longer term objectives, and intervention strategies that are planned and executed on a regional scale.

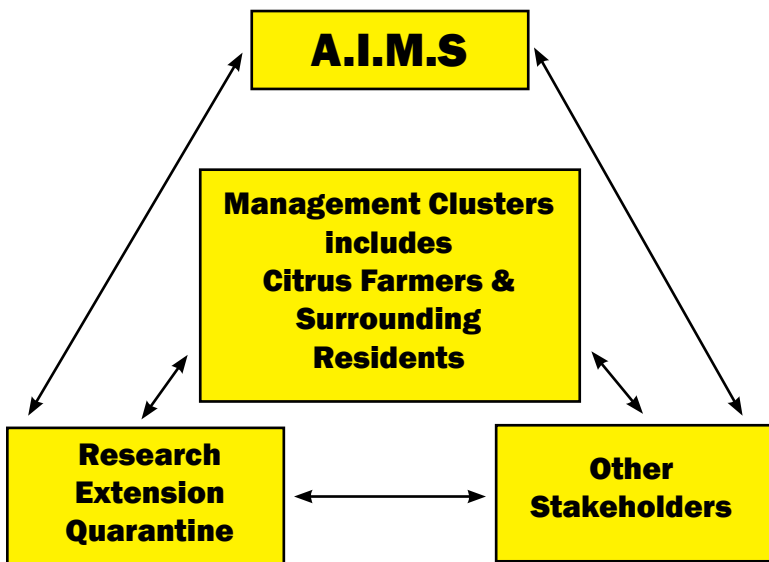
### **Area-wide IPM:**

- Requires the coordination between farmers

- Addresses the management of the total population of a pest in an area or region
- Gives consideration to the large - scale spatial distribution of the pest species both in cultivated as well as non-cultivated and urban areas
- Gives consideration to the temporal distribution of the pest in order to determine the periods when the pest is most vulnerable to preventive rather than remedial, interventions

When producers of a given area or region organize themselves to take area wide integrated action and target all individuals of the pest population, much fewer inputs are required and the control is usually more effective and sustainable (Tan, 2000).

Hence the objective of area-wide control is to reduce the pest population within the target area to a non-economic level. This is accomplished by attacking the entire insect population in the target area.



Networking among citrus stakeholders to implement A.I.M.S

# *Management Clusters: A Regional Approach to Implementation*

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The term management clusters usually refer to concentrations of firms or businesses that:

- are located in relatively close proximity
- compete with each other in similar markets
- cooperate to enhance technical skills and market access support, through social networks, growth and development of individual businesses
- share common inputs such as labour with specific skills
- recruit support industries based upon local concentration of firms
- benefit mutually from new, location-specific knowledge generation and
- work together to respond to new demands, such as environmental goals

The term management clusters can also be applied in the area of integrated pest management to groupings of stakeholders working together to prevent the regional movement and spread of pest and disease organisms that are a mutual threat to the economic and social base of the community.

## **Management Clusters and HLB control**

The main focus of management clusters is coordinated psyllid vector control and implementation of HLB management practices. Management clusters must have cluster leaders to liaise with the Ministry personnel regarding training needs and implementation schedules for treatment interventions. The eventual result of the coordinated application of treatments amongst farms within a cluster is an overall drop in psyllid populations while at the same time increasing the output from groves through nutritional and cultural management. This coordinated effort will delay the psyllid recolonization of groves and greatly reduce the overall population. To achieve this goal, management clusters are needed in all the major citrus producing areas.

Each management cluster must aim to:



1. Improve the horticultural practices being conducted by the farmers in their cluster.  
*This includes:*
  - a. A nutrient regime. This will be based on age of grove, soil profile and climate/environment.
  - b. Weed control. An untidy, largely bushy field will increase the chances of pests and diseases being housed amongst them.
  - c. Grove care. This includes pruning and gormandizing (removal of shoots from the rootstock), inspection of trees for other pests and diseases, and immediate treatment of pests and diseases if found.
2. Train farmers in the identification of both HLB and its ACP vector. Training should also include methods of monitoring psyllids and data recording.
3. Inspect groves on a regular basis for signs of psyllid activity and symptoms of HLB infection.
4. Remove infected trees from groves if symptomatic trees represent approximately 3% or less of total grove
5. Reduce the level of psyllid populations in groves by:
  - a. Treating young trees with a drench of systemic insecticides to 'knock-down' initial population.
  - b. Participating in the coordinated spraying of groves within a cluster during the dry season as well as when circumstances call for it.
  - c. Coordinating amongst the cluster for the release of the bio-control parasitoid, *Tamarixia radiata*, particularly in abandoned fields and urban areas.
6. Jamaica has many residential properties within close proximity of citrus farms with backyard citrus. This makes management of HLB and the psyllid even more challenging.

There is also an abundance of Orange Jasmine (myrtle) or *Murraya* plants, an alternate host for the psyllid vector located in many homes as hedge plants across Jamaica. As such, a residential programme is included to aid in HLB management, especially on a regional scale.



*The following information is necessary for such a programme:*

1. Use of a systemic soil drench on backyard citrus avoid acquisition and movement of HLB by psyllids.
2. Increase the production and eventual release of the bio-control wasp, *Tamarixia radiata*, into residential areas to parasitize nymphs, especially in myrtle hedges.
3. Seek cooperation from residents in replacing their Orange Jasmine with an alternative non-host to HLB and the psyllid.



The decision not to control greening compromises the effectiveness of neighbouring growers who implement disease management practices and is the least profitable strategy in an environment of greening.

In controlling the spread of HLB and in rehabilitating disease-infected orchards, although strong government support is a critical factor, success cannot be achieved without the full cooperation of all stakeholders in the citrus industry, especially the growers/farmers and owners of backyard citrus.

## Vector control in conventional plantings

1. It must be noted that in the presence of greening, biological control alone will not effectively control psyllid populations especially if established psyllid populations are abundant.
2. Chemical intervention will still be required at strategic times to knock adult psyllid populations thus favouring more sustainable management by natural enemies

3. Biological control agents should be augmented during the flushing (leaf or flower) stages to manage the immature stages of the psyllid
4. Only four pesticide treatments are recommended throughout the year
  - a. Dormant sprays
    - i. One after last fall (November – December) flush and the other before the first spring (March –April) flush of the following year
    - ii. For bearing trees pesticide applications must be applied 30 days before first Spring flush and thirty days after last fall flush (systemic insecticides 120-212days post harvest interval (PHI)
  - b. Only two pesticide applications are recommended during the May to November period
    - i. Do not treat trees during flushing cycle with broad spectrum chemicals since this will harm natural enemies of citrus pests
5. Growers must monitor both adult and immature psyllid populations during flushing cycle.
  - a. If adult psyllid numbers are increasing over three weeks a treatment may be applied only if there is no leaf or flower flush
6. In plantings nonbearing trees use systemic insecticides containing imidacloprid, thiamethoxam, alternated with foliar applications of contact insecticides containing abamectin + oil, diflubenzuron, Spinetoram, or Spirotetramet during flushing cycle, Zeta cypermethrin can also be used but outside of flushing cycle, preferable before spring flush
7. For bearing trees products containing Zeta cypermethrin, Fenpropathrin, dimethoate should be used during the November – January dormant season. Use contact insecticides containing abamectin, diflubenzuron, Spinetoram, or Spirotetramet during flushing cycle.
8. Use of Low volume ground applications (2-10 gallons per acre applied by modified mosquito foggers, or mist blower with micronair nozzle or Proptec low volume sprayer ( 90 $\mu$  particle size recommended) for chemicals registered for low volume application see label

Active ingredient	Product Brand Name Examples	Impact on natural enemies
Abamectin + oil	Agri-mek *0.15 EC, New Mectin* 0.4 EC	Medium
Diflubenzuron	Micromite80WG#	Low
Fenpropathrin	Danitol 2.4 EC*	High
Imidacloprid	Admire Pro (soil), Provado 1.6F(foliar) Confidor *70WG (Foliar)	Low (soil) Medium (foliar)
Spinetoram	Delegate WG	Low
Spirotetramat	Movento 240SC#	Low
Thiamethoxam	Actara*, (foliar) Platinum (soil)	Low (soil, medium (foliar)
Zeta cypermethrin	Mustang insecticide	High

*Products with (\*) registered in Jamaica (#) registrations pending*

## Vector control in organic and Global GAP certified plantings

1. Management of ACP in organic orchards is challenging since systemic chemicals are not approved
2. Petroleum oil and botanical oils eg. neem, Kaolin clay and pyrethrin based products recommended
  - a. Kaolin clay acts as an anti-feedant and ovipositional deterrent on adults
  - b. Oils provide moderate control of the immature stages of the psyllid
  - c. Pyrethrin based products from chrysanthemum. Effectiveness against ACP not tested.
3. Treatment in organic groves should begin 1-2 days before applications of conventional treatments to “treatment blocks” in non organic/conventional groves due to vector movement

4. Follow in two weeks with another application
5. The treatments mentioned above are not known to produce effective long lasting control of the vector
6. Petroleum oils and horticultural oils are not recommended in GLOBAL GAP, however the following are allowed by the EU

Active ingredient	Product Brand Name Examples	Maximum Residue Limits (mg/kg) or ppm
Diflubenzuron	Micromite80WG	1
Fenpropathrin	Danitol 2.4 EC*	2
Imidacloprid	Admire Pro (soil), Provado 1.6F(foliar) Confidor	1
Spinetoram	Delegate WG	0.2
Spirotetramat	Movento 240SC	1
Thiamethoxam	Actara*, (foliar) Platinum (soil)	0.2
Zeta cypermethrin	Mustang insecticide	2

*Products with (\*) registered in Jamaica*

### ***Vector Control in abandoned, unmanaged groves backyard citrus and Murraya hedges***

1. Releases of biological control agent *Tamarixia radiata* to augment existing populations of the parasitoid
2. Drenching of backyard citrus plants with systemic insecticide once per year during November-January period.

# *Nutrient Management*

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When groves have too high a percentage of infection to reduce inoculum effectively by tree removal, growers should do everything possible to maintain economic viability. Mature citrus trees can survive infection especially if only one single or a few shoots are infected. In contrast trees with all their shoots infected will decline rapidly. Thus rigorous psyllid control is still essential to minimize multiple infections of the same tree.

Micronutrient applications may prolong tree life by correcting the symptoms of the disease but will not cure the disease and are unlikely to be a permanent solution. Micronutrient application must be combined with effective psyllid control and is not a substitution for the wholistic management approach but rather a last resort in a bad situation when high infections rates prevail.

Ideally, a citrus nutrient management plan should provide maximum citrus yield and quality while minimizing the potential for loss. However in the presence of HLB intensive nutrient management will be required in the short term to prolong tree productivity.

## **Citrus nutrient management**

In general citrus nutrient management can be divided into four components: Monitoring, program development, application, and evaluation (IFAS EDIS).

- Monitoring can be qualitative (visual observations of tree performance), or quantitative (laboratory analysis of soil and/or leaf tissue samples).
- In programme development, the grower decides what type of fertilizer sources will be used, and the rate, timing, and frequency at which nutrients will be applied.
- The application phase centers on methods used to place the nutrients (e.g. spreading dry fertilizer, applying suspension fertilizers, or spraying soluble nutrients on leaves).
- Following fertilizer application, the evaluation step determines whether the desired crop response was achieved, usually by evaluating foliage appearance, tree growth, fruit yield, and fruit quality.

As a rule of thumb, healthy citrus trees that are well fertilized in their non-bearing years tend to show that good water management alone can provide about 30% to 40% of maximum yield. When sufficient amounts of N and K fertilizer are combined with good water management, production can reach or surpass 90% of its maximum. Thus, the remaining 10% or less of a grove's yield potential can be attributed to the combined effect of the remaining essential elements. It is important to reiterate that available P and micronutrient fertilizers must be applied early in the tree's development. However in the presence of HLB, the nutrition of the tree is severely compromised and will require corrective measures to sustain productivity. Hence an understanding of citrus nutrition is critical to the implementation of the appropriate corrective measures.

Citrus yield is most sensitive to the omission of N, P, and K, and least sensitive to the omission of micronutrients. It has been shown that it may take 7 years for omission of micronutrients to show negative effects. However when HLB is present macro and micronutrient deficiency symptoms will appear even more quickly due to interference with the transport of nutrients from the roots to the rest of the tree and the transport of products produced in the leaves to the roots.

Due to the high incidence of HLB (>30%) in citrus groves across Jamaica, and the fact that individual groves are on average less than 1000 ha, adherence to the removal of symptomatic trees under the traditional HLB management programme will be challenging to keep remaining trees healthy. At this time until a long term solution can be found, prolonging the productivity of existing trees will warrant investment into an enhanced nutrient management programme with inclusion of applications of foliar micro- and macro-nutrient sprays due to the impact of the disease on soil uptake of nutrients.

Many different foliar nutritional programmes are being used in the industry. Almost all of them contain the following elements Zinc (Zn), Magnesium (Mg), Iron (Fe), Boron (B), Calcium (Ca), and various biostimulants (that may include - salicylic acid, citric acid to adjust pH, and glutamic acid).

Foliar nutritional supplements are applied 3-4 times per year to citrus groves following major flushing cycles. It must be noted that the foliar nutritional programme is not a cure for HLB but will only prolong the life of the tree and help to give a respectable level of fruit production. The foliar nutritional supplement is in addition to the grower continuing with the regular fertilization of ground applied fertilizers of NPK as recommended for growing citrus in Jamaica. If a regular fertilizer programme

is absent then the foliar nutritional supplement will not give the added benefit of improving your citrus trees.

It should be kept in mind that foliar feeding is not intended to completely replace soil-applied macronutrient fertilization. Furthermore, there is a perception that foliar spray of macronutrients is more expensive because several applications are required to satisfy plant needs and maintain high yield. On the other hand, foliar applications of micronutrients are more effective than soil applications, especially in cases of high or low pH, with the exception of Fe. Foliar micronutrient (Zn, Manganese (Mn), Cu, B) sprays provide a more rapid response and are easier to apply, but the effect does not last as long as that of soil application.



# *Data Logging and Recording Keeping*

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It is very important that there is accurate information on the citrus industry in order to assist with policy decisions for the improvement of the industry. This will require accurate data being provided by the farmer, extension, quarantine and research personnel. The data to be recorded include,

## **Farm Data**

- Acreage
- Number of citrus trees on the farm (not acreage of land on which citrus field is located)
- Pesticide use and application records
- Nutritional programme
- Cultural practices

## **Inputs and Production data**

- In order to determine if the citrus cultivation is profitable, the following information is required,

## **Expenditure**

- Cost of inputs
- Fruit harvest data

## **Pest management data**

- Results of tap sampling and yellow sticky traps
- Pesticide usage: Name of the pesticide, size of field treated, quantity of product used, crop to which applied, pest targeted, date for next treatment, applicator's name.

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# *Appendix 1*

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## **Nutrients affected by HLB and their importance in citrus production**

### **Nitrogen(N)**

Nitrogen is the mineral element used most by citrus trees to produce leaves, flowers, and fruit, although Ca and K are also used in great amounts. Nitrogen is the key component in mineral fertilizers applied to citrus groves; it has more influence on tree growth, appearance, and fruit production/quality than any other element. Nitrogen affects the absorption and distribution of practically all other elements and appears to be particularly important to the tree during flowering and fruit set.

### **Phosphorus (P)**

Phosphorus is necessary for many life processes such as photosynthesis, synthesis and breakdown of carbohydrates, and the transfer of energy within the plant. It helps plants store and use energy from photosynthesis to form seeds, develop roots, speed maturity, and resist stresses. Phosphorus is involved in nutrient uptake and translocation.

### **Potassium (K)**

Citrus fruits remove large amounts of K compared with other nutrients. Potassium moves from leaves to fruit and seeds as they develop. Potassium is necessary for several basic physiological functions like the formation of sugars and starch, synthesis of proteins, normal cell division and growth, and neutralization of organic acids. Potassium is important in fruit formation and enhances fruit size, flavour, and colour. It helps reduce the influence of adverse weather conditions like drought, cold, and flooding

Potassium improves plant health and resistance to disease and tolerance to nematodes and insects.

A shortage of K can result in lost crop yield and quality. Moderately low plant K concentrations will cause a general reduction in growth without visual deficiency symptoms. The onset of visual deficiency symptoms mean that production has already been seriously impaired.

### **Calcium (Ca)**

Calcium resides mainly in plant leaves. Calcium is an important element for root development and functioning and is an important constituent of cell walls. Plant growth and fruit yield can be reduced by inadequate Ca supply long before deficiency symptoms become evident.

### **Magnesium (Mg)**

Magnesium influences the movement of carbohydrates from the leaves to other parts of the tree and also stimulates P uptake and transport.

### **Zinc (Zn)**

Involved in plant carbon metabolism. A necessary component of several enzyme systems that regulate various metabolic activities within plants. It is essential for the formation of chlorophyll and function of normal photosynthesis. Zinc is needed to form auxins, which are growth-promoting substances in plants and is associated with water relations in plants and improves water uptake.

Zinc deficiency has traditionally been the most widespread deficiency in citrus.

Under severe deficiency conditions, a foliar Zn spray may be necessary on each major growth flush to keep the trees free of symptoms because Zn does not translocate readily to successive growth flushes. Maximum benefit is obtained if spray is applied to young leaves when they are two-thirds to nearly fully expanded, before hardening off. Treatment on the spring flush is preferable.

### **Manganese (Mn)**

Involved in the production of amino acids and proteins. An activator of several enzymes. Mn plays an essential role in respiration and N metabolism and is necessary for the reduction of nitrates and helps make them usable by plants. It plays a role in photosynthesis and in the formation of chlorophyll.

Manganese deficiency may greatly reduce crop volume and the fruit color. The fruit may become smaller and softer than normal and the rind pale in color. Manganese deficiency is frequently associated with Zn deficiency.

Foliar spray application quickly clears up the deficiency pattern on young leaves, but older leaves respond less rapidly and less completely. When Mn is sprayed on Mn-deficient orange trees, fruit yield, total soluble solids in the juice and pounds solids per box of fruit increase.

### **Boron (B)**

Important in sugar translocation and carbohydrate metabolism. Particularly needed at the location of active cell division. It plays an important role in flowering, pollen-tube growth, fruiting processes, N metabolism, and hormone activity. Boron maintains Ca in a soluble form, thus insuring its proper utilization. Deficiencies may be aggravated by poor root function.

### **Copper (Cu)**

Part of several enzyme systems has a role in photosynthesis and chlorophyll formation.

It may have an important function in root metabolism. (Cu appears to be concentrated more in the rootlets of plants than in leaves or other tissues. Cu in citrus fibrous roots may be 5 to 10 times greater than in leaves.). Copper regulates several biochemical processes within the plant. It is important in the utilization of proteins in the growth processes of plants. (The photosynthesis rate of Cu-deficient plants is abnormally low.)

Copper deficiency can be a controlling factor in fruit production, and acute Cu deficiency may put trees entirely out of production. Foliar sprays are useful emergency treatments when symptoms of Cu deficiency are first observed.

For most macronutrients, soil application is still recommended because of the large quantities required. However, fertilizer applications to the soil are subject to various fates including leaching, runoff, and fixation to forms not available to plants. Therefore, foliar application should be considered as a possible supplement to soil application for some nutrients. Foliar application of N, K, Mg, Zn, Mn, and B has several positive attributes. It is of significant importance

when the root system is unable to keep up with crop demand such as in the case of HLB. It has also proven to be useful under prolonged spells of wet or dry soil conditions, calcareous soil, or cold weather, which decrease the plant's ability to take up nutrients when there is a demand. Foliar application can reduce overall fertilizer application rates and energy use, and can improve the uptake efficiency of micronutrients because they are directly absorbed into the leaves. Foliar application is the quickest method of getting nutrients into plants over the short term when a nutritional deficiency is diagnosed, but is not usually relied upon for long-term tree nutrition.



# *Appendix 2*

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## **Application of foliar nutritional supplement**

The foliar nutritional supplement product currently available in Jamaica is Citrimix and it is recommended for 3 to 4 applications per year and it is augmented with Agphite, providing phosphite. The schedule for the application and the cost of the foliar nutritional supplement is outlined below:

### **When to apply the product**

The product must be applied consistently and in a timely manner and at the right time for it to have maximum effect on the plants. The best time for the application is after the rain periods and new flush is two third to almost fully expanded. It must be noted that the earlier a farmer embarks on the programme when impact on the tree is minimal the better the response from the groves.

### **Influence of tree age**

Evidence to date has shown that the response is greater in mature trees >10 years old which have one single or a few infected shoots.

### **Material and Equipment needed**

The minimum equipment that is needed by the farmer to apply this treatment is a mist blower and the large grower will need to have a fan sprayer.

Application (x3)

Agphite-@ 1-3 pints/acre

Citri-Mix-@ 1 pack/acre for full grown trees

Citri-Mix-@ 1 pack/4acres for trees 2-3 years and younger (under 4 feet tall)

- This will be applied at bloom (2weeks prior -2 weeks after)
- Again in June
- Again late Sept -mid Oct

Application (x4)

Agphite-@ 1-3 pints/acre

Citri-Mix-@ 1 pack/acre for full grown trees

Citri-Mix-@ 1 pack/4acres for trees 2-3 years and younger (under 4 feet tall)

- This will be applied at bloom (2weeks prior -2 weeks after)
- again in May
- again in July
- again late Sept -mid Oct

The cost of the inputs for four applications per year

Cost Analysis

Agphite

$\$420.60/\text{pint} \times 3 = \$1,261.80$

Citri-Mix

Cost of Citri-Mix =  $\$3,737.25/\text{pack}$

Total cost =  $(\$3,737.25 + \$1,261.80 \times 4) = \$19,996.20/\text{acre}/\text{year}$

**N.B Please note that it is not possible to work out how much product to be used in each load of mixture. This is an activity that the farmer will have a do as the volume of liquid used will depend on the sizes of the trees and the speed at which the sprayer moves. For mature trees 6.5 pound of products should spray 50 plants and 3.25 pounds should spray 25 plants. For young trees 1 pound 10 ounces is needed to spray 50 trees while 13 ounces is needed to spray 25 trees.**

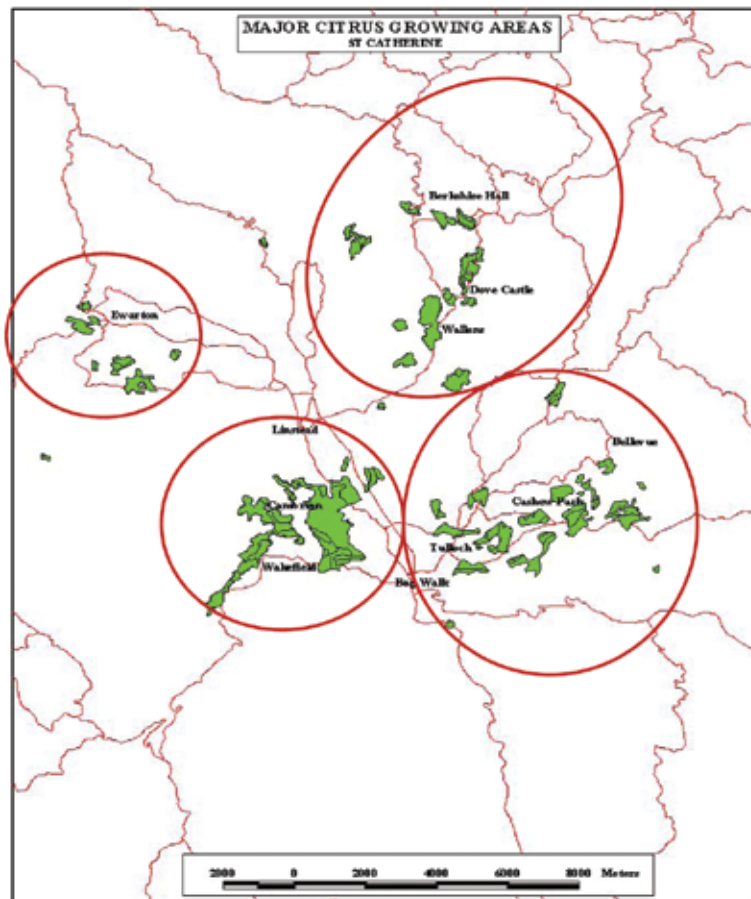
**Do not apply any products not fully labeled for use on citrus**

**Do not apply any products without full label disclosure of ingredients**

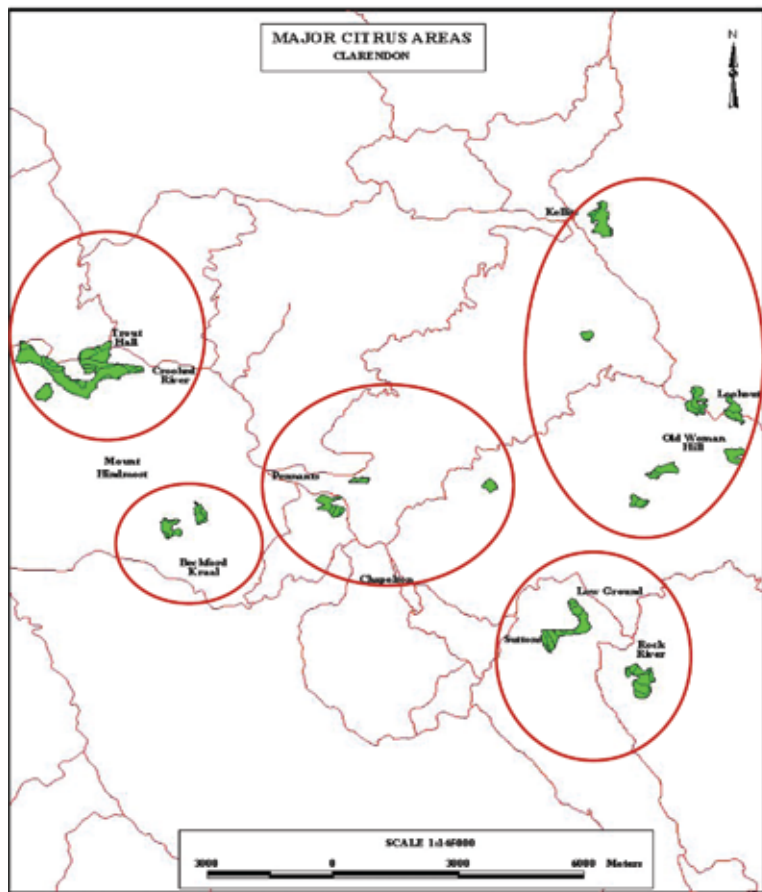
**Avoid products with “magical” inert ingredients**

# Appendix 3

## Citrus greening management areas



## Citrus greening management areas





Printed in 2012

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