

# Citrus Nursery Tree Production and Disease Exclusion



Ministry of Agriculture  
& Fisheries



FOOD AND AGRICULTURE  
ORGANIZATION OF THE  
UNITED NATIONS

*Prepared under  
The Citrus Greening FAO TCP Project*

***Citrus Nursery Tree Production***  
***And***  
***Disease Exclusion***

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**FOOD AND AGRICULTURE ORGANIZATION OF  
THE UNITED NATIONS**

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# Table of Contents

Acknowledgements .....	3
Introduction .....	4
Role of Government .....	5
Universities and Research .....	6
Budwood Foundation .....	7
Seed Productino .....	10
Nursery Site Selection .....	12
Structure Types and Coverings for Production Houses.....	13
Sanitation Practices .....	15
Production Practices .....	18
ANNEX 1. Personnel Sanitation .....	21
ANNEX 2. Equipment Sanitation .....	23
ANNEX 3. Budwood Harvesting & Storage .....	26
ANNEX 4. Seed Treatment & Storage .....	27
ANNEX 5. International Society of Citrus Nurserymen .....	28
References.....	29

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Without disease-free citrus nursery trees, it is impossible to have a citrus industry that is productive and profitable.

# Introduction

The overall objective of the project TCP/JAM/3302 Assistance to manage Citrus Greening in Jamaica is to build technical capacity within the Ministry of Agriculture and Fisheries (MoAF) and other institutions to efficiently respond to Huanglongbing (HLB) or Citrus Greening disease. One of the activities under the project is the training of nursery personnel in the disease exclusion during plant / tree production. This Manual was developed following a three-day training course, carried out by the Consultant during his Mission to Jamaica from 18-24 November 2012.

It is not the intention of the Manual to focus on the production aspects of citrus nurseries, but rather to focus on the exclusion of pathogens from the production process. Disease exclusion from citrus nurseries is a multi-layered process. There is not one single measure that can be implemented to prevent disease. It is the consultant's opinion that prevention of diseases should be thought of as a series of practices that when combined provide sufficient measures for the prevention of disease infection. This Manual will review these practices or measures in order to help citrus nurserymen of Jamaica to prevent disease infection.

Additionally, the type of disease affects the measure or combination of measures that should be implemented. In today's world, diseases are not static, they constantly move. The speed at which they move depends on the vector moving them. The human vector may now be the most difficult vector to control and the most dangerous to plant

health. For example, every region of the world has tourists and ethnic communities that like to bring with them from their homeland food that can be infected with a disease. This action subsequently moves a disease from one region of the world to another. While such disease relocation is not intentional, the end result is the same and should be kept in mind when considering measures for implementation. It is important to remember that in future, a new disease may have to be excluded from citrus nurseries.

In view of the above, there are many risk factors for citrus nurseries to consider. Some of these risks are the sole responsibility of the nurseryman. Personnel sanitation practices are an example of nursery responsibility. Some risk factors, such as illegal importation of citrus plants, are outside the control of the nurseryman. Other risk factors are unknown until they show up in the nursery and learning how to control these risks takes research.

Thus, the prevention of disease in citrus nurseries is a multi-layered process that requires all sides to participate. This participation benefits the whole country, not just citrus nurserymen.

# Role of Government

The role of Governments in maintaining a productive agricultural system is vital. Governments are the only ones that can implement, on a national scale, regulations that benefit its farmers and thereby its people. Without government regulation and enforcement, agricultural diseases can enter into new regions on a frequent basis.

In terms of citrus nursery production, the following are areas that Governments can assist in maintaining a healthy and productive citrus industry:

- 1) Implement regulations that:
  - a. Prevent the unauthorized importation of citrus plants, leaves and fruits. This will assist in excluding diseases that affect citrus.
  - b. Ensure citrus trees are propagated and grown using disease free plant material and seed.
  - c. Require trees in nurseries remain disease free until they are planted in the field.
  - d. Prevent and punish the propagators of citrus trees that are not grown in accordance with government regulations.
- 2) Support and fund research and education about citrus diseases.

- 3) Work with other governments and agencies worldwide to share and collect as much knowledge about citrus production as possible.

If citrus nurseries are going to be able to recover the costs associated with building structures, using containers, double entrances and other increased costs, they have to have the support of their government and industry.

The first rule of maintaining a sustainable business is that the business must be profitable.



# Universities and Research

The primary function of Universities should be education. A part of that education process is to generate, collect, analyze, synthesize and distribute information. In collecting information, the answers are not always clear and seeking the answers requires research. This is true for citrus nursery production. Nursery growers routinely encounter production challenges. Overcoming these challenges at times requires working with someone who has specific expertise. This expertise is usually only found at a university (or similar) research center.


Additionally, many diseases that affect citrus have no known cure. The only “cure” currently in place is a combination of prevention of disease infection, followed by eradication if early detection occurs, and finally disease suppression and management. Each of these phases, be it individually or in some combination, is being used in every citrus growing region worldwide.

Together with the implementation of the above phases of disease prevention, new research is also being conducted. The new research results are helpful for disease control actions in every citrus growing region. Therefore, it is important for researchers to collaborate with other citrus researchers in different parts of the world.

- 1) Whenever possible, university research centers should make available the opportunity for growers and researchers to interact and discuss production issues.

- 2) Universities should hold routine education seminars for the purpose of teaching about and sharing the latest technology about citrus nursery production.
- 3) Researchers should, as much as feasible, collaborate with other researchers around the world to collect and share information about citrus production.

# Budwood Foundation

 Budwood foundation is critical to maintain a disease-free citrus industry. This foundation should have available to its nursery industry budwood for each and every variety that the industry propagates.

It is not the purpose of this Manual to discuss the process used for disease / pathogen detection. There are specific processes and methods used for detecting each disease. This is also an area where new technologies are being developed and implemented. Additionally, disease detection is only one part of maintaining a healthy budwood program. Removal of each disease also has specific processes and methods and can be technically challenging. The below referenced book<sup>1</sup> provides a lot of good information and support, but additional assistance may be required when establishing a new citrus disease detection process.

Where funds are limited, it is advisable to consider purchasing budwood from reputable, known, clean sources. This is more cost-effective and will provide budwood to the citrus industry faster. There are several established programs in the world and researchers that are involved in international programs will know how to contact these sources.

In situations where an industry has a special regional variety that is not grown in other parts of the world or a proprietary variety and

<sup>1</sup>*Graft-Transmissible Disease of Citrus, Handbook for detection and diagnosis, FAO 1991.*

disease detection or removal is required, it is possible to contract for these services. If contracting with another research institution is not an option, then a disease removal program must be implemented. It is the consultant's recommendation that advice should be sought from some leading researchers on the best and most current methods of disease detection and removal.

The disease-free sources must be maintained in such a manner that prevents any disease infection. This requires the construction of a screen house or greenhouse-type structure. Ideally, these structures would include the following:

- 1) Be solid and built to withstand the local climate and conditions.
- 2) Have an impermeable roof that prevents trees inside from being impacted by storm events [the foundation trees should never get wet during a rain or wind storm].
- 3) Sides could be made of solid material or screen. Whichever material is used, it must exclude insects and diseases from entering into the structure.
- 4) Screen opening size should be  $\frac{1}{2}$  the thorax size of the smallest adult insect being excluded.
- 5) Any opening larger than the size described above should be sealed as soon as discovered. This includes door and window seals, holes in roof, tears and pin holes in screen, cracks in concrete, fan openings, and any other place where an opening would allow insects to enter.
- 6) A monthly inspection for openings and holes should be conducted and documented.
- 7) Access should be limited and only designated personnel should be allowed to enter the foundation block.
- 8) Double entrances should be utilized and open access to the outside should be strictly prohibited.

- 9) Air curtains and positive pressure air flows should be utilized to prevent insects from hitch hiking on people into the foundation area.
- 10) Strict sanitation procedures should be established and enforced.
- 11) Sanitizing foot baths should be required for all people entering the foundation.
- 12) Clean clothes and hand washing should be required at all times
- 13) All tools, clippers, knives, and etc should be sanitized between each tree.
- 14) The structures should be large enough to allow adequate spacing between trees to prevent the trees from touching one another.
- 15) There should be a designated space for harvesting budwood and minimum contact with people, clothing, tools and any other possible sources of disease infection.
- 16) Each variety should be clearly identified. This identification should include variety and rootstock as well as plant date and its original source, if known.
- 17) Accurate records should be maintained about each foundation tree and a history compiled for long term use. These records should, at a minimum, include test dates and results in addition to fruit, leaf, tree size and characteristics.
- 18) Harvested budwood should include a chain of custody documentation, such that budwood in nurseries can be traced back to its original source tree.
- 19) Any tree that has tested positive or is suspect for possible disease infection should not be used for harvesting budwood.

For further information regarding the detection of citrus diseases, please refer to: Graft-Transmissible Disease of Citrus, Handbook for detection and diagnosis, FAO 1991.



**Figure 1**  
*Budwood Foundation Trees growing in ground*

# Seed Production

Seeds are a necessary part of citrus nursery tree production. All nurseries need seeds to produce rootstocks. These seeds either have to be grown locally or purchased from another growing region.

## *Seed production locally:*

- 1) Seed trees should be started from known true-to-type sources that are disease-free
- 2) The budwood for seed sources could be purchased from other citrus growing regions and propagated locally in accordance with nursery production guidelines.
- 3) Seed blocks should be well defined, with each variety clearly indentified
- 4) Access should be limited to necessary personnel alone
- 5) Seed trees should be visually inspected quarterly for disease.
- 6) Trees should be sampled annually for diseases.
- 7) Disease infected seed trees should be removed forthwith and destroyed.
- 8) As a general rule, seed fruit should not be harvested until fruit is fully ripe. This can vary with variety, as well as chilling requirements and production location.

- 9) Following seed extraction, seed should be sterilized and prepared for storage or planting.

### *Purchased Seed:*

- 1) Understand what diseases, if any, are in the region you are purchasing seed from and how the supplier is dealing with those diseases
- 2) Understand the importation requirements of your own country to prevent seed from spoiling during shipment
- 3) Understand the sanitation practices of the seed supplier
- 4) Enquire when the supplier will harvest next year's seed, plan ahead to fill your needs.

Seed production is also an area where new technologies are being developed. HLB is affecting seed production in many parts of the citrus-growing world and new management practices are being developed on how to deal with diseases. Currently, to the best of the consultant's knowledge, there is no other economic alternative to growing seed trees outside of structures. Several attempts have been made to grow seed trees inside of screen structures for the purpose of excluding psyllids. The fruit produced in these structures is usually very low-seeded or seedless, making screen house seed production currently non-viable.

Rooted cuttings may be an option for producing rootstock seedlings but requires large quantities of cuttings. These sources would have to be grown in a screen house or greenhouse structure to ensure that they are disease-free. Additionally, the cuttings would have to be propagated in a screen house/greenhouse structure prior to transplanting and budding. It is also the consultant's recommendation that the industry should do some field trials of rooted cutting rootstocks



and evaluate for production characteristics.

Tissue Culture is another area being investigated as a method for producing rootstock seedlings. This technology is relatively new and to the best of the consultant's knowledge there are only a few companies currently pursuing this type of production. It will most likely be many more years before this type technology is readily available and economically viable on a large scale.

# Nursery Site Selection

Nursery site selection is a difficult topic, especially for those who were producing citrus nursery trees prior to the introduction of devastating diseases. But once diseases like HLB or Citrus Canker infect a citrus industry, measures must be put in place to prevent nursery tree infection. Protecting young citrus trees from insect and mechanically-vectorized diseases requires a physical structure. With this type of investment, selecting the proper location is an important decision.

## *Factors to consider:*

- 1) Isolation from producing citrus groves is important. A minimum of one mile radius from other citrus trees is desirable. When one mile is not possible, select a location with as much distance from citrus trees as possible.
- 2) Utilize natural wind breaks and topography for protection from storms.
- 3) If natural wind breaks are not available, consider planting wind break trees to provide protection from storms.
- 4) Location should have a readily-available source of pathogen-free water. Water should be tested for pathogens and nutrients. Water quality is very important and testing water is suggested in advance of purchasing or building a permanent structure.

- 5) A source of electricity is necessary.
- 6) Locations that allow for exclusion of unauthorized people are preferred.
- 7) Nursery site must have good road access for getting production goods in and getting trees shipped out.
- 8) Ensure room for future expansion.
- 9) Consider room to have access on all sides of the structures to perform routine maintenance.
- 10) Consider ground elevation and slopes. The rain water from roofs and excess irrigation water needs to drain.

# Structure Types and Coverings for Production Houses

Insect and mechanically-vectorated diseases of citrus require nurseries to invest in structures that exclude both insects and wind and rain. The types of diseases as well as the kind of weather conditions determine the type and kind of structure needed to protect citrus nursery trees from diseases.

A disease like citrus Canker that is mechanically-vectorated by wind and rain requires different control methods, compared to HLB that is transmitted by psyllids. Therefore, screen roof structures do not prevent Citrus Canker infections although it will exclude psyllids. For these reasons, it is very important to understand how each disease being excluded is vectorated. It is also important to understand which diseases are most likely to affect citrus nursery production in the future.

*When building a structure consider the following:*

- 1) Structures should be well-built and structurally designed for the climatic conditions of the region. Designs should include wind load ratings so they can withstand tropical force winds.
- 2) Metal frame structures:
  - a. Metal is stronger and has a long life.

- b. Metal has a higher cost and requires more specialized tools to build.
- 3) Wooden Frame structures:
- a. Wooden frames are lower cost, but higher maintenance.
  - b. Materials are more readily available.
- 4) Roof Coverings:
- a. Glass: very expensive and not best choice for subtropical climates
  - b. Polycarbonate: very expensive, long life, and more flexible in storms than glass
  - c. Single & Double poly: lower cost, 4-5 years, easy to replace and keeps plants dry in rainy weather. Double poly requires electricity to inflate.
  - d. Screen: lowest cost, multi year life, allows rain to enter structure.
- 5) Side Walls: (*see figure 2*)
- a) Side walls can be of any material that will exclude the insect and/or disease.
  - b) Screen opening should be  $\frac{1}{2}$  the thorax size of the smallest insect necessary to exclude.
  - c) Solid walls are also acceptable, but are usually not preferred because the reduced air flow increases temperatures inside the structures.
  - d) Along the bottom edge of structures it is best to have some type of short wall to attach the screen and provide

a barrier to minimize holes from animals and machinery. This can be metal, concrete block, polycarbonate and others.



**Figure 2**

*Metal Frame structure, gutter connected with gutter at 10 feet.  
Screen sides, Metal Knee wall, Double poly roof and motorized curtain.*

# Sanitation Practices

Sanitation should become part of every nurseryman's daily management practices. There is no such thing as too sanitary for the citrus nursery operation. A grower must be constantly vigilant to exclude diseases. Fully-enclosed operations have high humidity and temperatures which provide an ideal climate for the multiplication and spread of bacteria and fungus. As a result, nursery operators must be ever-vigilant.

Sanitation generally comprises two general groups. Group one is people, tools, and other day-to-day activities that require contact with plants. Group two is budwood, seed & seedlings, containers & trays, substrates and other necessary components of the production process.

## *Group One:*

- 1) People are always a risk to nursery operations. The level of sanitation required for people is determined by the pathogens being excluded. For insect-vectoring diseases the human level of sanitation is lower and the minimum level of sanitation should be the following:
  - a. Do not let persons into the nursery that have been in contact with other citrus plants.
  - b. Hands should be washed and fingernails scrubbed with anti-bacterial soap.

- c. Feet and shoes walked through a foot bath prior to entering.
- 2) When diseases like Citrus Canker and Citrus Black Spot are being excluded then the following applies:
- a. Do not let persons into the nursery that have been in contact with other citrus plants.
  - b. Hands should be washed and fingernails scrubbed with anti-bacterial soap.
  - c. Feet and shoes walked through a foot bath prior to entering.
  - d. Clothes should be freshly laundered and not have been in contact with other citrus plants since laundering. Clothes should also be misted with an anti-bacterial product to ensure the clothes do not contain a live pathogen that can infect the trees.
  - e. If clean clothes are not available, changing into clean uniforms or coveralls is acceptable.
  - f. This includes everyone: visitors, customers, inspectors and employees. No exceptions!
  - g. See Figure 2
- 3) Tools:
- a. Tools should at a minimum be cleaned and sanitized daily.
- 4) Irrigation systems are a stand-alone subject and many books have been written on this subject. The type of irrigation system selected does have an impact on bacterial and fungal diseases. One of the important factors in selecting an irrigation system is keeping the



plants as dry as possible. In the consultant's, opinion keeping plants dry is a sanitation practice and reduces the infection rate of disease as well as the spreading of disease by water.

- a. Hand watering and drip irrigation systems provide the least wetting of trees and reduce fungal and bacterial infections.
- b. When hand watering with a hose, do not allow the watering end of the hose to come into contact with the ground or let water on the floor splash onto the end, putting water into the pot. This may spread Phytophthora. Keep hoses clean and sanitize regularly.

*Group Two:*

- 1) Budwood must come from clean sources and grown from established true-to-type sources. Do not use budwood that has not been tested for diseases.
- 2) Before planting, seed should be sanitized.
- 3) Substrates should only come from clean sources. Be sure to check substrates for Phytophthora, nematodes and other soil borne diseases.
- 4) Store substrates on clean dry surfaces and prevent the wind from blowing debris into the substrate pile. Bagged substrates can be an alternative, if available.
- 5) Seedling trays, containers, pots and other growing items should be sanitized before each use.
- 6) Keep trays and containers above ground and do not let water from ground splash onto the trays

It is impossible to cover every situation where Phytophthora or some other disease can enter the nursery operation. The grower must always be observing the production process and looking for ways that disease can enter and adjust his practices accordingly to prevent disease entry.



*Figure 3*  
*Hand Washing, Foot Baths, Clean Clothes.*

# Production Practices

The nursery production practices ensure that all plant material and seed is free of disease. The structure excludes insects and keeps plants dry. Containers should be new or sanitized. Substrates are free of soil borne pathogens and parasites. The tools and water hose are cleaned and sanitized. The actual growing of the trees is a key element to a sustainable nursery operation. All of the before-mentioned processes have to take place at the same time. They go on around the tree during the production process. Part of producing citrus nursery trees is providing a pathogen-free environment while at the same time providing the proper amounts of water, nutrition, sunlight and temperature.

Recognizing the visual signs of nutritional deficiencies and toxicities as well as diseases is a key component in the production of citrus nursery trees. Every nursery grower should have access to reference books that allow comparison of leaf and stem samples to pictures. A few good reference books will more than recover their costs. A good public library of citrus reference books at the research center is a necessary grower tool. This public library would allow for donations from private and public institutions. This is not only important for production, but also important for recognizing disease infection. One of the first signs of HLB can be zinc deficiency, but if soil pH is outside acceptable ranges, then zinc deficiency can also appear. Good reference books with pictures can help determine if additional tests are required. Observation of trees throughout the

production process is part of producing quality trees and in itself is a sanitation practice. Early recognition of infection and understanding actions to take will not only reduce losses but can potentially save the industry millions of dollars.

Growers should frequently walk and observe their trees throughout the production process. During this time, the grower should record his observations.

*Keep notes on the following:*

1. Substrate type and source.
2. Rootstock variety and plant date.
3. Budding date along with variety and variety source.
4. The budder.
5. The number budded and percent live
6. The percent of bud push.
7. Length of scion growth over time.
8. Observations about water use, any insects, diseases etc.
9. Fertilizer / nutrition program
10. Date shipped, customer, and grove location.

These in combination with observation and record keeping will, over time, build a history that will increase production, reduce tree losses, make more money per tree and allow the nurseryman to make intelligent decisions about which sanitation practices to implement and when.

## ***Chemical Use***

### ***Use of Neonicotinoids***

Imidacloprid, Thiamethoxam, and Clothianidin are all neonicotinoid insecticides which, depending on the formulation, may be applied as either soil-drench or foliar applications. However, soil drench applications are by far the most effective way to use these products on young trees. Drench applications should be applied directly at the soil-rootstock interface. Use restrictions to limit the number of applications that can be made in a growing season. Imidacloprid applications are limited to no more than 0.5 lbs Active Ingredient / Acre (AI/A) per growing season, regardless of application method. Thiamethoxam applications are limited to no more than 0.172 lb AI/A (or 3.67 oz Platinum) per growing season regardless of which Thiamethoxam product is used. Clothianidin is currently labeled for non-bearing use only and is limited to 0.4 lbs AI/A (or 12.8 oz Belay 50 WDG) per growing season. Imidacloprid, Thiamethoxam, and Clothianidin all share the same mode of action and thus these products are not considered alternatives for rotation to prevent pesticide resistance. Foliar sprays of products other than these Neonicotinoids should be used between soil-drench applications to provide additional control of psyllid populations and to help minimize the potential for insecticide resistance development.

Using Neonicotinoids in the nursery provides an additional layer of protection from HLB infection. If there is a breach in the structure and psyllid entry occurs, these products will help to prevent infection. This is due to the feeding method of the psyllid. The insect pierces the leaf and feeds on the sap of the tree using long continuous draughts. These long continuous draughts allow the Neonicotinoid to kill the psyllid before it “spits” back into the tree thereby causing an HLB infection. An HLB infection can take up to three years to express visual symptoms, so detecting HLB infections in young trees is difficult. Preventing psyllids from feeding on trees is the best practice, but in the

event of a breach, the use of Neonicotinoids when used properly will prevent psyllids from feeding on more than one tree. This at the very least will minimize the risk of an infection. This should not, however, be considered a long term solution to controlling HLB infections. It is widely thought that psyllid resistance to Neonicotinoids is just a matter of time.

Due to the different levels of neonicotinoids in the products discussed above, the application rates vary. It is important to read, understand and follow the labels of each of the chemicals. The products only work when used correctly.

# Annex 1.

## *Personnel Sanitation*

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DECONTAMINATION OF PERSONNEL: All persons should disinfect hands, arms and any other parts of the body that have been in contact with citrus and surrounding vegetation, plus gloves and hats, and any clothing, shoes and small personal items (pen, hand lens, glasses, pocketknife, etc.) that may have come in contact with risky plant material, using one of the following prescribed products in accordance with label directions. Some personnel decontaminants are one-step no-rinse products, which are listed below under the heading, “PERSONNEL DECONTAMINANTS for use on Clothing AND Skin,” and can be applied to clothing while being worn, in addition to skin. Other personnel decontaminants, which are listed below under the heading, “PERSONNEL DECONTAMINANTS for use ONLY on Skin,” are approved for skin use only, requiring a follow-up water rinse, or soap and water hand-washing BEFORE use of the product. When using these materials, allow the no-rinse products to air-dry. For thorough decontamination of hands, use normal hand-washing action for 20 to 30 seconds, paying special attention to fingernails and areas between fingers. Products marked with “\*” are in a formulation that can be applied to clothing and shoes using a spray dispenser. With all products, avoid contact with eyes, and observe product safety precautions given by the manufacturer. It is important that the users of any of these products always READ AND FOLLOW THE LABEL DIRECTIONS.

***PERSONNEL DECONTAMINANTS for use on Clothing AND Skin:***

<b>Name of Product</b>	<b>Manufacturer</b>	<b>Contact Number</b>
1. * GX 1027 Antimicrobial Soap	Galloway Chemical	800-445-1143
2. * Canker Guard	Flo-Tech, Inc.	800-335-6832
3. * Csan 154 QT Soap	Bell Chem Corporation	800-659-2355
4. * EcoCare 360	Ecolab	651-293-2848
5. * Medi Kwik AntiMicrobial & Fungicidal Skin Cleanser	Envirosafe, Inc.	800-227-9744
6. * Triple Crown Super Healer	Envirosafe, Inc.	800-227-9744
7. * QHS Quaternary Hand Sanitizer	Chemstar Products, Inc.	813-978-8648
8. * C Soap	Agri Flow	863-381-2628

***PERSONNEL DECONTAMINANTS for use ONLY on Skin:***

<b>Name of Product</b>	<b>Manufacturer</b>	<b>Contact Number</b>
A. Hibiclens	SSL	888-566-3468
B. Hibistar	SSL	888-566-3468
C. EcoCare 250	Ecolab	651-293-2848
D. EcoCare 350 (alcohol base/no rinse)	Ecolab	651-293-2848
E. FS Antimicrobial Hand Cleaner;	ZEP Manufacturing Co.	800-313-8439
F. Acclaim Antibacterial Liquid Hand Soap	ZEP Manufacturing Co.	800-313-8439
G. Nobac Instant Foam Hand Sanitizer	Mason Chemical	800-362-1855
H. Zep Foam San	ZEP Manufacturing Co.	800-313-8439
I. Zep Foamy Sanz	ZEP Manufacturing Co.	800-313-8439
J. Selig Foaming Hand Sanitizer	Selig Industries	800-313-8439
K. Selig Perfect Touch Selig Industries (800) 313	Selig Industries	800-313-8439
L. QS Plus (non alcohol hand sanitizer)	Aero Chemical Co.	800-795-9222

Source: <http://www.freshfromflorida.com/pi/chrp/schedules/decontamination.pdf>



## Annex 2.

# *Equipment Sanitation*

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***Decontamination of Equipment:*** Equipment and vehicle surfaces (including under-carriages) should be regularly inspected for freedom from plant debris and soil residue, pressure-washed with detergent, and then further disinfected with any of the following approved equipment decontamination materials applied to all surfaces to the point of runoff. Recommended contact time for all listed chemical decontaminants is ten minutes. Where skin sensitivity is of concern, these articles may be immersed in prescribed Quaternary Ammonium Chloride (QAC) or chlorine solutions for ten minutes, and then rinsed in clean water prior to use. Since the following QAC decontamination materials are not labeled for use on personnel, it is recommended that care be taken to avoid contact with personnel when applying these products. It is important that the users of these products always READ AND FOLLOW THE LABEL DIRECTIONS.

***Quaternary Ammonium Chloride 'QAC':*** The use of these compounds is recommended for vehicles, tools and equipment. Do not use on personnel. Apply all QAC products at 2000 ppm (0.2%) QAC solution to all equipment surfaces to the point of runoff (dilution ratio 1:108). Recommended contact time is 10 minutes. The following QAC products are approved for use in the decontamination of equipment, and carry EPA Section 3 registrations:

Name of product	Manufacturer	Contact Number
1. CITRA-SOLV/CANKER-SOLV	FLO-TEC Inc.	(800) 335-6832
2. CS-170-C	Chemical Systems of Florida, Inc.	(407) 886-2329
3. Canquat 110c	Fresh Mark Corporation	(352) 429-4171
4. Canquat 108	Fresh Mark Corporation	(352)429-4171
5. BELQUAT 612	Bell Chem Corporation	(407) 339-2355
6. SAN-O-256	Hill Manufacturing Co.	(800) 445-5123
7. ZEP X-1400	ZEP Manufacturing Co.	(800) 313-8439
8. DECCOSAN 321	Decco Cerexagri, Inc.	(800) 221-0925
9. CPF QUAT	Theochem Laboratories, Inc.	(800) 237-2591
10. HDQ-22 High Dilution Quat	Chemstar Products, Inc.	(813) 978-8648
11. Canker Control Concentrate	Galloway Chemical Division	(800) 445-1143
12. C-Quat	Genesis Technologies	(800) 825-5810
13. J & J Disinfectant Spray	J & J Chemical Co.	(800) 345-3303
14. Canker-Solv (neutral pH)	FLO-TEC Inc.	(800) 335-6832
15. Canker-Solv Reduced Corrosion	FLO-TEC Inc.	(800) 335-6832
16. AP Neutral Disinfectant Cleaner	APCO Equipment & Supply	(863) 648-9774
17. Microdyne Extra	Eurochem International	(404) 696-9867
18. C-Quat Plus	Genesis Technologies	(800) 825-5810
19. CANKER QUAT	International Chemical Corp.	(800) 352-2436
20. HDH Quat 108	HDH Agri Products LLC	(352) 343-3484

## ***ALTERNATIVE METHODS FOR DECONTAMINATION OF EQUIPMENT***

(A) ***Peracetic Acid:*** Only approved formulations may be used, only with injection systems, and may only be used on equipment including food contact surfaces. Rinsing is not required if used in accordance with product label. This material must be applied to reasonably clean equipment, follow label instructions for ratio. The following products are approved for use in decontamination of equipment, and carry EPA Section 3 registration:

Name of product	Manufacturer	Contact information
1) VigorOx Citrus XA	FMC Fresh Produce Technologies	(863) 683-5411
2) VigorOx XA-15	FMC Fresh Produce Technologies	(863) 683-5411
3) Peroxy-Solv	FLO-TEC Inc.	(800) 335-6832
4) JET-Oxide	JET Harvest Solutions	(877) 866-5773
5) Peraclean 5	A Growing Alternative, Inc.	(828) 766-6179

(B) *Hydrogen Peroxide Products:* Only approved formulations may be used, only with injection systems, and may only be used on equipment, including food contact surfaces. Rinsing is not required if used in accordance with product label. This material must be applied to reasonably clean equipment, at CCEP-approved ratio of 1:200. The following products are approved for use in decontamination of equipment, and carry EPA Section 3 registration:

Name of product	Manufacturer	Contact information
1)OxiDate	BioSafe Systems	(888) 273-3088
2)Oxyfresh	Fresh Mark Corporation	(352) 429-4171
3)HDH Peroxy	HDH Agriproducts LLC	(352) 343-3484

(C) *Copper-based products:* Only approved formulations may be used, and only on equipment, vehicles, tools, clothing and shoes. Not for use on skin. This material must be applied to reasonably clean equipment at CCEP-approved ratio indicated. Dilute with clean water with the pH adjusted to <7.0 before mixing. The following product is approved for use in decontamination of equipment, and carries EPA Section 3 registration:

1) Eradicator The New Magna-Bon Corp. (863) 357-0400

Dilution ratio 1:1000

- (D) ***Household Bleach (Chlorine) or Commercial Hypochlorite Products:*** A solution for decontamination of tools and equipment can be made using household bleach or other more concentrated hypochlorite products. Apply 200 ppm available chlorine to all surfaces to the point of run-off and maintain a pH of 6.0 to 7.5. Most solutions made with 30 ml of household bleach to 4 litres of water meet these criteria. This solution loses its strength rapidly, and should be made fresh daily. Bleach is not an effective decontaminant if used on dirty equipment.
- (E) ***Hot Water and Detergent:*** Wash thoroughly with a hot water and detergent solution, under high pressure, at a minimum of 70 degrees °C, covering all surfaces to the point of runoff.
- (F) ***Steam:*** Apply steam, with minimum temperature of 70 °C, to all surfaces. This temperature must be maintained at the point of contact. Note: It has been proven to be extremely difficult to maintain the 70 °C temperature in actual use. Applying steam with a combination of dry heat in an enclosed chamber has been successful.

*Source: <http://www.freshfromflorida.com/pi/chrp/schedules/decontamination.pdf>*

## Annex 3.

# *Budwood Harvesting & Storage*

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### *Preparation:*

- 1) Make sure your tools are clean and properly sanitized. This includes clippers, gloves, sharpening stones, knives, storage containers, and anything else that you take into the budwood house.
- 2) Trees should be fully hydrated and free of diseases.
- 3) Be sure the trees are identified correctly. Check twice.

### *Time to cut:*

- 1) Check to be sure you are cutting the right variety.
- 2) Citrus trees are usually fully hydrated in the morning hours until noon. During the afternoon or times of high temperatures, trees begin to lose moisture. This moisture will increase budding losses.
- 3) Leaves should be removed as soon as sticks are cut.
- 4) Sticks should be kept cool / shaded until washed.
- 5) Budwood should not go more than an hour before washing and storage.

### *Washing:*

- 1) Wash in water and antibacterial soap.

- 2) Rinse in clean water
- 3) Dip in 10% by volume bleach water
- 4) Shake all excess water from wood
- 5) Put washed wood in clean plastic bag, include paper towel to soak up extra moisture.
- 6) Be sure to tag/ mark each bag with the varietal information and harvest date and location.

*Storage:*

- 1) Store harvested orange and mandarin budwood at 4.5°C, grapefruit at 7 °C.
- 2) Budwood can be easily stored for one month.
- 3) Can be stored for 3 months, but must be rewashed and sanitized each month

*Transportation:*

- 1) Budwood should always be kept cool and out of the sun.
- 2) Transport budwood in coolers with ice. Keep a newspaper layer between budwood and ice to avoid freeze damage to wood.

## Annex 4.

# *Seed Treatment & Storage*

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Harvest seed fruit and be sure to keep varieties separate.

Extract seed using local method.

Only extract one variety at a time to avoid mixing varieties.

Wash and separate pulp and peel.

Hot water treat @52 °C for 10 minutes

Cool off seed with 10% by volume household bleach for 10 minutes

Dip in 8-hydroxy-quinoline sulfate for 5-10 minutes. One tablespoon per gallon

An alternative treatment is 2 teaspoons Captan dusted on 2 lbs seed.

Place seed in cool shady area to allow it to slowly surface dry.

Pack in plastic bags. Remove as much air as possible.

Be sure to mark / tag each variety with varietal information and harvest date and location.

Store at 4.5 °C

Inspect monthly.

## Annex 5.

# *International Society of Citrus Nurserymen*

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Every three years there is an international meeting of citrus nurserymen. This meeting takes place in a different part of the world each time. The purpose of the meeting is to provide opportunities for citrus nurserymen as well as citrus researchers to collaborate and share the latest research. In conjunction with the meetings, there is usually a pre and post tour of citrus nurseries and the citrus industry in that region. These meetings are great opportunities for nurserymen to learn more about their profession and make advancements in their own production practices. To learn more, visit the website [www.iscn.com](http://www.iscn.com) or Google “International Society of Citrus Nurserymen.”





## References

Food and Agriculture Organization of the United Nations (1991). Graft-Transmissible Disease of Citrus, Handbook for detection and diagnosis. FAO, Rome, Italy. 286 pp .

Citrus Growers Association (2003). Propagation of Citrus, Extension Bulletin No. 3. Ministry of Agriculture and Fisheries, Government of Jamaica. St. Catherine, Jamaica. 27 pp.

<http://www.freshfromflorida.com/pi/chrp/schedules/decontamination.pdf>

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**Food and Agriculture Organization**  
**of the United Nations**