LEGISLATIVELY ESTABLISHING A HEALTH CERTIFICATION PROGRAMME FOR CITRUS

JESSICA VAPNEK

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1. Introduction

Many countries have implemented plant material certification programmes to preserve or rebuild certain agricultural sectors. These programmes aim to produce and distribute high quality planting materials that are free from systemic diseases and pests. Certification programmes generally set forth eligibility requirements for nurseries, growers and other purveyors of plants. Only those varieties of plants that have been registered and approved by the competent national authority; that have been evaluated, indexed[1] and found free from any systemic diseases; and that thrive in the region may be certified. Generally, the agricultural ministry administers certification programmes, although the competent authority will vary by country.

Many different crops throughout the world are subject to certification. Citrus[2] is one of the major cultivated fruit crops in the world, grown in more than 100 countries throughout the tropical, sub-tropical and Mediterranean climate regions. For most of these countries, citrus is a significant export. South Africa, for example, exported over one million metric tonnes of oranges in the 2008/2009 marketing year, whereas the world export total was over three million tonnes. Citrus is also one of the crops most susceptible to and most easily harmed by pathogens transmitted through plant propagation, a type of plant reproduction whose object is to preserve the unique characteristics of a desirable plant from one generation to the next. Different types of plant propagation include grafting (uniting two plants to make them grow as a single plant by inserting one or more buds of one plant – the scion – into the rootstock or stock of the other) and budding (common for propagating young citrus trees: here the scion, consisting of a single bud, is attached just underneath the bark).

As will be discussed in more detail below, citrus diseases range from prokaryotic (bacteria and mollicute, i.e. without a cell wall) to fungal (true fungi and oomycetes, i.e. pathogens that look like fungi but on a molecular level more closely resemble algae) to viral (true viruses and viroids, i.e. viruses without proteins). Some diseases, such as citrus tristeza, huanglongbing and witches' broom, are so serious that they can cripple, debilitate or even destroy a citrus industry in a country or region. A citrus certification programme producing disease-tested propagative material is one of the most efficient ways to eliminate or contain graft-transmissible and other citrus diseases.

This paper is designed as a resource for national or sub-national governments that are interested in designing and implementing a citrus certification programme. The paper first provides a background to the diseases and transmission vectors to which citrus species are susceptible. It then outlines examples of certification programmes, voluntary and mandatory, and then provides a detailed description of the specific elements of a certification programme and the legislation needed to put it in place.

2. Citrus Diseases

Citrus diseases are caused by fungi, bacteria, viruses, viroids, phytoplasmas and spiroplasmas. Disease symptoms include leaf and fruit spots, cankers, rots, leaf chlorosis, dieback, quick decline, bark scaling, stem pitting and trunk concavities, stunting, small, harden, misshapen, bitter or acidic fruit, and leaf mottling. Each pathogenic agent is spread and infects citrus in a different manner. Fungal or bacterial citrus pathogens for example are carried by the wind, rain, insect vectors or reside in the soil and infect citrus plants through natural openings, wounds or vector feeding. Fungi use mycelia, spores and other fruiting bodies whereas bacteria are spread as complete bacterial cells.

All systemic citrus pathogens (i.e. viruses, viroids, phytoplasmas, spiroplasmas and bacteria) are contained in propagation materials (buds, stocks and some of them in seeds) of the plant. These pathogens may not produce symptoms in the initial host plant, but they cause disease when introduced into certain citrus hosts or cultivars. Most of these systemic pathogens are also transmitted by specific insect vectors that feed on citrus plants.

[1] Indexing means any test that will positively and consistently confirm the presence (or absence) of a transmissible pathogen, or that will identify the disease.
[2] Citrus is one of 33 genera in the sub-family *Aurantioideae*. Although its taxonomy is not precisely established, most researchers recognize 16 species of citrus, the most common of which are oranges, grapefruit, lemons, some limes and some tangerines.

Eight citrus diseases and what causes them are shown in Table 1.

Table 1 – Citrus Diseases and Their Causal Agents

Disease	Causal Agent	Vector	Detection means
Huanglongbing (HLB)/ citrus greening	*Candidatus* Liberibacter sp. (Phloem bacterium)	Citrus Psyllid	PCR (polymerase chain reaction) and quantitative real time PCR
Citrus variegated chlorosis (CVC)	*Xylella fastidiosa* (Xylem bacterium)	Sharpshooter	Culture, serology, PCR
Tristeza, quick decline, stem pitting and seedling yellows	*Citrus tristeza virus* (CTV) (Phloem virus)	Aphid	Bioindexing, serology, PCR
Black spot	*Guignardia citicarpia* (Fungus, teleomorph)	None	Symptoms, culture
Citrus chlorotic dwarf	Probable virus	Whitefly	Bioindexing
Witches' broom of lime	*Candidatus* Phytoplasma aurantifolia	Leafhopper	Bioindexing, hybridization, serology, PCR
Exocortis	*Citrus exocortis viroid* (CEVd)	None	Bioindexing, gel electrophoresis, hybridization, PCR
Stubborn	*Spiroplasma citri*	Leafhopper	Bioindexing, culture, PCR

Source: Roistacher, 1993 and APS, 2000.

The most important viral pathogen of citrus worldwide is the citrus tristeza virus (CTV) which causes three severe and distinct diseases: quick decline on sour orange rootstock; stem pitting of grapefruit, sweet orange and lime; and seedling yellows of sour orange, lemon and grapefruit. It is graft-transmissible but natural spread also occurs by aphid vectors. Another serious citrus disease, citrus variegated chlorosis (CVC), is caused by the bacterium *Xylella fastidiosa*, which is present only in the xylem of infected plants. It causes an inter-veinal chlorosis of leaves along with brown lesions in the centres. Infected fruit ripen early and are undersized and hard. It is graft-transmissible and vector-transmissible by several species of xylem-feeding sharpshooters (leafhoppers). CVC was first reported in Brazil in 1987 and is now present in all major citrus areas of that country.

Another major citrus disease is huanglongbing (HLB, also known as citrus greening), initially thought to be caused by phloem-inhabiting bacteria. Recently, more pathogenic agents (phytoplasmas) have been associated with HLB. HLB is characterized by blotchy mottle on the leaves and misshapen, poorly coloured and off-tasting fruit. In areas where the disease is endemic, citrus trees may live for only five to eight years and never bear usable fruit. The disease occurs in much of Asia, sub-Saharan Africa, several small islands in the Indian Ocean and the Saudi Arabian peninsula. Recently the disease was discovered in the Americas (South, Central and North – i.e. the United States). HLB-causing bacteria are transmitted primarily through infective citrus psyllids (jumping plant lice) and also through grafting. HLB has not been successfully managed anywhere in the world. More research is needed on rapid and robust diagnosis, disease epidemiology and vector control.

Other diseases, and the parts of the world they have affected in the recent past, are:

- citrus canker (Asia, West Africa, South America, United States – Florida)
- tristeza decline on sour orange (worldwide)
- tristeza severe stem pitting (worldwide)
- citrus blight (Florida; Central and South America)
- citrus chlorotic dwarf (Turkey)
- fruta bolita (Argentina)
- sudden death disease (Brazil)
- witches' broom disease of lime (Oman, United Arab Emirates, Iran).

Source: Roistacher, 1993 and APS, 2000.

3. Country Examples

Almost every country facing the threat of citrus disease has adopted a certification programme to rebuild or preserve its citrus industry. One of the earliest certification programmes had its roots in the 1930s when the first graft-transmissible agent, citrus psorosis, was discovered at the Citrus Experiment Station in Riverside, California, United States. That discovery triggered the establishment of probably the first citrus budwood and nursery programme in the world called the "Psorosis Free Program". In 1956, following a string of advances in citrus indexing that greatly increased the number of diseases that could be tested – and that also shortened the indexing period from a matter of years to weeks – the Psorosis Free Program evolved, with the support of the citrus industry, into the California Variety Improvement Program (CVIP).

The CVIP, now known as the Citrus Clonal Protection Program (CCPP), maintains blocks of trees that serve as a source of disease-free, true-to-type budwood[3] of all important fruit and rootstock varieties for California's citrus industry and citrus researchers, and also provides a safe mechanism to import citrus from anywhere in the world. California law and United States federal law require all citrus material entering California to pass through the CCPP. Thus the CCPP serves as the first line of defence to protect the multi-billion dollar citrus industry. Other states with important citrus industries include Arizona, Florida and Texas, all of which have established different certification programmes linked to the type of production, their resources, growing conditions and pest and disease status (Vidalakis *et al.*, --).

While the CCPP concentrates on citrus varieties that have commercial potential for California, the United States National Clonal Germplasm Repository for Citrus and Dates (NCGRCD), also based in California, focuses on species that have interesting or useful germplasm characteristics and supplies the germplasm to requestors from any country. The objective of the NCGRCD is to acquire, preserve, distribute and evaluate genetic diversity within *Citrus*, the 32 related genera and date palms and their relatives and to do research supporting this objective. The NCGRCD is one of three sites in the United States with a recognized citrus quarantine facility. Only the CCPP, the Florida citrus programme and the NCGRCD are allowed to import and handle citrus propagative material under quarantine in the United States.

The Citrus Variety Improvement Programme of Spain (CVIPS) was launched in 1975 based on the CCPP model with the objectives of (a) establishing pathogen-free plants of local cultivars by shoot-tip grafting (STG); (b) importing foreign genotypes through an STG-based quarantine procedure; (c) maintaining healthy genotypes in a Germplasm Bank; and (d) releasing healthy budwood to citrus nurseries through a certification programme. Only healthy genotypes are maintained in the Germplasm Bank, which contains a total of 475 genotypes (272 selected in Spain and 203 imported from other countries), representing 43 citrus species and 33 species from 17 citrus-related genera. The Germplasm Bank has a field collection used for research, a cryo-stored collection for long-term maintenance and a screen house that is used to release budwood to nurseries. Release of healthy budwood from the CVIPS to nurseries started in 1979, when there were only 10 registered nurseries. Currently, there are 39 registered nurseries, which use budwood from the Germplasm Bank for all commercial propagation (Navarro *et al.*, 2002).

The CVIPS has had a positive impact on the Spanish citrus industry. Since it started, about 92 million certified nursery trees originating from the

[3] A shoot or stem of a living plant that is bearing buds suitable for bud grafting.

Germplasm Bank have been planted in the field, which represents more than 75% of the plantings in the country. Virus and virus-like diseases have not caused any significant damage in new plantings, and a wide selection of healthy material from the best varieties is available for growers. There is high interest and demand for certified virus-tested trees in the country. Planting of virus-free certified trees went from 2 million trees in 1982 to 35 million in 1992, and the percentage of citrus in Spain produced from virus-free buds went from 40% in 1982 to 100% just 6 years later.

The French Department of Corsica has a Citrus Sanitary Improvement Program which has been in operation for 25 years under the aegis of the Agricultural Research Station (SRA) at San Giuliano. Under the relevant French legislation, only the SRA is authorized to import citrus propagating material into France. The material is introduced into a quarantine screen house and released only after complete indexing and after the plants have been found free from viruses and other fungal or bacterial diseases. To date, over 300 cultivars free from virus and virus-like diseases have been selected or introduced from other countries. Trees of these cultivars are held in a field planting and used as sources of budwood for commercial propagation in nurseries. Several virus-free cultivars from Corsica have also been established in other countries.

The Italian government promulgated a law in 1991 which governs certification of clonal propagating material (D.M. 289). This framework law was followed by specific regulations for stone fruits, strawberry, olive, citrus, pome fruits and walnut. The certification programme relies on traceability to allow for the identification of the original source of propagating material at each stage of the programme.

The virological problems of Cyprus are similar to those of its neighbours in the Mediterranean. The most severe disease faced by the local citrus industry is tristeza, which led the government to pass a law in 1991 (60/91, N. 2584) to regulate the production, maintenance and distribution of healthy propagating material, including citrus. The law establishes a nine-member National Council which has representatives from the plant protection and horticulture sections of the Department of Agriculture, the Agricultural Research Institute and private nurseries. One responsibility of the Council is the registration of nurseries and the issuance of licences for their operation. Regulations issued in 1993 under the 1991 law establish the detailed requirements for nursery registration and set out details for the production and release of healthy planting material for the main horticultural crops, in particular, citrus.

In Israel, the Citrus Registration and Certification Programme (CRCP) was established in 1950. Initially, the CRCP applied to only one disease and two citrus varieties, but was extended to all citrus cultivars in 1952. Additional regulations were implemented in 1961 to prevent the spread of tristeza. The programme is based on the Israeli Seed Law (1956) and on regulations concerning growing of citrus nursery trees (1964). The latter regulations forbid the purchase, sale or grafting of citrus bud material unless the material has been taken from registered trees. The programme is carried out jointly by the Department of Plant Protection and the Citrus Extension Service of the Ministry of Agriculture.

No members of the genus *Citrus* or its close relatives are indigenous to America, so citrus diversity in the Western Hemisphere has been obtained from overseas introductions, from the collection of material arising from mutations, from natural hybrids or from breeding programmes. Argentina, Brazil, Chile and Uruguay are important citrus-producing countries which have implemented certified citrus nursery tree programmes to guarantee use of high-quality propagation material within their citrus industries. Argentina began its mandatory citrus certification programme for propagation material in 1998, and by the year 2000 there were 117 disease-free and true-to-type commercial cultivars available for the nursery industry (Anderson, 2000). The country also maintains citrus germplasm for research. All four countries just cited are using their local gene banks in genetic improvement programmes aimed at obtaining new rootstock and scion varieties.

Until comparatively recently, only Cuba and Florida in the Caribbean Basin had mandatory citrus certification programmes, although Belize and Jamaica soon followed. Cuba's mandatory programme is operated by the Citrus Research Institute under the supervision of the National Certification Commission composed of several agencies and research institutes. Other scientific

institutions are also involved and cooperate with the indexing work. The programme covers the entire production cycle from propagation to multiplication, with the goal of eliminating or reducing to a minimum the incidence of vectors that transmit diseases and that damage citrus plants. Among other requirements, the programme requires the use of sterile media to avoid infestations from nematodes and fungi; a testing system to guarantee the healthiness of the propagation material; and the staggering of seedling production to guarantee four cycles of propagation per year. The programme is responsible for supplying all budwood for propagation throughout the country.

The regulations for Belize and Jamaica, which were prepared with FAO assistance, are quite similar to one another. They aim to guarantee that citrus material originates from "clean" stock and will be traceable as it proceeds through propagation and sale. Thus, if there is an upsurge of CTV or another citrus disease, the origins of the infected material, as well as where it has been and is located, are on record and action can be taken. Under the citrus certification programmes in these two countries, nurseries dealing in citrus material have to apply for registration, which is granted and maintained only if they follow certain detailed sanitary procedures necessary to contain the spread of CTV and other graft-transmissible diseases. The regulations also establish requirements for different categories of trees or blocks of trees: parent trees, certified scion trees, seed source trees, certified citrus trees, quick multiplication blocks and varietal blocks. As will be explained in more detail below, these specific rules for propagation of citrus trees are designed to prevent infected material from spreading. Similarly, the requirements that certified citrus trees be clearly identified and their movements recorded permit the competent authority in each country to monitor and react to any outbreaks of citrus disease.

The regulations in both Belize and Jamaica provide for appeals against actions taken under the certification programme. For example, a person can appeal the denial of an application for nursery registration or for the certification of a seed source tree, or its cancellation. In Belize the Minister delegates his authority to decide appeals to the Citrus Certification Board established in the regulations whereas in Jamaica the Minister delegates his authority to hear appeals to the Jamaica Citrus Protection Agency established in separate legislation. Nonetheless, in both cases the Minister retains ultimate authority to decide whether a nursery owner or other person has a legitimate grievance under the programme.

Oman also has a citrus certification programme in place (the "Ocitrus" programme), also prepared with assistance from FAO. Although like in Belize and Jamaica the Minister responsible for agriculture has the ultimate authority, a Nursery Committee established under Nursery Regulations oversees and implements the Ocitrus programme. Every person intending to propagate or sell citrus trees must register his or her nursery, and all nurseries, whether small or large, commercial or retail, are covered under the programme.

4. Voluntary vs. Mandatory Certification

A successful certification programme actually comprises three linked sub-programmes: a quarantine programme, a clean stock programme and a certification programme (Lee, 2006). The quarantine programme ensures that exotic species are safely introduced into the country or region in question; the clean stock programme tests and produces pathogen-free species; and the certification programme ensures that the already quarantined and tested plants are distributed and tracked after distribution.

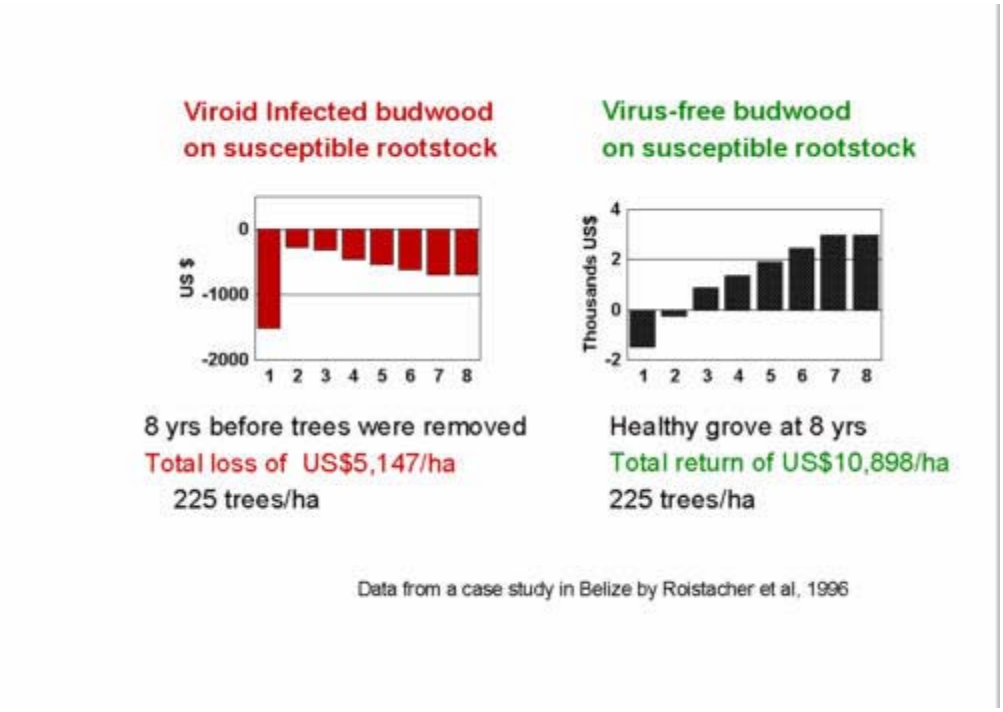
Certification programmes can be of extraordinary utility in controlling citrus diseases, but they must be mandatory to be effective. Voluntary programmes inevitably have varying levels of compliance by farmers, and therefore see inconsistent results. Even those voluntary programmes that have some initial success later see shortcuts and avoidance. Without widespread adherence, farmers have little incentive to abide by the rules, since a farmer who complies with the (voluntary) requirements of the certification programme will bear higher private costs and still risk having his or her crops harmed by others' actions or inactions. This is because inattention to or wilful disregard of protocols at one nursery can jeopardize the productivity and potential livelihoods of neighbouring ones.

Mandatory programmes, by contrast, create precise requirements and obligations to prevent the introduction and spread of the relevant diseases. By distributing and requiring the use of pathogen-tested and pathogen-free budwood, mandatory certification decreases the ability of pathogens to infiltrate citrus crops. The measures also make it difficult for any pathogens to get into the citrus budwood supply, since most or nearly all budwood for propagation originates and is distributed via the mandatory programme. The use of certified budwood reduces citrus pathogens, especially extremely destructive pathogens, throughout a region or country.

Mandatory certification, plus strict quarantine measures, ensures that pathogens can be quickly detected and eliminated.

An additional benefit of mandatory certification is its self-perpetuation. Certified trees are profitable and growers begin to demand them, since healthy citrus groves last for generations. The ability to establish and maintain groves with healthy, pathogen-free trees can mean the difference between making a profit or not, as shown in Table 2.

Table 2 – Profitability of Citrus Production



Growers began to demand certified trees in Egypt, which established a programme in 1996 to improve planting material through the importation of trees from countries with sanitary programmes. Before the creation of the programme, Egypt's citrus industry was suffering a steep decline, especially compared to other Mediterranean countries. After implementation of the programme, the prices per tree rose and the demand for trees outpaced the capacity to produce them (Hofer, 2006).

Despite the clear need and the clear benefits of having a certification programme, some nurseries, growers, farmers and others in the agricultural industry resist making this type of programme mandatory. Mexico, for example, has had a certification programme in place since 2000 where the only nurseries that participate are those completely convinced of the benefits of certification. In most countries, the primary reason for opposition is usually that the start-up costs may be prohibitive, as nurseries have to implement a series of physical and other changes to how they propagate and maintain their citrus plants. Another argument against mandatory certification is that it may prevent the free movement of goods and therefore lower

prices and restrict trade. Subsistence growers and individuals interested in growing ornamental or exotic species are often the most resistant to measures they perceive as restricting their freedom to move and sell their plants.

Critiques based on the high initial costs may be mitigated by government financial support and subsidies to growers. Education and awareness-raising programmes to demonstrate the clear economic benefits of the programme and the risks from making it voluntary can also be used to reduce opposition and garner support.

Some jurisdictions have gone from voluntary programmes to mandatory programmes after diseases devastated the industry. For example, the U.S. State of Florida's nematode phytosanitary measures were made mandatory after a citrus disease called "spreading decline" devastated citrus orchards in the 1950s. The damage caused by this disease, which is spread by the burrowing nematode (*Radopholus similis*), prompted the adoption of internal phytosanitary measures and the implementation of a citrus nursery certification programme. The programme requires that citrus propagation material be produced in accordance with strict sanitation practices, and that non-infested orchards be protected from the introduction of the nematodes from infested trees or other contaminated sources.

Similarly, after the citrus industry expressed concern about the inadequacy of Florida's voluntary budwood registration programme, the state adopted a mandatory Quality Tree Program (QTP) in 1997, which after its limited beginnings expanded to cover even dooryard nurseries. The QTP requires the identification of all sources of propagating material and is one of the first lines of defense in reducing long-distance spread of diseases.

Mandatory citrus certification programmes can be established in a number of ways, including through new specific primary or secondary legislation[4] or through already existing legislation. Generally, it is preferable to establish a certification programme through new legislation, for several reasons: the legislation can establish and assign detailed powers to an appropriate agency or body to manage and implement the programme; government processes generally require the budget to take account of all bodies and programmes established in new legislation; discussion of the legislation through the legislative process can serve a useful public education function; and anchoring a citrus certification programme in primary legislation means that it is protected from political vicissitudes and changing political will. The U.S. State of Texas, for example, relies on primary legislation and devotes a whole chapter of its Agriculture Code to defining its citrus budwood certification programme.

Nonetheless, in some circumstances it may be necessary to establish a certification programme through secondary legislation. For example, where a severe outbreak calls for rapid action or where the political environment makes adoption of new primary legislation too slow or otherwise impractical, regulations issued under an existing law may be the only option. Both Belize and Jamaica created their citrus certification programmes through secondary legislation. Belize created the programme under the Agricultural Health Authority Act of 1999 whereas Jamaica issued regulations under the Plants Quarantine Act of 1993. Both primary laws grant broad authority to the Minister to elaborate regulations relating to plant health,

One benefit of using secondary legislation is that, unlike laws subject to the lengthy parliamentary process, regulations and other secondary instruments can be more rapidly elaborated and promulgated, and also more easily and quickly changed in response to changing conditions and scientific advancements. On the other hand, some countries' legal systems have strict rules about which types of provisions must be promulgated in primary legislation, for example assigning powers to inspectors to enter property, authorizing the competent authority to collect fees and establishing offences and associated penalties. These features of the particular jurisdiction will have to be taken into account in the decision on how to implement a mandatory certification programme.

[4] In this article, "primary" legislation refers to legislation adopted by the Parliament or other high legislative body, whereas "secondary" legislation means regulations, rules, orders or other legal instruments adopted at a lower level, for example by a Minister responsible for agriculture or a state Secretary of Agriculture.

5. Elements of a Citrus Certification Programme

It should be clear from the review of country examples in Section 3 that citrus certification programmes vary by jurisdiction depending on the particular circumstances, Nonetheless, they share some fundamental elements and, as noted earlier, all successful programmes rest on three linked sub-programmes: (1) a quarantine programme to ensure the safe introduction of planting material, (2) a clean stock programme to test and produce pathogen-free species and (3) a certification programme to distribute and track the safe plant material. The next sections outline exemplars of detailed requirements of a typical citrus certification programme – requirements drawn from discussions with leading citrus virologists who have worked on certification programmes around the world. The technical requirements may either be issued as secondary legislation under the primary legislation establishing the citrus certification programme, or it may be a separate non-binding document which is incorporated by reference into the legislation and may thus be modified with greater ease.

5.1. Competent Authority

Certification programmes require that there be a competent authority assigned responsibility for implementation and control. Often, this is a unit within the ministry/department responsible for agriculture but some countries choose other organs. In Jamaica, separate legislation created a special agency, the Jamaica Citrus Protection Agency, to implement the country's citrus plant certification programme. In the U.S. State of Texas, it is the state Department of Agriculture that administers the Citrus Budwood Certification Program. The Department inspects nurseries and sets standards, while an advisory council helps with implementation. The U.S. State of Florida also has an advisory board to help oversee its Citrus Budwood Protection Programme. The board is guided by a technical advisory committee of nursery owners, growers, researchers and regulators, who provide input into the programme; among other things, the committee recommends testing strategies to manage new diseases.

5.2. Quarantine Rules

A certification system requires quarantine rules to govern the introduction of new or exotic species of citrus into the country (or province/state, if the programme is sub-national) which might carry pathogens or pests. To minimize the risk of harm from new plant introductions, legislation should (1) ban the introduction of plants except for those that are certified or quarantined, (2) monitor new plants through quarantine measures and (3) institute penalties for non-compliance with quarantine rules. The quarantine of citrus plants may include planting them in areas isolated from other citrus plants or using greenhouses or other physical barriers. The U.S. State of California, for example, prohibits the introduction of budwood unless it has a special permit or until it has been quarantined. Jamaica, also, passed regulations under its Plant Quarantine Act of 1993 to establish controls on the entry of exotic species into the country. The regulations include specifications for import permits and clearing quarantine and also for the size and packaging of imported plants and seeds.

5.3. Types of Trees or Growing Blocks

A crucial element of a comprehensive system for certification of citrus trees is a set of rules for the propagation of citrus plants. Commonly, the certification programme will establish categories of citrus plants and set out clear rules for the propagation of each.

5.3.1. Parent Trees

Parent trees are the foundation of citrus certification programmes. Several programmes, such as those in the U.S. State of Texas, Jamaica and Oman, require that parent trees be certified as pathogen-free accessions from a recognized clean stock programme. This is necessary where the risk of present or future infection in local trees is too high to use local trees. Other certification programmes do permit a local clone to become a parent tree but only upon recommendation by the competent authority (see section 5.3) – for example, where the competent authority determines that the selection is of proven or anticipated commercial value to the country's citrus industry, based on documented yield and fruit quality data. All certification programmes, including those that produce their own parent trees, provide that all parent trees

must be maintained under protected conditions, tested and found negative for all graft-transmissible diseases at intervals set by the competent authority and kept free of recognizable disease symptoms, fruit and foliage mutation and plant pests.

In most countries all parent trees are initially maintained by the government, and in this way guaranteed of protection and follow-up. Other countries trust some private growers to maintain the initial stock of parent trees. In either case, the legislation usually provides that if a particular private or government nursery can demonstrate that it can maintain parent trees and can carry out the necessary testing to the satisfaction of the competent authority, the government may authorize it to maintain parent trees at some stage.

For all new accessions of prospective parent trees, the competent authority or its authorized representative forwards the trees to a recognized facility to be shoot-tip grafted, indexed to verify freedom from graft-transmissible diseases and returned as pathogen-free accessions. The competent authority then carries out short-term indexes for citrus tristeza virus, citrus viroids and the psorosis complex of viruses,[5] and plants two trees on specified rootstocks as an index for citrus cachexia viroid and citrus tatterleaf virus. In the Belize, Jamaica and Oman citrus certification programmes, the cost of this indexing is borne by the Ministry if the new accession is to be distributed throughout the country for the benefit of the citrus industry, or borne by the person submitting the local clone if use of the new accession is to be restricted.

In California, the CCPP carries out a comprehensive biological indexing programme to detect graft-transmissible diseases that may arrive in an imported budline. The tissue of the imported budline is grafted onto citrus indicator seedlings, used to detect specific diseases. The indicator varieties are selected because of their sensitivity to diseases and their ability to express symptoms. Laboratory tests are also used for disease diagnosis. If any disease or pathogen is found, various therapies are used and if successful, the budline enters a full-scale variety introduction index (Vidalakis *et al.*, --).

5.3.2. Varietal Blocks

A varietal block is a group of at least five trees originating from the same parent tree, planted for observation of horticultural traits. Varietal block trees must originate from parent trees and must be grown according to several strict protocols: they must be propagated on rootstocks that are recommended by the competent authority or proven for the industry; separated from other propagations; grown with gaps set by the competent authority for the particular variety; and identified with plainly visible, durable markers as trees intended for varietal blocks. Varietal block trees must be made available to the competent authority for annual inspection. Depending on the rules of the certification programme, varietal blocks may be maintained by the government or by private nurseries.

5.3.3. Quick Multiplication Blocks

Quick multiplication blocks are specially designated nursery propagations made to multiply supplies of budwood rapidly for the production of certified citrus trees. The rules of the certification programme will set out the requirements for quick multiplication blocks, for example that they consist of groups of at least five trees and be maintained under protected conditions, propagated on vigorous rootstocks and separated from other propagations. Depending on the level of detail, the rules may also require that trees within a multiplication block from the same clone be separated by the required gap, properly labelled with the clone and date budded and identified as quick multiplication block trees with plainly visible, durable markers.

Budwood for quick multiplication block trees must originate from parent trees or varietal block trees. Quick multiplication block trees may serve as sources of budwood for production of certified citrus trees for a defined time period after budding. For example, Jamaica allows the use of quick multiplication blocks for up to 24 months after budding. Jamaica's quick multiplication block trees must be tested for citrus tristeza virus at intervals to be set by the Jamaica Citrus Protection Agency (JCPA). If the virus is not found upon testing, or if it is present but the infected trees are removed, the 24-month time period may be extended for up to 6 more months

[5] Budwood which tests negative for the short-term indexes may be conditionally released for propagation of quick multiplication block trees (see sub-section 5.3.3) and certified citrus trees (see sub-section 5.3.5), although it is subject to recall and destruction by the competent authority if a citrus disease or physiological disorder is detected.

(i.e. to a total of 30 months), at the discretion of the JCPA. Quick multiplication block trees may also be used as varietal block trees, or as certified citrus trees (see below), if they are planted in the field after the end of the time period during which they may be used as sources of budwood (24 or 30 months, whichever is applicable).

5.3.4. Certified Citrus Trees

Budwood for certified citrus trees must originate from parent trees, varietal block trees or quick multiplication block trees. The rules generally provide that any such bud cutting must take place within 24 months of budding and must be witnessed by an authorized representative of the competent authority. Only registered nurseries (see section 5.4) may propagate certified citrus trees, and they must follow the detailed requirements established by the legislation establishing the citrus certification programme. Only rootstocks that have not previously had a bud inserted in them may be used, and if rebudding is necessary, only buds from the same bud source as the original bud may be used. Budwood from certified citrus trees cannot be used as a further source of budwood.

One principal goal of the citrus certification programme is to ensure that every certified citrus tree in the country has a tag (usually bar-coded) which summarizes the history of the tree. This enables the competent authority to trace back problem trees to their source, and also enables buyers to ensure that the trees that they buy are free from diseases. Belize's tagging requirements reflect standard practice, requiring that the competent authority issue a certified citrus tree tag for each certified citrus tree, labelled with the nursery registration number, the clone, the rootstock and the date of budding. The nursery owner must attach the tag to the certified citrus tree and ensure that it is clearly visible at the nursery site.

The citrus certification programme should make it illegal to sell or otherwise trade in uncertified citrus trees. Although it can be difficult to prevent friends from giving cuttings of dooryard citrus propagations to their neighbours, a comprehensive information and public education campaign can go a long way toward explaining the danger of allowing uncertified trees to circulate.

5.3.5. Seed Source Trees

A seed source tree is a tree that supplies seeds for propagation of citrus plants. The certification programme will generally require that anyone wishing to propagate citrus seed must certify each prospective seed source tree. For example, in California's CCPP, all trees must be registered as budwood source trees before budwood may be cut from the foundation blocks. In the Jamaica and Belize programmes, the owner submits a seed source tree application to the competent authority, pays any applicable fee and agrees to abide by the technical requirements of the certification programme. The owner must also agree to make the tree available for annual inspection during fruiting.

Within a certain number of days after receiving the application, the competent authority carries out an inspection. First, it verifies that the seed source tree originates from a parent tree (see section 5.3.1). It then carries out a visual inspection of the prospective seed source tree and the trees surrounding it during fruiting to determine whether they are free from bark and leaf symptoms of the psorosis complex of viruses, witches' broom, citrus blight, citrus viroids, decline, gummosis and any other recognizable symptom of citrus disease, and that the prospective seed source tree is free of fruit and foliage mutation. If so, the competent authority collects buds from the prospective seed source tree and indexes them for the psorosis complex of viruses and witches' broom. If the indexing is negative, the competent authority assigns a seed source tree number to the tree and issues the applicant a seed source tree certificate, which is valid for a limited time period (e.g. four years) and must be attached to the tree so that it is clearly visible.

Where the competent authority denies an application for certification of a seed source tree, generally it must notify the applicant in writing of the reasons and may permit an applicant to reapply. In Jamaica and Belize, owners who have been denied certification for a seed source tree or have had their certification cancelled have the right to appeal the denial or cancellation.

The legislation usually includes provisions taking into account existing trees. For example, the relevant regulations for Oman provide that a tree already existing at the implementation date of the country's citrus certification programme may be certified as a seed source tree if it has borne

fruit that is horticulturally true-to-type and has no evidence of fruit or foliage mutation. Applications for certification of existing trees had to be made within one year after the implementation of the country's citrus certification programme.

Generally, certification of a seed source tree may be cancelled if annual inspection during fruiting reveals any of the following: symptoms of virus or other graft-transmissible disease on the seed source tree or any of the trees immediately surrounding that tree; careless handling of seeds collected from the seed source tree or of the records relating to that tree, likely to confuse the facts regarding the identity of the tree; or an unacceptable degree of mutation of the fruit or foliage of the seed source tree. Certification may also be cancelled where indexing on indicator plants discloses evidence of the psorosis complex of viruses or witches' broom. The certificate holder can also voluntarily request cancellation in writing to the competent authority. Reapplication after cancellation is treated as a new application.

5.3.6. Bud Cutting Forms

Another essential element of a citrus certification programme is a form that records details about bud cuttings. The form has two parts: one part of the form records the number of buds cut, and the other records the number of buds actually propagated. Generally, the rules require that the first part of the form be filled out in the following circumstances:

(a) where budwood is cut from parent trees for the purpose of producing varietal block trees, quick multiplication block trees or certified citrus trees;
(b) where budwood is cut from varietal block trees to propagate quick multiplication block trees or certified citrus trees;
(c) where budwood is cut from quick multiplication block trees to propagate certified citrus trees.

In each of these instances, the bud cutting must be witnessed by an authorized representative of the competent authority and the half-filled out form accompanies the budwood bundle. The other part of the form is completed by any person receiving or acquiring a budwood bundle for the purpose of establishing varietal block trees, quick multiplication block trees or certified citrus trees. The person receiving the budwood bundle retains a copy and submits the original to the competent authority within a certain period of time after receiving the budwood bundle (e.g. 30 days).

Upon receipt of a fully filled-out bud cutting form that refers to a certified citrus tree, and after the tree's owner has paid any applicable fee, the competent authority issues to the owner a certified citrus tree tag, labelled with the nursery registration number, the clone, the rootstock and the date of budding. It is understood that if a nursery is sold, the bud cutting forms should remain with the land and the trees, and not with the person. This is because they are needed to demonstrate the source and history of the relevant trees.

5.4. Nursery Registration

A principal feature of a citrus certification programme is the registration of nurseries that will grow and distribute citrus plants. Once registered, these citrus nurseries grow only approved plants under conditions designed to eliminate certain diseases, prevent their transmission and propagate resistant plants. In addition, citrus certification programmes generally require that all citrus plants in the country (or region) be sold only from registered nurseries, thus restricting the likelihood of the introduction of infected or susceptible plants. Registration of nurseries also assists in tracking disease outbreaks.

An important decision is whether all nurseries will be covered under the citrus certification programme. As noted earlier, with the ease of spread of many citrus disease (e.g. by aphids or other insect vectors), even dooryard plantings can cause devastation in a country's citrus industry as the failure of one nursery to follow the strict protocols can put all other nurseries at risk. For that reason, most citrus certification programmes do call for the registration of all nurseries, whether small or large, commercial or retail. The U.S. State of Florida, for example, requires registration of all nurseries. Only nurseries meeting the requirements may be registered, and registered nurseries must comply with the registration requirements. For example, all citrus nursery propagation must occur in enclosed greenhouse structures, for which detailed requirements are set out in the regulations.

To register, any person intending to propagate or sell citrus trees files an application with the

competent authority and pays the applicable fee. In some countries, such as Oman, the competent authority also inspects the nursery sites before approving an application. Legislation generally requires that nursery owners file a separate application for each nursery site (e.g. where there are multiple sites under the aegis of one overall nursery), and if the application is approved each site is issued citrus nursery certificate with a separate citrus nursery registration number. Generally once the certificate is issued (if not earlier – for instance in conjunction with filing the application with the competent authority), the owner must sign a declaration agreeing to comply with the technical requirements of the citrus certification programme.

Several countries have nursery registration requirements in their certification programmes, including Oman and Jamaica. The detailed technical requirements for citrus nurseries under Jamaica's citrus certification programme include the following:

(a) nursery owners must prominently display a Citrus Nursery Certificate for each registered nursery site;
(b) run-off irrigation water must be led out of the nursery area by means of a suitable drainage system, and the area must not be contaminated with run-off water from other citrus plantings;
(c) seed boxes and seedling trays must be raised completely off the ground;
(d) an effective nematode- and phytophthora-control programme must be in place;
(e) all rootstocks must be grown in polyethylene bags or other suitable containers;
(f) the soil or potting mix used in boxes, trays, bags or containers must permit effective drainage, be free from harmful pathogens and not be mixed or stored on a surface which is or may become infested with soil pathogens;
(g) the roots of plants in containers must not be permitted to come into contact with soil outside of the container;
(h) budded seedlings must be kept in rows with gaps between different budwood sources, with the first and last bag or container of seedlings budded from each budwood bundle clearly labelled with the bud source, rootstock and date of budding.

To avoid contamination of new plantings, the legislation establishing the citrus certification programme will generally provide that new citrus nurseries not be established on sites that were previously planted with citrus. In addition, existing citrus nurseries are usually granted one year or some other limited time period in which to upgrade their equipment and systems to meet the requirements of the nursery registration programme, else they must relocate or cease operation.

Generally the competent authority is assigned power in the legislation to revoke or cancel nursery registration in certain enumerated circumstances. For example, registration might be cancelled where a nursery owner knowingly sells trees infested with a pest or fails to follow the technical requirements set out in the legislation establishing the certification programme or in the accompanying technical guidelines.

5.5. Enforcement

Any person who disagrees with a decision of the competent authority under the citrus certification programme, such as the denial or cancellation of nursery registration or of seed source tree certification, may file a written appeal (usually to the Minister), who is authorized to apply whatever remedy he or she deems necessary. If the appeal is denied, the Minister will generally be obligated to provide the reasons in writing within a certain time period, and that decision is final. This is the case in the legislation of Belize, Jamaica and Oman.

The legislation establishing the citrus certification programme will generally set out the penalties that will apply to any violation, but this depends on the legal system of the country and the legislative practice. In some countries the legislation on the certification programme can set out the offences and the applicable penalties, for instance where the programme is established in primary legislation.[6] On the other hand, in some legal systems (e.g. civil law systems) all offences and penalties are set out in a criminal code and not in sectoral legislation such as legislation

[6] This is because in most legal systems, offences and penalties can only be established in parliamentary-level (primary) legislation not in secondary legislation such as regulations.

establishing a citrus health certification programme.

5.6. Schedules

Legislation establishing a citrus health certification programme generally contains subsidiary instruments such as schedules or orders. These contain the technical guidelines which nursery owners must adhere to, as well as the forms, certificates and fees. Belize, for example, includes seven schedules following its citrus certification regulations. They include everything from registration and tag fees to nursery registration certificates and seed source tree applications.

6. Conclusion

Citrus has become an increasingly important world crop in recent decades. Total world production has increased from 20 million tons to more than 100 million tons, and some countries and regions have come to really heavily on citrus for livelihoods and earnings. In the U.S. State of Florida, citrus is a $9.3 billion industry that employs over 76 000 people.

Although emerging citrus diseases and exchange of infected plants or vectors through world travel have greatly increased the risk of industry-crippling outbreaks, certification programmes have proven themselves effective at protecting citrus industries. Moreover, certified and virus-free trees are more profitable than other trees. Nursery operators and growers overwhelmingly prefer them to non-indexed and non-certified trees because they produce more and higher-quality fruit.

As described above, a number of countries have established functioning and successful certification programmes that can serve as models. Although many components of a programme are relatively simple to design and implement, some (such as indexing and procedures for recovering pathogen-free plants from local varieties) require technical expertise or outside resources. For example, germplasm banks such as the United States National Clonal Germplasm Repository for Citrus and Dates send clean stock propagating materials to countries or other entities interested in starting certification programmes. The initial start-up costs may be high but the benefits to growers, consumers and governments are clear and convincing.

References

American Phytopathology Society (APS). 2000. *Compendium of Citrus Diseases (2nd ed.)*, L.W. Timmer, S.M. Garnsey & J.H. Graham, eds. St Paul, Minnesota, APS Press.

Anderson, C. 2000. *Citrus Germplasm Resources and their use in Argentina, Brazil, Chile, Cuba, and Uruguay***.** Proceedings of the Global Citrus Germplasm Network, 7-8 Dec. 2000.

Chen, J., Pu, X., Deng, X., Liu, S., Li, H. & Civerolo, E. 2009. A Phytoplasma Related to 'Candidatus Phytoplasma asteri' Detected in Citrus Showing Huanglongbing (Yellow Shoot Disease) Symptoms in Guangdong, P.R. China. *Phytopathology*. Vol. 99, No. 3 (March). pp. 236—242.

European & Mediterranean Plant Protection Organization (EPPO). 1998. EPPO Standard, *Certification Schemes: Pathogen-tested citrus trees and rootstocks.* PM 4/12 (1) (available at archives.eppo.org/EPPOStandards/PM4_CERT/pm4-12-e.doc).

EPPO. 2000. Schemes for the production of healthy plants for planting: Nursery requirements. PM 4/7(2) (available at archives.eppo.org/EPPOStandards/PM4_CERT/pm4-07-e.doc).

Hofer, J. 2006. *Achievements and Impact of the Citrus Improvement Program (CIP) in Egypt.* GTZ (available at www.globalfoodchainpartnerships.org/cairo/papers/JoachimHoferEgypt.pdf).

Lee, R.F. 2007. Beginning with Healthy Plants: The Cornerstone of Integrated Pest Management for Perennial Crops. *USDA ARS National Clonal Germplasm Repository for Citrus and Dates*.

Navarro, N., Pina, J.A., Juárez, J., Ballester-Olmos, J.F., Duran-Vila, N., Guerri, J., Moreno, P., Ortega, C., Navarro, A., Arregui, J.M., Cambra, M., Zaragoza, S. 2002. *The Spanish varietal certification system.* Instituto Valenciano de Investigaciones Agrarias, Valencia, Spain.

Roistacher, C.N. 1993. *Arguments for establishing a mandatory certification programme for citrus.* Citrus Industry (October).

Roistacher, C.N. & Lee. R.F. *Certification Programs for Citrus* (unpublished manuscript). On file with author.

Teixeira, D.C., Wulff, N.A., Martins, E.C., Kitajima, E. W., Bassanezi, R.A. Ayres, J., Eveillard, S., Saillard, C. & Bové, J.M. 2008. A Phytoplasma Closely Related to the Pigeon Pea Witches'-Broom Phytoplasma Is Associated with Citrus Huanglongbing Symptoms in the State of São Paulo, Brazil. *Phytopathology*. Vol. 98, No. 9 (September). pp. 977—984.

Timmer, L.W., Garnsey, S.M. & Graham, J.H., eds. 2000. Graft-Transmissible, Systemic Diseases. *In* APS, *Compendium of Citrus Diseases* (2nd ed.) 92 pp. St Paul, Minnesota, APS Press.

Vidalakis, G., da Graça, J.V., Dixon, W.N., Kesinger, M., Krueger, R.R., Lee, R.F., Polek, M., Sieburth, P.J., Williams, L.L. & Wright, G.C. --. Quarantine, Sanitary and Certification Programs to Prevent Citrus Quarantine Pests in the USA (forthcoming, on file with author).

Zemzami, M. *The Program for the Production of Certified Citrus Trees at the Agricultural Domaines in Morocco* (available at ressources.ciheam.org/om/pdf/b43/00800069.pdf).