CITRUS TRISTEZA

Introduction

Citrus tristeza virus (CTV), occurs throughout the citrus growing world and is considered a major threat to the global citrus industry.

Losses from Citrus tristeza virus attacks vary greatly with the particular scion-rootstock combination grown in a particular area, the strain of the tristeza virus, and the abundance and efficiency of the aphid vectors.

CTV apparently originated in Asia where it existed for centuries unrecognized, possibly because the commonly grown citrus cultivars were highly tolerant. The major diseases of concern at the time were *Phytophthora* gummosis and root rot. Consequently trees were grafted onto the highly adaptable *Phytophthora*-resistant sour orange rootstock. This decision has contributed to the dramatic effect that CTV has had on world citrus production (Mooney and Harty, 1992). The first tristeza disaster was reported in the 1930s in Argentina, where 90% of the citrus was planted on sour orange rootstock.

Quick decline was first identified in Australia and New Zealand in 1940. This was preceded by similar symptoms being noted in South Africa in 1900, Java in 1928, Argentina in 1930, Brazil in 1937 and then California/USA in 1939. (Mooney and Harty, 1992).

There are more than 30 virus and virus-like diseases of citrus known in the world, of which Citrus tristeza virus (CTV) is arguably the most destructive. (Mooney and Harty, 1992).

The CARICOM countries of Belize and Jamaica face devastation of their citrus industries and presently Jamaica is undertaking a countrywide replanting programme of over 2000ha of sweet orange on resistant rootstocks to CTV. (Lionel James, (Caribbean Development Bank (CDB)), personal communication, 2002).

Identity

Classification

Genome	: (+) ss RNA
Family	: Closteroviridae
Genus	: *Closterovirus*
Synonyms	: Citrus quick decline virus (Fawcett and Wallace 1946); Grapevine A virus; Hassaku dwarf virus; Lime dieback Closterovirus

Category

Role	: Pest

There are several known strains: Seedling yellows virus (Fraser, 1959); Grapefruit stem pitting virus (Oberholzer et al., 1946): Grapefruit stunt bush virus (Anon,1950); Lime die-back virus (Hughes and Lister, 1949); Ellendale and Mandarin decline virus (Stubbs, 1952).

Signs & Symptoms

Agrios (1991)

The most economically important symptom is the quick decline or death of orange, grapefruit and mandarin trees on sour orange rootstock. The inverse pinholing in sour orange below the union, foliar symptoms is characteristic of CTV.

Tristeza symptoms vary in different hosts and even in the same hosts if they are grown on different rootstocks. The typical tristeza symptoms appear as a quick or chronic decline of trees budded on susceptible rootstocks but seedling or budded trees may also develop stem pitting.
The typical tristeza symptoms in older orange trees appear as suppression of new growth and bronzed to yellow leaves that tend to stand upright. As the disease progresses, the older leaves begin to fall, abscission often taking place between the petiole and the leaf blade, leaving the twigs defoliated or with a few younger leaves. Twigs begin to die back from the tip and later smaller limbs die and only a few weak shoots on the main limbs still have leaves. Twig growth becomes weaker each season until the tree dies, but some trees seem to linger on for many years. In some cases, affected trees quickly collapse after a sudden wilting and drying of the leaves. Tristeza affected trees also show root symptoms consisting of a marked depletion of starch, death and decay of the feeder rootlets, and the injury later extends to the larger roots.
Seedlings and budded trees of many different varieties of citrus, especially lime and grapefruit, develop stem pitting as a result of infection with tristeza. Stem pitting consists most commonly of longitudinal grooves or depressions in the stem paralleling the grain of the wood **(Fig. 1).**

Morphology

Citrus tristeza virus is a single stranded RNA closterovirus and is one of the longest plant viruses, appearing as a thread-like particle approximately 2000nm long by 12nm in diameter. One sedimenting component in purified preparations; sediment coefficient 140S(>>10). Density 1.257g/ml. (Brunt et al.1996).
Total RNA genome size is 17-20kb. Genome unipartite; largest (or only) genome part 17-20kb. Genomic nucleic acid isolated by Bar-Joseph et al. (1985).

Biology & Epidemiology

Infection of citrus plants with tristeza virus apparently occurs only when the virus is introduced into phloem sieve tubes. The virus seems to be limited to a few of the phloem cells in each bundle, and this may account for the ability of a second strain of the virus to infect the same plant by multiplying in some of the remaining phloem cells. After infection, the cells adjacent to a sieve tube begin to degenerate and become necrotic. In hosts that develop stem pitting, the degeneration spreads first into the cambium and inhibits the formation of normal xylem and phloem cells. The tissue produced in the lesion is soft and disorganized and usually remains attached to the bark so that when the bark is removed it leaves a pit in the wood. In some feeder roots the cambium is affected in its entirety rather than in localized areas and therefore no normal xylem or phloem is produced after the infection.
In hosts that develop seedling yellows, the degeneration appears in cells adjacent to phloem sieve tubes which in leaves and stems are only mildly affected, but most of those in feeder roots become extensively necrotic. Abnormal cambium activity and phloem formation are followed by the eventual deterioration of entire clusters of feeder roots (Agrios , 1991).
Tristeza is primarily a disease of citrus trees on sour orange rootstocks caused by a virus that is transmitted by grafting and by some kinds of vectors. The tristeza symptoms shown by scion trees of certain combinations of scion and rootstock are

due not to the susceptibility of the scions but to harmful effects produced by the virus on the phloem cells of the rootstock just below the union.

Dispersal / vectors

The virus is stylet borne and its vector becomes viruliferous after feeding for a few seconds and able to transmit the virus after equally short feedings.
The spread of the virus is accomplished readily through the use of tristeza-infected propagative material, both scion and root-stocks and through the insect vectors primarily *Toxoptera citricida. Aphis spiraecola, A. gossypiiana T. aurantii* (Dickson et al., 1951). The brown citrus aphis T. *citricida* is by far the most efficient vector of CTV (Mooney & Harty 1962).

Management

Quick decline caused by the Citrus quick decline virus can be effectively controlled by the use of CTV tolerant rootstocks such as *Poncirus trifoliata*, sweet orange,Troyer citrange, Cleopatra mandarin or rough lemon C. *aurantifolia, Swingle citrumelo.*
The use of protective CTV strains for cross protection is currently the most effective control strategy.
In the past, CTV cross protection has been used in the context of 'mild strain' and the use of these 'mild strains' as protective isolates. These 'mild' CTV strains were defined by their mild reaction on indicator seedlings. This has proved to be a false assumption as a protective isolate on one cultivar may not be mild reacting in other cultivars. For example, a very severe CTV stem pitting isolate on grapefruit was found to induce a very mild reaction in Mexican lime indicator seedlings (Mc Clean, 1977). Therefore the terminlolgy advocated by Roistacher, (1992), and for the purpose of cross protection the term 'protective'isolates or strains should be used rather than referring to them as 'mild'.
CTV cross protection or pre-immunization consists of inoculating plants with a vigorous protective isolate of the virus to afford protection against attack by a severe CTV strain. This has proven to be an economical and convenient means of reducing the effects of severe CTV in Australia, Brazil and South America (Muller and Costa, 1968).
Successful use of CTV virus protection involves careful evaluation of specific host effects and protecting abilities. The usual procedures for selecting a cross-protecting strain are as follows according to Mooney et al. (1994):

- To select protective strains from healthy looking field trees in older orchards, which have stunted or unhealthy trees showing symptoms of CTV infection.
- By bud selection from milder reacting isolates in indicator plants.
- By selection from field, trees or glasshouse plants which had previously been infected with CTV- SY (seedling yellows) and exhibited seedling yellows symptoms but had recovered and lost this symptom.
- By aphid transmission of CTV-SY or CTV-SP (stem pitting) in infected grapefruit, lemon or sweet orange seedlings to seedlings of grapefruit, lemon or Mexican lime, for production of attenuated isolates; or
- by aphid transmission of CTV-SY and CTV-SP from infected sweet orange to *Passiflora* spp. and then from *Passiflora* back to Mexican lime.

In the course of selecting and screening for potential protective CTV strains the following desirable traits are used as selection criteria (Lee et al, 1987).

Biological activity: The CTV strain should elicit mild symptoms not only in the target cultivar, but also in other citrus cultivars, species and relatives.
Titre and movement within the plant: The distribution of the protective strain within the plant should be uniform and the virus should have the ability to quickly invade new growth flushes. Any part of the plant which is virus free, even temporarily, provides an opportunity for an aphid to vector in a severe challenge CTV strain, which could result in the breakdown of the cross protection.
Effect of environment on cross protection: Some CTV strains are better adapted to warm conditions, whereas some prefer cooler temperatures. Therefore, it is important to evaluate potential cross protection strains under environmental conditions similar to those in which they will have to perform.
Ability to be aphid transmitted: Strains of CTV differ in their ability to be rapidly aphid transmitted, an ideal protective strain of CTV should be easily and rapidly aphid transmitted.

Pest Significance

CTV is of quarantine significance in the Caribbean region.
Quarantine must be vigorous to prevent the importation of uncertified budwood, and its use in propagation of new cultivation. In newer plantings introduction of tolerant scion-rootstock combinations has proven not only effective but economical.
Control of tristeza disease on existing plantings of susceptible scion-stock combinations is difficult or impossible. In Tristeza-affected areas some success has resulted from top working the existing still healthy sweet orange trees on sour orange rootstock to tristeza-resistant tops such as lemon and also from changing existing trees over to resistant rootstocks by inarching. Both practices, however, are expensive and time consuming and their success is influenced by several factors, particularly the environment. For these reasons it is generally more satisfactory and economical to remove susceptible trees after they become infected and to replant with a resistant combination using certified pathogen-free budwood as is currently done in Jamaica where the disease has seriously affected the sweet orange industry in the past eight years.

Host Notes	Brunt et al. (1996)

Tristeza affects practically all kinds of citrus plants but primarily orange *Citrus sinensis*, grapefruit *C paradisi*, lime *C.aurantifolia* (Brunt et al. 1996; Thomson, 1998).

Host range and symptoms that persist and are diagnostic as seen below:

- Citrus spp grafted onto *Citrus aurantifolia* (sour orange) rootstock – quick decline, pitted stems. Inverse pinholing in the roots tock.
- *C. paradisi* (grapefruit) – stunting.
- *C. aurantium* (lime) – die-back.
- *C. aurantium* (Seville orange) –seedling yellows.
- *C. reticulate* (mandarin) – decline.

- *Aeglopsis chevalieri, Afraegle paniculata, Pamburus missionis, Passiflora graulis*
- *Citrus aurantifolia* cvs. West Indian lime, Key lime, Mexican lime-chlorotic vein flecks, leaves cupped or canoe shaped, stem pitting
- *C. sinensis* on rootstock *C. aurantifolia* – sudden wilt, decline and death, overgrowth on bud union and honeycombing just below bud union
- *C. sinensis*, *C. paradisi* – stem pitting

Distribution

The disease has been reported in the African region, the Eastern Asian region, the Eurasian region, the Mediterranean region, the North and South American region, and the Pacific region; Algeria, American Samoa, Argentina, Australia, Belize, Bermuda, Bolivia, Brazil, Brunei, Darussalam, Cameroon, the Central African Republic, Chad, China, Colombia, Costa Rica, Cyprus, the Dominican Republic, Ecuador, Egypt, El Salvador, Ethiopia, Fiji, French Polynesia, Gabon, Ghana, India, Indonesia, Iran, Israel, Italy, Japan, Kenya, Korea Republic, Malaysia, Mauritius, Morocco, Mozambique, Nepal, Netherlands Antilles, New Caledonia, New Zealand, Nicaragua, Nigeria, Pakistan, Panama, Paraguay, Peru, The Philippines, Portugal, Puerto Rico, Saudi Arabia, Spain, Sri Lanka, Suriname, Taiwan, Tanzania, Thailand, Turkey, the USA, Uganda, Uruguay, Venezuela, Vietnam, Zaire, Zambia, Western Samoa, The former Yugoslavia, Zimbabwe (Brunt et al.1996).
In the CARICOM countries, the presence of Citrus tristeza virus (CTV) disease has been confirmed in Antigua and Barbuda, Belize, Guyana, Jamaica, Suriname and Trinidad & Tobago.

Error!

Fig.1 Stem pitting symptoms caused by Citrus tristeza virus (Picture taken from Mooney and Harty,1992)

Stem pitting symptoms are always associated with decreased vigour of the trees, poor bushy growth, and small and distorted fruit. Seedlings of certain citrus species such as sour orange, lemon, grapefruit and citron when inoculated with tristeza develop the so-called seedling yellow symptoms. (**Fig. 2 & 3**) (Mooney et al., 1994).

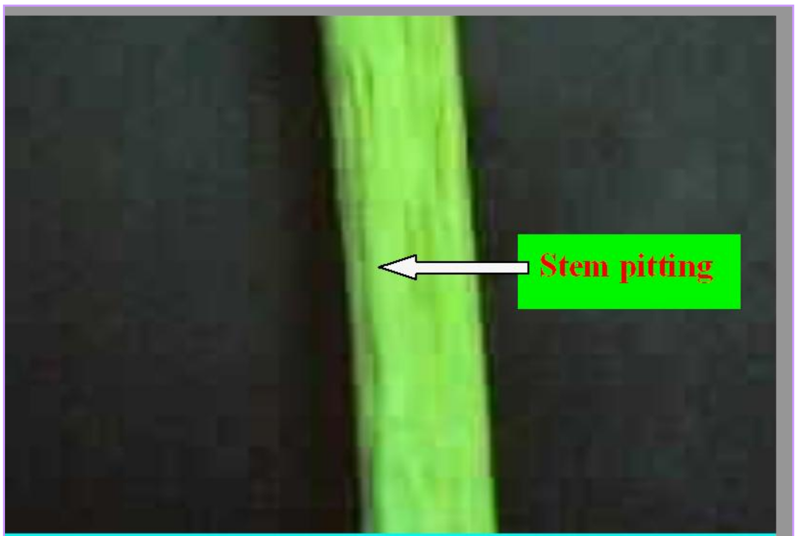

Fig. 2 Stem pitting caused by Citrus tristeza virus

Figure 3: Citrus seedling yellows symptom
(Courtesy of Mooney et al. 1994 Hort research Keri Keri, NZ)

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Web Resources: -

http//:www. biology.Annu edu. Au/Groups/MES/vide/.

http//: www.hortnet.co.nz./publications/science/kk0992.htm

http//:www.hortnet. Conz/publications/science/kkn0894.htm