EPPO Datasheet: *Citrus leprosis disease*

Last updated: 2024-01-09

IDENTITY

Preferred name: *Citrus leprosis disease*
Taxonomic position: Viruses and viroids
Common names: citrus leprosis, leprosis of citrus
view more common names online...
EPPO Categorization: A1 list
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EU Categorization: A1 Quarantine pest (Annex II A)
EPPO Code: CILV00

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Notes on taxonomy and nomenclature

Citrus leprosis is an important disease of citrus caused by several non-systemic viruses transmitted by *Brevipalpus* mites. For a long time, the identity of the causal agent(s) remained uncertain, in part because of confusing results and reports. Further efforts led to the gradual recognition that several distinct viruses were independently responsible for leprosis symptoms in citrus (Roy *et al.*, 2015a; EFSA, 2017). At present, seven viruses are recognized as being able to cause leprosis symptoms in various citrus species. These viruses fall in two very distinct groups that however share a similar biology. Firstly, citrus leprosis virus C (**CiLV-C**; virus species *Cilevirus leprosis*), citrus leprosis virus C2 (**CiLV-C2**; virus species *Cilevirus colombiaense*) and Hibiscus green spot virus 2 (**HGSV-2**; virus species *Higrevirus waimanala*) which are all in the Kitaviridae family and have positive-sense RNA genomes with a cytoplasmic replication (Roy *et al.*, 2013a; Ramos-González *et al*., 2016; Coock *et al.*, 2019). Secondly, Orchid fleck virus (**OFV**; virus species *Dichorhavirus orchidaceae*), citrus leprosis virus N (**CiLV-N**; virus species *Dichorhavirus leprosis*), citrus chlorotic spot virus (**CiCSV;** virus species *Dichorhavirus citri*) and the newly described citrus bright spot virus (**CiBSV**; a potential new species of the genus *Dichorhavirus*, Chabi-Jesus, 2021) have negative-sense RNA genomes with a nuclear replication and belong to the *Rhabdoviridae* family (Roy *et al.*, 2015b; Dietzgen *et al.*, 2014, 2018; Amarasinghe *et al*., 2019). Throughout this datasheet, these seven viruses will be collectively referred-to as citrus leprosis viruses or leprosis viruses and addressed individually using their acronym.

The evolution of the taxonomic status of some of the above viruses has been somewhat chaotic, leading to confusion. OFV virus was initially described as a pathogen of orchids. Viruses discovered in Mexico on citrus plants with leprosis symptoms were initially named citrus leprosis virus N (CiLV-N) (Roy *et al.*, 2013b) and citrus necrotic spot virus (CiNSV) (Cruz-Jaramillo *et al.*, 2014) but later these 2 viruses were re-classified as constituting the citrus strain of OFV (OFV-Cit1, Dietzgen *et al.*, 2014; Roy *et al.* 2015b; Afonso *et al.* 2016, EFSA PLH Panel, 2017). The situation was further complicated by the discovery in Mexico of a second strain of OFV (OFV-Cit2; Roy *et al.*, 2015b, 2020; Ramos-González *et al*., 2017; Chabi-Jesus *et al*., 2018), and by the differentiation of two orchid strains within orchid isolates of OFV (OFV-Orc1 and -Orc2; Kondo *et al.*, 2017; Roy *et al.*, 2020).

In parallel, a distinct virus causing citrus leprosis symptoms was described in Brazil (Ramos-González *et al*. 2017) and confusingly given the same name as the virus identified in Mexico mentioned above i.e. citrus leprosis virus N. The virus described in Brazil has retained the name (citrus leprosis virus N) and was recently given the binomial species name *Dichorhavirus leprosis* (Walker *et al*., 2022). To distinguish it from the OFV-Cit1 isolates initially named citrus leprosis virus N, it has sometimes been referred to as citrus leprosis virus N sensu novo and this convention will also be used here.

A novel *Dichorhavirus* was described in 2021 from citrus plants with leprosis symptoms (Chabi-Jesus *et al.*, 2021; 2023). This virus was tentatively named citrus bright spot virus (CiBSV). Although it appears to be distinct, it has not yet been recognized as a novel species by the ICTV so that its precise taxonomic status remains uncertain.

More viruses able to cause leprosis symptoms in citrus may be discovered and described in the future (EFSA, 2017;

Padmanabhan *et al.*, 2023).

HOSTS

Citrus leprosis disease has been reported from a range of citrus species, with sweet orange (*Citrus sinensis*) reported as the most susceptible host. The gradual discovery of the viruses associated with this disease causes uncertainty about the identity of the viruses involved in older reports. Consequently, information on the natural host range of individual viruses is frequently limited. Many of them have however been shown to be able to experimentally infect a larger range of plants than their known natural host range, which suggests that the natural host range may in many cases be broader than currently known.

Only a few non-rutaceous species were reported as naturally infected by one or another of the seven causal viruses (EFSA, 2017). However, for OFV, the orchid strains (OFV-Orc1 and Orc2) are able to infect a very broad range of orchid species as well as a range of non-orchid hosts (Kondo *et al.*, 2003). While isolates of these two strains have also been reported from citrus, there is no record to date of isolates of the citrus strains (OFV-Cit1 and Cit2) naturally infecting orchids.

CiLV-C host range includes various citrus species with sweet orange (*Citrus sinensis*) being the most affected. Other reported hosts include sour orange (*C. aurantium*), rough lemon (*C. jambhiri*), Citron (*C. medica*), Cleopatra mandarin (*C. reshni*), mandarin (*C. reticulata*), Grapefruit (*C. paradisi*), sweet lime (*C. limettioides*), Key lime (*C. aurantiifolia*), Rangpur lime (*C. limonia*), and hybrids such as Tangelo (*C. reticulata x C. x paradisi*) or Citrange (*C. sinensis x Poncirus trifoliata*). Lemon (*C. limon*) is considered as practically immune (Bastianel *et al.*, 2010). CiLV-C has also been observed in natural infection in *Commelina benghalensis* and *Swinglea glutinosa* and has been experimentally transmitted to plants of more than 25 families (León *et al.*, 2008; Nunes *et al.*, 2012; Garita *et al.*, 2014; Freitas-Astúa *et al.*, 2018; Chabi-Jesus *et al.*, 2021).

CiLV-C2 has only been reported so far from *C. sinensis* and a few other non-citrus hosts including *S. glutinosa*, *Dieffenbachia* spp., *Hibiscus spp.* (including *H. rosa-sinensis*) and passionfruit (*Passiflora edulis*) (Melzer *et al.*, 2013; Roy *et al.*, 2015a, Olmedo-Velarde *et al.*, 2022; Padmanabhan *et al.*, 2023).

In Hawaii, HGSV-2 mainly infects hibiscus plants (*Hibiscus arnottianus*, *H. tiliaceus*) but has also been found in natural infection in a few *C. sinensis*, *C. reticulata* and *C. volkameriana* (Volkamerian lemon) plants (Melzer *et al.*, 2012; Roy *et al.*, 2015a)

In addition to infecting orchids (Kondo *et al.*, 2003) and a range of other non-citrus hosts, the orchid strains of OFV (OFV-Orc1 and OFV-Orc2) have been respectively reported in South Africa from *C. sinensis* (Cook *et al.*, 2019) and in the USA (Hawaï) from *C. reticulata* and *C. jambhiri* (Olmedo-Velarde *et al.*, 2021). The citrus strains of OFV (Cit1 and Cit2) have respectively been reported so far from *C. sinensis*, *C. aurantiifolia*, *C. aurantium*, *C. limetta*, *C. latifolia*, *C. limon*, *C. paradisi* and *C. reticulata* (Cit1) (Cruz-Jaramillo *et al.*, 2014; Roy *et al.*, 2015a, b) and from *C. aurantium* and *C. sinensis* (Cit2) (Roy *et al.*, 2020).

CiLV-N sensu novo has so far only been reported in natural infection in *C. sinensis*. It was not identified in mandarin (*C. reticulata*) or in Key lime (*C. aurantifolia*) growing near infected *C. sinensis* suggesting that mandarin and Key lime may not be part of its host range (Ramos-González *et al.*, 2017). It has also been observed in mixed natural infection with CiLV-C2 in *S. glutinosa* and in *Dieffenbachia* sp. (Roy *et al.*, 2015a).

CiCSV has been reported so far from only three natural hosts: *C. sinensis*, *Agave desmettiana* and *H. tiliaceus* (Chabi-Jesus *et al.*, 2018, 2019).

The most recently described virus, CiBSV has only been reported so far from *C. sinensis* (Chabi-Jesus *et al.*, 2023).

	Viruses causing the Leprosis disease						
Rutaceous host plants	**CiLV-C**	**CiLV-C2**	**HGSV-2**	**OFV (citrus strains)**	**CiLV-N sensu novo**	**CiCSV**	**CiBSV**

Citrus aurantiifolia	**X**			**X**			
C. aurantium	**X**			**X**			
C. deliciosa							
C. jambhiri	**X**			**X**			
C. latifolia				**X**			
C limettioides	**X**						
C. limetta				**X**			
C. limon				**X**			
C. limonia	**X**						
C. medica	**X**						
C. paradisi	**X**			**X**			
C. reshni	**X**						
C. reticulata	**X**		**X**	**X**			
C. sinensis	**X**	**X**	**X**	**X**	**X**	**X**	**X**
C. suhuiensis	**X**						
C. volkameriana	**X**		**X**				
C. reticulata x C. paradisi	**X**						
C. clementina x C. reticulata	**X**						
C. reticulata x C. sinensis	**X**						
C. sinensis x P. trifoliata	**X**						
Swinglea glutinosa	**X**	**X**			**X**		
Non rutaceous host plants							
Agave desmettiana						**X**	
Commelina benghalensis	**X**						
Dieffenbachia spp.		**X**			**X**		
Hibiscus arnottianus			**X**				
H. rosa-sinensis		**X**					
H. tiliaceus			**X**			**X**	
Passiflora edulis		**X**					

Host list: *Agave desmettiana, Citrus hybrids, Citrus medica, Citrus reshni, Citrus reticulata, Citrus x aurantiifolia, Citrus x aurantium var. deliciosa, Citrus x aurantium var. paradisi, Citrus x aurantium var. sinensis, Citrus x aurantium, Citrus x latifolia, Citrus x limon var. limetta, Citrus x limon var. limettioides, Citrus x limon, Citrus x limonia var. jambhiri, Citrus x limonia var. volkameriana, Citrus x limonia, Commelina benghalensis, Dieffenbachia sp., Hibiscus arnottianus, Hibiscus rosa-sinensis, Hibiscus tiliaceus, Passiflora edulis, Swinglea glutinosa*

GEOGRAPHICAL DISTRIBUTION

Citrus leprosis disease has been reported from South, Central and North America (including Hawaii) and South Africa. Due to the gradual discovery of the causal agents and to the uncertainties about which viruses are involved in older reports, there are significant uncertainties about the distribution of individual viruses.

CiLV-C is by far the most widespread virus associated with citrus leprosis disease. It has been reported from South America (Argentina, Bolivia, Brazil (Acre, Amazonas, Bahia, Ceara, Distrito Federal, Espirito Santo, Goias, Mato Grosso, Mato Grosso do Sul, Minas Gerais, Para, Parana, Piaui, Rio de Janeiro, Rio Grande do Sul, Rondonia, Roraima, Santa Catarina, Sao Paulo, Sergipe, Tocantins), Colombia, Paraguay, Uruguay, Venezuela), Central America and the Carribean (Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama) and North America (Mexico).

CiLV-C2 has been reported from Colombia (Roy *et al.*, 2013a, Padmanabhan *et al.*, 2023) and, in non-citrus hosts (*H. rosa-sinensis*, *P. edulis*) from Hawaii and Florida (USA) (Melzer *et al.*, 2013; Roy *et al.*, 2018; Olmedo-Velarde *et al.*, 2022).

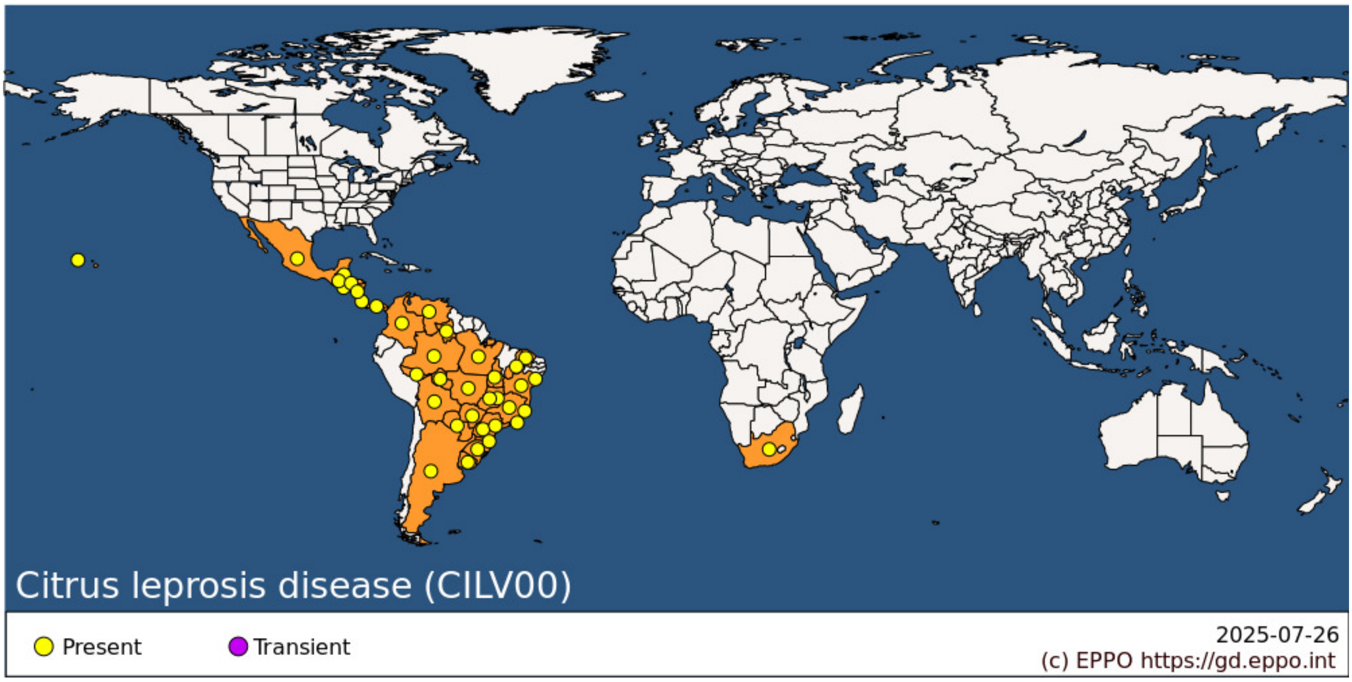
HGSV-2 has so far only been reported from Hawaii (USA).

OFV. The orchid strains (Orc1 and Orc2) of OFV have been reported from a range of countries but have only been reported from *Citrus* spp. in South Africa (Cook *et al.*, 2019) and in Hawaii (Olmedo-Velarde *et al.* 2021). The citrus strains (Cit1 and Cit2) of OFV have been described in several countries of the Americas (Brazil, Colombia, Mexico, Panama) (Cruz-Jaramillo *et al.*, 2014; EFSA PLH Panel, 2017; Roy *et al.*, 2013b, 2015a, 2020).

CiLV-N sensu novo has so far only been detected in Brazil in the State of São Paulo (Ramos-González *et al.*, 2017)

CiCSV has so far only been reported from Brazil (State of Piaui) (Chabi-Jesus *et al.*, 2018).

CiBSV has so far only been reported from Brazil (States of Rio Grande do Sul and Santa Catarina) (Chabi-Jesus *et al.*, 2023).



Africa: South Africa
North America: Mexico, United States of America (Hawaii)
Central America and Caribbean: Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama
South America: Argentina, Bolivia, Brazil (Acre, Amazonas, Bahia, Ceara, Distrito Federal, Espirito Santo, Goias, Mato Grosso, Mato Grosso do Sul, Minas Gerais, Para, Parana, Piaui, Rio de Janeiro, Rio Grande do Sul, Rondonia, Roraima, Santa Catarina, Sao Paulo, Sergipe, Tocantins), Colombia, Paraguay, Uruguay, Venezuela

BIOLOGY

Unlike most viruses, the leprosis-causing viruses are unable to spread systemically in their hosts and only cause localized lesions corresponding to the replication and local spread of the viruses by cell-to-cell movement, close to an inoculation point (Bastianel *et al.*, 2010; Roy *et al.*, 2015a; Dietzgen *et al.*, 2018; Freitas-Astúa *et al.*, 2018). All leprosis viruses are transmitted by false spider mites of the genus *Brevipalpus* (Tenuipalpidae) (Rodriges & Childers, 2013, Roy *et al.*, 2015a; Beltran-Beltran *et al.*, 2020). These mites feed on young plant tissues (leaves, twigs, fruits etc.) and, if viruliferous, transmit the virus when wounding the plants with their stylets (Ferreira *et al.*, 2020). The virus will then replicate in the inoculated cell and spread to neighbouring cells in a gradual process. Disease symptoms are limited to the patches of infected plant tissues resulting from this localized, non-systemic spread of the virus. Plant tissues outside these infection sites are unaffected but when a large population of viruliferous mites is present, the entire tree canopy can show symptoms, mimicking a systemic infection (EFSA, 2017). Symptom development can take a few weeks after inoculation with most of the symptoms appearing between 3 and 4 weeks post inoculation (Chiavetto *et al.*, 1984; Tassi *et al.*, 2017).

Mites acquire the virus by feeding on patches of infected host tissue. *Brevipalpus* mites transmit all leprosis viruses in a persistent circulative manner and the mites remain viruliferous for an extended period of time. All life stages can acquire and transmit the viruses but viruses are not transmitted transovarially to the progeny (Rodrigues *et al.*, 2003; Bassanezi & Laranjeria, 2007). There are indications that Dichorhaviruses (OFV, CiLV-N, CiCSV, CiBSV) replicate in their mite vectors so that they could have a circulative-replicative mode of transmission (Kondo *et al.*, 2003; Roy *et al.*, 2015a; Chabi-Jesus *et al.*, 2018). However, the ability of cileviruses to replicate in their mite vectors has not been clearly established (Tassi *et al.*, 2017; Chabi-Jesus *et al.*, 2018; Tassi *et al.*, 2022).

The taxonomy of *Brevipalpus* mites is complex (Navia *et al.*, 2013) and has significantly evolved over time. It should also be noted that transmission experiments involving mites are notoriously complex to perform. The information on virus-vector relationships in the case of leprosis viruses is therefore limited and the vector range of individual viruses might be broader than currently reported.

Within the *B. phoenicis sensu lato* species complex (Beard *et al.*, 2015), *B. yothersi* is considered the most important vector of the Cileviruses CiLV-C and CiLV-C2. *B. papayensis* and *B. phoenicis sensu stricto* can also transmit CiLV-C, but with lower efficiency (Ramos-González *et al.*, 2016; Nunes *et al.*, 2018; García-Escamilla *et al.*, 2018; Ferreira *et al.*, 2020). The *Higrevirus* HGSV-2 has been shown to be transmitted by *B. azores* but the mechanism involved is still poorly documented (Olmedo-Velarde, 2021, 2023).

B. californicus has been shown to be a vector of OFV-Cit1 (García-Escamilla *et al.*, 2018), whereas *B. phoenicis sensu stricto* transmits CiLV-N *sensu novo* (Ramos-González *et al.*, 2017). *B. yothersi* and a possible new related species ("*B.* aff. *yothersi*") have been shown to transmit CiCSV (Chabi-Jesus *et al.*, 2018, 2019; Ramos-González *et al.*, 2017), while citrus bright spot virus has been shown to be vectored by *B. azores* (Chabi-Jesus *et al.*, 2023).

DETECTION AND IDENTIFICATION

Symptoms

Round to elliptical local lesions are seen on fruits, leaves and twigs. Their severity varies with the species of citrus host and, possibly, the virus involved. Leaf symptoms are usually roundish with a dark-brown central spot about 2-3 mm in diameter, surrounded by a chlorotic halo, in which 1 to 3 brownish rings frequently appear surrounding the central spot. The overall lesion size varies from 10 to 20 mm, though larger lesions may form by the fusion of 2 or more adjacent lesions. On fruits, lesions are 10-20 mm wide necrotic spots, with a necrotic centre. Gum exudation is occasionally observed on the lesion. On green fruits, the lesions are initially yellowish, becoming more brown- or blackish, sometimes depressed and reducing the market value of the fruits. On twigs, lesions are protuberant, cortical, grey, brownish, or sometimes dark-reddish. Lesions may coalesce when present in large numbers, leading to the death of the twig. Superficially lignified tissues such as the main trunk do not show symptoms but the trunk of young seedlings may. In extreme cases, such as those seen in Argentina (where the disease is called lepra explosiva de los cítricos), severe defoliation and fruit fall are observed (Frezzi, 1940; Bitancourt, 1955; Rossetti *et al.*, 1969;

Bastianel *et al.*, 2006; Roy *et al.*, 2013a; Moreira *et al.*, 2022).

Citrus leprosis lesions are usually very characteristic, but may sometimes be mistaken for lesions of citrus canker, caused by the bacterium *Xanthomonas citri* pv. *citri* (EPPO, 2023) or zonate chlorosis, which is associated with infestation by *Brevipalpus* mites but shows symptoms that are essentially concentric green and chlorotic rings and do not become necrotic (Catara *et al.*, 2021).

Only a few differences have been reported in the symptoms induced by the different viruses and these were minor and not sufficient to allow an accurate diagnosis of the virus involved. Cytoplasmic viruses such as CiLV-C are reported to cause larger lesions that tend to be pale green in colour, with one or more concentric gummy ring(s), whereas lesions caused by nuclear viruses such as OFV-Cit1 tend to have a darker centre with orange or bright yellow rings at the periphery (Melzer *et al.*, 2013; Roy *et al.*, 2014).

Morphology

The cytoplasmic viruses (Cilevirus, Higrevirus) have non-enveloped bacilliform particles (50-70 × 110-120 nm) and cause the accumulation of electron-dense cytoplasmic inclusions. The nuclear viruses (Dichorhavirus) have non-enveloped, short rod-like particles (40–50 nm × 100–110 nm) and are associated with the presence of a large electron-lucent inclusion in the nucleus (Kitajima *et al.*, 2003; Freitas-Astúa, 2018).

Detection and inspection methods

Procedures for the inspection of places of production of citrus plants for planting and for the inspection of consignments of citrus fruits are provided in the EPPO Standards PM 3/(in press) (EPPO, 2023) and PM 3/90 (EPPO, 2020) respectively.

In addition to symptom observation and electron microscopy to observe viral particles or cytopathological alterations, leprosis viruses can be detected by mechanical inoculation of herbaceous indicators that react with the production of local lesions such as *Chenopodium amaranticolor*, *C. quinoa*, *Phaseolus vulgaris* and *Gomphrena globosa* (Colariccio *et al.*, 1995; Garita *et al.*, 2013). However, no indicators have been described for the most recently discovered leprosis viruses such as CiCSV and CiBSV.

Serological detection tests were developed for some of the leprosis viruses but antibodies are not commercially available. For example, polyclonal and monoclonal antibodies were obtained against CiLV-C and CiLV-C2 and used to detect these viruses in ELISA tests or in immunocapture reverse-transcription polymerase chain reaction (RT-PCR) tests (Calegario *et al.*, 2013; Choudhary *et al.*, 2013, 2014, 2017).

The most broadly used technique for the detection of leprosis viruses is RT-PCR. RT-PCR tests based on species-specific primers targeting different genomic regions of the viruses allow the detection of the leprosis viruses in infected plant tissues and also in viruliferous vectors (Locali *et al.*, 2003; Roy *et al.*, 2013a; Melzer *et al.*, 2012, Olmedo-Velarde *et al.*, 2021; Roy *et al.*, 2020; Ramos-Gonzalez *et al.*, 2017; Chabi-Jesus *et al.*, 2018, 2021). RT-PCR-based tests for the simultaneous detection of several viruses causing leprosis have also been developed (Roy *et al.*, 2017; Adducci *et al.*, 2017). It should however be stressed that for the most recently described viruses, few isolates have been sequenced so that the primers designed on these sequences may not capture the whole diversity within these species and may therefore not be suitable to amplify all isolates. A very sensitive one-step real-time RT-PCR is also available for the detection of CiLV-C and allows diagnosis at early infection stages (Choudhary *et al.*, 2015). A Taq-Man RT- real-time PCR test with high sensitivity has also been developed that may allow the quantification of CiLV-C in asymptomatic plants and also in *B. yothersi* individuals (Arena *et al.*, 2023)

Finally, recent developments in high-throughput sequencing technology allow the detection of all viruses present in a sample, even in the absence of any prior knowledge of the virus(es) present (Olmos *et al.*, 2018). While such approaches are not currently used as routine detection methods, their power for the identification and study of leprosis viruses has already been demonstrated (Padmanabhan *et al.*, 2023).

PATHWAYS FOR MOVEMENT

Leprosis viruses only infect plants locally, each lesion being associated with an inoculation event by a vector mite. The viruses do not move systemically in host plants (Bastianel *et al*., 2010; Roy *et al*., 2015a). In the absence of *Brevipalpus* mite vectors, movement through latently infected plants for planting (which is a common pathway for most plant viruses) is unlikely for leprosis viruses. The same would apply to plants for planting of non-regulated rutaceous and non-rutaceous hosts (in particular for CiLV-C and CiLV-C2, known to naturally infect *S. glutinosa, C. benghalensis* and *Dieffenbachia* sp.) and also to fruits of susceptible citrus species as *Brevipalpus* spp. vector mites are known to be able to acquire the viruses from fruit lesions (Tassi *et al*., 2017). In practice, the main pathway for movement and dispersal, both locally from plant to plant or long distance between citrus growing areas is with the *Brevipalpus* vector mites. These colonize most *Citrus* spp. and many other plant species; according to Oliveira (1986), *Brevipalpus* mites have been found infesting more than 200 different plant species and several species (*B. azores*, *B. californicus*, *B. yothersi*) vectoring leprosis viruses are known to occur in some countries of the EPPO region.

On their own, *Brevipalpus* mites are slow moving and have limited dispersal abilities (Alves *et al.*, 2005; EFSA, 2008). They can however be dispersed by wind or passively carried on on packaging, agricultural commodities (e.g. fruit), animals or humans (e.g. on their clothes) (Alves *et al.*, 2005; Bassanezi & Laranjeira, 2007; Childers & Rodrigues, 2011).

PEST SIGNIFICANCE

Economic impact

While symptoms severity may vary depending on citrus species and, in some cases varieties (Bastianel *et al.*, 2008), leprosis is considered a very important disease in affected areas (Bastianel *et al.*, 2010; Roy *et al.*, 2015a). As the leprosis viruses are not systemic, the number of lesions and thus the impact of the disease are directly linked to the size of mite vector populations. If proper mite control is not undertaken, severe losses in yield may occur, in both quantity and quality, in particular in sweet orange which is the most susceptible species. Fruits with lesions have low commercial value, especially for direct consumption. In severe disease cases, twigs may die, jeopardizing succeeding production while leaf drop will severely affect the tree canopy and result in dieback so that recovery following the adoption of vector control measures may take up to two years (EFSA, 2017). Furthermore, untreated orchards may serve as a source for the mite thus favouring spread of citrus leprosis to other plantations in the area (Bassanezi & Laranjeira, 2007).

Economic and environmental impacts also result from the need for vector control strategies that often rely on heavy use of acaricide sprays. In Brazil, it has been estimated to represent a significant portion of production costs, with 80-100 million USD invested annually in the early 2000s on vector control alone (Bastianel *et al.*, 2010).

Control

Citrus leprosis is mainly controlled by controlling the *Brevipalpus* vector population using integrated pest management practices targeting the vectors, such as acaricide treatments or, potentially, the use of biological control agents (Argolo, 2020). Other practices that may contribute to control include cultural practices that decrease sources of inoculum and movement of mite vectors such as pruning infected plants (since leprosis viruses are not systemic), using wind break barriers to limit mites dispersal or eliminating alternative host plants. Although some citrus species are less susceptible, there are currently no resistant varieties available for important citrus host species.

Phytosanitary risk

Leprosis viruses can affect many citrus species which are important crops of the southern part of the EPPO region, in particular sweet orange. These viruses cause a severe disease with high economic and environmental impact. There are no known ecoclimatic constraints for leprosis viruses establishment, except those affecting their hosts; and some of the *Brevipalpus* vector species favouring the establishment and spread of the viruses have been reported in southern EPPO region countries with citrus production (EFSA, 2017). It was therefore considered justified by several EPPO countries to prevent establishment and spread of leprosis viruses.

PHYTOSANITARY MEASURES

The import of *Citrus* L. plants and their hybrids, other than fruits and seeds is regulated/prohibited in many EPPO countries which strongly reduces the risk of introduction of citrus leprosis via this pathway. For example in the EU, their import is prohibited from third countries, by Annex VI of Commission Implementing Regulation (EU) 2019/2072 (EU, 2023).

In other countries, appropriate phytosanitary measures to import plants for planting (excluding seeds and pollen) of citrus hosts that are free from leprosis viruses could require that these plants are produced in a pest free area or in a pest free place/site of production, or shown to be free from the various citrus leprosis viruses by appropriate diagnostic methods. In addition, specific measures targeting the *Brevipalpus* vector could be required (e.g. acaricide treatments).

Measures specifically addressing the risk with *Brevipalpus* vector mites on other plant material or as a contaminant would be needed, but the small size of these mites, the variety of commodities that could host viruliferous mites, and the fact some species are already present in some countries of the EPPO region, make the development of such measures complicated.

Addressing other identified pathways such as plants for planting of non-citrus rutaceous and non-rutaceous hosts or fruits of susceptible citrus species could also be considered.

REFERENCES

Adducci B, Wei G, Roy A, Mavrodieva VA, Dennis G, Schneider W, Brlansky RH & Nakhla MK (2017) Validation of a quadruplex Real-Time RT-PCR assay for simultaneous detection of three Citrus leprosis viruses in plants. *Phytopathology* **107**, S5.53. https://apsjournals.apsnet.org/doi/epdf/10.1094/PHYTO-107-12-S5.1

Afonso CL, Amarasinghe GK, Bányai K, Bào Y, Basler CF, Bavari S & Kuhn JH (2016) Taxonomy of the order *Mononegavirales*: update 2016. *Archives of Virology* **161**, 2351-2360. https://doi.org/10.1007/s00705-016-2880-1

Alves EB, Casarin NF & Omoto C (2005) Mecanismos de dispersão de *Brevipalpus phoenicis* (Geijskes) (Acari: Tenuipalpidae) em pomares de citros. *Neotropical Entomology* **34**, 89-96. https://doi.org/10.1590/S1519-566X2005000100013

Amarasinghe GK, Ayllón MA, Bào Y *et al.* (2019) Taxonomy of the order *Mononegavirales*: update 2019. *Archives of Virology* **164,** 1967-1980. https://doi.org/10.1007/s00705-019-04247-4

Arena GD, Ramos-Gonzalez PL, Tassi AD, Machado MA & Freitas-Astua J (2023) A TaqMan RT-qPCR assay for absolute quantification of citrus leprosis virus C lineage SJP: disclosing the subgenomic/genomic ratio in plant and mite vector, plant organ-specific viral loads, and the kinetics of viral accumulation in plants. *Tropical Plant Pathology* **48**, 30-41. https://doi.org /10.1007/s40858-022-00539-4

Argolo PS, Revynthi AM, Canon MA, Berto MM, Andrade DJ, Döker I, Roda A & Carrillo D (2020) Potential of predatory mites for biological control of *Brevipalpus yothersi* (Acari: Tenuipalpidae). *Biological Control*, **149**, 104330. https://doi.org/10.1016/j.biocontrol.2020.104330

Bassanezi RB & Laranjeria FF (2007) Spatial patterns of leprosis and its mite vector in commercial citrus groves in Brazil. *Plant Pathology* **56**, 97-106. https://doi.org/10.1111/j.1365-3059.2006.01457.x

Bastianel M, Freitas-Astúa J, Kitajima EW & Machado MA (2006) The Citrus leprosis pathosystem. *Summa Phytopathologica* **32**, 211-220. https://www.scielo.br/j/sp/a/gdtT4FJyJ43td5bGSt84XYt/?format=pdf&lang=en

Bastianel M, Freitas-Astúa J, Nicolini F, Segatti N, Novelli VM, Rodrigues V, Medina CC & Machado MA (2008) Response of mandarin cultivars and hybrids to Citrus leprosis virus. *Journal of Plant Pathology* **90**, 307-312. https://www.jstor.org/stable/41998508

Bastianel M, Novelli VM, Kitajima EW, Kubo KS, Bassanezi RB, Machado MA & Freitas-Astúa J (2010) Citrus leprosis: Centennial of an unusual mite virus pathosystem. *Plant Disease* **94**, 284-292. https://doi.org/10.1094/PDIS-94-3-0284

Beard JJ, Ochoa R, Braswell WE & Bauchan GR (2015) *Brevipalpus phoenicis* (Geijskes) species complex (Acari: Tenuipalpidae) - a closer look. *Zootaxa* **3944**, 1-67. https://doi.org/10.11646/zootaxa.3944.1.1

Beltran-Beltran AK, Santillán-Galicia MT, Guzmán-Franco AW, Teliz-Ortiz D, Gutiérrez-Espinoza MA, Romero-Rosales F & Robles-García PL (2020) Incidence of Citrus leprosis virus C and Orchid fleck dichorhavirus citrus strain in mites of the genus *Brevipalpus* in Mexico. *Journal of Economic Entomology* **113**, 1576-1581. https://doi.org/10.1093/jee/toaa007

Bitancourt AA (1955) Studies on citrus leprosis. *Arquivos do Instituto Biológico de São Paulo* **22**, 161-231.

Calegario RF, Locali EC, Stach-Machado DR, Peroni LAO, Caserta R, Saroli RB, Freitas Astúa J, Machado MA & Kitajima EW (2013) Polyclonal antibodies to the putative coat protein of Citrus leprosis virus C expressed in *Escherichia coli*: production and use in immunodiagnosis. *Tropical Plant Pathology* **38**, 188-197. https://doi.org/10.1590/S1982-56762013005000005

Catara AF, Bar-Joseph M & Licciardello G (2021) Exotic and emergent citrus viruses relevant to the Mediterranean Region. *Agriculture* **11**, 9, 839. https://doi.org/10.3390/agriculture11090839

Chabi-Jesus C, Ramos-Gonzalez PL, Postclam-Barro M, Salgado Fontenele R, Harakava R, Bassanezi RB, Moreira AS, Kitajima EW, Varsani A & Freitas-Astúa J (2021) Molecular epidemiology of Citrus leprosis virus C: a new viral lineage and phylodynamic of the main viral subpopulations in the Americas. *Frontiers in Microbiology* **12**, 641252. https://doi.org/10.3389/fmicb.2021.641252

Chabi-Jesus C, Ramos-Gonzalez PL, Tassi AD, Barguil BM, Beserra Jr JEA, Harakava R, Kitajima EW & Freitas-Astúa J (2019) First report of citrus chlorotic spot virus infecting the succulent plant *Agave desmettiana*. *Disease Notes* **103**, 6. https://doi.org/10.1094/PDIS-09-18-1617-PDN

Chabi-Jesus C, Ramos-Gonzalez PL, Tassi AD, Guerra-Peraza O, Kitajima EW, Harakava R, Beserra Jr JEA, Salaroli RB & Freitas-Astúa J (2018) Identification and characterization of Citrus chlorotic spot virus, a new *Dichorhavirus* associated with Citrus leprosis-like symptoms. *Plant Disease* **102**, 1588-1598. https://doi.org/10.1094/PDIS-09-17-1425-RE

Chabi-Jesus C, Ramos-González PL, Tassi AD, Rossetto Pereira L, Bastianel M, Lau D, Canale MC, Harakava R, Novelli VM, Kitajima EW & Freitas-Astúa J (2023) Citrus bright spot virus: a new *Dichorhavirus*, transmitted by *Brevipalpus azores*, causing citrus leprosis disease in Brazil. *Plants (Basel)* **12**, 1371. https://doi.org/10.3390/plants12061371

Chiavegato LG & Salibe AA (1984). Transmissibility of leprosis symptoms by *Brevipalpus phoenicis* to young citrus plants under laboratory conditions. *Proceedings of the Ninth IOCV Conference, 1983. Riverside, CA, USA: IOCV*, 218-221. https://escholarship.org/content/qt37m0z5t2/qt37m0z5t2_noSplash_c53e95d71d3844619398ad52ac9b216b.pdf?t=p0w8fo

Childers CC & Rodrigues JCV (2011) An overview of *Brevipalpus* mites (Acari: Tenuipalpidae) and the plant viruses they transmit. *Zoosymposia* **6**, 180-192. https://doi.org/10.11646/zoosymposia.6.1.28

Choudhary N, Roy A, Govindarajulu A, Nakhla MK, Levy L & Brlansky RH (2014) Production of monoclonal antibodies for detection of Citrus leprosis virus C in enzyme-linked immuno-assays and immunocapture reverse transcription-polymerase chain reaction. *Journal of Virological Methods* **206**, 144-149. https://doi.org/10.1016/j.jviromet.2014.06.010

Choudhary N, Roy A, Guillermo LM, Picton DD, Wei G, Nakhla MK, Levy L & Brlansky RH (2013) Immunodiagnosis of Citrus leprosis virus C using a polyclonal antibody to an expressed putative coat protein. *Journal of Virological Methods* **193**, 548-553. https://doi.org/10.1016/j.jviromet.2013.07.035

Choudhary N, Roy A, Leon MG, Wei G, Nakhla MK, Levy L & Brlansky RH (2017) Production of mono-and polyclonal antibodies to Citrus leprosis virus C2 and their application in triple antibody sandwich ELISA and immunocapture RT-PCR diagnostic assays. *Journal of Virological Methods* **243**, 177-181. https://doi.org/10.1016/j.jviromet.2017.02.012

Choudhary N, Wei G, Govindarajulu A, Roy A, Li W, Picton DD, Nakhla MK, Levy L & Brlansky RH (2015) Detection of Citrus leprosis virus C using specific primers and TaqMan probe in one-step real-time reverse transcription polymerase chain reaction assays. *Journal of Virological Methods* **224**, 105-109. http://doi.org/10.1016/j.jviromet.2015.08.022

Colariccio A, Lovisolo O, Chagas CM, Galleti SR, Rossetti V & Kitajima EW (1995) Mechanical transmission and ultrastructural aspects of citrus leprosis disease. *Fitopatologia Brasileira* **20**, 208-2013. https://www.researchgate.net/publication/281200751_Mechanical_transmission_and_ultrastructural_aspects_of_citrus_lepros

Cook G, Kirkman W, Clase R, Steyn C, Basson E, Fourie PH, Moore SD, Grout TG, Carstens E & Hattingh V (2019) Orchid fleck virus associated with the first case of Citrus leprosis-N in South Africa. *European Journal of Plant Pathology* **155**, 1373-1379. https://doi.org/10.1007/s10658-019-01854-4

Cruz-Jaramillo JL, Ruiz-Medrano R, Rojas-Morales L, Lopez-Buenfil JA, Morales-Galvan O, Chavarin-Palacio C, Ramirez-Pool JA & Xoconostle-Cazares B (2014) Characterization of a proposed *Dichorhavirus* associated with the Citrus leprosis disease and analysis of the host response. *Viruses* **6**, 2602-2622. https://doi.org/10.3390/v6072602

Dietzgen RG, Freitas-Astúa J, Chabi-Jesus C, Ramos-González PL, Goodin MM, Kondo H & Kitajima EW (2018) Dichorhaviruses in their host plants and mite vectors. *Advances in Virus Research* **102**, 119-148. https://doi.org/10.1016/bs.aivir.2018.06.001

Dietzgen RG, Kuhn JH, Clawson AN, Freitas-Astúa J, Goodin MM, Kitajima EW, Kondo H, Wetzel T & Whitfield AE (2014) *Dichorhavirus*: a proposed new genus for *Brevipalpus* mite-transmitted, nuclear, bacilliform, bipartite, negative-strand RNA plant viruses. *Archives of Virology* **159**, 607-619. https://doi.org/10.1007/s00705-013-1834-0

EFSA (2008) Pest risk assessment made by France on *Brevipalpus californicus*, *Brevipalpus phoenicis and Brevipalpus obovatus* (Acari: Tenuipalpidae) considered by France as harmful in the French overseas departments of Guadeloupe and Martinique - Scientific Opinion of the Panel on Plant Health. *EFSA Journal* **6**(5), 678, 25 pp. https://doi.org/10.2903/j.efsa.2008.678

EFSA Panel on Plant Health (2017) Scientific Opinion on the pest categorisation of Citrus leprosis viruses. *EFSA Journal* **15**(12), 5110, 32 pp. https://doi.org/10.2903/j.efsa.2017.5110

EPPO (2020) PM 3/90 (1) Inspection of citrus fruits consignments. *EPPO Bulletin* **50**, 383-400. https://doi.org/10.1111/epp.12684

EPPO (2023) PM 3 Inspection of places of production – Citrus plants for planting. *EPPO Bulletin* (in press)

EU (2023) Consolidated text Commission Implementing Regulation (EU) 2019/2072 of 28 November 2019 establishing uniform conditions for the implementation of Regulation (EU) 2016/2031 of the European Parliament and the Council, as regards protective measures against pests of plants, and repealing Commission Regulation (EC) No 690/2008 and amending Commission Implementing Regulation (EU) 2018/2019. Available at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02019R2072-20230809 [accessed on 25 September 2023]

Ferreira LM, Nunes MA, Sinico TE, Soares AJ & Novelli VM (2020) *Brevipalpus* species vectoring citrus leprosis virus (*Cilevirus* and *Dichorhavirus*). *Journal of Economic Entomology* **113**, 1628-1634. https://doi.org/10.1093/jee/toaa070

Freitas-Astúa J, Ramos-González PL, Arena GD, Tassi AD & Kitajima EW (2018) *Brevipalpus* transmitted viruses: parallelism beyond a common vector or convergent evolution of distantly related pathogens? *Current Opinion in Virology* **33**, 66-73. https://doi.org/10.1016/j.coviro.2018.07.010

Frezzi MJ (1940) "Lepra explosiva" of orange. Studies in the pathology laboratory of Bella Vista (Corrientes). *Boletin Frutas y Hortalizas* **5**, 1-15.

García-Escamilla P, Duran-Trujillo Y, Otero-Colina G, Valdovinos-Ponce G, Santillán-Galicia MT, Ortiz-García CF, Velázquez-Monreal JJ & Sánchez-Soto S (2018) Transmission of viruses associated with cytoplasmic and nuclear leprosis symptoms by *Brevipalpus yothersi* and *B. californicus*. *Tropical Plant Pathology* **43**, 69-77. https://doi.org/10.1007/s40858-017-0195-8

Garita LC, Tassi AD, Calegario RF, Freitas-Astúa J, Salaroli RB, Romao GO & Kitajima EW (2014) Experimental host range of Citrus leprosis virus C (CiLV-C). *Tropical Plant Pathology* **39**, 1. https://doi.org/10.1590/S1982-56762014005000004

Garita LC, Tassi AD, Calegario RF, Kitajima EW, Carbonell SAM & Freitas-Astúa J (2013) Common bean: Experimental indicator plant for Citrus leprosis virus C and some other cytoplasmic-type *Brevipalpus*-transmitted viruses. *Plant Disease* **97**, 1346-1351. https://doi.org/10.1094/PDIS-12-12-1143-RE

Kitajima EW, Chagas CM & Rodrigues JC (2003) *Brevipalpus*-transmitted plant virus and virus-like diseases: cytopathology and some recent cases. *Experimental and Applied Acarology* **30**, 135-160. https://doi.org/10.1023/b:appa.0000006546.55305.e3

Kondo H, Hirota K, Maruyama K, Andika IB & Suzuki N (2017) A possible occurrence of genome reassortment among bipartite rhabdoviruses. *Virology* **508**, 18-25. https://doi.org/10.1016/j.virol.2017.04.027

Kondo H, Maeda T & Tamada T (2003) Orchid fleck virus: *Brevipalpus californicus* mite transmission, biological properties and genome structure. *Experimental and Applied Acarology* **30**, 215-223. https://doi.org/10.1023/b:appa.0000006550.88615.10

León MG, Becerra CH, Freitas-Astúa J, Salaroli RB & Kitajima EW (2008) Natural infection of *Swinglea glutinosa* by the Citrus leprosis virus cytoplasmic type (CiLV-C) in Colombia. *Plant Disease* **92**, 1364. https://doi.org/10.1094/PDIS-92-9-1364C

Locali EC, Freitas-Astúa J, de Souza AA, Takita MA, Astúa-Monge G, Antonioli R, Kitajima EW & Machado MA (2003) Development of a molecular tool for the diagnosis of leprosis, a major threat to citrus production in the Americas. *Plant Disease* **87**, 1317-1321. https://doi.org/10.1094/PDIS.2003.87.11.1317

Melzer MJ, Sether DM, Borth WB & Hu JS (2012) Characterization of a virus infecting *Citrus volkameriana* (Ten. & Pasq.) with Citrus leprosis-like symptoms. *Phytopathology* **102**, 122-127. https://doi.org/10.1094/PHYTO-01-11-0013

Melzer MJ, Simbajon N, Carillo J, Borth WB, Freitas-Astúa J, Kitajima EW, Neupane KR & Hu JS (2013) A *Cilevirus* infects ornamental hibiscus in Hawaii. *Archives of Virology* **158**, 2421-2424. https://doi.org/10.1007/s00705-013-1745-0

Moreira RR, Machado FJ, Lanza FE, Trombin VG, Bassanezi RB, de Miranda MP, Barbosa JC, da Silva Junior GJ & Behlau F (2022) Impact of diseases and pests on premature fruit drop in sweet orange orchards in São Paulo state citrus belt, Brazil. *Pest Management Science* **78**, 2643-2656. https://doi.org/10.1002/ps.6894

Navia N, Mendonça RS, Ferragut F, Miranda LC, Trincado RC, Michaux & Navajas M (2013) Cryptic diversity in *Brevipalpus* mites (Tenuipalpidae). *Zoologica Scripta* **42**, 406-426. https://doi.org/10.1111/zsc.12013

Nunes MA, de Carvalho Mineiro JL, Rogerio LA, Ferreira LM, Tassi A, Novelli VM & Freitas-Astúa J (2018) First report of *Brevipalpus papayensis* as vector of Coffee ringspot virus and Citrus leprosis virus C. *Plant Disease* **102**, 1046-1046. https://doi.org/10.1094/PDIS-07-17-1000-PDN

Nunes MA, Oliveira CAL de, Oliveira ML, Kitajima EW, Hilf ME, Gottwald RT & Freitas-Astúa J (2012) Transmission of Citrus leprosis virus C by *Brevipalpus phoenicis* (Geijskes) to alternative host plants found in citrus orchards. *Plant Disease* **96**, 968-972. https://doi.org/10.1094/PDIS-06-11-0538

Olmedo Velarde A, Larrea-Sarmiento A, Wang X, Hu JS & Melzer MJ (2023) A breakthrough in kitavirids: genetic variability, reverse-genetics, Koch's postulates and transmission of hibiscus green spot virus 2. Phytopathology (early view). https://doi.org/10.1094/PHYTO-04-23-0110-R

Olmedo Velarde A, Roy A, Larrea-Sarmiento A, Wang X, Padmanabhan C, Nunziata S, Nakhla MK, Hu J & Melzer M (2022) First report of the hibiscus strain of citrus leprosis virus C2 infecting passionfruit (*Passiflora edulis*). *Plant Disease* **106**, 2539. https://doi.org/10.1094/PDIS-10-21-2314-PDN

Olmedo-Velarde A, Roy A, Padmanabhan C, Nunziata S, Nakhla MK & Melzer M (2021) First report of orchid fleck virus associated with citrus leprosis symptoms in rough lemon (*Citrus jambhiri*) and mandarin (*C. reticulata*) the United States. *Plant Disease* **105**, 2258. https://doi.org/10.1094/PDIS-12-20-2736-PDN

Olmos A, Boonham N, Candresse T, Gentit P, Giovani B, Kutnjak D, Liefting L, Maree HJ, Minafra A, Moreira A, Nakhla MK, Petter F, Ravnikar M, Rodoni B, Roenhorst JW, Rott M, Ruiz-García AB, Santala J, Stancanelli G, Van Der Vlugt R, Varveri C, Westenberg M, Wetzel T, Ziebell H & Massart S (2018) High?throughput sequencing technologies for plant pest diagnosis: challenges and opportunities. *EPPO Bulletin* **48**, 219-224. https://doi.org/10.1111/epp.12472

Padmanabhan C, Nunziata S, Leon M G, Rivera Y, Mavrodieva VA, Nakhla MK & Roy A (2023) High-throughput sequencing application in the detection and discovery of viruses associated with the regulated citrus leprosis disease complex. *Frontiers in Plant Science* **13**, 1058847. https://doi.org/10.3389/fpls.2022.1058847

Ramos-González PL, Chabi-Jesus C, Guerra-Peraza O, Breton MC, Arena GD, Nunes MA, Kitajima EW, Machado MA & Freitas-Astúa J (2016) Phylogenetic and molecular variability studies reveal a new genetic clade of Citrus leprosis virus C. *Viruses* **8**, 153. https://doi.org/10.3390/v8060153

Ramos-González PL, Chabi-Jesus C, Guerra-Peraza O, Tassi AD, Kitajima EW, Harakava R, Salaroli RB & Freitas-Astúa J (2017) Citrus leprosis N: a new *Dichorhavirus* causing Citrus leprosis disease. *Phytopathology* **107**, 963-976. https://doi.org/10.1094/PHYTO-02-17-0042-R

Rodrigues JCV & Childers CC (2013) *Brevipalpus* mites (Acari: Tenuipalpidae): Vectors of invasive, non-systemic cytoplasmic and nuclear viruses in plants. *Experimental and Applied Acarology* **59**, 165-175. https://doi.org/10.1007/s10493-012-9632-z

Rodrigues JCV, Kitajima EW, Childers CC & Chagas CM (2003) Citrus leprosis virus vectored by *Brevipalpus phoenicis* (Acari: Tenuipalpidae) on citrus in Brazil. *Experimental and Applied Acarology* **30**, 161-179. https://doi.org/10.1023/b:appa.0000006547.76802.6e

Rossetti V, Lasca C & Negretti S (1969) New developments regarding leprosis and zonate chlorosis in citrus. In: Proceedings of the International Citrus Symposium Vol. 3 (Ed. by Chapman, H.D.), pp. 1453-1456. University of California Press, Riverside, Etats-Unis.

Roy A, Choudhary N, Guillermo LM, Shao J, Govindarajulu A, Achor D, Wei G, Picton DD, Levy L, Nakhla MK, Hartung JS & Brlansky RH (2013a) A novel virus of the genus *Cilevirus* causing symptoms similar to Citrus leprosis. *Phytopathology* **103**, 488-500. https://doi.org/10.1094/PHYTO-07-12-0177-R

Roy A, Hartung JS, Schneider WL, Shao J, Leon G, Melzer MJ, Beard JJ, Otero-Colina G, Bauchan GR, Ochoa R & Brlansky R (2015a) Role bending: complex relationships between viruses, hosts and vectors related to Citrus leprosis, an emerging disease. *Phytopathology* **105**, 1013-1025. https://doi.org/10.1094/PHYTO-12-14-0375-FI

Roy A, Leon MG, Stone AL, Schneider WL, Hartung J & Brlansky RH (2014) First report of Citrus leprosis virus nuclear type in sweet orange in Colombia. *Plant Disease* **98**, 1162. https://doi.org/10.1094/PDIS-02-14-0117-PDN

Roy A, Stone A, Otero-Colina G, Wei G, Choudhary N, Achor D, Shao J, Levy L, Nakhla MK, Hollingsworth CR, Hartung JS, Schneider WL & Brlansky RH (2013b) Genome assembly of citrus leprosis virus nuclear type reveals a close association with orchid fleck virus. *Genome Announcements* **1**, e00519-13. https://doi.org/10.1128/genomeA.00519-13

Roy A, Stone AL, Leon Martinez G, Otero-Colina G, Melzer MJ, Hartung JS, Wei G, Mavrodieva VA, Brlansky RH, Schneider W & Nakhla MK (2017) Development of two multiplex RT-PCRs for simultaneous detection of five cytoplasmic and three nuclear viruses associated with citrus leprosis complex. *Phytopathology* **107**, S5.53. https://apsjournals.apsnet.org/doi/epdf/10.1094/PHYTO-107-12-S5.1

Roy A, Stone AL, Melzer MJ, Hartung JS, Mavrodieva VA, Nakhla MK, Schneider WL & Brlansky RH (2018) First report of a Cilevirus associated with green ringspot on senescent Hibiscus leaves in Tampa, Florida. *Plant Disease* **102**, 1181. https://doi.org/10.1094/PDIS-11-17-1699-PDN

Roy A, Stone AL, Otero-Colina G, Wei G, Brlansky RH, Ochoa R & Hartung JS (2020) Reassortment of genome segments creates stable lineages among strains of orchid fleck virus infecting citrus in Mexico. *Phytopathology* **110**, 106-120. https://doi.org/10.1094/PHYTO-07-19-0253-FI

Roy A, Stone AL, Shao J, Otero-Colina G, Wei G, Achor D, Choudhary N, Levy L, Nakhla MK, Hartung JS, Schneider WL & Brlansky RL (2015b) Identification and characterization of nuclear Citrus leprosis virus, an unassigned *Dichorhavirus* genus associated with Citrus leprosis disease in Mexico. *Phytopathology* **105**, 564-575. https://doi.org/10.1094/PHYTO-09-14-0245-R

Tassi AD, Garita-Salazar LC, Amorim L, Novelli VM, Freitas-Astúa J, Childers CC & Kitajima EW (2017) Virus-vector relationship in the Citrus leprosis pathosystem. *Experimental and Applied Acarology* **71**, 227-241. https://doi.org/10.1007/s10493-017-0123-0

Tassi AD, Ramos-González PL, Sinico TE, Kitajima EW & Freitas-Astúa J (2022) Circulative transmission of cileviruses in *Brevipalpus* mites may involve the paracellular movement of virions. *Frontiers in Microbiology* **13**, 836743. https://doi.org/10.3389/fmicb.2022.836743

Walker PJ, Siddell SG, Lefkowitz EJ *et al.* (2022) Recent changes to virus taxonomy ratified by the International Committee on Taxonomy of Viruses. *Archives of Virology* **167**, 2429–2440. https://doi.org/10.1007/s00705-022-05516-5

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Lázaro E, Vanaclocha P, Vicent A, Vives MC & Delbianco A (2023) Pest survey card on Citrus leprosis viruses. *EFSA Supporting Publication* EN-7804. https://doi.org/10.2903/sp.efsa.2023.EN-7804

CABI Datasheet on Citrus leprosis virus C (leprosis of citrus). *CABI Compendium*. https://doi.org/10.1079/cabicompendium.13449

CABI Datasheet on Citrus leprosis N Dichorhavirus. *CABI Compendium*. https://doi.org/10.1079/cabicompendium.88562658

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