REVISÃO

The citrus leprosis pathosystem

Marinês Bastianel[1], Juliana Freitas-Astúa[1,2], Elliot Watanabe Kitajima[3] & Marcos Antonio Machado[1]

[1]Centro APTA Citros Sylvio Moreira/ IAC. Rod. Anhanguera, km 158, CP 04, 13490-970, Cordeirópolis, SP.
[2]Embrapa Milho e Sorgo, Rod. MG424, km 65, CP 151, 35701-970, Sete Lagoas, MG.
[3]ESALQ/USP, Depto. Entomol., Fitopatol. e Zool. Agríc., CP 09, 13418-900, Piracicaba, SP.

1211

ABSTRACT

Bastianel M.; Freitas-Astúa J.; Kitajima E.W.; Machado M. A. The citrus leprosis pathosystem. ***Summa Phytopathologica****,* v.32, n.3, p.211-220, 2006.

Citrus leprosis is considered the main viral disease for the Brazilian citrus production, particularly for the State of São Paulo, due to the high costs spent for the chemical control of its vector, the tenuipalpid mite *Brevipalpus phoenicis*. In addition, its global importance has significantly increased in the last years, with the dissemination of the virus to new countries in South and Central America. In Brazil, despite its economical importance and occurrence for more than seven decades, the most significant advances towards understanding the pathosystem interactions have been obtained only in the last ten years. This review focuses on various aspects of the disease, beginning with a historical view, its main characteristics, alternatives for its control, its increasing economical importance in Brazil and abroad, and the new data on the search for understanding the interactions amongst the mite vector, the virus, and the plant host.

Additional Keywords: leprosis, citrus, CiLV-C, CiLV-N, *Brevipalpus* spp.

RESUMO

Bastianel M.; Freitas-Astúa J.; Kitajima E.W.; Machado M. A. O patossistema leprose dos citros. ***Summa Phytopathologica****,* v.32, n.3, p.211-220, 2006.

A leprose dos citros é considerada a principal virose na citricultura brasileira, com maior destaque no Estado de São Paulo, principalmente pelos altos custos demandados para o controle químico do vetor, o ácaro *Brevipalpus phoenicis*. Além da relevância dessa virose para a citricultura local, sua importância mundial vem sendo ampliada consideravelmente nos últimos anos, principalmente com a disseminação do vírus em novos países da América do Sul e Central. No Brasil, apesar da sua importância econômica e ocorrência por mais de sete décadas, os mais importantes avanços no entendimento das interações do patossistema leprose têm sido obtidos apenas nos últimos dez anos. Essa revisão aborda os diferentes aspectos dessa doença, trazendo um breve histórico da doença, principais características da leprose, alternativas de controle, sua crescente importância econômica na cadeia citrícola nacional, os mais recentes relatos de sua ocorrência em outros países e os novos resultados obtidos pela pesquisa buscando um melhor entendimento das interações entre ácaro, vírus e hospedeiro vegetal.

Palavras-chave adicionais: leprose, citros, CiLV-C, CiLV-N, *Brevipalpus* spp.

HISTORY

Citrus leprosis, initially named scaly bark, because of the symptoms it induces in stems, was first described in Florida (USA) in 1901 (27). However, despite this report, the disease has not been found in USA for decades and the disappearance might be related to the recurrence of freezes and use of sulfur (21). In South America, leprosis was first identified in Paraguay by Spegazzini (85), who named it "lepra explosiva". In a short period of time, the disease was also observed in Argentina and, in 1931, it was reported in Sorocaba, SP, Brazil, in ´Bahia´ sweet orange (*Citrus sinensis* L. Osbeck) leaves (6, 7).

Since there was no description of the leprosis symptoms in citrus leaves, which was rare in Florida and common in Brazil, it was not possible to immediately associate the symptoms observed in the country with those previously reported, and hence, the disease was named "varíola". Only two years after that, it was concluded that those leaf symptoms corresponded to the same disease that occurred in Florida, known as leprosis (7). Old reports mention the presence of leprosis in the Asian and African continents (7, 29), but there are no recent confirmations (60).

Currently, the disease is restricted to the South and Central Americas (76). It was recently confirmed in Costa Rica (2), Panama (25), Guatemala (58), Bolivia (41), and Colombia (52). The recent confirmation of the presence of the virus in Central American countries has been a reason for concern for the United States citrus industry (20).

Even though leprosis is particularly important in the State of São Paulo, where it is widely present wherever citrus are grown (83), the disease has been observed in other Brazilian States, such as Acre, Bahia, Minas Gerais, Paraná, Rio de Janeiro, Rio Grande do Sul, Santa Catarina, Tocantins, and Distrito Federal (7, 10, 24, 33, 34, 54). Apparently it does not occur in some important citrus production areas of the country, such as the State of Sergipe.

ECONOMICAL IMPORTANCE

The mite *Brevipalpus phoenicis* Geijskes occurs wherever citrus is cultivated, but only where the virus is present it is considered a key pest for the crop and is constantly controlled with chemicals (73, 77, 84).

According to Rodrigues & Machado (77), acaricides in Brazilian citrus orchards are used mainly to control the leprosis mite and the rust mite, *Phyllocoptruta oleivora* Ashmead. Of the US$ 90 million plus spent annually in acaricides in Brazil, around US$ 75 million have been used for the control of the leprosis vector.

Approximately 80% of the citrus planted in São Paulo State are sweet orange varieties, highly susceptible to the virus. According to Salva & Massari (83), in 1995 more than 60% of the State citrus orchards had plants with leprosis symptoms, which explains why the chemical control of the vector is widely applied.

However, the large-scale utilization of chemicals, besides problems of inducing the appearance of resistant populations of mites, generates ecological and economic concerns. Because of that, there is an increase search for alternatives to control leprosis; among them, the commercial use of different types of biological control agents that will be later discussed and the use of varietal resistance observed in some citrus genotypes or obtained through genetic breeding.

CAUSAL AGENT: CITRUS LEPROSIS VIRUS (CiLV)

The etiology of citrus leprosis was controversial for several decades. In early works on the "scaly bark", disease fungal etiology (*Hormodendron* sp.; *Cladosporium herbarium* var. *citri*) was considered (27, 28), a view shared by Spegazzini (85). Later, the disease was associated with the presence of tenuipalpid mites (38, 61, 87) and it was suggested that the symptoms were a response to the injection of toxins present in the mite salivary glands or to a pathogen, possibly a virus transmitted by the mite (38, 49, 87).

During the decades of 1930 and 1940, Bitancourt pointed out similarities between leprosis and other citrus viral diseases, such as psorosis, South African concentric ring-blotch, and zonate chlorosis, and suggested that leprosis could also be caused by a virus (7). However, only after the observation of virions in symptomatic tissue by transmission electron microscopy (TEM) (46) and the expansion of leprosis lesion of stem bark to healthy tissue of recipient citrus stem through patch grafting (12, 49) and the transmission of leprosis to alternative hosts through mechanical inoculation (22), the viral etiology of the disease was confirmed.

Kitajima et al. (46) were the first to describe leprosis virions in citrus leaves. The particles resembled those of rhabdoviruses, but shorter, occurring in the nucleus or cytoplasm, and were associated with the presence of a viroplasm in the nucleus of the cells (Fig. 1). The cytopathic effects were similar to those observed in plants infected with orchid fleck virus (OFV) (26). After that initial report, however, TEM analyses of samples symptomatic for leprosis revealed the presence of short, bacilliform particles in the endoplasmic reticulum and dense viroplasm in the cytoplasm (Fig. 2), rather than in the nucleus, of infected cells (22, 48). This virus, referred to as the cytoplasmic

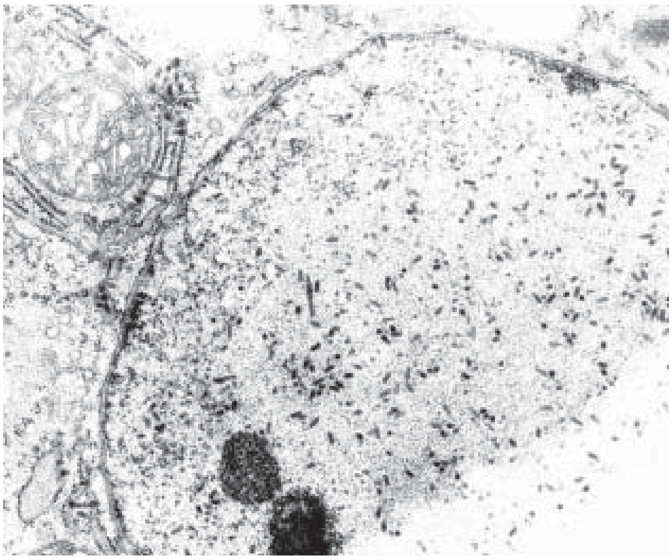

Fig. 1. Transmission electron micrograph of CiLV-N-infected cells exhibiting intranuclear viroplasm and virions. Virions are also present in the cytoplasm associated with the endoplasmic reticulum.

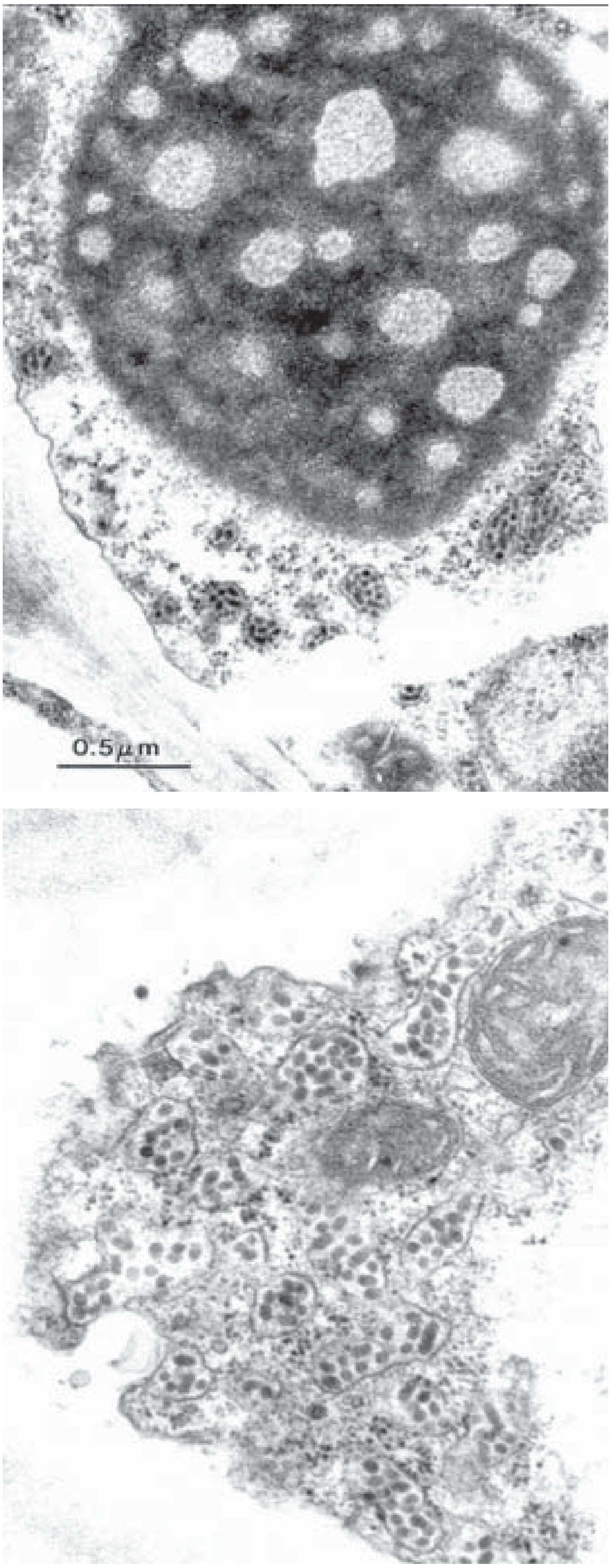

Fig. 2. Transmission electron micrographs of CiLV-C-infected cells exhibiting A) cytoplasmic viroplasm and B) virions in the lumen of the endoplasmic reticulum.

type (CiLV-C), has shown to be prevalent in citrus orchards, while the nuclear type (CiLV-N), described in 1972, is of rare occurrence (76). In the last years, CiLV-N was found only in one region of Panama (25), and in few places of São Paulo and Rio Grande do Sul States, in Brazil (34, 45).

CiLV-C has been successfully transmitted mechanically, though with some difficulty, from sweet orange to sweet orange and to some herbaceous host (22). Recently evidences showed that some weeds and plants used as living fence around orchards may host not only the vector, but CiLV-C (56, 64). Concerning CiLV-N, it was transmitted from sweet orange to sweet orange by *B. phoenicis*, but so far mechanical transmission attempts have been unsuccessful (45).

Because of its morphology, and its presence either in the cytoplasm or in the nucleus of infected cells, CiLV has been considered a tentative member of the *Rhabdoviridae* family. However, in 2003, the first CiLV-C genomic sequences obtained suggested that it has a ssRNA positive sense, bipartite genome (instead of negative sense, monopartite genome, as typical rhabdoviruses). In addition, the putative replicase and movement protein gene sequences showed similarity with those of rigid rod viruses, such as furoviruses, tobamoviruses, hordeiviruses etc. rather than with rhabdoviruses (54). Recently, that data was confirmed by the sequencing of the complete genome of CiLV-C by two groups (55, 69). In fact, a new genus (cilevirus) has been suggested for this virus (55).

The molecular characterization of CiLV-C was possible through the extraction of dsRNA molecules from citrus leaves symptomatic for leprosis. Colariccio et al. (23) and Rodrigues (72) were the first to show the presence of dsRNA molecules in leprotic tissue, while Locali et al. (54) demonstrated the viral nature of such molecules, and used them to build CiLV-C cDNA libraries. With the partial sequencing of the CiLV-C genome, two pairs of primers that specifically amplify regions within the putative replicase (Rep) and movement protein (MP) genes of the virus were designed and have been used for the detection of CiLV-C by RT-PCR (54).

For years, the only methods used for the diagnosis of the disease were symptom analyses (leprosis is quite easily recognized by the typical local lesions in leaves, stems, and fruits), mite and mechanical transmission or TEM analyses of infected tissue (22, 46, 76). However, all of these methods present one or more of the following disadvantages: unspecificity, unreliability, high cost, and long time needed for the results to be available (53). Recently, Locali et al. (54) developed the first specific, molecular-based method for the diagnosis of the disease through RT-PCR, which allows fast and efficient detection of the virus in all citrus aerial tissues. This technique has been particularly important for the detection of CiLV-C from samples originated from areas in Brazil and abroad where the disease is rare or of new occurrence and hence, the symptoms are not promptly identified by the growers (33, 35, 41). The molecular test has been used to confirm the presence of the virus in the vector (35, 36) and to study genetic resistance and tolerance of citrus genotypes, since it is possible to detect the virus in asymptomatic plants (4).

Primers that efficiently amplify regions of CiLV-C (53) failed to do so in extracts from lesions of CiLV-N, thus providing more evidence that they are different entities (36). As a working hypothesis, CiLV-N may probably be included in the group of orchid fleck virus (OFV), whose genome has been sequenced (50) and is different from that of CiLV-C (55; 67).

Distribution of CiLV-C is overwhelmingly larger than that of CiLV-N. So far nuclear type has been found in places with colder climate. In spite of being spread by the same vector, cytoplasmic type might be more adapted and overcome the nuclear one, which found a safe heaven in places where CiLV-C has difficulties to prosper.

THE MITE VECTOR: *Brevipalpus phoenicis* Geijskes, 1939 (Acari: Tenuipalpidae)

False spider mites or flat mites, belonging to the genus *Brevipalpus* (*B. phoenicis, B. californicus* Banks, and *B. obovatus* Donnadieu) are considered the most economically important within the Tenuipalpidae family (20). However, even though they can cause injuries to citrus leaves and fruits, as well as other plants due to the action of toxins present in their saliva (19), their importance is heavily associated to their ability to transmit plant viruses (14, 37, 44, 47, 50). The three species within this genus reported as CiLV vectors are polyphagous and cosmopolitan, even though, in most countries, they are not known to vector any pathogen (20).

Maia & Oliveira (56) identified host plants that are potential reservoirs for *B. phoenicis* (Fig. 3) populations in citrus fields in Brazil. They include windbreakers such as *Mimosa caesalpiniaefolia* Benth and *Malvaviscus arboreus* Cavanillas and weeds such as *Bidens pilosa* L. In a recent review, Childers et al. (20) reported 928 species, belonging to 513 genera and 139 families, of host plants to one or more species of *Brevipalpus*. *B. phoenicis* was found colonizing 486 plant species from 118 genera and 64 families.

Brazil, *B. phoenicis* has been associated with leprosis since the beginning of the 1960s (61), while *B. californicus* and *B. obovatus* were considered the vector of the pathogen in the United States and Argentina, respectively (49, 87). Recently, Rodrigues et al. (79) reported that at least one population of *B. obovatus* did not transmit a Brazilian isolate of CiLV, but other populations of the mite should be tested in order to confirm such results.

Brevipalpus sp. is also associated with the persistent transmission of other economically important rhabdo-like viruses that induce local symptoms that resemble those of leprosis. The specie *B. phoenicis* is known as a vector of the coffee ringspot virus (CoRSV) (14) and the passionfruit green spot virus (PFGSV) (47), besides other less important diseases of ornamental plants (44, 75). *B. californicus* has been reported as the vector of orchid fleck virus (OFV) in Japan and Brazil (31, 50), and *B. obovatus* was recently reported in Brazil transmitting cestrum ringspot virus (CesRSV) (37), *Solanum violaefolium* ringspot (SvRSV) and chlorotic spot (SvCSV) viruses (30).

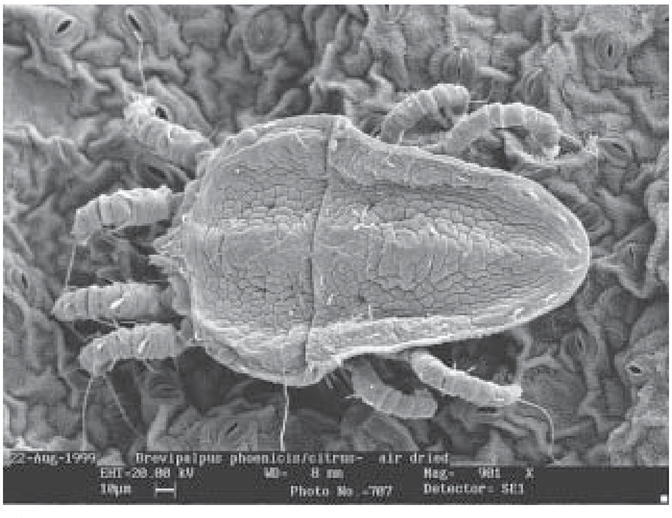

Fig. 3. Scanning electron micrograph of *Brevipalpus phoenicis*.

The biology of *B. phoenicis* was widely studied by Chiavegato (15, 16). This mite presents the egg, larvae, protonymph, deutonymph, and adult stages during its biological cycle (51). In between each developmental stage, there is a latent, but physiologically active, phase. Each phase is extremely variable and relates to environmental conditions, mainly temperature and humidity, and to the host species and variety (18, 86).

When reared under optimal environmental conditions (25°C and 65 to 70% relative humidity), the complete mite life cycle lasts around 25 days. Each female lays one to four eggs a day for approximately 20 days, yielding several generations per year (42). When *Brevipalpus* mites colonize fruits, particularly those infected by scab lesions, their development is better than when reared on leaves (17). Hence, the longer the mites remain on the fruits, the better the conditions for their population to increase. Because of that, one important aspect of the management of the disease in the field is the recommendation of anticipated harvest (65).

According to Chiavegato (16), all active phases of the mites, with exception to the eggs, are equally able to transmit citrus leprosis. The author suggests that differences in transmission efficiency observed in different phases of the development occur due to differences in opportunities to acquire the virus. However, these results differ from those obtained by Chagas et al. (13), who suggested that the larvae are more efficient to transmit the virus than the adults.

It is accepted, however, that there is no transovarial transmission of CiLV from the adult female to its descendents (9). Hence, each newly hatched larvae needs to feed on infected plant tissues in order to acquire the virus to further transmit it. This increases the importance of the source of inoculum in orchards for disease dissemination (72). On the other hand, since the virus is circulative/propagative (it multiplies in the vector), once infected, the mite remains viruliferous – and able to transmit the virus - for its whole life (9).

Brevipalpus mites are haploid organisms and have two non-homologous chromosomes (70). They reproduce through theletokous parthenogenesis (females originate females without fertilization), which yield clonal populations in the field (43, 88). It was recently demonstrated that the presence of an endosymbiont bacterium blocks the formation of the androgenic gland of the mite, blocking the production of androgen hormone during the first stages of the development of the individual (88). As a consequence, very low number of males, commonly less than 1%, is found in the population (19, 43). The presence of this endosymbiont was confirmed by polymerase-chain reaction (PCR) in eggs and adults of *B. phoenicis* and *B. obovatus* mite populations from various regions of Brazil, suggesting its horizontal and vertical transmission within the genus (62, 63).

Even though asexual reproduction yields low variability within a particular population of *B. phoenicis*, genetic diversity has been observed amongst populations from citrus and other hosts, and amongst populations from the same host, but from different geographical regions (1, 74).

MITE POPULATION DYNAMICS

Recent studies suggest that *B. phoenicis* do not efficiently move in citrus orchards, probably due to their flat anatomy and their typical behavior to hide in cracks and other protected areas on the plant surface, such as scab lesions (1, 15). However, even though the flat mite dispersal is low within an orchard, the number of mites that eventually disperse can be enough to form new and significant foci of infestation in a long period of time (1).

The vector is present in all aerial organs of the plant. However, there are differences in the population dynamics of mites in stems, leaves, and fruits (64, 72). Leaves are considered the main reservoir of mites, probably due to their persistence in the plant and their large surface areas (72) even though higher number of mites is found in fruits (65).

During the rainy season, when relative humidity is higher (October to March in the Southeast Brazil), the number of mites tends to drop. From April to September (dry season), the mite population reaches its peak (66). Besides the environmental conditions, the presence of predators and pathogens of the vector and the management of the orchard (use of fertilizers and chemicals such as pesticides etc.) can also affect the mite population fluctuation on the flat mite in citrus orchards (1, 66).

Studies on the spatial patterns of the *B. phoenicis* and citrus attacked by leprosis in the citrus orchards revealed that there are aggregations of infected plants but this pattern does not overlap with the aggregation of mite infested plants (3). This observation has implications in the chemical control procedures. Presently acaricide spraying to prevent leprosis is made according to thresholds in mite population, which would be justifiable only if the presence of the disease is confirmed.

SYMPTOMS

Viruses transmitted by *Brevipalpus* mites induce the appearance of chlorotic or necrotic local lesions on their plant hosts at the mites feeding area (22, 45, 76). Kitajima et al. (46) reported the occurrence of virus-like particles in leaf tissues symptomatic for leprosis, but did not find such particles in surrounding, asymptomatic areas. This indicates that the virus does not spread systemically in the host, which was corroborated by Freitas-Astua et al. (*unpublished data*) using RT-PCR. Hence, plant disease dispersion occurs through viruliferous mites' movement within the orchard, and is a consequence of its feeding habit (76).

Bitancourt, in a pioneer study on leprosis in Brazil, describes in details the symptoms associated with the disease in various citrus varieties (7). These descriptions have been used to date for the identification of the disease even in different varieties and locations. Recent surveys conducted by our group, focusing on symptom variability of citrus genotypes infected with leprosis, have corroborated Bitancourt's initial descriptions.

Leprosis can cause symptoms in citrus leaves, stems, and fruits and, even though they may vary according to the host species, the stage of the development of the plant, and the pathogen isolates (81), the symptoms exhibit a common pattern (Fig. 4). In leaves, lesions are often shallow, visible on both sides, but extremely variable, even within sweet oranges (*Citrus sinensis* Osbeck), but mainly amongst citrus species and varieties. Typical lesions are chlorotic or necrotic, varying in color from light yellow to dark brown, and are often circular with diameter ranging from 5 to 12 mm. Sometimes, it is possible to observe a darker central point in older lesions and ringspots may also occur. Particularly when manifested under high temperature, the center of the necrotic leaf tissue may tear apart. Leaves can fall in large numbers.

In young stems, symptoms often appear as small, chlorotic, shallow lesions that become darker brown or reddish and salient. Older lesions may coalesce and appear very large in old stems. The older the lesions, the corkier and more salient they normally are. In such case, lesions can be confused with those caused by citrus canker and psorosis (7, 81).

It is quite frequent to observe up to 30 lesions per fruit, covering significant portion of the peel. These lesions are often dark and depressed, although they only affect the external part of the fruit and not the albedo (81). These symptoms, associated with intense fruit drop that is often observed, can lead to significant commercial losses. Although less common, in some cases lesions can be light yellow to light green, with flat appearance. Symptomatic fruits tend to change color earlier, wilt, and become more susceptible to various rots than healthy oranges (7, 81).

A critical comparison of symptoms caused by CiLV-C and CiLV-N has shown that the lesions caused by the nuclear type (Fig. 5) are usually smaller when mature than those caused by the cytoplasmic type, with a small necrotic center and a more chlorotic halo, without forming ring-like pattern as is commonly observed in the cytoplasmic type (45).

Light microscopy revealed that pronounced hyperplasia and hypertrophy occur in palisade and spongy parenchyma in the lesions caused by CiLV-C in the leaves, stem and fruits, interspersed by a group of necrotic cells where gum accumulation may occur. Hyperplasia, in the form of periclinal divisions of the palisade parenchyma, produces masses of cells that causes enlargement of the leaf thickness (57). Similar changes also are present in the lesions caused by CiLV-N but to a lesser degree (40). A preliminary study of the distribution of cytopathic effects in the leaf lesions caused by CiLV-C showed that while in young lesions, hyperplasia and hypertrophy were absent and most of the cells contained viroplasm and/or viral particles, in mature lesions hyperplasia and hypertrophy were widely present but cells containing viroplasm and/or virions represented less than 1% of the total examined (39). The efficiency in extracting viral material for molecular purposes from young rather than mature lesions agrees with this observation. Usually vascular tissues did not contain viroplasm and/or virions, but occasionally they were infected, including phloem parenchymal cells. Thus it is not impossible that infective material may reach the phloem vessels. If this occurs, a possible explanation to the fact that the virus does not become systemic is that this infectious material either are degraded in the vessel or cannot get out from the vessel to the companion cell.

Fig. 4. Typical local lesion symptoms of leprosis (cytoplasmic type) in (A) leaves and fruits of sweet orange (*Citrus ssp*) (B).

Fig. 5. Typical local lesion symptoms caused by CiLV-N in leaves (A) and fruits of sweet orange (*C. sinensis*) (B).

GENETIC RESISTANCE

Plants belonging to the genus *Citrus* are the only known natural hosts of CiLV (76), although mechanical transmission is possible to be performed under laboratory conditions, to *Chenopodium amaranticolor* Coste & Reyn., *C. quinoa* Willd. and *Glomphrena globosa* L. (22). Within citrus, sweet oranges are considered the most susceptible to the virus, with 'Pêra' variety, one of the most planted in São Paulo State, being widely affected by the disease (7, 78). Even though there are differences in susceptibility amongst sweet oranges (72, 78, 80), none of the commercial varieties are resistant to leprosis.

Lemons [*Citrus limon* (L.) Osbeck], limes [*C. aurantifolia* (Christmann) Swingle], mandarins (*C. reticulata* Blanco), grapefruit [*C. paradisi* (McFad.) Hooker] and some tangors (hybrids between sweet oranges and mandarins) exhibit variable levels of resistance to the virus (5, 7, 18). Lemons and limes are considered immunes to leprosis, while some mandarin varieties often exhibit symptoms of the disease (24, 54, 84). It has been reported that the main tangor variety produced in Brazil, 'Murcott´, can host CiLV even when asymptomatic (4, 8).

Differential behavior towards leprosis amongst citrus varieties, even among the susceptible ones, has been reported by several authors (72, 78, 80, 86) and may be a reaction either to the virus or the vector (8).

Few studies have been carried out to date with the objective to assess citrus resistance to CiLV. Among those, the large majority reports the behavior of different varieties in the field under natural conditions of infestation, and only few of them compare levels of severity. Assessment of phenotypic segregation of the disease in a F_1 population obtained from crosses between ´Pêra´ sweet orange and ´Murcott' tangor, susceptible and resistant to the pathogen, respectively, is being carried out at the Centro APTA Citros SM/IAC, and the preliminary data suggests that few genes are involved in leprosis resistance (5).

The molecular advances with the recent decoding of the CiLV-C genome will soon result in transgenic plants expressing viral genes, some of them resistant to the virus. We can speculate that the use of these transgenic CiLV-C resistant plants may result in the suspension of the intensive spraying to control the vector, a significant reduction in production cost. But this may permit the spread of CiLV-N against which these plants may not be resistant.

CONTROL OF CITRUS LEPROSIS

The presence of *B. phoenicis* and leprosis source of inoculum in citrus orchards in São Paulo State throughout the year (83) demand rigorous control of the mite populations, which is often done by the use of chemicals (84). According to Rodrigues et al. (76), when virus inoculum is present in the field and the vector is not controlled, the whole orchard can be infected in short (two to three years) periods of time, and represent a high risk for the citrus production. Because of that, most of the studies on leprosis focus on the chemical control of the mite vector in the field, as well as its ability to develop resistance to acaricides (1, 67, 68).

Organoestanic acaricides are the main chemical products used for the control of *B. phoenicis* in Brazil (1) and, because of that; several reports of resistance to them have been reported (1, 11, 68). According to Alves (1), low dispersion of susceptible mites from non-treated areas or from alternative hosts can be an important factor for the management of acaricides resistance. On the other hand, with the increase of resistance, there is a tendency of the growers to increase the rate of the product, the number of applications, use mixtures of products (often incorrectly), and replace one acaricide by another with often of higher toxicity and cost (1, 32).

Predaceous mites are considered the most efficient natural enemies of phytophagous mites, particularly those belonging to the Phytoseiidae family, the most frequently found in citrus in Brazil (72). Studies on acaricides that selectively kill phytophagous mites have been done with promising results (71). Other alternative strategies attempted include the use of biofertilizers (58) and entomopathogenic fungi (82). Preservation of entomopathogenic fungi and predaceous mites in citrus orchards has been a concern of the modern citrus producers and aims to reduce the use of acaricides and, consequently, minimize costs and the negative effects on the environment that their use represent (71, 82).

Cultural practices such as pruning, use of windbreaker, control of weeds that may be reservoirs for the vector (and possibly for the virus), and control of entry of people and tools in orchards are recommended to diminish source of inoculum and hence, the incidence and severity of the disease (83, 77). The control of the false spider mite in foci has also been used as a feasible strategy for leprosis control, since it can reduce selection pressure for the constant use of the same chemical product and allow that susceptible individuals from other areas within the same orchard survive and dilute the product resistance frequency. In addition, this is a cheaper, and normally efficient, way to control the vector (1).

REFERENCES

01. Alves, E.B. **Dinâmica da resistência de *Brevipalpus phoenicis* (Geijskes, 1939) (Acari: Tenuipalpidae) ao acaricida dicofol**. 2004. 79f. Tese (Doutorado em Ciências) – Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo, Piracicaba.

02. Araya Gonzáles, J. **Informe sobre la prospección de la "leprosis de los cítricos" en la zona fronteriza sur (Costa Rica – Panamá),** Panamá: Ministerio de Agricultura y Ganadería, 2000, 5p.

03. Bassanezi, R.B.; Laranjeira, F.F. Padrões espaciais da leprose dos citros e do ácaro vetor em pomares do estado de São Paulo. **Fitopatologia Brasileira**, Fortaleza, v.29, p.53-S54, 2004.

04. Bastianel, M. Freitas-Astúa, J.; Rodrigues, V.; Arrivabem, F.; Antonioli-Luizon, R.; Machado, M.A. Resposta do tangor ´Murcott´ à inoculação do vírus da leprose dos citros em campo e em casa de vegetação. **Laranja**, Cordeirópolis, v.27, n.2, p.337-348, 2004.

05. Bastianel, M.; de Oliveira, A.C.; Rodrigues, V.; Cristofani, M.; Freitas-Astúa, J.; Machado, M.A. Avaliação da herança da resistência a leprose dos citros. **Fitopatologia Brasileira,** Fortaleza, v.29, p.87, 2004.

06. Bitancourt, A.A. Relação das doenças e fungos parasitas observados na secção de Fitopatologia durante os anos de 1931 e 1932. **Arquivos do Instituto Biológico**, São Paulo, v.5, p.185-196, 1934.

07. Bitancourt, A.A. Estudos sobre a leprose dos citros. **Arquivos do Instituto Biológico**, São Paulo, v.22, p.161-231, 1955.

08. Boaretto, M.A.C.; Chiavegato, L.G. Transmissão da leprose por ácaros *Brevipalpus phoenicis* (Geijskes, 1939) (Acari: Tenuipalpidae) temporariamente mantidos em hospedeiros intermediários, em condições de laboratório. **Científica,** São Paulo, v.22, n.1, p.81-93, 1994.

09. Boaretto, M.A.C.; Chiavegato L.G.; Silva, C.A.D. Transmissão da leprose através de fêmeas de *Brevipalpus phoenicis* (Geijskes, 1939) (Acari: Tenuipalpidae) e de seus descendentes, em condições de laboratório. **Científica**, São Paulo, v.21, n.2, p.245-253, 1993.

10. Brioso, P.S.T.; Cunha Junior, J.O.; Bonis, M.; Montano, H.G.; Pimentel, J.P.; Faccini, J.L.H. Partial characterization of an isolate of citrus leprosis virus and occurrence of leprosis vector predator, in the State of Rio de Janeiro. In: Conference of the International Organization of Citrus Virologists, XIV., 1998, Campinas, **Annals.** Campinas: IOCV, 1998. p.167.

11. Campos, F.J.; Omoto, C. Resistance to hexythiazox in *Brevipalpus phoenicis* (Geijskes, 1939) (Acari: Tenuipalpidae) from Brazilian citrus. **Experimental and Applied Acarology**, Dordrecht, v.26, p. 243-251, 2002.

12. Chagas, C.M.; Rosseti, V. Transmission of leprosis symptoms by a grafting infected tissue. In: Conference of the International Organization of Citrus Virologists, IX., 1983, Riverside, **Annals.** Riverside: IOCV, 1983. p.70.

13. Chagas, C.M.; Rosseti, V.; Chiavegato, L.G. Influence of the biological cycle of *Brevipalpus phoenicis* Geijskes on leprosis transmission. In: Conference of the International Organization of Citrus Virologists, IX., 1983, Riverside, **Annals.** Riverside: IOCV, 1983. p.69.

14. Chagas, C.M.; Kitajima, E.W.; Rodrigues, J.C.V. Coffee ringspot virus vectored by *Brevipalpus phoenicis* (Acari: Tenuipalpidae) in coffee. **Experimental and Applied Acarology**, Dordrecht, v.30, n.1-3, p.181-203, 2003.

15. Chiavegato, L.G. Biologia do ácaro *Brevipalpus phoenicis* em citros. **Pesquisa Agropecuária Brasileira**, Brasília, v.21, n.8, p.813-816, 1986.

16. Chiavegato, L.G. Aspectos biológicos e transmissão de leprose pelo ácaro *Brevipalpus phoenicis* (Geijskes, 1939) (Acari: Tenuipalpidae) em citros. **Laranja**, Cordeirópolis, v. 17, n.1, p.229-235, 1996.

17. Chiavegato, L.G.; Kharfan, P.R. Comportamento do ácaro da leprose *Brevipalpus phoenicis* (Geijskes.) (Acari: Tenuipalpidae) em citros. **Anais da Sociedade Entomológica do Brasil**, Piracicaba, v.22, n.2, p.355-359, 1993.

18. Chiavegato, LG.; Mischan, M. Comportamento do ácaro *Brevipalpus phoenicis* (Geijskes, 1939) (Acari: Tenuipalpidae) em frutos de diferentes variedades cítricas. **Científica**, São Paulo, v.15 n.1/2, p.17-22, 1987.

19. Childers, C.C.; French, J.V.; Rodrigues, J.C.V. *Brevipalpus californicus*, *B. obovatus*, *B. phoenicis*, and *B. lewisi* (Acari: Tenuipalpidae): a review of their biology, feeding injury and economic importance. **Experimental and Applied Acarology,** Dordrecht, v.30, n.1/3, p.5-28, 2003.

20. Childers, C.C.; Rodrigues, J.C.V.; Welbourn, W.C. Host plants of *Brevipalpus californicus, B. obovatus,* and *B. phoenicis* (Acari: Tenuipalpidae) and their potential involvement in the spread of one or more viral diseases vectored by these mites. **Experimental and Applied Acarology,** Dordrecht, v.30, n.1/3, p.29-105, 2003.

21. Childers, C.C.; Rodrigues, J.C.V.; Derrick, K.S.; Achor, D.S.;

French, J.V.; Welbourn, W.C.; Ochoa, R.; Kitajima, E.W. Citrus leprosis and its status in Florida and Texas: past and present. **Experimental and Applied Acarology,** Dordrecht, v.30, n.1/3, p.181-202, 2003.

22. Colariccio, A.; Lovisolo, O.; Chagas, C.M.; Galetti, S.R.; Rossetti, V.; Kitajima, E.W. Mechanical transmission and ultrastructural aspects of citrus leprosis virus. **Fitopatologia Brasileira**, Brasília, n.20, p.208-213, 1995.
23. Colariccio, A.; Lovisolo, O.; Boccardo, G.; Chagas, C.M.; D'Aquilio, M.; Rossetti, V. Preliminary purification and double stranded RNA analysis of citrus leprosis virus. In: Conference of the International Organization of Citrus Virologists, XIV., 2000, **Annals.** Riverside: IOCV, 2000, p.159-163.
24. Domingues, A.D.; Rodrigues, J.C.V. Ocorrência de leprose dos citros em Paraíso do Tocantins (TO). **Laranja**, Cordeirópolis, v.20, n.1, p.35-50, 1999.
25. Dominguez, F.S.; Bernal, A.; Childers, C.C.; Kitajima, E.W. First report of citrus leprosis on Panama. **Plant Disease,** St. Paul, v.85, p.228, 2001.
26. Doi, Y.; Chang, KM.U.; Yora, K. **Orchid fleck virus**. Kew: C.M.I/ C.A.B./A.A.B., 1977. n.p. (C.M.I./A.A.B. Descriptions of Plant Viruses, 183)**.**
27. Fawcett, H.S. Report of assistant plant pathologist. **Florida Agricultural Experimental Station Annual Report**, Gainesville, p.75-80, 1909.
28. Fawcett, H.S. Scaly bark or nail-head rust of citrus. Bull. 106. **Florida Agricultural Experimental Station Bulletin**, Gainesville, v.106, 1911, 41p.
29. Fawcett, H.S. **Citrus diseases and their control**. 2nd ed. New York, McGraw-Hill. 1936. 656p.
30. Ferreira, P.T.O. **Caracterização de um vírus baciliforme isolado de *Solanum violaefolium* transmitido pelo ácaro *Brevipalpus phoenicis* Geijskes (Acari: Tenuipalpidae).** 2005. 95f. Tese (Doutorado em Ciências) – Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo, Piracicaba.
31. Ferreira, P.T.O.; Freitas-Astúa, J**.;** Rodrigues, J.C.V.; Kitajima, E.W. Dados preliminares de transmissão mecânica e por ácaros de alguns dos vírus transmitidos por *Brevipalpus* (Acari: Tenuipalpidae). **Fitopatologia Brasileira,** Fortaleza, v.28, p.250, 2003.
32. Franco, C.R. **Detecção e caracterização da resistência de *Brevipalpus phoenicis* (Geijskes, 1939) (Acari: Tenuipalpidae) ao acaricida Propargite**. 2002. 138f. Dissertação (Mestrado em Ciências) – Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo, Piracicaba.
33. Freitas-Astúa, J.; Cavalcante, M.J.B.; Locali, E.C.; Antonioli, R.; Laranjeira, F.; Domingues, A.D.; Machado, M.A. RT-PCR detection of citrus leprosis virus in samples from the Northern region of Brazil. **Virus Reviews & Research**, Rio de Janeiro, v.9, supl.1, p.246-247, 2004.
34. Freitas-Astúa, J.; Kitajima, E.W.; Bastianel, M.; Locali, E.C.; Antonioli, R.; Machado, M.A. Identification of citrus leprosis virus-nuclear type (CiLV-N) in sweet orange in the State of Rio Grande do Sul. **Virus Reviews & Research**, Rio de Janeiro, v.9, supl.1, p.247, 2004.
35. Freitas-Astúa, J.; Locali, E.C.; Antonioli, R.; Rodrigues, V.; Kitajima, E. W.; Machado, M.A. Detection of citrus leprosis virus in citrus stems, fruits and the mite vector. **Virus Reviews & Research**, v.8, supl.1, p.196, 2003.
36. Freitas-Astúa, J.; Kitajima, E.W.; Locali, E.C.; Antonioli-Luizoni, R.; Bastianel, M.; Machado, M.A. Further evidence to support that citrus leprosis virus-cytoplasmic and nuclear types are different viruses. In: Annual Meeting of the American Phytopathological Society, Caribbean Division, XLV., 2005, **Annals.** San Jose: APS**,** 2005, p.93.
37. Freitas-Astúa, J.; Rodrigues, V.; Locali, E.C.; Astúa-Monge, G.; Ferreira, P.T.O. Kitajima, E.W.; Machado, M.A. Transmissão do vírus da mancha anular da dama-da-noite por ácaros *Brevipalpus* spp. **Summa Phytopathologica**, Botucatu, v.30, n.1, p.80, 2004.
38. Frezzi, M.J. La lepra explosiva del naranjo. Investigaciones realizadas por el laboratorio de patologia de Bela Vista (Corrientes). **Boletim de Frutas y Hortalizas**, Buenos Aires, n.5, p.1-16, 1940.
39. Gomes, R.T.; Appezzato-da-Glória, B.; Salaroli, R.B.; Kitajima, E.W. Distribution of CiLV-C in the citrus leaf lesions. In: Congresso Brasileiro de Biologia Celular, XII., 2004, **Resumos.** Campinas: CBBC, 2004, p..
40. Gomes, R.T.; Marques, J.P.R.; Appezzato-da-Gloria, B.; Kitajima, E.W. Anatomical comparison of citrus leprosis (cytoplasmic and nuclear types), citrus zonate chlorosis and citrus chlorotic ring blotch lesions. **Virus Reviews & Research**, Rio de Janeiro, v.9, supl.1, p.246, 2004.
41. Gómez, E.M.; Vargas, R.C.; Rivadameira; Locali, E.C.; Freitas-Astúa, J.; Astúa-Monge, G.; Rodrigues, J.C.V.; Mesa Cobo, N.C.; Kitajima, E.W. First report of citrus leprosis virus on citrus in Santa Cruz, Bolivia. **Plant Disease,** St Paul, v.89, n.6, p.686, 2005.
42. Haramoto, P.H. Biology and control of *Brevipalpus phoenicis* (Geijskes) (Acarina: Tenuipalpidae). **Hawaii Agricultural Experimental Station Technical Bulletin,** Mãnoa, n.68, p.1-63, 1969.
43. Helle, W.; Bolland, H.R.; Heitmans, W.R.B. Chromosomes and types of parthenogenesis in the false spider mites (Acari: Tenuipalpidae). **Genetica**, v.54, p.545-550, 1980.
44. Kitajima, E.W.; Chagas, C.M.; Rodrigues, J.C.V. *Brevipalpus*-transmitted plant virus and virus-like diseases: cytopathology and some recent cases. **Experimental and Applied Acarology,** Dordrecht, v.30, n.1-5, p.135-160, 2003.
45. Kitajima, E.W.; Ferreira, P.T.O; Freitas-Astúa, J.; Machado, M.A. Ocorrência da leprose dos citros, tipo nuclear (CiLV-N) nos municípios paulistas de Monte Alegre do Sul e Amparo. **Summa Phytopathologica**, Botucatu, v.30, p.68, 2004.
46. Kitajima, E.W.; Müller, G.W.; Costa, A.S.; Yuki, W. Short, rod-like particles associated with citrus leprosis. **Virology,** New York, v.50, p.254-258, 1972.
47. Kitajima, E.W.; Rezende, J.A.M.; Rodrigues, J.C.V. Passion fruit green spot virus vectored by *Brevipalpus phoenicis* (Acari: Tenuipalpidae) in passion fruit in Brazil. **Experimental and Applied Acarology,** Dordrecht, v.30, n.1-3, p.225-231, 2003.
48. Kitajima, E.W.; Rosillo, M.A.; Portillo, M.M.; Muller, G.W.; Costa, A.S. Microscopia eletrônica de tecidos foliares de laranjeiras infectadas pela lepra explosiva da Argentina. **Fitopatologia**, Lima, v.9, p.55-56, 1974.
49. Knorr, L.C. Studies on the etiology of leprosis in citrus. In: Conference of the International Organization of Citrus Virologists, IV., 1968, **Annals.** Gainesville: IOCV**,** 1968, p.332-341.
50. Kondo, H.; Maeda, T.; Tamada, T. Orchid fleck virus: *Brevipalpus californicus* mite transmission, biological properties and genome structure. **Experimental and Applied Acarology,** Dordrecht, v.30, n.1-3, p.215-223, 2003.

51. Lal, L. biology of *Brevipalpus phoenicis* (Geijskes) (Tenuipalpidae: Acarina). **Acarologia**, Paris, v.20, n.1, p.97-101, 1978.
52.Leon, G.A.; Realpe, C.E.; Garzon, P A; Rodriguez, J. A; Moreno, M. G.; Childers, C.C.; Achor, D.; Freitas-Astúa, J.; Antonioli-Luizon, R.; Salaroli, S.B.; Cobo, N.C.M.; Kitajima, E.W. Occurrence of citrus leprosis virus in Llanos Orientales, Colombia. **Plant Disease**, St Paul, v. 90, n.5, p.682-682, 2006.
53. Locali, E.C.; Freitas-Astúa, J.; Machado, M.A. Leprose dos citros: Biologia e diagnóstico. **Laranja**, Cordeirópolis, v.25, n.1, p.53-68, 2004.
54. Locali, E.C.; Freitas-Astúa, J.; Souza, A.A.; Takita, M.A.; Astúa-Monge, G.; Antonioli, R.; Kitajima, E.W.; Machado, M.A. Development of a molecular tool for the diagnosis of leprosis, a major threat to Citrus production in the Americas. **Plant Disease**, St Paul, v.87, n.10, p.1317-1321, 2003.
55. Locali, E.C.; Freitas-Astua, J.; Souza, A.A.; Takita, M.A.; Astua-Monge, G.; Antonioli-Luizon, R.; Rodrigues, V.; Targon, M.L.N.P.; Machado, M.A. Complete nucleotide sequence, genomic organization and phylogenetic analysis of Citrus leprosis virus cytoplasmic type (CiLV-C). **Journal of General Virology** (*in press*).
56. Maia, O.M.A.; Oliveira, C.A.L. Capacidade de colonização de *Brevipalpus phoenicis* (Geijskes, 1939) (Acari: Tenuipalpidae) em cercas vivas, quebra-ventos e plantas daninhas. In: Congresso Brasileiro de Entomologia, XIX., 2002, **Resumos.** Manaus: SBE, 2002, p.249.
57. Marques, J.P.R.; Appezzato-da-Gloria, B.; Kitajima, E.W. Anatomia das lesões foliares e de frutos de *Citrus* spp. causadas pela doença leprose. In: Congresso Brasileiro de Botânica, 55., 2004, Viçosa: Sociedade Botânica do Brasil, 2004., 1 CD ROM.
58. Mejia, L.; Paniagua, A.; Cruz, N.; Porras, M.; Palmieri, M. Citrus leprosis, disease that endangers plantations in Guatemala. In: Annual Meeting of the American Phytopathological Society, Caribbean Division, 42., 2005, **Annals.** Antigua: APS, 2002, p.17-19.
59. Medeiros, M,B. **Ação de biofertilizantes líquidos sobre a ecologia do ácaro *Brevipalpus phoenicis*.** 2002. 110 f. Tese (Doutorado em Ciências) – Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo, Piracicaba.
60. Murayama, D.; Agrawal, H.O.; Inoue, T.; Kimura, I., Shikata, E.; Tomaru, K.; Tsuchizaki, T.; Triharso (Ed.). **Plant viruses in Asia**. Bulasksumur: Gadjah Mada University Press, 2000, 1263p.
61. Musumeci, M.R.; Rosseti, V. Transmissão dos sintomas da leprose dos citros pelo ácaro *Brevipalpus phoenicis*. **Ciência e Cultura**, São Paulo, v.15, n.3, p.228, 1963.
62. Novelli, V.M.; Freitas-Astúa, J.; Astúa-Monge, G.; Carvalho, S.A.; Locali, E.C.; Rodrigues. V.; Arrivabem, F.; Hilf, M.E.; Gottwald, T.R.; Machado, M.A. Widespread occurrence of an endosymbiont bacterium in *Brevipalpus phoenicis* populations in the Southeastern region of Brazil. In: Conference of the International Organization of Citrus Virologists, XVI., 2004, **Annals.** Monterrey: IOCV, 2004, p.188.
63. Novelli, V.M.; Freitas-Astúa, J.; Astúa-Monge, G.; Carvalho, S.A.; Locali, E.C.; Rodrigues. V.; Arrivabem, F.; Hilf, M.E.; Gottwald, T.R.; Machado, M.A. Detection of CLO (Cytophaga-like organism) endosymbionts in adults and eggs of citrus leprosis vectors. **Summa Phytopathologica**, Botucatu, v.31, p.65, 2005.
64. Nunes, M.A. **Constatação da transmissibilidade do vírus da leprose dos citros por *Brevipalpus phoenicis* (Geijskes, 1939) em cercas vivas, quebra-ventos e plantas daninhas através da microscopia eletrônica de transmissão.** 2004. 46f. Dissertação (Mestrado em Agronomia – Entomologia Agrícola), Faculdade de Ciências Agrárias e Veterinárias, Universidade Estadual Paulista, Jaboticabal.
65. Oliveira, C.A.L. Flutuação populacional e medidas de controle do ácaro *Brevipalpus phoenicis* em citros. **Laranja**, Cordeirópolis, v.6, n.1, p.1-32, 1986.
66. Oliveira, C.A.L. Ácaro vetor da leprose dos citros: aspectos biológicos. **Laranja**, Cordeirópolis, v.17, n.1, p.229-295, 1996.
67. Omoto, C. Resistência de *Brevipalpus phoenicis* (Acari:Tenuipalpidae) aos produtos químicos na citricultura. In: Oliveira, C.A.L.; Donadio, L.C. (ed.). **Leprose dos citros**. Jaboticabal: FUNEP, 1995, p.179-188.
68. Omoto, C.; Alves, E.B.; Ribeiro, P.C. Detecção e monitoramento da resistência de Brev*ipalpus phoenicis* (Geijskes, 1939) (Acari: Tenuipalpidae) ao dicofol. **Anais da Sociedade Entomológica do Brasil**, Piracicaba, v.29, n.4, p.757-764, 2000.
69. Pascon, R.C.; Kitajima, J.P.; Breton, M.C.; Assumção, L.; Greggio, C.; Zanca, A.; Okura, V.K.; Alegria, M.C.; Camargo, M.E.; Silva, G.G.C.; Cardozo, J.C.; Vallim, M.A.; Franco, S.F.; Silva, V.H.; Jordão Jr., H.; Oliveira, F.; Giachetto, P.F.; Ferrari, F.; Aguillar-Vildoso, C.; Franchisini, F.J.B.; Silva, J.H.I.; Arruda, P.; Ferri, J.A.; Reinach, F.; Silva, A.C.R. The complete sequence and genomic organization of citrus leprosis virus (CiLV). **Virus Gene** (*in press*), 2005.
70. Pijnacker, L.P.; Ferwerda, H.R.; Helle, W. Cytological investigations of the parthenogenetic privet mites *B. obovatus* Donnadieu (Phytoptipalpidae, Acari). **Acarologia**, Paris, v.22, p.157, 1981.
71. Poletti, M. **Variabilidade inter e intraespecífica na suscetibilidade de ácaros fitoseídeos (Acari: Phytoseiidae) a dicofol e deltametrina em citros**. 2002. 87f. Dissertação (Mestrado em Ciências), Escola Superior de Agricultura 'Luiz de Queiroz", Universidade de São Paulo, Piracicaba.
72. Rodrigues, J.C.V. **Relações patógeno-vetor-planta no sistema leprose dos citros**. 2000, 168f. Tese (Doutorado em Ciências),Centro de Energia Nuclear na Agricultura -Universidade de São Paulo, Piracicaba.
73. Rodrigues, J.C.V.; Childers, C.C.; Kitajima, E.W.; Machado, M.A;. Nogueira, N.L. Uma estratégia para o controle da leprose dos citros. **Laranja**, Cordeirópolis, v 22, n.2, p.412- 423, 2001.
74. Rodrigues, J.C.V.; Gallo-Meagher, M.; Ochoa, R.; Childers, C.C.; Adams, B.J. Mitochondrial DNA and RAPD polymorphisms in the haploid mite *Brevipalpus phoenicis* (Acari: Tenuipalpidae). **Experimental and Applied Acarology,** Dordrecht, v.34, p.275-290, 2004.
75. Rodrigues, J.C.V.; Kitajima, E.W. Levantamento de vírus transmitidos por Brevipalpus (Acari: Tenuipalpidae) na região de Manaus e Urucu, AM. **Summa Phytopathologica**, Botucatu, v.31, p.26, 2005.
76. Rodrigues, J.C.V.; Kitajima, E.W.; Childers, C.C.; Chagas, C.M. Citrus leprosis virus vectored by *Brevipalpus phoenicis* (Acari: Tenuipalpidae) on citrus in Brazil. **Experimental and Applied Acarology,** Dordrecht, v.30, n.1/3, p.161-179, 2003.
77. Rodrigues, J.C.V.; Machado, M.A. Virus-*Brevipalpus*-plant relationships of the citrus leprosis pathosystem. **Proceedings of the International Society of Citriculture**, Orlando, v.1, p.768-770, 2000.
78. Rodrigues, J.C.V.; Muller, G.W.; Nogueira, N.L.; Machado, M.A. Yield damage associated to citrus leprosis on sweet-orange

varieties. **Proceedings of the International Society of Citriculture**. Orlando, v.1, p.1055-1059, 2000.

79. Rodrigues, V.; Arrivabem, F.; Freitas-Astúa, J.; Bastianel, M.; Antonioli-Luizon, R.; Novelli, V.M.; Locali, E.C.; Goulart, C.; Machado, M.A. Não-transmissão de isolado brasileiro do vírus da leprose dos citros por *Brevipalpus obovatus*. **Summa Phytopathologica**, Botucatu, v.31, p.64, 2005.
80. Roessing, C.; Salibe, A.A. Incidência da leprose em variedades cítricas. **Ciência e Cultura**, São Paulo, v.19, n.2, p.303, 1967.
81. Rosseti, V. A leprose dos citros no Brasil. In: Oliveira, C.A.L.; Donadio, L.C. (ed.). **Leprose dos citros**. Jaboticabal:FUNEP, 1995. p.1-12.
82. Rossi, L.S. **Seleção de fungos entomopatogênicos e infecção de *Hirsutella* sp. em *Brevipalpus phoenicis* (Geijskes, 1939)**. 2002. 107f. Dissertação (Mestrado em Ciências) - Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo, Piracicaba.
83. Salva, R.A.; Massari, C.A. Situação do ácaro da leprose no estado de São Paulo, levantamento – Fundecitrus, agosto 1995. In: Oliveira, C.A.L.; Donadio, L.C. (ed.) **Leprose dos citros**. Jaboticabal: FUNEP, 1995. p.13-18.
84. Salvo Filho, A. Notas sobre o tratamento fitossanitário em citros. **Laranja**, Cordeirópolis, v.18, p.155-163, 1997.
85. Spegazzini, C. Sobre algunas enfermedades y hongos que afectan las plantas de "agrios" en el Paraguay. **Annales de la Sociedad Científica Argentina**, Buenos Aires, v.90, p.155-188, 1920.
86. Trindade, M.L.B.L; Chiavegato, L.G. Colonização por *Brevipalpus obovatus* (Donnadieu, 1875), *Brevipalpus californicus* (Banks, 1904) e *Brevipalpus phoenicis* (Geijskes, 1939) (Acari: Tenuipalpidae) em variedades cítricas. **Laranja**, Cordeirópolis, v.11, n.1, p.227-240, 1990.
87. Vergani, A.R. **Transmisión y naturaleza de la "lepra explosiva" del naranjo**. Buenos Aires: Instituto Sanidad Vegetal, Ministerio de Agricultura de la Nación. 1945. p.1-11.
86. Weeks, A.R.; Marec, F.; Breeuweber, J.A.J. A mite species that consists entirely of haploid females. **Science**, Washington, v.292, p.2479-1482, 2001.