# Transmission of Citrus Leprosis Disease (CL) —A Review

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ABSTRACT. Citrus leprosis disease is transmitted in Brazil by the mite, *Brevipalpus phoenicis,* with symptoms appearing 20 or more days after transmission. Other species of *Brevipalpus* have been associated with the disease in Argentina, Venezuela and the United States. Larvae (immature stages) of *B. phoenicis* are more efficient vectors than adults. Graft transmission has been achieved by inserting diseased leaf and stem pieces into the stems of young, healthy citrus seedlings. Mechanical transmission from citrus to citrus and to some herbaceous plants (*Chenopodium amaranticolor, C. quinoa, Gomphrena globosa*) has recently been obtained in which all developed only local lesions. Systemic transmission was never observed in the field or in the experiments. These transmission experiments, together with evidence of rhabdovirus-like particles in infected tissue, eliminate the possibility that leprosis is caused by mite salivary toxins.

Citrus leprosis is not a new disease. According to Knorr (22), the first report, dated 1860, refers to an infected orange tree in a grove in Tampa Bay, Florida. Today the disease is known in North, Central and South America, mainly in Brazil and Argentina, where it is a very important disease affecting mainly sweet orange. Leprosis causes symptoms on foliage, fruit and twigs, and, when severe, it results in significant crop losses. Other citrus types are less severely affected (3, 36).

## SYMPTOMS AND AFFECTED VARIETIES

The symptoms may vary with the following factors: a) species or varieties of host plant; b) locality, region or country; c) phase of development of the affected organs; d) probable different strains of the causal agent, though this has not been proven (3).

**Foliar symptoms.** On sweet orange leaves, the lesions start as chlorotic patches, visible on both sides. They may develop a necrotic center, with a chlorotic, transluscent halo. Larger lesions, when older, may contain, in part, concentric brown rings sometimes impregnated with gum and somewhat raised dark brown or brilliant yellow areas (1, 2). These types of lesions were called "ciclosis", "ombrosis" or "crisosis", due to gum exudation on old lesions (3). Severe attacks can cause leaf drop. On Pera sweet orange, lesions are round or elongated and measure about 5 to 12 mm. These lesions are chlorotic with necrotic centers. On Bahianinha sweet orange leaves, necrotic centers are rare but lesions are larger. In Brazil, the first name given to the disease was "variola" (1, 2), but soon it was found identical to leprosis, the name given in Florida (22), and "lepra explosiva" in Argentina (16, 39). Foliar symptoms have also been observed on other species and cultivars, such as tangerines and mandarins in Brazil, Argentina, Paraguay, Uruguay, Louisiana (USA) (15).

**Fruit symptoms.** These start to appear as flat yellow patches when the fruit measure about 5 cm in diameter. As the fruit matures, they become larger, black or brown with somewhat depressed areas. They are irregularly distributed on the fruit surface. When lesions are abundant, fruit may drop.

**Twig and branch symptoms.** Lesions start as yellowish or chlorotic small flat patches, which

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develop into raised and large brown or reddish coalescent areas. When older, they become greyish. At this stage, they may be confused with citrus canker (30). Extensive development on twigs causes dieback, and may be confused with psorosis (16).

## TRANSMISSION

**Transmission by mites.** Experiments carried out from 1937 to 1941 in Brazil by Bittancourt (1, 2, 3) showed that leprosis was associated with mites. In Argentina, it was found associated with *Tenuipalpus* (= *Brevipalpus*) *pseudocuneatus* Blanch.(16, 39), and in Florida, with the mite, *B. californicus* (22). In Brazil, it has been experimentally transmitted by *Brevipalpus phoenicis* Geijskes 1939 (29, 30, 31, 32, 33) for the first time. In Venezuela and Argentina, it has also been associated with *B. obovatus* (16). Leprosis spread occurs when affected trees and the mites are present in the same orchard or region. This fact was clearly demonstrated in Brazil when *B. phoenicis* occurred in the regions of Araraquara and Bebedouro for years, but trees did not show any symptoms of leprosis. At that time, greenhouse transmission trials were carried out in São Paulo (29, 31, 32, 33, 34, 35), using fruits sent weekly from that area badly affected by scab, because mites usually live mostly protected by scab raised lesions (26). Plants infested with these mites did not develop leprosis symptoms. Leprosis lesions only appeared in the region when a citrus juice industry was established and fruit was transported from other regions of São Paulo State. Mite transmission and the biology of *B. phoenicis* were extensively studied by Knorr (22), in Florida, and by Chiavegato and co-workers (9, 10, 11, 12, 13) in Brazil. Transmission only occurs with mites which have been fed on lesion areas of fruit and leaves. In Brazil, leprosis has been more efficiently transmitted by larvae of *B. phoenicis* than by adults (8). Young potted plants infested with infected mites show symptoms about 15 to 20 or more days after infestation and lesions appear first on old leaves of the lower part of the plant (24, 33, 15). *B. phoenicis* is also suspected as vector of citrus zonate chlorosis (31, 34) and coffee ring spot (4, 5), but cross inoculations carried out in the greenhouse on coffee and sweet orange seedlings showed that the three diseases are different (31).

**Transmission by grafting.** In Florida, leprosis was transmitted by inserting affected tissue of donor plants to twigs of young plants (22) in the absence of mites. In Brazil, affected leaf tissue grafted into healthy young plants gave positive results 4 mo later (6). Better results were obtained with tip grafts of infected shoots. In both cases, symptoms on the receptor plants remain adjacent to the lesion of the donor plant. Time of development varied from 4 to 12 mo. (7).

**Mechanical transmission.** Studies on mechanical transmission were recently conducted in Brazil at the Instituto Biológico in São Paulo (14, 15, 23). Naturally affected field material from different regions of the State of São Paulo and other localities was collected. Tissue with typical leprosis symptoms from leaves, fruit rind and stems were separately crushed in liquid nitrogen. TACM (pH 8) and phosphate (pH 7) buffers were added to the resulting powder in the presence of activated carbon. The inoculum was then rubbed on carborundum-dusted leaves of young seedlings of Caipira sweet orange, Tahiti lime and a number of herbaceous plants. The citrus species developed typical leprosis lesions, and local lesions also appeared on mechanically inoculated *Chenopodium amaranticolor*, *C. quinoa* and *Gomphrena globosa*. *Chenopodium* plants showed conspicuous chlorotic leaf lesions with a

necrotic center and transluscent halo. Young lesions measured 1 to 3 mm, while mature lesions were larger, measuring about 1.2 cm in diameter. These lesions were better seen against light. On *Gomphrena globosa*, lesions were somewhat larger with a brownish color. Control inoculations with tissue not showing symptoms gave negative results. None of the tested plants showed systemic symptoms.

## THE CAUSAL AGENT

The causal agent of leprosis is presumed to be a bacilliform virus non-enveloped virus particle similar to rhabdovirus were observed in infected tissue by electron microscopy (20, 21, 28). These particles were found only in tissue with lesions of the disease. Recently, these results were confirmed by electron microscopy in leprosis lesions of Pera and Caipira sweet oranges obtained by mechanical transmission (14, 15) in Brazil. Virus-like bacilliform particles measuring 120 to 130 × 50 to 55 nm were found in the endoplasmic reticulum of mesophyll and vascular parenchyma cells. Some authors have suggested that a toxin secreted by *B. phoenicis* could be the cause of leprosis symptoms (17, 19, 22). Mechanical transmission, cytopathic characteristics and the fact that mites from leprosis-free tissue do not induce the disease symptoms, disprove the possibility of a mite toxicogenic effect and demonstrate the occurrence of a pathogenic agent, most probably a virus. Evidence so far suggests that a rhabdovirus may be involved, but further research is required.

## CONTROL

The control of leprosis is based on the elimination of the inoculum, by severely pruning affected plants and applying acaricides to reduce mite populations. Work on mite population fluctuation has been carried out and is important for control programs (25, 27 35, 37, 38). Recently, some success on leprosis control using extracts of *Datura metel* has been reported (18).

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