

INSECT TRANSMISSION OF TRISTEZA VIRUS OF CITRUS IN FLORIDA

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Among the virus diseases commonly infecting citrus in Florida, tristeza is the only one that has been shown to be insect transmitted.

There is ample evidence of natural spread of this disease in Florida. A survey by the State Plant Board of Florida, after discovery of tristeza in 1952, revealed the presence of infected trees in every citrus area of the State. Seventy-two virus-free parent trees in Orange County selected for entry in the Citrus Budwood Program in 1953 were free of the virus when tested in 1955, but later 15 of 38 trees were found to have tristeza (Burnett, 1960). In another group of 84 formerly virus-free seedling trees, in the Citrus Budwood Program, 26 are now known to be tristeza-infected. Twelve percent of 1,739 trees surveyed by the Florida Plant Board throughout the State during 1959-60 carried the virus. Gerald Norman (1961) reported natural spread in Polk County where previously healthy trees in three locations, when indexed with Key lime, were found to have the disease. Norman attributed this spread to the heavy infestations of aphids that occurred in the spring of 1959 and 1960.

INSECT TRANSMISSION OF TRISTEZA VIRUS DISEASE OF CITRUS

Transmission of tristeza virus by the brown citrus aphid (*Toxoptera citricidus* [Kirk.]), an aphid which does not occur in continental United States, was demonstrated in Brazil by Meneghini (1946) and Bennett and Costa (1949), in Argentina by Valiela (1948), and in South Africa by McClean (1950). Dickson *et al* (1951) reported transmission of quick decline (tristeza) by the melon aphid (*Aphis gossypii* Glov.) in California. The brown citrus aphid is an efficient vector of the virus, but the melon aphid is considered to be comparatively inefficient as a vector.

In Florida, one of several potted Key lime seedlings placed around infected trees in 1952 developed vein-clearing and stem-pitting symptoms typical of a mild strain of tristeza virus (Norman and Grant, 1954). Large numbers of spirea aphids (*A. spiraeicola* Patch) observed on or near the test plants, suggested this species as a possible vector. Later, after 160 unsuccessful tests with infected Valencia orange trees and Key lime seedlings serving as inoculum, the virus was successfully transmitted by spirea aphids from a stunted Temple orange tree on red lime (Rangpur type) rootstock to 9 of 128 Key lime test plants. In subsequent experiments, the melon aphid transmitted the virus to one of 26 Key lime indicator plants. The first positive evidence of transmission of tristeza virus by the black citrus aphid (*Toxoptera aurantii* [Fonsc.]) was obtained in 1956 with an infected Valencia orange scion on a Key lime rootstock grown in a greenhouse as the source of inoculum and Key lime as the indicator plant (Norman and Grant, 1956).¹

¹ Identity of these aphids was confirmed by Louise M. Russell, taxonomist, of the Entomology Research Division.

Insects and mites found on citrus in Florida, which failed to transmit tristeza in tests conducted at Orlando, included the green peach aphid (*Myzus persicae* [Sulz.]), citrus mealybug (*Pseudococcus citri* [Risso]), the leafhoppers *Homalodisca coagulata* (Say) and *Oncometopia undata* (F.), a big-footed plant bug (*Acanthocephala femorata* [F.]), the southern green stink bug (*Nezara viridula* [L.]), another stink bug *Euschistus obscurus* (P. de R.), and the citrus red mite (*Panonychus citri* [McG.]) (Norman and Grant, 1956).

TRANSMISSION OF MILD AND SEVERE STRAINS OF TRISTEZA

The existence of different strains of tristeza virus is widely recognized. They are identified on the basis of their effect on plant growth, degree of symptom expression, and stability of differences in symptom expression after repeated transmissions through a series of test plants.

Two mild strains of tristeza virus (T_1 and T_2) were obtained from Key lime plants that had been inoculated by spirea aphids from a Temple orange tree (Norman and Grant, 1956). A severe form of tristeza (T_3) was obtained by tissue transmission from a lime tree in the field (Grant and Higgins, 1957). These strains of the disease have been transmitted to Valencia, Temple, Florida sweet seedling, and Pineapple orange trees, and to Cleopatra mandarin and Rough lemon seedlings by means of leaf-piece inoculations.

The spirea aphid (300-400 per test plant) transmitted the T_2 mild strain of tristeza from Temple, Florida sweet seedling, and Valencia sources to seven out of 13 Key lime indicator plants. The melon aphid (700 per test plant) also transmitted the T_2 strain of virus from a Temple source to six indicator plants. In these tests, initial symptoms of tristeza were detected on one or more branches of the indicator plant five to eight weeks after aphid inoculation. New, young leaves of infected branches showed distinct vein-clearing and a veinlet pattern that frequently faded as growth matured. After the initial vein-clearing symptoms disappeared, some leaf cupping and deficiency signs remained. Presence of the virus in the indicator plants was confirmed by tissue transmissions to additional Key lime plants (Norman and Grant, 1956).

The melon aphid (200-400 per test plant) transmitted the T_3 severe strain from a Pineapple orange source to 10 of 12 indicator plants. The same number of aphids fed on a Rough lemon source infected one of two indicator plants but no transmission occurred from a Cleopatra mandarin source to two indicator plants. Ten months after inoculation it was noted that five of the 11 infected plants in the T_3 series exhibited extreme stunting, some vein-corking on the upper surfaces of the older leaves, leaf drop, and branch dieback, with five of the remaining plants stunted, and showing leaf cupping and yellowing. All but one of the 11 infected plants had very thick bark and showed stem pits and striations. Although the remaining plant produced some new growth and there was a slight tendency towards milder symptoms, nonetheless it had thick bark with distinct pits and striations separated by normal-appearing wood. (Norman and Grant, 1959).

DIFFERENCES IN TRANSMISSION EFFICIENCY OF APHID CLONES

Simons (1959), working with southern cucumber mosaic, found considerable differences in the ability of several clones of the melon aphid to transmit this virus. A melon aphid clone obtained from John N. Simons, University of Florida, Everglades Experiment Station, Belle Glade, and another developed at Orlando were used in tristeza transmission studies during 1958 and 1959. The Belle Glade clone transmitted tristeza virus to six of 21 indicator plants compared with only two of 21 for the Orlando clone. The aphids obtained from Belle Glade had been reared on pepper. The clone from Orlando had been reared entirely on citrus. Aphids from both clones were transferred to kenaf two weeks before use in the initial tests. Of interest in these preliminary tests was the transmission efficiency of the Belle Glade melon aphids, a clone considered to be an inefficient vector of southern cucumber mosaic by Dr. Simons. Results suggesting that the Belle Glade aphids may be more efficient vectors of tristeza than the Orlando aphids, need confirmation in further tests.

INSECT TRANSMISSION OF TRISTEZA VIRUS FROM DIFFERENT CITRUS VARIETIES

In Florida, aphids appear to be attracted to Temple oranges because these trees habitually have more succulent growth than many other citrus varieties. The first transmissions of tristeza virus with the spirea aphid in Florida were from Temple orange to healthy Key limes. Attempts at that time to transmit the disease from infected Valencia orange trees and from Key lime test plants with spirea aphids produced negative results. In later tests in which Temple orange inoculum was again used, 11 of 12 indicator plants became infected with the T₃ severe strain of tristeza when 100-300 melon aphids were used per test.

The suitability of Meyer lemon as an inoculum source was investigated in 16 tests with the black citrus aphid and 21 tests with the melon aphid. No positive transmissions were obtained in these experiments. In 107 tests with the spirea aphid in which the Meyer lemon was used as the only source of inoculum, two positive transmissions resulted. Vein-clearing symptoms occurred on young leaves of indicator lime plants five months later, but these became less evident as leaves matured. Subsequent new growth showed no further symptoms. Indicator plants inoculated with budwood from the branch of this Meyer lemon on which the aphids had fed developed strong vein-clearing symptoms that were evident for a longer period and were more distinct than those observed on the original Key lime infected by aphids.

The Meyer lemon scion on one of the graft-inoculated Key lime indicator plants was allowed to develop. Spirea aphids successfully transmitted tristeza virus from this Meyer lemon to one of two Key lime plants, with transitory leaf symptoms developing four months after inoculation. The limited symptom expression of tristeza suggested that either the inoculum contained a very mild tristeza virus strain or that the aphids had transmitted only a portion of a virus mixture. Further experiments provided additional evidence that a milder form of tristeza virus had been transmitted from the Meyer lemon by the aphids than had been transmitted by tissue grafts from the same source.

In 1958, an evaluation was made of the ability of aphids to transmit a severe strain of tristeza from orange varieties Hamlin, Bedmar, Sanguina Grosse Ronde, Maltese Oval, Mediterranean Blood, Valencia, Florida sweet seedling, Pineapple, Cuba sweet, Selecta, Joppa, Precose de Valence, St. Michael, Morocco, Princess Early, and McIlhenny. Melon aphids transmitted the virus from Hamlin, Maltese Oval, Precose de Valence, and Florida sweet sources. The black citrus aphid transmitted the virus from Precose de Valence and St. Michael sources of inoculum, but not from Mediterranean Blood or Cuba sweet orange varieties. Alate spirea aphids transmitted tristeza virus from a Hamlin orange source but not from Princess Early or Joppa orange seedlings.

The vector studies in Florida showed that under laboratory conditions the spirea, melon, and black citrus aphids were capable of transmitting mild and severe strains of tristeza virus. Research is currently being conducted to determine the possible differences in the efficiency with which these aphids transmit the different virus strains, as well as the relationship of such factors, as temperature, inoculum source, and aphid strain to transmission and the character of virus infections in the field.

The possibility that recent natural spread of tristeza in Polk County reported by Gerald Norman (1961) may be associated with heavy aphid infestations on citrus in 1959 and 1960 suggested that the vectors may not always be abundant or efficient enough under normal conditions to cause rapid spread. If large populations of aphids are necessary, their control may provide important practical benefits by limiting natural spread of tristeza. In view of the value of citrus trees in full production, any reasonable measures that might be taken to prolong their productive life should be worthwhile.

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