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Distribution and Movement of Psorosis and Tristeza Viruses in Citrus Plants

Few studies have been made of the distribution and movement of viruses affecting citrus plants. Schneider (3) suggested that tristeza virus moves through sieve tubes and multiplies in parenchymatous tissues adjacent to them. Anatomical studies by Schneider (4) on graft-unions revealed the absence of sieve tube connections between *Citrus* as a scion and *Aeglopsis* or *Afraegle* as rootstock. He suggested that this might be the reason for the failure of tristeza virus to infect *Aeglopsis* and *Afraegle* by grafting to *Citrus*.

The objectives of the present study were to check for the presence of psorosis and tristeza viruses in the cambial tissues ensheathing the woody cylinder of infected hosts and to determine whether or not either virus can move to the xylem of citrus plants.

Testing for presence of psorosis virus in the cambial tissue ensheathing the woody cylinder of sweet orange.—Beladi sweet orange [*Citrus sinensis* (L.) Osbeck] seedlings about 2 years old and exhibiting bark lesions of psorosis were used as a source of inoculum. These seedlings had been inoculated previously with bark patches from a tree about 23 years old that was growing at the farm of Cairo University. A slice of bark and wood was cut from the stem of the infected seedling and the bark was separated from the wood, exposing the cambial surface. The test plant, beladi sweet orange, was then sidegrafted with the wood-patch with its cambium touching the exposed tissues of the test plant. Every test plant received at least 3 wood patches.

Of 24 sweet orange plants grafted with wood patches from infected sweet orange plants, 20 developed young leaf symptoms and bark lesions of psorosis. Of 10 plants grafted with bark patches, 7 developed both young leaf symptoms and bark lesions. Of 6 plants grafted with pieces of root of an infected plant, 4 developed young leaf symptoms and 2 developed bark lesions.

FAILURE TO DETECT TRISTEZA VIRUS IN THE CAMBIAL SURFACE ENSHEATHING THE WOODY CYLINDER.—Twelve plants each of four-year-old Foster grapefruit (*C. paradisi* Macf.), beladi sweet orange, sour orange (*C. aurantium* L.), Palestine sweet lime (*C. limettioides* Tanaka), and beladi lime plants budded on beladi lime rootstock and infected with tristeza virus were indexed for tristeza virus in the cambial surface ensheathing their woody cylinders. Branches 2-3 mm in diameter were cut from each of the five infected hosts. The branches were cut into pieces about 3 cm long and the bark of each piece was slipped so as to expose the woody cylinder, which was then side-grafted to a healthy beladi lime seedling. Each beladi lime seedling was grafted with at least 3 pieces of woody cylinder. None of the 60 index plants developed symptoms of tristeza, thus demonstrating the absence of tristeza virus from the cambial surface ensheathing the woody cylinder.

MOVEMENT OF PSOROSIS AND TRISTEZA VIRUSES TO THE XYLEM OF CITRUS PLANTS.—To test for movement of psorosis and tristeza viruses to the xylem of citrus plants, the following technique was used. A bracelet of bark about 3 cm long was removed, exposing the woody cylinder of the test plant, and was left to dry out. Budwood infected with psorosis virus, tristeza virus, or a mixture of both was grafted either above or below the ring. To retard and minimize the death of the portion of stem above the ring, periodic pruning and defoliation of the growth below the ring took place. Seedlings about 2 years old of beladi, Parson Brown, and Pineapple sweet orange were used to test for the movement of psorosis virus to their xylem. Beladi lime seedlings were used to test for the movement of tristeza virus. Budwood containing a mixture of psorosis and tristeza viruses was grafted above the ring made on the stems of Parson Brown sweet orange seedlings.

A year after inoculation, the inoculated and non-inoculated portions of the stem were indexed for presence of virus. Rough lemon (*C. jambhiri* Lushington) seedlings were used as index plants for psorosis virus, and beladi lime seedlings for tristeza virus.

Of 47 plants inoculated with psorosis virus above the ringed area 7 indexed positive, whereas of 30 inoculated with psorosis virus below the ring none indexed positive. Of 6 plants inoculated with tristeza virus above the ring and 14 inoculated below the ring none indexed positive.

Of 15 plants inoculated above the ring with a mixture 3 indexed positive for psorosis virus and none indexed positive for tristeza virus. The results indicate that psorosis virus can enter the xylem of sweet orange plants and move downward across the ring through the exposed woody cylinder and that upward movement takes place much less frequently, if at all. On the other hand, no evidence was obtained that tristeza virus can enter the xylem of either beladi lime or Parson Brown sweet orange plants.

It is worth mentioning that leaves above the ring made on inoculated and non-inoculated (control) seedlings usually exhibited downward cupping and a corky-vein condition. This might be due to an excess of carbohydrates above the ring. It has been noted that pruning and defoliation of growth below the ring help in the formation of new growth above the ring.

Discussion

Except for Pierce's disease of grape (1) and phony disease of peach (2), very little is known about the movement of plant viruses into the xylem and through it. In the present study, psororis A virus was found to move into the xylem and then downward through a portion of stem from which a ring of bark had been removed and manifested itself below the ringed area as clearing and etching of the veins of the immature leaves of sweet orange. The virus was never detected above the ring when the inoculum was grafted below the ring.

Ringing a branch results in the accumulation of carbohydrates above the ring, either in the bark or in the woody cylinder. Periodic pruning and defoliation of leaves of the branches below the ring might have caused a case of partial carbohydrate-starvation in the roots. Movement of excess metabolites from above the ring downward through the woody cylinder might translocate the psorosis virus with it. We could not check this hypothesis by not pruning or defoliating the growth below the ring in comparative seedlings since the portion above the ring would then usually wilt and die in a few weeks.

Literature Cited

1. Houston, B. R., Esau, K., and Hewitt, W. B. 1947. The mode of vector feeding and the tissues involved in the transmission of Pierce's disease in grape and alfalfa. Phytopathology 37: 247-253.

2. HUTCHINS, L. M. 1939. Apparent localization of phony disease virus in the woody cylinder. Phytopathology 29: 12.
3. SCHNEIDER, H. 1959. The anatomy of tristeza-virus infected citrus, p. 73-84. *In* J. M. Wallace [ed.], Citrus Virus Diseases. Univ. Calif. Div. Agr. Sci., Berkeley.
4. SCHNEIDER, H. 1961. Anatomical aspects of tristeza-diseased Citrus, Aeglopsis, and Afraegle, p. 136-140. *In* W. C. Price [ed.], Proc. 2nd Conf. Intern. Organization Citrus Virol. Univ. Florida Press, Gainesville.