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Tahiti Lime Bark Disease Is Caused by Exocortis Virus

In the Tahiti lime (*Citrus latifolia* Tanaka) orchards of Brazil about 5 per cent of the trees die each year. Trees of this variety develop longitudinal cracks or sunken areas in the bark of the trunk and branches, which are often invaded by fungi that cause gum exudation; the symptoms resemble those referred to by Tisdale (8, 9) as lime bark disease. They are very similar to the symptoms obtained when certain varieties such as Rangpur lime (*C. limonia* Osbeck), Palestine sweet lime (*C. limettioides* Tanaka), and citron (*C. medica* L.) are inoculated with exocortis virus.

This paper reports some studies conducted at the Limeira Citrus Experiment Station with the purpose of determining whether or not Tahiti lime bark disease is caused by exocortis virus.

Materials, Methods, and Results

Six selections of Tahiti lime were planted in an experimental plot at the Limeira Station in 1961. They were IA-1, a Tahiti lime existing in the collection at the Limeira Station, very probably introduced from Florida, IA-2 a very productive Tahiti lime selection in that same collection, IA-3 a very vigorous Tahiti lime tree about 20 years old growing at Santa Cruz in Araras, IA-4 an outstanding tree growing among 10,000 trees in the Oliveira Carvalho farm in Rio de Janeiro, IA-5 a selection of Tahiti lime named Bearss that was introduced from Peru by Dalmo Giacometti, and IA-6 a selection made in a grove of 20,000 Tahiti lime trees at Lagoa Bonita in Leme. The parent and daughter trees of these Tahiti lime selections were affected by the lime bark disease to various degrees, the most severely affected selection being IA-6,

followed by IA-1, and IA-2. The trees of IA-3 were moderately diseased and those of IA-4 had very few cracks. The Bearss lime trees, selection IA-5, were all very vigorous and healthy and had no cracks in the trunks or branches. Several inspections, in two seasons, revealed no yellow blotching of leaves or sectorial chimeras in fruits indicative of wood pocket (blotch) (1, 3, 6).

Plants in the experimental block were tested for exocortis virus by using Rangpur lime seedlings as indicators. Five seedlings were inoculated with buds taken from each one of the Tahiti lime selections. Inoculations were made in September, 1961, and periodical inspections thereafter indicated that all selections except IA-5 (Bearss lime) were infected with one or another strain of the virus. The severity of the strain was judged by the size of the yellow areas and extent of cracking in the bark of the Rangpur lime sprouts and on the time required for appearance of these symptoms. Final inspections, carried out 15 months from the beginning of the tests, indicated a direct relationship between the intensity of bark cracking in the various Tahiti lime selections and the severity of the exocortis virus strain carried by these selections. Trees of the IA-5 selection, which were free from symptoms, were found to be free from exocortis virus.

The Perrine lemon [*C. aurantifolia* (Christm.) Swing. x *C. limon* (L.) Burm. f.] trees in Brazil normally develop cracks in the trunk and branches similar to those in Tahiti lime trees. Some trees of the Perrine lemon were therefore tested for exocortis virus at the same time; results showed that they were carrying a very weak strain of the virus.

In another series of tests, two lines of Tahiti lime were used, the old-line Tahiti IA-4 and a seedling line presumed to be of nucellar origin because of the similarity of its foliage and seedless fruit to those of Tahiti lime. This seedling line was produced in Minas Gerais from seeds developed from open pollinated flowers of Tahiti lime and introduced into São Paulo by Dr. Dalmo Giacometti. Buds from these two lines were budded on seedlings of Caipira sweet orange [*C. sinensis* (L.) Osbeck], one year old in the nursery. At the same time, these seedlings were inoculated partly with buds from a Hamlin orange tree infected with a severe strain of exocortis virus, partly with buds of Tahiti lime IA-1, known to be carrying a mild strain of exocortis virus and some others with buds taken from a nucellar Hamlin orange tree to serve as exocortis virus free controls. These buddings were made in November, 1960. Measurements made five months later, in the sprouts of the old-line Tahiti lime (IA-4) plants inoculated with the severe strain of exocortis

virus (average height 23.7 cm) showed a reduction of vigour of 49.1 per cent, and those with Tahiti IA-1 carrying mild exocortis (average height 41.9 cm) a reduction of 10.1 per cent when compared with the controls (average height 46.6 cm). In the plants of the presumed nucellar line, the reduction was 60.9 per cent in the first instance (average height 27.5 cm), and 38.6 per cent in the second (average height 43.2 cm) in relation to the controls (average height 70.4 cm). Some of the plants with exocortis virus developed yellow areas and cracks in the bark and died.

Observations made 12 and 24 months after inoculation revealed that all the plants of the old-line Tahiti lime (IA-4) had more intensive bark cracks when inoculated with the severe exocortis virus strain and that the plants of the presumed nucellar Tahiti lime showed cracks only when inoculated (Fig. 1).

Discussion and Conclusion

In 1934, Tisdale (8) reported a bark disease of Tahiti lime and Perrine lemon in Florida, characterized by longitudinal cracks and dead areas, sometimes with gum in the bark of branches and trunk of trees. He observed that the bark cracking occurred during the growing season (9) and that the rapid killing of the trees was due to parasites invading the wood as well as the bark.

In 1943, Ruehle (7) described a disease affecting Persian (Tahiti) lime, the symptoms of which were blotching of leaves, fruit with chimera-like longitudinal sectors, and breaks in the bark of the trunk and branches. He suspected that this disease was caused by a virus. Gates and Soule (4) in a survey in Florida found that more than 31 per cent of the bearing lime trees in 18 groves (844 trees examined) had symptoms of lime bark disease.

The similarity of the disease described by Ruehle (7), later named lime blotch, to wood pocket of lemon (3) has been pointed out by many authors (1, 5, 6). Calavan (1) reported wood pocket in seedless lime trees in California and evidence has been published (1, 6) that wood pocket of lemon in California and lime blotch of Tahiti lime in Florida are not infections and are probably due to an unstable chimera of genetic origin.

Cohen, Ruehle, and Lincoln (2) have also been unable to transmit wood pocket (lime blotch) from diseased Tahiti lime trees to apparently healthy trees or to relate this condition to any known virus. They concluded that lime bark disease is of genetic origin.

FIGURE 1. *a. Tahiti lime bark disease characterized by longitudinal cracks and sunken areas in the bark of trunk and branches. b. Branch from a presumed nucellar Tahiti lime tree inoculated with exocortis virus and subsequently exhibiting cracks and sunken areas.*

The results of the experiments here reported suggest that a bark disease of some Tahiti lime selections in Brazil is caused by exocortis virus. Inoculation with bark of diseased Tahiti lime trees induced yellow areas and cracks in Rangpur lime seedlings, indicative of exocortis virus infection. Inoculation with exocortis virus apparently caused severe cracks in old-line Tahiti lime plants and caused bark cracks in presumed nucellar plants of this variety.

The difference in results obtained in the tests carried out in the United States and Brazil may indicate that two different diseases are

involved, one of genetic origin and another caused by exocortis virus. It should be pointed out that a similar disease, the shell bark of lemons, is largely considered of genetic origin. However, shell bark symptoms have developed in young Harvey lemon trees two years after inoculation with exocortis virus (Salibe, unreported).

Literature Cited

1. Calavan, E. C. 1957. Wood pocket disease of lemons and seedless limes. Calif. Citrograph 42 (7): 265-268, 300-304.
2. Cohen, M., Ruehle, G. D., and Lincoln, F. B. 1961. Influences of some virus and genetic conditions on the growth of Tahiti lime. Proc. Florida State Hort. Soc. 74: 24-29.
3. Fawcett, H. S., and Calavan, E. C. 1947. Wood pocket, a newly reported disease of lemons. Phytopathology 37: 843.
4. Gates, C. M., and Soule, M. J., Jr. 1950. A survey of diseases lethal to Tahiti (Persian) limes in Dade County. Proc. Florida State Hort. Soc. 63: 225-228.
5. Knorr, L. C., and Price, W. C. 1955. Factors affecting the development of tristeza in Florida. Univ. Florida Agr. Exp. Sta. Ann. Rept. 1955. p. 213-215.
6. Knorr, L. C., and Childs, J. F. L. 1957. Occurrence of wood pocket (blotch), chimeric breakdown and endoxerosis in Florida, with particular reference to the Tahiti lime. Proc. Florida State Hort. Soc. 70: 75-81.
7. Ruehle, G. D. 1943. A new disease of Persian (Tahiti) lime transmitted through budwood. Proc. Florida State Hort. Soc. 56: 126-128.
8. Tisdale, W. B. 1934. Diseases of lime trees. Proc. Florida State Hort. Soc. 47: 123-127.
9. Tisdale, W. B. 1936. Present status of lime bark diseases. Proc. Florida State Hort. Soc. 49: 148-149.