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### *The Question of Seed Transmission of Cachexia- Xyloporosis Virus*

**T**HAT CACHEXIA DISEASE of Orlando tangelo (*Citrus paradisi* Macf. x *C. reticulata* Blanco) (2), and xyloporosis disease of sweet lime [*C. aurantifolia* (Christm.) Swing.], as described by Reichert and Perlberger (13), are caused by the same virus now seems established (1, 4, 10, 11). Sweet lime reacts to the virus more slowly and less vigorously than Orlando tangelo (1, 11) and reacts also to exocortis virus (11), which Orlando tangelo apparently does not.

In Reichert and Perlberger's original description of xyloporosis (13), they noted that "the disease also appears on unbudded sweet lime especially underneath the limbs of the trunks of trees whose central system has been pruned away." Reichert reported (15) additional observations of xyloporosis in unbudded sweet lime trees in 1959. Because the virus nature of cachexia was established first (3) and because xyloporosis has become confused in the literature with other disorders of citrus, the name cachexia-xyloporosis will be used hereafter in this paper. Circumstantial evidence suggesting seed transmission of cachexia-xyloporosis was reported from Florida by Childs (5) and by Norman *et al.* (8). The mild symptoms reported by Childs were probably the result of scale infestation as recognized by DuCharme and Knorr (6) and later by Grant *et al.* (7).

Occurrence of cachexia-xyloporosis symptoms in unbudded seedlings could be explained also on the basis of insect transmission. However, Reichert *et al.* (15) reported that attempts to transmit cachexia-xyloporosis with aphids, *Toxoptera aurantii* (Fonsc.) and *Aphis gossypii* Glover, were negative after 3 years. An extensive series of experimental attempts by Norman and Childs (9) to transmit cachexia-xyloporosis by aphids,

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*A. spiraecola* Patch, *A. gossypii* Glover, and *Myzus persicae* (Sulzer); scale, *Icerya purchasi* Maskell; and leafhopper, *Oncometopia nigricans* (Walker) was negative after 3 years.

Experiments specifically designed to investigate seed transmission of cachexia-xyloporosis appear limited to two. In one experiment (5), 50 seedlings were grown from seeds of an infected Orlando tangelo tree and compared with 50 seedlings grown from seeds of a cachexia-xyloporosis-free tree. After 4 years, no symptoms were evident in any of the trees, at which time they were destroyed to provide space for other work. In a recent experiment, Olson (12) observed 118 seedlings from 5 Palestine lime trees infected with cachexia-xyloporosis for 3 years without finding symptoms. Fifty-six that survived the freeze were still symptom-free 19 months later.

The question of seed transmission of cachexia-xyloporosis bears directly on the problem of obtaining virus-free seedlings and nucellar clones for indexing purposes and for commercial propagation. Because the situation was confused by conflicting evidence, further investigation of the question of seed transmission was undertaken.

### *Methods*

Previous observations suggested that seed transmission of cachexia-xyloporosis occurred infrequently, if at all, and that large numbers of plants would be necessary for an adequate test. To that end, seeds from many citrus trees known to be or believed to be infected with cachexia-xyloporosis were collected and germinated in the greenhouse, January through February, 1956.

The following sources were represented: sweet lime, 104 seedlings; sweet orange [*C. sinensis* (L.) Osbeck], 228 seedlings; sour orange (*C. aurantium* L.), 167 seedlings; rough lemon [*C. limon* (L.) Burm. f.], 672 seedlings; Villafranca lemon (*C. limon*), 97 seedlings; Duncan grapefruit (*C. paradisi* Macf.), 92 seedlings; Clementine mandarin (*C. reticulata* Blanco), 92 seedlings; tangelo, 238 seedlings; Rusk citrange [*Poncirus trifoliata* (L.) Raf. x *C. sinensis*], 95 seedlings; and hybrids of Temple orange by various species and Clementine mandarin by various species, 61 seedlings.

Seedlings were transplanted to quart cans, 1 per can, and in July, 1956, when they were 2-3 mm in diameter were budded with Orlando tangelo. The Orlando tangelo buds were obtained from seedlings, grown from seed of a tree free of cachexia-xyloporosis. On February 6 and 7,

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1957, the budded trees were planted in the field. In addition, seedling hybrids of Clementine mandarin [*Citrus reticulata* x Orlando tangelo (*C. paradisi* x *C. reticulata*)] and seedlings of a cross between Temple orange (probably a tangor) and Orlando tangelo were budded on Orlando tangelo stocks and set out in May, 1958, as a continuation of the above-mentioned planting. The Clementine parent is infected with cachexia-xyloporosis virus and large numbers of the seedling progeny of both crosses exhibited mild wood pitting that suggested possible infection with cachexia-xyloporosis.

These trees were planted rather closely, 1.5 x 8 feet, between 2 lakes that protected them from cold damage. However, heavy rains in 1960 caused the lakes to flood part of the planting. Flooding killed approximately 100 trees and led to the death of 30 more from foot rot (*Phytophthora* sp.). Nineteen of these latter were on rough lemon roots and 8 were on Valencia 9-30-15 roots. Otherwise the trees grew vigorously, reaching a height of 9-11 feet in 1962, in spite of being topped once and hedged 3 times. Trunk diameters averaged about 3 inches at the union. In 1958 all the trees on Whidden sweet lime roots were examined by cutting a strip of bark about 1-inch wide and 2-inches long across the union. The strip was cut off at the top and pulled down to expose the cambial face of the wood and bark across the bud-union. After inspection, the bark strips were tied back in place with plastic tape. In 1959, all trees were examined in this manner. In 1961, 7 of the 11 rows of trees were examined. In 1962, more than 6 years after budding, every tree was examined for the last time. In many cases 2-4 strips of bark were cut, and in a few cases bark strips were sectioned, stained, and examined microscopically to make quite sure of the diagnosis. The trees were destroyed after the 1962 inspection because the owners of the land wanted it for other purposes.

### *Results*

Of the 1,750 trees remaining in August, 1962, 1,705 had been budded a little more than 6 years; and 45—the two lots of hybrids budded on Orlando tangelo roots—had been budded 5 years and 4 months.

No symptoms attributable to cachexia-xyloporosis were found on the Orlando tangelo, either tops or roots. Nor did trees consisting of Orlando tangelo budded on susceptible varieties, such as sweet lime, Clementine mandarin, Thornton, and Nocatee tangelos, exhibit symptoms of cachexia-xyloporosis below the union.

*Discussion and Conclusions*

It was hoped that budding Orlando tangelo on very young seedlings would cause symptoms to appear earlier and speed completion of the experiment. In previous experiments under Florida conditions (4), symptoms were recognized on some Orlando plants in 2½-3 years, but 5 years was required for all inoculated plants to develop symptoms. Consequently, this experiment was continued 6 years from the time of budding to provide a margin of safety. In that time no symptoms appeared in the 1,338 seedlings from cachexia-xyloporosis-infected parents or in 362 trees from parents believed infected. Thus, under the conditions of this experiment, seed transmission of cachexia-xyloporosis did not occur once in 1,750 times.

No evidence is known that suggests insect transmission of the cachexia-xyloporosis virus in commercial citrus orchards in Florida. Moreover, in early transmission experiments (4), cachexia-xyloporosis-free Orlando trees (checks) remained free of the virus during the 7 years the experiment was continued. In the experiment reported here, the trees remained free for 6 years. These results further confirm that insect transmission of cachexia-xyloporosis is very rare or non-existent in Florida.

*Literature Cited*

1. CALAVAN, E. C., CHRISTIANSEN, D. W., and WEATHERS, L. G. 1961. Comparative reactions of Orlando tangelo and Palestine sweet lime to cachexia and xyloporosis, p. 150-158. *In* W. C. Price [ed.], Proc. 2nd Conf. Intern. Organization Citrus Virol. Univ. Florida Press, Gainesville.
2. CHILDS, J. F. L. 1950. The cachexia disease of Orlando tangelo. *Plant Disease Repr.* 34: 295-298.
3. CHILDS, J. F. L. 1951. Cachexia, a bud-transmitted disease and the manifestation of phloem symptoms in certain varieties of citrus, citrus relatives and hybrids. *Proc. Florida State Hort. Soc.* 64: 47-51.
4. CHILDS, J. F. L. 1952. Cachexia disease, its bud transmission and relation to xyloporosis and tristeza. *Phytopathology* 42: 265-268.
5. CHILDS, J. F. L. 1956. Transmission experiments and xyloporosis-cachexia relations in Florida. *Plant Disease Repr.* 40: 143-145.
6. DUCHARME, E. P., and KNORR, L. C. 1954. Vascular pits and pegs associated with disease in citrus. *Plant Disease Repr.* 38: 127-142.
7. GRANT, T. J., GRIMM, G. R., and NORMAN, P. 1959. Symptoms of cachexia in Orlando tangelo, none in sweet lime and false symptoms associated with purple scale infestations. *Plant Disease Repr.* 43: 1277-1279.
8. NORMAN, G. G., NIXON, R. R., JR., HORNE, L., and GRANTHAM, J. T. 1959. Symptoms indicating xyloporosis in uninoculated Orlando tangelo seedlings. *Plant Disease Repr.* 43: 1120-1121.
9. NORMAN, P. A., and CHILDS, J. F. L. 1963. Attempted transmission of xyloporosis of citrus with insects. *Proc. Florida State Hort. Soc.* 76: 48-50.

PROCEEDINGS of the IOCV

10. OLSON, E. O., SLEETH, B., and SHULL, A. V. 1958. Prevalence of viruses causing xyloporosis (cachexia) and exocortis (Rangpur lime disease) in apparently healthy citrus trees in Texas. *J. Rio Grande Valley Hort. Soc.* 12: 35-43.
11. OLSON, E. O., SHULL, A., and BUFFINGTON, G. 1961. Evaluation of indicators for xyloporosis and exocortis in Texas, p. 159-165. *In* W. C. Price [ed.], *Proc. 2nd Conf. Intern. Organization Citrus Virol.* Univ. Florida Press, Gainesville.
12. OLSON, E. O. 1965. Evidence that xyloporosis virus does not pass through seeds of Palestine sweet lime, p. 86-89. *In* W. C. Price [ed.], *Proc. 3d Conf. Intern. Organization Citrus Virol.* Univ. Florida Press, Gainesville.
13. REICHERT, I., and PERLBERGER, J. 1934. Xyloporosis, the new citrus disease. *Jewish Agency for Palestine, Agr. Exp. Sta. (Rehovot) Bull.* 12, p. 1-50.
14. REICHERT, I., BENTAL, A., and YOFFE, I. 1956. Transmission experiments on the tristeza and xyloporosis diseases of citrus. *Ktavim (Rehovot, Israel)* 6: 69-75.
15. REICHERT, I. 1959. A survey of citrus virus diseases in the Mediterranean area, p. 23-28. *In* J. M. Wallace [ed.], *Citrus Virus Diseases*, Univ. Calif. Div. Agr. Sci., Berkeley.