On the Transmission and Translocation of the Greening Pathogen in Citrus

A. L. MARTINEZ

THIS PAPER describes studies on the transmission and translocation of the infectious agent of greening (leaf-mottle-yellows) in tests conducted in a screenhouse of the Lipa Experiment Station, Bureau of Plant Industry, Lipa City. The greening pathogen was transmitted from a field tree by the vector *Diaphorina citri* Kuw. to small trees of Szinkom mandarin on calamandarin rootstock, which subsequently served as sources of inoculum for the experiments. The small source trees were maintained in the screenhouse.

Materials and Methods

TRANSLOCATION.—A ring of bark 3 cm wide was removed from the stem of seedlings of Ladu, ponkan, and Szinkom mandarin and Madam Vinous sweet orange. The seedlings were then inoculated by grafting 3 inoculum buds from the source trees below the girdled portion of the stem or, in another group of test seedlings, above the girdled portion.

All girdled plants exhibited leaf abnormalities characteristic of nutritional deficiency symptoms within

10 months of inoculation. The inoculated and noninoculated portions of each test plant were indexed separately to Szinkom mandarin seedlings. The greening pathogen was detected in the inoculated portions of all test plants but not in the noninoculated portion of any of them. The results suggest that the pathogen was translocated in the phloem—that it failed to enter the xylem where it could be translocated across the girdled area.

TIME REQUIRED FOR TRANSMISSION FROM INFECTED BUDS.—Seedlings of Ladu and ponkan mandarin were inoculated by placing 2 inoculum buds from the source trees at the same height in their stems. On the fifth day, and on every day until the sixteenth day, 3 inoculated seedlings of each variety were cut back immediately below the inoculum buds. All the test plants were observed for the appearance of greening symptoms.

TABLE 1. NUMBER OF SEEDLINGS INFECTED OF 3 INOCULATED WHEN INOCULUM BUDS WERE REMOVED AFTER THE NUMBER OF DAYS INDICATED

Treated seedlings	Number of days inoculum buds remained in test plants											
	5	6	7	8	9	10	11	12	13	14	15	16
Ladu	0	0	1	1	0	2	2	3	3	3	3	3
Ponkan	0	0	1	0	2	1	2	3	3	3	3	3

No infection occurred when the stem sections bearing the inoculum buds were removed on the fifth and sixth days after inoculation (Table 1). Two of the 6 plants were infected when the buds were removed on the seventh day. All plants were infected when the inoculum was left in the plants 12 days or longer.

In a second experiment, inoculum buds were left in plants 5, 6, and 7 days. There was no infection in the 5- and 6-day groups, but 5 of the 10 plants in the 7-day group became infected.

Conclusions and Discussion

The results reported above—that the greening pathogen moved from the inoculum buds to seedlings of Ladu and ponkan mandarin in 7 days and that it failed to move upward or downward through the girdled portion of the stem of Ladu, ponkan, and Szinkom mandarin and Madam Vinous sweet orange—may be compared with those reported by others.

Nour-Eldin and El-Banna (3) reported that psorosis virus can enter the xylem of sweet orange plants and move downward through a ringed area of the stem, and that upward movement takes place much less frequently, if at all. Price (4) on the contrary, found that psorosis and tristeza viruses both failed to move upward or downward through the girdled portion of stems of citrus seedlings and concluded that both viruses are translocated in the phloem, not the xylem. Another study (5) has demonstrated that psorosis and tristeza viruses, after entering the plants, move rapidly in both directions.

Price (4) reported that tristeza virus passed from the inoculation bud to the seedling stock within 8–17 days and that psorosis virus passed within 9–17 days. He stated that the varia-

tion in movement of both viruses is related to the time required for the stock and scion to unite. Salibe (6) reported that a period of 5–13 days is necessary for exocortis virus to move from the inoculating bud into the rootstock, but Garnsey and Jones (1) more recently found that exocortis virus is easily transmitted by an instantaneous cut through citrus tissues with a contaminated knife or razor blade. Evidently, in Salibe's experiments transmission was not obtained during the initial contact between the infected scion and the stock but only after a union of sorts had been accomplished. Kunkel (2) reported that the virus of peach mosaic passed from the inoculating bud to the stock in 2 or 3 days but that the pathogens of peach yellows and peach rosette did not pass until the eighth to the fourteenth day. It does not seem likely that a true union of stock and scion in a woody plant can be made in 2 days, and consequently it may be that only contact between the protoplasts of living cells of the stock with those of the scion are required for transmission of some pathogenic agents but that an actual union is required for others. It is possible also that not only the nature of the pathogen but also its concentration in the inoculating bud and its rate of movement in the host plant may be of importance in the rate of movement between scion and stock. If an actual union between stock and scion is required for transmission, then the rate at which this union occurs will determine the length of time required for transmission. This rate is no doubt influenced by the growth conditions of both the inoculum buds and the seedlings in which they are placed. The growth of both would be expected to depend upon temperature, nutrition, and other factors of the environment. In the studies described in this paper, 7 days were required before infection took place. It was not determined whether vascular connections were established in that period of time.

ACKNOWLEDGMENT.—The author wishes to thank Dr. J. M. Wallace for his valuable suggestions and for editing this paper.

Literature Cited

1. GARNSEY, S. M., and JONES, J. W. 1967. Transmission of exocortis virus with contaminated budding tools. Plant Disease Reptr. 51: 410–13.
2. KUNKEL, L. O. 1938. Contact periods in graft transmission of peach viruses. Phytopathology 28: 491–97.
3. NOUR-ELDIN, F., and EL-BANNA, M. T. 1965. Distribution and movement of psorosis and tristeza viruses in citrus plants, p. 272–75. *In* W. C. Price (ed.), Proc. 3d Conf. Intern. Organization Citrus Virol. Univ. Florida Press, Gainesville.
4. PRICE, W. C. 1968. Translocation of tristeza and psorosis viruses, p. 52–58. *In* J. F. L. Childs (ed.), Proc. 4th Conf. Intern. Organization Citrus Virol. Univ. Florida Press, Gainesville.
5. PRICE, W. C., and KNORR, L. C. 1960. Isolation, characterization and interrelationship of citrus viruses. Univ. Florida Agr. Expt. Sta. Ann. Rept., p. 204.
6. SALIBE, A. A. 1965. Distribution and movement of exocortis virus in citrus trees, p. 276–79. *In* W. C. Price (ed.), Proc. 3d Conf. Intern. Organization Citrus Virol. Univ. Florida Press, Gainesville.