Effect of Host Preference on Transmission of Curly Top Virus to Tomato by the Beet Leafhopper

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ABSTRACT

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During the 1st hr after viruliferous beet leafhoppers were confined on seedlings of a preferred host, sugar beet, and a nonpreferred host, tomato, an equal percentage of plants of the two species became infected. During the next 3 hr, percentage transmission to tomato was twice as great as to sugar beet. Thereafter, transmission to sugar beet continued steadily, but transmission to tomato dropped off and nearly stopped 8 hr after confinement. This pattern of transmission appeared to reflect changes in feeding behavior and health of the vector when confined on the two species. Leafhoppers confined on tomato began dying after 12-16 hr, and few were still alive after 72 hr. Leafhoppers fed only 3% sucrose solution lived for up to 2 wk. Leafhoppers fed only water died at about the same rate as those on mature tomato. Leafhoppers held 8 hr on tomato and 16 hr on sugar beet daily lived as well as those on sugar beet.

Additional key words: *Circulifer tenellus*, *Lycopersicon esculentum*.

Curly top virus (CTV) is transmitted in nature in North America only by the beet leafhopper, *Circulifer tenellus* (Baker) (1). The virus is circulative but not propagative in the vector. The capacity of the vector to transmit CTV continues essentially undiminished for life when the vector is reared on infected plants (1).

The cultivated tomato, *Lycopersicon esculentum* (Mill.) is not a satisfactory host of the beet leafhopper. Our observations repeatedly have confirmed reports (4, 7) that the leafhopper feeds only transiently in tomato fields, will not reproduce on tomato plants, and will die within days if confined on tomato plants. Yet, the vector transmits CTV to tomatoes, and the infection incidence often approaches 100% in fields in Western United States (11). Several other species which are not satisfactory hosts of the vector also are affected by CTV (8).

Instances of vector-virus-host relationships like this one, in which the host of the virus is not a satisfactory host of the vector, occur commonly in nature (3). However, the authors are not aware of previous virus transmission studies involving relationships of this type.

We previously reported (10) that beet leafhoppers released on a mixed planting of tomato and sugar beet seedlings initially moved equally to both kinds of plants without distinguishing between them. Later, after a trial feeding of about 45 min, leafhoppers began to accumulate on the preferred sugar beet seedlings through a random movement and sampling process.

The previous observations suggested that feeding behavior and health of beet leafhoppers change rapidly when they feed on tomato. If such changes are likely to alter virus transmission, results of transmission studies that require long exposure period, or that presuppose that test and control plants receive equal inoculation, could be affected.

The purpose of these studies was to determine how progressive changes in feeding preference and health of the vector affect rate of virus transmission to a nonpreferred host, tomato, as compared to a preferred host, sugar beet.

MATERIALS AND METHODS

Rate of infection at intervals after leafhoppers were confined on plants was compared for susceptible tomato cultivar, VR Moscow, and the susceptible sugar beet cultivar, NB4. Leafhoppers were captured the day before the experiments began, placed three per cage in 1.2-cm clip cages, and held overnight on sugar beet leaves. At 0800 hours, 64 cages were placed on cotyledons of sugar beet seedlings and 64 were placed on tomato seedlings. In each of 10 replications, 16 plants of each species were exposed for 1, 4, 8, or 24 hr, then cages were removed and the number of plants which later developed symptoms was noted.

To determine the longevity of leafhoppers confined on tomatoes, a black polyethylene film was stretched over a 10-cm diameter clay pot filled with composted soil and held in place with a rubber band. Five VR Moscow tomato seedlings were transplanted through small slits in the polyethylene. Five days after transplanting when true leaves were beginning to unfold, a lamp chimney, its top covered with cheesecloth, was placed over the seedlings.

Fifteen leafhoppers were introduced, and the pot was placed under a bank of cool-white fluorescent lights. Ambient temperature was 27 C, light intensity 11,800 lux, and daylength 16 hr. The number of dead leafhoppers, easily observed against the black polyethylene, was counted at intervals. This experiment was repeated 16 times.

To determine longevity of leafhoppers artificially fed on 3% sucrose or on water, 10 leafhoppers were placed in a cage made with 3.7-cm I.D. acrylic tubing cut into 2.5-cm lengths and covered on the ends with nylon netting. A 4-cm square of Parafilm was stretched into a thin film and placed over one end of the cage. One drop of water or sucrose solution (0.6 ml) was placed on the Parafilm, and a second Parafilm membrane was stretched over the first. The liquid was sandwiched between the two Parafilm membranes. The cages were placed on a light box, liquid up, and the leafhoppers readily fed on the liquid through the membrane. On alternate days fresh liquid was injected between the membranes with a hypodermic needle, and the number of dead leafhoppers was counted daily. Temperature at cage level was 26 C. This experiment was repeated 10 times each with sucrose and water.

To determine the effect of feeding leafhoppers alternately on sugar beet and tomato plants, three groups of ten 1.2-cm clip cages were prepared with five leafhoppers each. One group was held continuously on mature leaves of sugar beet plants, another was held on mature leaves of VR Moscow tomato plants, and the third was held on tomato from 0800 to 1700 hours, then transferred back to sugar beet the remainder of each day. The number of dead leafhoppers was counted daily for 12 days.

RESULTS

The rate of transmission of CTV at intervals after beet leafhoppers were confined on plants differed in tomatoes and sugar beets (Fig. 1). During the 1st hr the rate of transmission was the same to tomatoes and sugar beets, but the rate of transmission was nearly twice as high to tomato as to sugar beet between the 1st and 4th hr of exposure. Transmission of CTV to tomato dropped off sharply after 4 hr and it nearly ceased after 8 hr. Transmission to sugar beet continued steadily, and within 24 hr more sugar beet than tomato plants became infected.

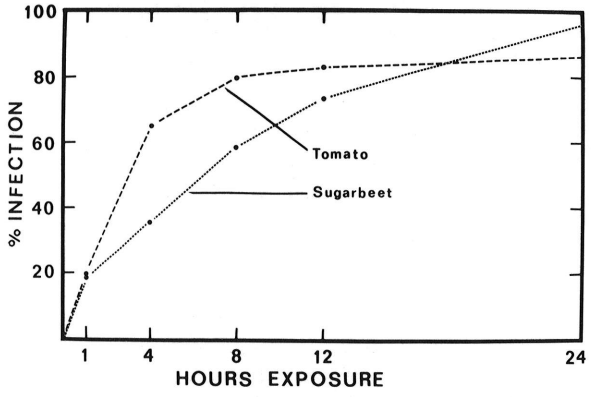

Fig. 1. Rate of transmission of curly top virus by the beet leafhopper to tomato and sugar beet seedlings.

Leafhoppers began dying 12-16 hr after confinement on tomatoes, and few remained alive after 3 days (Fig. 2). Some leafhoppers in the pots of tomato seedlings were observed resting on the sides of the lamp chimney cages, but most remained on the plants and appeared to continue feeding until death. Occasionally a leafhopper remained attached to the plant after death, apparently with its stylets inserted.

The mortality rate of leafhoppers confined on tomatoes was essentially the same as that for leafhoppers fed only water (Fig. 2). A slight delay in mortality occurred among the group confined on seedling tomatoes as compared with those on mature tomatoes or water, but after 4 days the mortality was the same in the three groups.

Leafhoppers fed only 3% sucrose survived much longer than did those on tomato or water (Fig. 2). After five days 50% remained alive, and after 2 wk a few still were alive.

Leafhopper survival was the same for the group confined on tomatoes for 8 hr and sugar beet 16 hr daily as for the group that received a steady sugar beet diet (Fig. 2). Nearly 70% of the leafhoppers remained alive after 12 days.

DISCUSSION

It is clear, based on these results, that feeding behavior and health of beet leafhoppers change rapidly when they feed on tomatoes. These changes markedly alter the pattern of virus transmission to tomato from that expected on a preferred host and must be accounted for in transmission studies. The fact that transmission to tomato is actually stimulated at one stage may help explain why transiently feeding leafhoppers so efficiently transmit CTV in fields of tomatoes.

It was not surprising that beet leafhoppers transmitted CTV as often to tomato as to sugar beet during the 1st hr of exposure, since previous results (7) indicated that leafhoppers placed on the two species do not distinguish

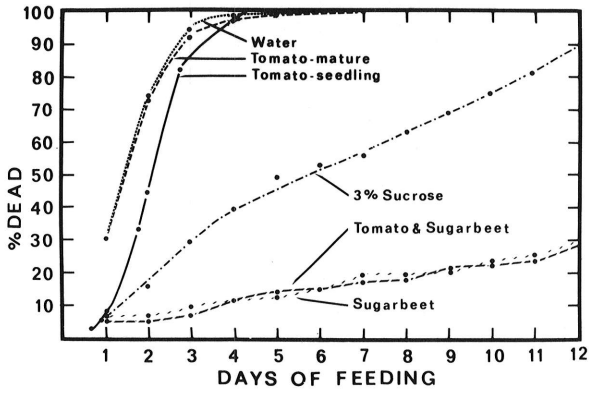

Fig. 2. Mortality rate of beet leafhoppers artificially fed water, artificially fed 3% glucose, confined on tomato seedlings, confined on mature tomato leaves, confined on mature sugar beet leaves, or alternately confined on tomato 8 hr and sugar beet 16 hr daily.

between them until after a 45-min trial feeding period. In the previous study, leafhoppers routinely departed from tomato after the trial feeding period and selected the preferred host, sugar beet, by a random movement and sampling process. Therefore, the high rate of CTV transmission to tomato compared with sugar beet between the 1st and 4th hr after confinement was unexpected. This result suggests that leafhoppers repeatedly may probe (i. e., sample) the same tomato plant when the random movement portion of their normal host selection process is prevented. Repeated probing may result in a higher rate of transmission than the steady feeding from a single probe that usually occurs on sugar beet. The report by Bennett and Wallace (2) who found that most CTV transmission occurs within the first 3-5 min of a single probe supports this hypothesis.

It seems probable that the rapid decline and near cessation of virus transmission to tomato after 8 hr of confinement is related to the death of leafhoppers on tomato which began a few hours later. Refusal of leafhoppers to feed on tomato at this stage could account for both cessation of transmission and ultimately death of the leafhoppers. The fact that leafhoppers fed alternately on tomatoes and sugar beets lived as well as those fed continuously on sugar beet supports this hypothesis. This fact also negates the possibility that the leafhoppers succumbed to a toxic substance from tomato. Furthermore it is unlikely that tomato failed to provide sufficient nutrients to sustain life since they lived much longer on 3% sucrose than on tomato, and sucrose, the main sieve tube constituent (6), ranges in concentration from 10 to 25% depending on species (9).

An alternate hypothesis accounting for the death of leafhoppers on tomato is found in the report by Green and Ryan (5) that a powerful inhibitor of animal proteinases accumulates in tomato in response to mechanical wounding or feeding by insects. In their studies, the inhibitor was detectable within 12 hr after wounding, and in our experiments, leafhoppers began dying 12-16 hr after confinement. Thus, leafhoppers confined on tomato might die of protein starvation. However, since leafhoppers lived much longer on a sucrose solution devoid of protein, other factors might be involved.

Studies are underway to determine whether the proteinase inhibitor which accumulates in tomato foliage in response to leafhopper feeding functions as a protective mechanism against the beet leafhopper.

LITERATURE CITED

1. BENNETT, C. W. 1971. The curly top disease of sugarbeet and other plants. Phytopathological Monograph No. 7. The American Phytopathological Society, St. Paul, Minnesota. 81 p.
2. BENNETT, C. W., and H. E. WALLACE. 1938. Relation of the curly-top virus to the vector, Eutettix tenellus. J. Agric. Res. 56:31-52.
3. BROADBENT, L. 1964. Control of plant virus diseases. Pages 330-364 *in* M. K. Corbett and H. D. Sisler, eds. Plant Virology. University of Florida Press, Gainsville. 527 p.
4. CANNON, O. S. 1960. Curly top in tomatoes. Utah Agric. Exp. Stn. Bull. 424. 12 p.
5. GREEN, T. R., and C. A. RYAN. 1972. Wound-inducing proteinase inhibitor in plant leaves: A possible defense mechanism against insects. Science 175:766-777.
6. KURSANOV, A. L. 1963. Metabolism and the transport of organic substances in the phloem. Pages 209-274 *in* R. D. Preston, ed. Advances in botanical research, Vol. 1. Academic Press, New York. 384 p.
7. SEVERIN, H. H. P. 1928. Transmission of tomato yellows, or curly top of sugar beet, by Eutettix tenellus (Baker). Hilgardia 3:251-275.
8. SEVERIN, H. H. P., and C. F. HENDERSON. 1928. Some host plants of curly top. Hilgardia 3:339-393.
9. SWANSON, C. A. 1959. Translocation of organic solutes. Pages 481-551 *in* F. C. Steward, ed. Plant Physiology, Vol. 2. Academic Press, New York. 758 p.
10. THOMAS, P. E. 1972. Mode of expression of host preference by Circulifer tenellus, the vector of curly top virus. J. Econ. Entomol. 65:119-123.
11. THOMAS, P. E., and M. W. MARTIN. 1971. Apparent resistance to establishment of infection by curly top virus in tomato breeding lines. Phytopathology 61:550-551.