Etiological Distinctions Between Tomato Yellow Top Virus and Potato Leafroll and Beet Western Yellows Viruses

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ABSTRACT

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Tomato yellow top virus (TYTV) is serologically related to potato leafroll (PLRV) and beet western yellows (BWYV) viruses. Tests were performed to determine whether the etiology of TYT disease was the same as that of PLR or BWY diseases in tomatoes, potatoes, and sugar beets. In August, TYTV-infected tomato plants occurred sparsely and were distributed at random in a field adjacent to a plot of potatoes chronically infected with PLRV. In contrast, a high incidence of PLRV was detected in symptomless tomato plants in the row adjacent to the potato plot. The distribution and incidence of TYT-diseased plants throughout the field adjacent to PLRV-diseased potatoes was similar to that found in a field 300 m away. Sugar beets were grown between rows of tomatoes that contained about 50% TYTV-infected tomato plants by the end of the season. Among 500 sugar beets tested, none were infected with a virus transmissible to *Physalis floridana*, a common host of the three viruses. Therefore, the etiology for TYT was distinct from that of PLR or BWY diseases despite serological relationships between the causal viruses. Although potatoes are not involved in the epidemiology of TYTV at present, the virus infects potato and could become prevalent in potatoes because it produces mild symptoms in this host. Thus, it could have an important economic impact on both tomato and potato production.

A new tomato disease called tomato yellow top (TYT) first appeared in the Yakima Valley of eastern Washington in 1973 (8). We have shown that TYT is caused by a luteovirus (TYTV) that is related to, but distinct from, potato leafroll virus (PLRV) and beet western yellows (BWYV) (4). Antisera of the TYTV of Washington reacted with the TYTV of Australia (6) in agar double-diffusion tests (J. E. Thomas, *personal communication*) and with an isolate of the TYTV of Florida (10) obtained from J. E. Duffus. Antisera of TYTV isolates react with isolates of PLRV and BWYV in varying degrees (*unpublished*).

Because of the relationship between their causal viruses, it seemed possible that the epidemiology of TYT would be associated with that of potato leafroll disease (PLR) in eastern Washington, where potato is a major crop and where overwintering potato volunteers provide an abundance of PLRV inoculum (7). It also seemed possible that the epidemiology of TYT could be associated with sugar beets. The TYT syndrome was first observed in tomatoes interplanted with rows of sugar beets in beet curly top virus (BCTV) elimination trials, and Duffus (2) has shown that many PLR-diseased potatoes of the Northwest contain virus variants serologically related to BWYV.

These studies on the epidemiology of TYT were performed to determine whether its etiology was the same as that of PLR and BWY diseases.

MATERIALS AND METHODS

Standard ELISA procedures, described by Clark and Adams (1), were used in these studies, with minor variations in incubation times and temperatures. Antiserum, prepared in our laboratory, against a standard isolate (no. 1) of PLRV that does not infect *Capsella bursa-pastoris* (L.) was used.

Physalis floridana (Rydb.) was used as the index host in the greenhouse because it is a common host of PLRV, BWYV, and TYTV. Green peach aphids were placed on leaves of test plants in petri dishes containing moist filter paper for 48 hr, transferred to small seedling plants for 72 hr, and killed with nicotine sulfate fumes in a chamber. Symptom development was observed for 6 wk after inoculation.

RESULTS

Association with potatoes. To determine whether the epidemiology of TYT was associated with potatoes, a 0.5-ha plot of tomatoes was grown beside a 0.5-ha plot of potatoes. The potatoes were nearly 100% chronically infected with PLRV. There was no interruption or obstacle between tomato and potato rows that would hamper free dissemination of vectors, and insecticides were not applied to either species. Two groups of 10 healthy potato plants were grown in the potato row adjacent to the first row of tomatoes. A control plot of tomatoes, isolated from the immediate inoculum source of the potato plot, was grown 300 m from the test plot.

All healthy control potatoes in the row adjacent to the tomatoes had distinct current-season symptoms of PLR by the end of June. A 4- to 5-wk incubation period is required in the spring for potatoes to develop PLR symptoms (9). Thus, all control plants already had contracted infection by the end of May, at the latest. During the second week of June, 436 green peach aphids (*Myzus persicae* (Sulzer)) were counted on 100 potato leaflets harvested near the soil line at random locations in the potato plot, and numerous winged aphids were observed on tomato plants in August. These data establish that an intense potential for rapid dissemination of aphid-transmissible viruses began at the interface between the inoculum source (potato plot) and the tomato plot early in the spring and continued to emanate from the potato plot throughout the season.

The TYT-diseased plants in the tomato plot were easily recognized by their conspicuous symptoms. Only 21 plants developed TYT disease in the entire tomato plot, a lower incidence of the disease than had been observed in tomato fields in any previous year since the disease was discovered. The 21 infected plants were not concentrated in the rows adjacent to the potato rows but were evenly distributed across the entire plot, with no more than three infected plants in any row. A similar incidence and distribution (a total of 29 infected plants, with zero to four infected plants per row) of TYT-diseased plants occurred in the control plot isolated from potatoes.

Because tomato plants experimentally infected with PLRV in the greenhouse had very mild symptoms, it seemed possible that symptomless PLRV-infection might be present in tomato

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plants in rows adjacent to potato plants. To test this possibility, aphid transmission to indicator hosts was attempted in August from 18 randomly selected tomato plants in the row adjacent to potatoes. PLRV was transmitted from six of the 18 plants tested.

A very mild yellows-type symptom began appearing widely among tomato plants late in August and it intensified in September. Because the symptoms were mild and variable and the plants were senescing, it was impossible to distinguish with certainty which plants had symptoms. However, aphid transmissions were attempted from 18 plants without symptoms and from an equal number with symptoms. PLRV was transmitted from three of 18 plants without symptoms and from nine of 18 plants with apparent mild yellows symptoms. Survival of aphids on tomato leaves was poor, however, because the leaf surfaces contained a thick exudate in which the aphids were entrapped. A much higher incidence of PLRV infection was detected in the same plants by ELISA than by aphid transmission. PLRV was detected in 12 of 18 plants with symptoms and in six of 18 without symptoms. Plants containing PLRV clearly did not show the typical, conspicuous symptoms of TYT disease.

Association of TYTV with sugar beets. A 2-ha plot used to screen tomato progeny for BCTV resistance was employed to test the association between sugar beets and epidemiology of TYT. Sugar beets (cultivar mixture Klien E, U.S. 33, and a commercial seedlot) were interplanted in every third row with tomatoes. Near the end of June, July, August, and September, transmissions were made individually from each of 100 sugar beets to *P. floridana* in a greenhouse, using 15 aphids per transmission. For the September tests, beets were selected that appeared most likely to be infected with BWYV. In the other months, test beets were selected randomly throughout the field.

About 50% of the tomatoes developed TYT symptoms by the end of the season. A heavy infestation of annual black nightshade (*Solanum nigrum* (L.)) plants, growing as weeds in the tomato field, contained many aphids. Virtually all nightshade plants had PLR-like disease symptoms at the end of the season, evidence that an intense potential for dissemination of aphid-transmissible viruses existed in this plot. Not a single sugar beet, among 500 tested, contained a virus transmissible to *P. floridana* by aphids.

DISCUSSION

The virus that incited TYT disease was etiologically distinct from those that cause PLR and BWY diseases. The random distribution and low incidence of TYT in a tomato plot under an intense potential for PLRV dissemination emanating from one side and the demonstration that PLRV was present in tomato plants that did not express TYT symptoms are strong indications that TYTV is etiologically distinct from PLRV. These results are also evidence that TYTV is an uncommon component, if it exists at all, among the complex of variants causing PLR disease in the northwestern United States. The demonstration that sugar beet plants grown between rows of TYTV-infected tomatoes did not contain a virus that would infect *P. floridana* was strong evidence that TYTV was also etiologically distinct from BWYV. The biological distinction occurs despite the fact that some isolates of TYTV are serologically related to BWYV and to PLRV and some infect the critical host of BWYV, *C. bursa-pastoris* (2).

The finding that TYTV is not a component of the PLRV complex that infects potatoes of the Northwest supports our earlier conclusion (7) that it is a new virus in the region. Although TYTV infects potatoes (4), it has not become endemic in potatoes of the Northwest since its first appearance 10 yr ago. Few of the seed potatoes grown in Washington are produced there. Thus, the chances for seed-piece transmission of TYTV is reduced. The lack of endemicity in potatoes may also reflect differences in epidemiological factors affecting the two viruses.

Because TYTV produces very mild or no symptoms on potato, its introduction into potatoes could have an important impact on the potato industry. At present, leafroll is reduced to trace levels in seed potatoes by roguing plants with symptoms from seed production fields. Because it would be difficult to recognize TYTV-infected plants on the basis of symptoms, the virus could become prevalent, thus causing a major economic problem in the potato industry. We do not know whether TYTV causes the typical PLRV tuber symptoms called net necrosis. If so, this would increase its economic impact.

Howell and Mink (5) found a high incidence of BWYV in sugar beets throughout the growing region in eastern Washington. They implicated volunteer sugar beets as the chief source of overwintering inoculum. Because sugar beets have not been grown in eastern Washington since 1978, there are no more volunteer sugar beets, and BWYV is no longer found in sugar beet research plots.

When potato plots are grown in eastern Washington without protection of insecticides, nearly all of the plants become PLR-diseased (3), as did the black nightshade weeds growing in the plot containing tomatoes and sugar beets. BWYV has been implicated as a major causative component of the PLR disease syndrome in the northwestern United States (2). None of the sugar beets in these studies were infected by a virus that could be transmitted to *P. floridana*, a common host of BWYV, PLRV, and TYTV. Thus, variants of BWYV that occur in potatoes in the Northwest are variants that do not infect sugar beet.

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