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FIRST REPORT OF TOMATO SPOTTED WILT VIRUS (TSWV) ON FIELD-GROWN PEPPERS IN THE MIDWEST

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Tomato spotted wilt was first observed in Australia in 1915 on tomatoes and was shown to be caused by a virus, TSWV, in 1930 (Francki and Hatta, 1981). TSWV particles are roughly spherical in shape approximately 85 nm in diameter with a lipoprotein envelope and may contain 4 major structural polypeptides. The nucleic acid of TSWV is a single-stranded RNA. The TSWV is now considered to have a world-wide distribution. It has been of great interest to plant pathologists, because of the serious diseases it can cause in a number of important crops, its extremely wide host range, and its transmission by thrips. TSWV appears to be the only virus transmitted by thrips.

In both greenhouse and field crops, over 170 species of plants in 35 different families are susceptible to TSWV. TSWV is seed transmitted in only one floral plant, *Cineraria* (R. K. Jones, NCSU, personal communication). The host range of ornamental plants includes cut flowers, pot plants, bedding plants, and some houseplants (Table 1). Tomato spotted wilt virus also affects non-ornamental field crops (Table 2), and numerous weed hosts (Table 3), which may serve as reservoirs for the virus.

Greenhouse epidemics of this virus disease had not been noted prior to the introduction of *Frankliniella occidentalis*, the western flower thrips (WFT), as the dominant species in the 1950's (Robb, *et al.*, 1988). The genetic potential of the virus for a significant rate of mutation along with the ability of WFT to develop insecticide resistance may have contributed to the rapid establishment of TSWV in greenhouse crops. Only thrips which acquire TSWV while they are in the larval stage can successfully transmit the virus to other plants as adults (R. Mau, U. HI, personal communication). Thus, the virus only survives for one thrips generation.

General symptoms of TSWV infection include ringspots and line patterns on leaves, stem necrosis, and a general ragged appearance due to developing necrotic areas on leaves. Symptom development may be slow on some plants and appears to be affected by the age of the plant and the stage of growth when infection occurs. Symptoms may also mimic those caused by *Phytophthora* root rot or other fungal wilts. Flowers may also become spotted or distorted (Nameth, *et al.*, 1988).

During the summer of 1988, samples of pepper plants showing symptoms typical of a virus disease were submitted to the diagnostic clinic for disease iden-

TABLE 1. Ornamental hosts of tomato spotted wilt virus (Best, 1968; Matteoni, *et al.*, 1988).

African Violet	Cineraria	Geranium	Phlox
Ageratum	Coleus	Gerbera	Poppy
Amaranthus	Columbine	Gladiolus	Primrose
Amaryllis	Cosmos	Gloxinia	Ranunculus
Anemone	Cyclamen	Gypsophila	Salvia
Aster	Dahlia	Impatiens	Schefflera
Begonia	Delphinium	Lobelia	Snapdragon
Calceolaria	Dusty Miller	Lupin	Stock
Calendula	Evening Primrose	Marigold	Tiger Lilly
Calla Lilly	Exacum	Morning Glory	Verbena
China Aster	Forget-Me-Not	Nasturtium	Zebra Plant
Christmas Pepper	Fuschia	Poeny	Zinnia
Chrysanthemum		Petunia	

TABLE 2. Non-ornamental crop hosts of tomato spotted wilt virus (Best, 1968; Francki and Hatta, 1981).

Artichoke	Eggplant	Potato
Broad Bean	Endive	Romaine
Cauliflower	French Bean	Snap Bean
Celery	Garden Pea	Spinach
Chicory	Papaya	Sweet Pea
Coriander	Peanut	Tobacco
Cos Lettuce	Peppers	Tomato
Cowpea	Pineapple	

TABLE 3. Weed hosts of tomato spotted wilt virus (Best, 1968; Cho, 1987).

Amaranthus spp.	Jimson Weed (*Datura* sp.)
Beggarticks (*Bidens* sp.)	Lambsquarter (*Chenopodium* sp.)
Bindweed (*Polygonum* sp.)	*Malva* sp.
Bull Thistle (*Cirsium* sp.)	Mesembryanthemum
Capsella sp.	*Montia* sp.
Chickweed (*Stellaria* sp.)	Nightshades (*Solanum* sp.)
Conyza bonariensis	Poppy
Coreopsis	Saxifrage
Crepis spp.	Sow Thistle (*Sonchus* sp.)
Emilia sp.	Wild Tobacco
Gaillardia sp.	Yellow Sweet Clover (*Meliotus* sp.)
Godetia	

tification. The samples were from three separate commercial pepper fields in northern Indiana. Two of the fields near Plymouth were planted to sweet banana and sweet cherry peppers; the third field, in Highland, was planted to bell peppers. The sweet banana and sweet cherry samples were transplants which had been direct seeded into fumigated beds in Georgia, pulled and packaged, shipped into Indiana, and planted in late May. The bell peppers were raised in a greenhouse in northern Indiana and then transplanted to the field.

Symptoms of stunted plants were first noted in early July. In all three fields, less than 5% of the plants showed symptoms. The symptoms on diseased plants included distorted foliage and the ring patterns characteristic with TSWV. Diagnosis by symptoms alone, however, was not sufficient, since tomato ringspot virus and several other viruses also cause similar symptoms on peppers. Thus, serological confirmation of the suspected virus via Enzyme Linked Immunosorbent Assay (ELISA) was necessary. Samples of leaf tissue were sent to Dr. C. Sutula at AGDIA, a privately owned company in Mishawaka, Indiana, which performs serological testing for numerous virus diseases on a number of different hosts. Samples were also sent to Dr. S. T. Nameth at Ohio State University in Columbus, Ohio. Both labs confirmed the presence of TSWV in the leaf tissue via the ELISA technique. In addition, Dr. Nameth used double-stranded RNA (dsRNA) analysis to confirm the TSWV diagnosis. No dsRNA was present in the pepper tissue, thus ruling out tomato ringspot virus and other pepper virus diseases containing dsRNA. With two independent positive ELISA results and the negative dsRNA result, we felt confident of our diagnosis of TSWV as the causal agent. Future studies could include detection of inclusion bodies in infected tissue (Christie and Edwardson, 1986) and the use of bioindicator plants (Nameth, *et al.*, 1988).

As the summer progressed, the disease incidence remained less than 5%. However, the severity of the symptoms increased. The lack of disease spread in the field was attributed to the absence of the WFT vectors. The pepper plants were apparently infected as young seedlings (both in Georgia and in the greenhouse situation). Perhaps, the symptoms were not visible until a later date due to a long incubation associated with TSWV infection. Notably, the Indiana greenhouse which housed the pepper seedlings also housed the floriculture seedlings, thus increasing the chance of the presence of the WFT.

In conclusion, the occurrence of TSWV in the field has raised several questions concerning:

1. Commercial growing practices such as those of mixing floricultural and vegetable crops in the same greenhouse;
2. Proper control strategies for the disease;
3. The possibility of new strains of TSWV; and
4. The necessity of disease-free transplants.

The first step in control is to get rid of infected plants. This is easier said than done, especially since plants may harbor the virus but show no symptoms. In addition, weeds must be eliminated in and around greenhouses and fields. Before killing weeds or discarding infected plants, they should be sprayed with an insecticide effective against thrips to lessen the chance that the insects will disperse as plants are moved or as weeds begin to die. The second major way in which TSWV can be managed is to control thrips. Management of WFT on greenhouse ornamentals and vegetables is extremely difficult. A combination of physical exclusion as well as cultural and chemical methods must be used to keep populations low enough to prevent visible plant damage and/or slow the spread of the TSWV. The use of yellow sticky traps to monitor thrips population trends is also extremely important.

The importance of healthy transplants for the commercial vegetable industry as well as the ornamental industry is a point which is often overlooked. Growers must be aware of potential problems and strive to produce disease-free transplants.

Recipients of transplants should take precautions to stave off the spread of potential problems by:

1. Refusing infected plants;
2. Monitoring fields and greenhouses for the Western Flower Thrips and other thrips;
3. Observing plants in the greenhouse and field for symptom expression; and
4. Being ready to initiate control procedures.

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