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Tomato Spotted Wilt Virus in California Processing Tomatoes

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Most tomato growers, processors, pest control advisers, and allied industries know that since 2003 there has been increased incidence of *Tomato spotted wilt virus* (TSWV) in several tomato growing areas of California. Certain areas of the Westside of Fresno County have been particularly hard hit in 2005 and 2006, but the disease has been showing up in other crops in coastal and desert areas as well. Tomato plant symptoms are characterized by an initial chlorosis of leaves and terminal shoots that may develop into bronzing and necrosis. Fruit symptoms show faint to obvious concentric rings on green and/or red fruit. Sometimes the fruit is severely blotched, deformed, and unmarketable.

What we know about TSWV

The Economic Hosts: This virus is found worldwide and has one of the most extensive host ranges of any known plant virus infecting over 900 species of plants. Most are dicots, but some monocots are also susceptible. The important economic agricultural crops in CA are tomatoes, peppers, potatoes, lettuce, and chicory, but several important floral industries are also threatened by this disease, including ranunculus, chrysanthemum, petunia, impatiens, and zinnia.

The Vector: Worldwide, this virus is transmitted by at least eight thrips species. In CA the western flower thrips (*Frankliniella occidentalis)* is considered the most important vector. The only method of field spread is via the thrips vector; it is not transmitted by contact between plants; it is not transmitted by seed; and it is not transmitted by pollen. It is transmitted by the thrips in a persistent propagative manner meaning that the virus actually infects and multiplies in the thrips, however the thrips adult does not pass the virus on to its progeny (eggs). The virus is acquired only during the thrips larval stages; the instars can transmit the virus before they pupate, but adults more commonly transmit the virus. The thrips lifecycle is approximately 30 days, but fluctuates with temperature. In general thrips are more active under cool to moderate weather conditions (70 - 85 °F).

In the early 1980s the disease became a major threat to peanut, pepper, tobacco, and tomato in nine states in the southern USA and in Hawaii's lettuce, tomato, and pepper crops. Research there showed that lettuce supported large thrips populations. When measured 5 weeks after planting, thrips densities averaged 125-375 thrips per plant (0.5 - 1.5 million thrips per acre). Thrips continued to emerge from the soil for 2-3 weeks after crop residues were plowed and tilled. Cultivation and harvesting activity disrupted and agitated thrips and resulted in considerable intercrop movement. Several important fresh and processing tomato growing areas in the world have TSWV present including Spain, Italy, Brazil, Argentina, and Florida, USA.

Detection Methods: PCR, ELISA, Immuno-assay strips

There are several sensitive and reliable detection methods for TSWV. These include enzyme-linked immunosorbent assay (ELISA), a serological (antibody)-based method; and polymerase chain reaction, which detects the viral RNA. However, ELISA and PCR are methods that require laboratory facilities. More recently, a test was developed for TSWV that can be

conducted in the field in 15-30 minutes. This test, referred to as immunostrips, is serologically-based, but involves only sticking a 'strip' into a plastic bag with plant sap, allowing the sap to move up the strip and observing whether one or two lines appear at a certain point. One line is a control that tells you the strip was functional and the other indicates infections with TSWV. These immunostrips allow for rapid confirmation of infection in the field and require no laboratory facilities.

Management Strategies

Unfortunately TSWV is a complex disease with no rapid, easy solution to alleviate losses. Wherever TSWV has surged to epidemic proportions in agriculturally important host plants the virus remains as a chronic problem. To minimize disease damage requires a multi-disciplined approach.

2005-06 Plant Surveys conducted by Falk, Davis, LeStrange: Crops, ornamentals, and weeds were sampled in 2005-06 from several fields in Fresno and Merced counties to identify plant species that may serve as reservoirs for TSWV. Hundreds of samples from approximately 80 species were collected and tested with ELISA or immunoassay strips for the presence of the virus.

- Crops that tested positive included ones showing obvious symptoms: tomato, potato, pepper, lettuce and radicchio.
- Other crops such as almond leaves, cauliflower, celery, eggplant, pea, and spinach did not test postitive.
- Weeds testing positive for the virus included Russian thistle, black nightshade, ground cherry, dodder growing on an infected tomato plant, and prickly lettuce.
- Many other weeds were sampled but did not test positive, even though they are suitable hosts: cheeseweed, chickweed, groundsel, lambsquarters, London rocket, marestail, prostrate pigweed, shepherds purse, sow thistle, and yellow mustard.
- Only a few ornamental plants tested positive for the virus although several dozen species were sampled: canna lily, calla lily, and a helianthus daisy.

2006 Tomato Field Incidence Surveys: In 2004 and 2005 the Westside of Fresno county experienced tomato and pepper crop and sometimes whole field loss due to TSWV, but the affected fields were limited to a concentrated geographic area. In summer of 2006 tomato damage was more common and widespread over a larger area. Spring weather was characterized by above normal rainfall. TSWV incidence was not uniform over the area - one field would be affected while an adjacent field was not. Growers participated in a voluntary survey conducted through CTRI which asked where they noticed TSWV in 2005 and 2006, when they noticed TSWV, what were the planting/seeding date and the tomato variety? Growers also estimated disease severity in the field. Bryce Falk and Mike Davis analyzed these responses, however no trend was apparent and there was no specific correlation. Incidence seemed more common in spring/early summer and then again in late summer/fall. Incidence was equally common in transplant and direct seeded tomatoes. Incidence ranged from 2-75%.

TSWV in Westside Lettuce and Radicchio Crops: Lettuce was sampled in fall of 2005 and spring of 2006, but TSWV was not apparent. In fall 2006 TSWV was found in several lettuce fields in the Huron and Five Points areas with 2007 spring lettuce germinating in crop fields

nearby. This confirmed that TSWV could now be found in a crop virtually all year round and that there was no crop free period without the virus.

Radicchio crops sampled in fall-winter of 2005, spring - fall of 2006 and most recently in spring of 2007 have continually tested positive for TSWV and are capable of hosting a high population of thrips.

2007 Research Plans: UC researchers (Gilbertson, Ullman, Batuman, LeStrange, and Turini) are embarking on a comprehensive study this spring to determine if transplants could be the source of the virus and to characterize the populations of thrips moving into processing tomato fields over the season. Several tomato transplant greenhouse producers in California have agreed to be monitored for thrips populations.

Additionally tomato fields at three locations along the Westside of Fresno and Kings Counties will be monitored weekly for thrips populations and disease infection, starting prior to planting. We will start in the greenhouse where we will use sticky traps and indicator plants to speed up the virus detection process. We will follow the same transplants to the field and monitor them throughout the course of their growing cycle. Sites are selected based on past incidence of TSWV and current cropping conditions. Sticky traps and thrips/virus indicator plants will be strategically placed at field sites and changed out weekly. We will be monitoring thrips activity in transplanted and seeded processing tomatoes that are planted near spring harvested lettuce and summer harvested onions, and wheat or peppers.

TSWV Indicator Plants: A particular variety of petunia, *Celebrity Blue*, has been selected as the indicator plant to monitor for thrips carrying the TSWV. Petunia indicator plants show distinctive local lesions when infective thrips feed on them. These lesions appear as small brown to black spots of the leaves and look different from typical thrips feeding. Local lesions result from a hypersensitive response, which is the strategy used by the petunia as protection from the virus. In a hypersensitive response the tissue around the virus entry site dies rapidly preventing the virus from spreading and causing a system wide infection in the plant. Local lesions are apparent on petunias about 3-7 days after feeding by an infected thrips. Petunias make an excellent indicator plant because the plants don't support thrips development and seldom become systemically infected. As a result the plants do not serve as a source of the virus or additional thrips. When we see lesions on indicator plants (a sign that the thrips are carrying the virus) then we will start a sampling program to rate disease development in the field.

We will also be monitoring for TSWV/thrips reservoirs at additional sites such as extremely weedy areas, foothills, set aside land, etc. by placing indicator plants to detect TSWV infected thrips. Whenever the indicator plants show us a hypersensitive response with the TSWV, then we search the nearby weed/plant populations and determine where the source of the virus reservoir is for the thrips.

Insecticides: Thrips are not easily controlled by insecticides and can easily develop resistance. To suppress thrips populations in Hawaii, one to two insecticide applications were needed per week. The most effective insecticides included Orthene (acephate), Fury/Mustang (cypermethrin), Mavrik (fluvalinate), Lannate (methomyl), and Phosdrin (mevinphos). Many of

these products are no longer registered in CA, but a few others that may have activity against thrips have been registered on tomatoes.

Several insecticide-related issues to be addressed under Westside conditions include:

- the basic question regarding efficacy of available materials against thrips,
- the issue regarding potential benefit of reducing thrips populations for purposes of reducing TSWV incidence or severity, and
- determining if greater benefit is realized with a more intensive thrips control program.

The effect on thrips populations and TSWV of shank injected Platinum (thiomethoxam) at planting with and without foliar insecticide applications will be evaluated. Insecticides used for the foliar applications will be Warrior (Lambda cyhalothrin), Lannate, and Success (spinosad), which represents different modes of action.

In addition, materials that trigger a plant response that reduce damage done by viruses will be tested. Actigard (acibenzolar-S-methyl) has shown promise against a similar virus of onion. Early applications of this material will be evaluated. Other insecticides under consideration include Agrimek (abamectin) and Provado (imidacloprid).

Summary: The goal of this work is to develop an understanding of when and where TSWV infects processing tomatoes in California. The systematic examination of the crop, from start to finish, should provide insight into inoculum sources and viral biology. This information will be used to help develop an integrated pest management strategy for thrips/TSWV in processing tomatoes. As chemical control of thrips will likely be part of this strategy, we will evaluate materials for their efficacy in thrips control. In addition, we will gain important new information about thrips biology and TSWV in Central California.