College of Tropical Agriculture and Human Resources
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Plant Disease
March 2012
PD-81

Tomato Spotted Wilt

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Tomato spotted wilt, caused by the virus *Tomato spotted wilt virus* (TSWV), is one of the most economically devastating diseases of tomato around the world. TSWV was first discovered in Australia in 1919 and has been present in Hawaiʻi since the 1920s. Tomato production losses of 75–100% from tomato spotted wilt have been reported in Hawaiʻi.

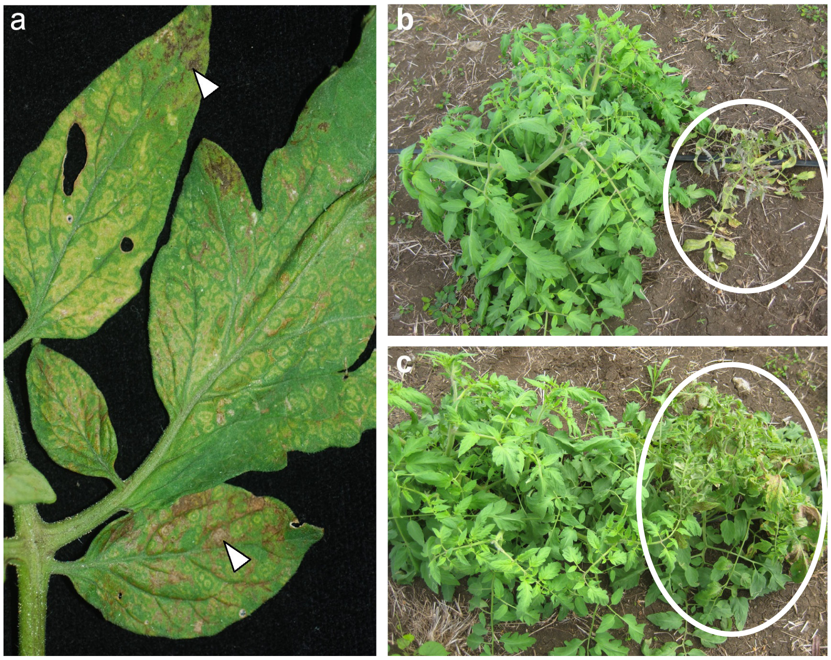

Figure 1. Symptoms of tomato spotted wilt. (a) Foliar chlorosis from TSWV infection results in a "bronzed" appearance (arrowheads) over time. (b) Plants infected with TSWV at a young age are severely stunted. (c) This stunting is less dramatic when mature plants are infected. Healthy plants are on the left and infected plants are circled on the right in (b) and (c).

Symptoms of Tomato Spotted Wilt

In tomato foliage, the first observable symptoms are small, chlorotic lesions on the leaflets that often have a darker green "halo." These chlorotic lesions may coalesce and become necrotic, giving the foliage a "bronzed" appearance (Fig. 1a). These necrotic regions spread to terminal shoots, causing them to "wilt." Tomato plants become severely stunted when infected at an early age (Fig. 1b). This effect is less dramatic when mature plants become infected (Fig. 1c). The most conspicuous symptoms of tomato spotted wilt are discolored blotches or concentric rings on the fruit of infected plants (Fig 2a). These fruit symptoms can mimic those caused by *Pepper mottle virus* (PepMoV) (Fig. 2b). PepMoV, however, does not cause obvious foliar symptoms. Therefore, plants with symptoms on both foliage and fruit are likely to be infected by TSWV, while plants with symptoms only on the fruit are likely to be infected with PepMoV.

Spread of TSWV

TSWV is transmitted by several species of thrips, including common blossom thrips (*Frankliniella schultzei*), tobacco thrips (*F. fusca*), eastern flower thrips (*F. intonsa*), western flower thrips (*F. occidentalis*), Florida flower thrips (*F. bispinosa*), *F. gemina*, chilli thrips (*Scirtothrips dorsalis*), light brown soybean thrips (*Thrips setosus*),

Table 1. Important alternative hosts of TSWV in Hawai'i

Scientific Name	Common Name
Amaranthus hybridus	Green amaranth
Amaranthus spinosus	Spiny amaranth
Amaranthus viridis	Slender amaranth
Apium graveolens	Celery
Arctium lappa	Burdock
Bidens pilosa	Spanish needle
Capsella bursa-pastoris	Shepherd's purse
Datura stramonium	Jimson weed
Galinsoga parviflora	Fuji grass
Ipomea congesta	Blue morning-glory
Lactuca sativa	Lettuce
Leonotis nepetaefolia	Lion's ear
Malva parviflora	Cheeseweed
Melilotus officinalis	Yellow sweet clover
Nicandra physalodes	Apple of Peru
Portulaca oleracea	Purslane
Solanum lycopersicum	Tomato
Sonchus oleraceus	Sowthistle
Stellaria media	Chickweed
Tropaeolum majus	Nasturtium
Verbesina encelioides	Golden crown beard
Xanthium saccharatum	Cocklebur

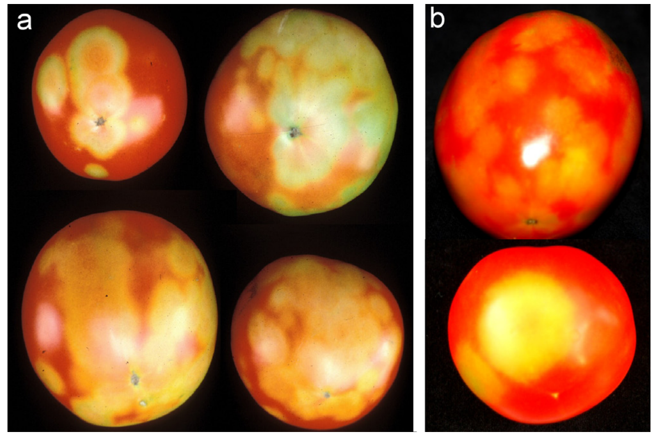

Figure 2. (a) Fruit from tomato plants infected with TSWV usually have chlorotic, concentric rings and are often misshapen. (b) These symptoms can be confused with plants infected by *Pepper mottle virus.*

and onion thrips (*T. tabaci*). In Hawai'i, western flower thrips is the most important vector of TSWV in tomato and other vegetable crops (Fig. 3); however, common blossom and onion thrips are largely responsible for the spread of the virus in other plants. Only during their larval stages are thrips are able to acquire TSWV, and they generally remain infective for life. Thrips larvae can acquire TSWV within 15 minutes of feeding on infected tissue. Adult thrips are the primary agent for plant-to-plant spread of the virus, but they do not transmit the virus to their offspring. Under ideal conditions TSWV can be transmitted mechanically, but it is generally not spread by gardening tools or by touch. Long-distance spread of TSWV results from the movement of infected plant material or from wind dispersal of thrips harboring the virus.

Other Hosts of TSWV

Worldwide, TSWV has a very wide host range, infecting hundreds of different plant species. In Hawai'i it infects at least 44 plant species from 16 different plant families. Of these, 26 species have been identified as important reservoirs of the virus, most of which are listed in Table 1. For the complete list of host plants of TSWV, see CTAHR Research Extension Series 078 "Host List of Plants Susceptible to Tomato Spotted Wilt Virus (TSWV)" http://www.ctahr.hawaii.edu/oc/freepubs/pdf/RES-078.pdf, by J.J. Cho et al. (1987). Often these alternative hosts, many of which are weeds in agricultural areas, show no obvious symptoms when infected. Conversely, TSWV causes severe symptoms in other agriculturally important crops such as lettuce and pepper, resulting in considerable crop losses.

Management of Tomato Spotted Wilt

Three field management approaches can be taken to control tomato spotted wilt. The first approach is to

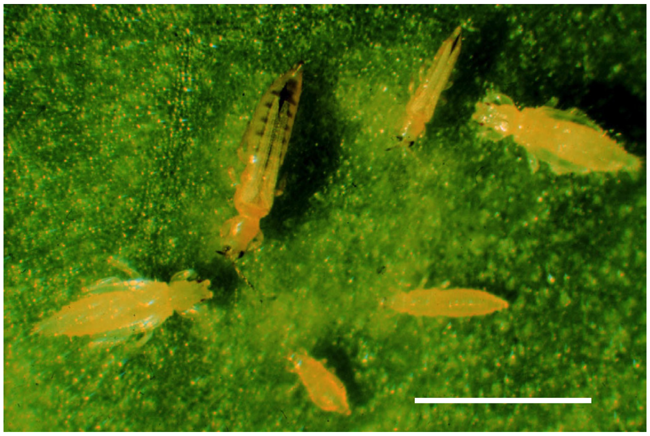

Figure 3. Western flower thrips (*Frankliniella occidentalis*) is the primary vector of TSWV in Hawai'i. The bar is approximately 1mm, or 1/25 inches.

remove sources of the virus in the field. This includes control of weed species in the area that may serve as symptomatic or asymptomatic hosts of the virus (Table 1). Symptomatic tomato plants must also be immediately removed, bagged, and disposed of to reduce the chance of infective thrips moving to nearby healthy plants.

The second approach is to manage thrips populations in the field by cultural or chemical control. Silver reflective mulches and row covers have been shown to hinder thrips infestation; these are most effective when the plants are young, with a small canopy. Table 2 lists insecticides currently registered for tomato in Hawai'i to control or suppress thrips populations in field and/or greenhouse environments; additional insecticides applied for the control of other tomato pests may also control or suppress thrips populations. The use of surfactants with some insecticides has been shown to increase their effectiveness against thrips. Always read and follow the label instructions of any insecticide before its application. Chemical control of thrips is most effective with systemic insecticides, since larvae like to inhabit tomato flowers and other areas that are difficult for contact insecticides to penetrate.

The third and most effective management option for the control of tomato spotted wilt is the use of tomato varieties resistant to TSWV. Vegetable breeders at the University of Hawai'i (UH) have been at the forefront of this approach. The tomato variety 'Pearl Harbor', which obtained the TSWV resistance gene Sw-1 from a close relative of tomato, was one of the first to show some resistance to the virus (Kikuta et al., 1945). Since then, UH has released several commercial tomato varieties that have helped local growers combat TSWV and other important tomato diseases. Today, another resistance gene, Sw-5, identified in a different tomato relative, has emerged as the most effective natural resistance gene for TWSV. This gene has been bred into many commercially available tomato varieties, including all varieties distributed by UH, which are usually listed as 'TSW' or 'TSWV' in seed catalogs or packaging. Due to the presence of another important tomato virus, *Tomato yellow leaf curl virus*, selecting tomato varieties that also have resistance to this virus—listed as 'TY' or 'TYLCV' in seed catalogs or packaging—is highly recommended; see CTAHR publication PD-70, "Tomato Yellow Leaf Curl," http://www.ctahr.hawaii.edu/oc/freepubs/pdf/PD-70.pdf, for more information.

Table 2. Products for the chemical control of thrips.

Active Ingredient	Trade Name (Manufacturer)
Carbaryl	Carbaryl 4L
	Sevin 4F (Bayer)
Imidacloprid	Alias 2F (Makhteshim-Agan)
Spinetoram	Radiant SC (Dow Agrosciences)
Spinosad	Conserve (Dow Agrosciences)
	Entrust (Dow Agrosciences)
	Green Light Lawn & Garden Spray
	Spinosad (Green Light)
	Monterey Garden Insect Spray (Lawn & Garden Products)
	Protector Pro (Prosolutions)
	Success (Dow Agrosciences)

Note. Mention of a specific product or manufacturer does not constitute an endorsement by CTAHR or the University of Hawai'i. Be sure to read and follow the label instructions of all pesticides before application.

Biotechnology and Management of Tomato Spotted Wilt in the Future

Although tomato varieties possessing the Sw-5 resistance gene are very effective at managing tomato spotted wilt in most regions, Hawai‘i is one of the few locations on the planet (the others are Australia, Spain, and South Africa) that has strains of TSWV that can overcome or “break” this resistance gene. Therefore, Hawai‘i’s tomato growers can still suffer considerable production losses to tomato spotted wilt even when using “resistant” germplasm. No resistance genes have been found in tomato or its close relatives that can counter these resistance-breaking strains of TSWV, so scientists are using biotechnology to supplement natural resistance genes.

Many different tools are now available for increasing and improving agricultural production. Traditional agricultural approaches are experiencing some resurgence today, and there is renewed interest in organic agriculture, an approach that does not embrace the use of genetically engineered crops. However, the role that genetic engineering stands to play in sustainable agricultural development is an important topic for the future.

With the development of any new technology there are concerns about associated risks, and agricultural biotechnology is no exception. However, all crops developed using genetic engineering are subjected to extensive safety testing before being released for commercial use. Risk assessments are conducted for these new varieties, and only those that are safe for human use are released. Extensive risk assessment and safety testing of crops developed throughout the process of genetic engineering has shown that there are no varieties in use that pose risks to consumers, though this is not to say that new varieties should not be carefully examined for safety; each case should be and is considered on its unique merits.

Due to the threat of these resistance-breaking strains of TSWV spreading to other tomato-growing regions, research labs around the world are modifying the genome of tomato to develop resistance to TSWV. For example, scientists at Cornell University inserted DNA sequences derived from TSWV into the genome of a tomato plant. This activated a natural response in these plants that makes them resistant to the virus. These plants were then crossed with tomato plants that had the Sw-5 resistance gene. The resulting progeny now possess two distinct resistance mechanisms that may provide a broad resistance to TSWV and other related viruses. These plants have performed well under greenhouse conditions and are now being evaluated under field conditions. Tomato plants rarely cross-pollinate in nature, and several safeguards can be taken to further prevent the unintended spread of these experimental plants or their pollen. This includes growing them in isolation, planting border rows of non-engineered tomato to trap pollen, and removing flowers to control pollen and eliminate seed production and dispersal. With the combination of natural resistance and biotechnology, losses to tomato spotted wilt and other virus diseases may become a thing of the past for Hawai‘i’s farmers.

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