Tomato spotted wilt virus (TSWV) and thrips vectors

Tomato spotted wilt virus (TSWV) is the type member of the genus *Tospovirus*, family *Bunyaviridae*. Particles are spherical, and membrane-bound, occurring singly or in clusters. Genome composed of three RNA particles: S RNA and M RNA are ambisense, while L RNA is of negative polarity.

Symptoms: Symptoms are highly variable, depending on host species, virus isolate, temperature, and age of plant. Many hosts are asymptomatic. General symptoms include necrotic spotting of leaves, stem necrosis, wilting, leaf curl/distortion, stunting, dieback of growing tips, poor fruit set, spots or rings on fruit, irregular ripening, line patterns and mosaic on leaves, premature leaf drop, chlorotic or necrotic ringspots, vein or petiole necrosis. Petals may show colored spots, line or ring patterns, or stripes. Peonies may show line patterns or mosaics on foliage.

Host Range: TSWV has a very large host range of over 1000 species in more than 85 plant families. Hosts include tomato, pepper, potato, lettuce, celery, spinach, cucurbits, cauliflower, beans, peas, alfalfa, lupin, dahlia, delphinium, peony, chickweed, curly dock, dandelion, spiny sowthistle, lambsquarters, black nightshade, shepherd's purse, smartweed, redroot amaranth, white clover, yellow sweetclover, and many greenhouse ornamentals. Most hosts become systemically infected for life.

Vectors and Epidemiology: TSWV is transmitted by at least 11 species of thrips, including: *Frankliniella fusca, F. occidentalis, F. schultzei, Thrips palmi, T. setosus, T. tabaci*, as well as one species of *Ceratothripoides* and one species of *Scirtothrips*. The contribution of vector species to virus spread changes over time and with varying agronomic practices. In potato, *F. occidentalis* and *T. tabaci* are probably the most important vectors, at least in the lower 48 states. *F. occidentalis* is usually considered a primary vector that introduces TSWV to a field, and *F. fusca* is usually considered a secondary vector that spreads the virus within a field. It is unclear which species are most important in spreading TSWV in peonies. The virus is circulative and propagative in its thrips vector. Acquisition occurs during the 1st or 2nd larval instar, virus circulates and replicates within the thrips salivary gland. Larvae move to soil or leaf litter to pupate. Adults transmit the virus to plants for the remainder of their lives, but do not transmit it transovarially (to their eggs). There is some evidence that thrips preferentially feed on tospovirus infected plants (possibly due to changes in leaf color). The virus is also transmissible by mechanical inoculation, and grafting. There are reports of seed transmission in tomato and a small number of other species.

Management: The most effective management strategies rely on exclusion of infected plants and vector thrips. Indicator plants such as petunia 'Calypso', 'Summer Madness', or 'Super Blue Magic' may be used as early warning systems to detect thrips feeding and TSWV infection. Blue or yellow sticky cards are attractive to thrips, and are useful for monitoring populations. Removal of infected (or suspected) plants is crucial, as is control of weeds that may harbor the virus or thrips. Reflective mulches have been demonstrated to reduce spread of TSWV in some systems (they are thought to cause confusion in thrips). Contact insecticides are often not effective against thrips due to oviposition in tissue, the presence of adults inside tight buds, and migration from surrounding plants. Systemic insecticides often do not kill thrips fast enough to slow epidemics. Many thrips biotypes exist with resistance to one or more insecticides, rotation of chemistries is vital to management. Resistant varieties of tomato and peanut have been developed, but the resistance has been broken within a few years of field deployment. There are no known varieties of peony resistant to TSWV.

Vectors of TSWV

Frankliniella occidentalis

Frankliniella occidentalis, the western flower thrips, is native to the American southwest. It was first described in Alaska in 1956. *F. occidentalis* spread around the world in the late 1980's with the ornamentals trade. It has become a major pest of greenhouse crops worldwide for its piercing feeding damage and oviposition scars, as well as transmission of *tospoviruses*, *ilarviruses*, and *carmoviruses*.

F. occidentalis has a very wide host range of both dicots and monocots, over 240 species in more than 60 families. Hosts include: pea, tomato, pepper, strawberry, rose, cucumber, bean, beet, carrot, onion, lettuce, cabbage, lambsquarters, jimson weed, and burdock. There are generally thought to be two ecotypes of *F. occidentalis*: those that thrive in hot/dry environments, and those that thrive in cool/moist environments.

F. occidentalis is considered one of the most important vectors of *tosposviruses* due to its vector efficiency, wide host range, high mobility, and reproductive potential. It can also transmit *Tobacco streak ilarvirus* (TSV), and *Pelargonium flower break carmovirus* (PFBV). Though weak long-distance fliers, thrips can colonize fields quickly, and are easily moved by wind and trade. Thrips often overwinter as pupae or adults under leaf litter.

Frankliniella fusca

Frankliniella fusca, commonly called tobacco thrips, is native to the eastern U.S., now distributed throughout the continent. Its hosts include: bean, tomato, pepper, dandelion, redroot amaranth, chickweed, white clover, many other common weeds, and various ornamentals. It is usually considered a secondary vector of TSWV, spreading the virus between plants locally.

Thrips tabaci

Thrips tabaci, the onion thrips, is thought to have originated in the eastern Mediterranean, but is now cosmopolitan. It prefers warm and dry environments. It has a wide host range, including: onion, garlic, leek, cucumber, cabbage, bedding plants, potato, melon, tomato, sugar beet, and weedy grasses. *T. tabaci* primarily feeds on new growth; outbreaks are most likely in hot, dry conditions. It typically overwinters in small grains, clover, and alfalfa. Virus transmission may differ based on thrips gender, virus isolate, and source plant of virus. In addition to *tospoviruses*, *T. tabaci* can also vector *Tobacco streak ilarvirus* (TSV), *Prunus necrotic ringspot ilarvirus* (PNRSV), *Maize chlorotic mottle machlomovirus* (MCMV), and *Sowbane mosaic sobemovirus* (SoMV).