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TOMATO SPOTTED WILT VIRUS

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Diseases affect both the quality and production volume of floriculture crops. However, few diseases can match the destruction of a floral crop as that caused by an infestation of Tomato Spotted Wilt Virus (TSWV).

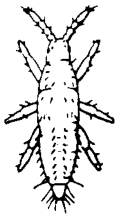
This virus disease was first described by Samuel et al. in 1930 and is consider one of the most destructive and important diseases on floral crops in the United States. The virus is transmitted by several thrip species; however the western flower thrip (WFT) ***Frankliniella occidentalis*** (Pergande) is the most important vector of TSWV (Robb, Parrella,& Newman, 1988). WFT is the most commonly found thrip species on greenhouse crops grown in the U. S. (Robb & Parrella, 1988) in part because of the shipment of plant material across the U. S. Unfortunately, WFT has shown some resistance to most all the major classes of insecticides, making effective control of TSWV difficult.

Biology of TSWV

Generally, the greenhouse environment provides favorable conditions for year-round reproduction of thrips. Under fluctuating temperatures between 62 and 98^0 F, WFT develop from eggs to adults in 7 to 13 days (Robb, Parrella, & Newman, 1988). Eggs are deposited in leaves, bracts or petals of plant tissues and hatch in 2 to 4 days. The translucent first instar larvae feed for 1 to 2 days before molting to a yellow-colored second instar. First and second instars normally feed within developing terminal foliage or under flower bud scales. The second larval instar continues to feed for an additional 1 to 4 days before pupating in the soil or plant litter. The pupal stage lasts an additional 2 to 5 days during which the whitish, soft-bodied thrips do not feed; moving only if disturbed. Female WFT deposit 150 to 300 eggs during a 30 to 45 day life span. They range in color from light yellow to dark brown and are larger than the pale

yellow male thrips. Both sexes have wings in the adult stage. Although females do not have to mate to lay eggs, the majority do (Robb et al. 1988). Unmated females only produce male offspring (Lewis, 1973).

WFT and Feeding Injury



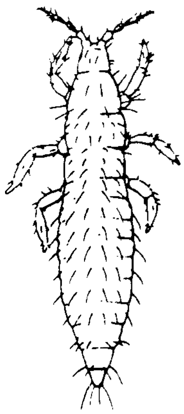
Prior to the discovery of TSWV, thrips were a pest because of feeding damage they caused to leaves, flowers and the growth of plants resulting in loss of quality of product and oftentimes rendering plants non-marketable. Although the losses caused by TSWV far exceed the losses incurred due to feeding injury, it still reduces plant quality and is of course, an indicator of the presence of thrips.

Thrips feed by puncturing the plant cell, followed by withdrawing cell fluid which severs as a nutrient source. Although they are often associated with flowers, WFT will also feed within developing and occasionally, fully expanded leaves. The symptoms produced vary with feeding location on plant parts.

" *Symptoms observed with some degree of regularity include .....* "

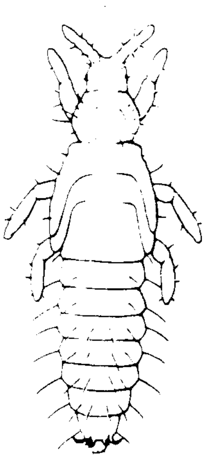
Symptoms produced by thrips feeding on flowers include streaks and discoloration of the petals with dark petals showing light streaks and light flowers showing dark streaks as the thrips move and feed. The feeding injury to flowers may prevent the flowers of some plants e.g. carnations from opening while flowers of other plants e.g. roses become blasted and distorted. Symptoms of thrips feeding on developing plant buds appear as herbicide injury with the presence of irregular necrotic areas. Moreover, thrips feeding on fully expanded leaves produce silvery blotches on the surface that may be spotted with shiny black fecal specks.

Symptoms and Transmission of TSWV



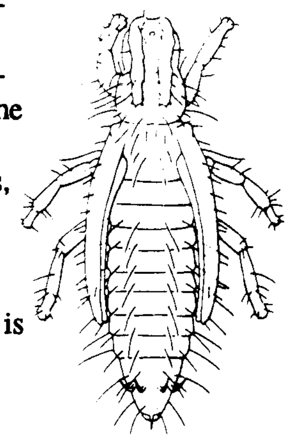
Symptoms of this disease on floral crops can vary tremendously making diagnosis based on symptom expression difficult. The type of symptoms observed include stunting, leaf distortion, mosaic patterns on the foliage, vein clearing, ringspots, dark purple-brown sunken lesions, stem necrosis, wilting on one side of the plant or wavy lines on the foliage (Smith, 1957; Nameth et al., 1988). However, symptoms observed of TSWV with some degree of regularity include: green to yellow concentric rings that often progress into brown rings or necrotic spots (ageratum, begonia, cyclamen, kalanchoe, New Guinea impatiens) leaf midrib browning and small to necrotic spots (gloxinia and impatiens) , stem browning (chrysanthemum), and tan leaves with rings as well as necrotic lesions on stem and wilting of the plant (exacum). In some cases, the virus will attack the center portion of the plant resulting in wilting and necrosis followed by plant death. These symptoms are very similar to those caused by root rot pathogens, but inspection of the root system usually shows no evidence of root disease. However, as mentioned above, symptom express varies and positive diagnosis can not be made on symptomology alone. Such variables as host age, greenhouse temperature, and nutritional status can all influence the type of symptoms observed. Detection of the virus can only be accomplished by the use of indicator hosts, nucleic acid probes, and serological methods. Suspect plants should be sent to a laboratory that is equipped to provide a diagnosis.

Tomato spotted wilt virus is acquired only by larvae feeding on infected plants and not by adult thrips; however, only adults can transmit the virus (Bald & Samuel, 1931). The incubation periods of TSWV in WFT is 4 - 10 days and only 15 - 30 minutes of feeding is necessary for WFT to transmit TSWV to a healthy plant (Sakimura, 1961a & 1961b). Once WFT acquires the virus the adults remain infective for life.



Host Plants of TSWV

Another dimension of this virus that makes it so opposing is that it can affect many different plant hosts. The pathogen affects many ornamentals, non-ornamentals and weeds (Best, 1968). A list of some of the susceptible plants is presented in Table 1.



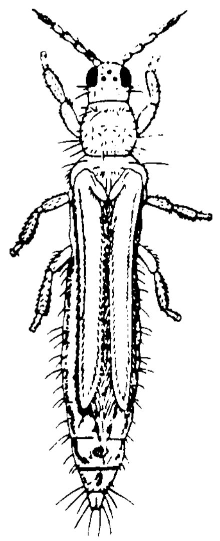
Tomato spotted wilt virus has been found on the following plants in Minnesota: African violet, Ageratum, Basil, Begonia, Browallia, Chrysanthemum, Cineraria, Columnea, Cyclamen, Exacum, Forget-me-not, Geranium, Gerbera, Gloxinia, Hosta, Hoya Hydrangea, Impatiens, Kalanchoe, Lipstick plant, Lobelia, Maranta, Marigold, New Guinea impatiens, Pothos, Snapdragon, Schefflera, Tiger vine, and Tomato

Control of Thrips Equals Control of Tomato Spotted Wilt Virus

Control of TSWV will require an integrated approach with early detection as

" *Early detection is the corner stone of TSWV control.* "

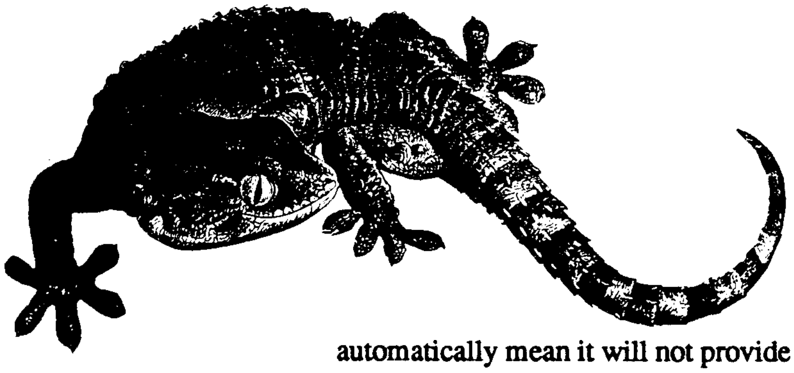
the corner stone of disease control. One effective method of monitoring thrip populations is to hang yellow sticky cards just above the crop surface. Placement of sticky cards near doors or vents to monitor thrips that may be coming into the greenhouse from the outside is advisable. Studies have shown that thrips are more attracted to blue sticky cards and less so to yellow. However, blue cards are less attractive to some other greenhouse insect pests. One suggestion is to use blue cards if thrips are your only concern and yellow cards if your pest management program includes other pests or a combination of both yellow and blue sticky cards.



Observe the traps at least once per week for the presence of thrips and record the number found. Look for very small insects as thrips will be the smallest insects captured. With the aid of a hand lens, thrips will appear pointed at both ends. Furthermore, you should regularly examine plant material and pay close attention to leaf and flower buds as they unfold. The presence of thrip damage on plants does not necessarily mean that an encounter with TSWV is emanate, but it should alert the grower that action must be taken to keep the insect in check. Chemical applications will be necessary to control thrips. The best results have occurred when three applications were made at 5 to 7 day intervals.

"Alternating insecticides remains the single best approach to deal with insect resistence."

Unfortunately, insecticide resistance has produced regional , as well as local, differences in the level of thrips control that different insecticides provide. Since WFT may be resistant in one greenhouse but not in another, the fact that a chemical is not working for your neighbor does not



automatically mean it will not provide acceptable control for you. The more intensively a pesticide is used, the greater the likelihood of resistance to that material. You may also find that an insecticide that has not been used in the greenhouse for a extended time may now provide acceptable control. Withholding poorly performing materials and retrying at a later date may help to extend the list of chemical options.

Alternating insecticides remains the single best approach to deal with insect resistance. The objective is to select materials with unlike modes of action. Fortunately, product chemistry can help in the selection process. The one thing that is not apparent is that carbamates and organophosphates have the same mode of action and should be considered in the same chemical category.

To be most successful, compounds from different chemicals groups should be alternated across generations of thrips. The intent is to minimize the chances of the same individual being exposed to the alternating compounds. For example, apply a chemical from category chemical group A until one generation (about 2 weeks or 2-3 treatments for WFT) is complete then apply a chemical from category B to the next generation. Continue to rotate between, not within, thrips generations.

There are several pesticides labeled for thrips control. Read all label information before applying any pesticide to make sure the product is registered and to avoid phytotoxcity problems. It is always advisable to conduct small trials with a selected insecticide before treating an entire crop. Some of the commonly used products and their chemical classes are as follows: **Pyrethroids**- bifenthrin (Talstar), cyfluthrin (Decathalon), fluvalinate (Mavrik), resmethrin (Resmethrin); **Organophosphates**- diazinon (Knox-out), acephate (Orthene); **Carbamates**- bendiocarb (Dycarb); **Chloronicotinyls**- imidacloprid (Marathon); **Bontanicals**- neem (Azatin), neem (Margosan-O); **Insecticidal Soap**-M-Pede. Product efficacy will vary depending on factors such as the crop, pest density, environmental conditions, etc. and thus, it is advisable to test different products to suit your individual situation.

There are some methods of insecticide application that growers may want to consider to improve the effectiveness of the compounds used in WFT control. Spray droplet sizes of 70-100 microns appear to give the best control. Most conventional hydraulic sprays produce droplets of larger size. Therefore, a grower may wish to use a fogging device to deliver insecticides.

Several researchers have shown increased thirips control with the addition of sugar to the spray mix (approximately 1 to 2 1/2 lb. of sugar per 100 gallons of water). However, depending on the chemical used, sugar does not always increase control. Apparently, the thrips feed more actively where the sugar is present, suggesting that chemicals with a mode of action of stomach poisons might produce the best results. Thrips control was improved in experimental trials when sugar was added to Orthene.

In addition to vector efficiency, the probability of a plant becoming infected with TSWV is related to the feeding preferences of thrips and the susceptibility of a plant to the virus. Not surprisingly, specific varieties within a crop were reported to differ in their attractiveness to the WFT, and in turn, to their susceptibility to TSWV. This makes it advisable to evaluate varietal susceptibility making sure not to place susceptible varieties in locations where thrips are most likely to be found.

Air flow movement in the greenhouse (fan jets & tubes, horizontal air flow) produce eddies where air currents slow down. Flying thrips can be caught in the moving air and stay aloft at higher velocities, 'dropping out' wherever the air current slows appreciably. Therefore, it is a good idea to know where these areas of low velocity are located in the greenhouse, and this will provide information where thrips are likely to descend to feed on the plants and where possible TSWV infected plants may first appear. It is recommended that growers put the most resistant plant varieties in these locations. Likewise, since thrips move into greenhouses from the outside, it is equally advisable to place resistant and not susceptible plant varieties near vents and doors. Also, western flower thrips show a preference to pupate in soil or plant litter away form the host plant. Therefore, removal plant litter from the bench and floor followed by steam sterilization of soil in the bench would be helpful in management of TSWV.

"The probability of a plant becoming infected with TSWV is related to the feeding preferences of thrips and the susceptibility of a plant to the virus."

Although TSWV has been reported to peak in May and June, it is advisable to consider the migration of thrips into greenhouses especially in the late summer or early fall as a potential problem that will have to be dealt with during the winter months if effective control is to be achieved. Since WFT feed on a wide-host range of plants including grasses and weeds that may be found outside near the greenhouse, it is advisable to eliminate these host plants; this would help minimize migration of thrips into the greenhouse.

Control of WFT is not easy but the probability of success can be improved by detecting the problem as early as possible, choosing insecticides that have not had a history of use in your greenhouse, rotating chemicals, applying insecticides as a fog if they can be used as such, making multiple applications at short intervals, and perhaps adding sugar to some of the sprays.

"It is very unlikely than an adult female can transmit TSWV to offspring"

Management of Tomato Spotted Wilt Virus

Results of studies have reported that it is very unlikely that an adult female thrips can transmit TSWV directly to the offspring. Therefore, newly hatched thrips can only acquire the virus from a plant that is already infected. This information reinforces the need for one of the major components of a management strategy of a TSWV and that is elimination of all plants that are known to be infected with TSWV. However, there are some plants that can harbor the virus yet express no or few symptoms e.g. Lipstick plant and pothos. Thus, if a few plants of a given cultivar are found to be infected in an area the possibility exists that most plants in that area will be infected. These plants represent a threat to other healthy plants growing in the greenhouse and should be discarded. However, remember that infected plants should be removed from the premises and not placed in a pile close to the greenhouse. Adult thrips can fly and they can simply move back into the greenhouse from plants that have been discarded and left just outside the greenhouse. Reports exists that WFT can also survive on culled flowers.

Many weeds serve hosts for WFT and many of these weeds are also hosts of TSWV and serve as a source of inoculum as thrips move in and out of greenhouses. Therefore, weed control must be considered an important part of the overall management of this destructive disease.

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Table 1. Ornamental, non-ornamental and weed hosts of Tomato Spotted Wilt Virus (TSWV).

Ornamentals		Non-Ornamentals	Weeds
Amaryllis			
Impatiens			
Broad Bean			
Amaranthus spp.			
Anemone	Lobelia	Cauliflower	Beggar Ticks
Aster	Marigold	Celery	Bindweed
Begonia	Morning Glory	Chicory	Bull Thistle
Calcoeleria	Nasturtium	Coriander	Capsella spp.
Calendula	Peony	Cos Lettcue	Chickweed
Calla Lily	Petunia	Cowpea	Clover
China Aster	Phlox	Eggplant	Coryza bonariensis
Chrysanthemum	Poppy	Endive	Coreopsis
Cineraria	Primula	Garden Pea	Crepis spp.
Columbine	Ranunculus	Papaya	Datura
Cosums	Salvia	Peanut	Emilia spp.
Cyclamen	Snapdragon	Pepper	Gaillardia spp.
Dahlia	Stock	Pineapple	Gidetia
Delphinium	Tiger Lily	Romaine	Lupin
Dusty Miller	Verbena	Snap Bean	Malva
Evening Primrose	Zinnea	Spinach	Mesmbryanthemum
Forget-me-Not		Sweet Pea	Nightshades
Geranium		Tobacco	Montia
Gerbera		Tomato	Physalis spp.
Gladiolus			Saxifrage
Gloxinia			Sow Thistle
Gypsophila			Wild Tobacco