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College of Agricultural, Consumer and Environmental Sciences

report on
PLANT
DISEASE

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TOMATO SPOTTED WILT VIRUS

Tomato spotted wilt is caused by the tomato spotted wilt virus (TSWV) which occurs worldwide. It has the widest host range of any virus and includes floral crops, bedding plants, vegetables, and a large number of weeds (Table 1).

Figure 1. Dark ringspots on Impatiens leaves caused by TSWV (Courtesy G.W. Simone).

The virus was first discovered causing a wilt and spotting of tomatoes. In Illinois, TSWV is most often found in garden and new Guinea impatiens, gloxinia, cyclamen, and exacum. TSWV has caused losses amounting to hundreds of thousands of dollars in a single greenhouse floral crop. In vegetables, affected plants yield poorly, producing small and unsightly fruit, or no yield at all. To home gardeners, TSWV means unthrifty plants with distorted, spotted, or blighted foliage or flowers; plants either die young or fail to grow.

Formerly, the disease was primarily a problem only in tropical and subtropical areas of the world. In more temperate regions, it occurred sporadically in greenhouses where the environmental conditions were favorable for the growth and maturation of the insects that transmit, or vector, the virus.

Figure 2. Ringspots and blotches on gloxinia leaves caused by TSWV (courtesy British Ministry of Agriculture).

TSWV, which has several strains, is transmitted in nature **only** by thrips (at least 9 species of *Thrips*, *Frankliniella* and *Scirtothrips*) and is the only virus transmitted by thrips. Adult thrips are unable to acquire the virus as they feed on diseased plants; it must first be acquired by the larval (immature) form. Later, the adult can transmit the virus. Once the larval form acquires the virus there is an incubation or latent period in the insect of 4 to 18 days before it is able to transmit the virus to a healthy plant. The incubation period varies depending on such factors as species of thrips involved, host plant, temperature, and virus strain. The minimum feeding (acquisition) period for the thrips to pick up the virus is 15 minutes. You can survey susceptible plants for thrips by dissecting flowers or by tapping the plant over a white piece of paper or crop cloth.

For further information concerning diseases of ornamental plants, contact Nancy R. Pataky, Extension Specialist and Director of the Plant Disease Clinic, Department of Crop Sciences, University of Illinois, Urbana-Champaign.

SYMPTOMS

Many symptoms have been attributed to TSWV infection. In general, symptoms vary greatly from crop to crop and include various degrees of yellowing, browning, stunting, and enations. Infected plants under 6 weeks of age will often decline and die. In older plants terminal bud killing (necrosis) and leaves with chlorotic (white-to-yellow) or necrotic ringspots and line patterns are common. Infected leaves are often distorted with vein and petiole necrosis. Black or purple stem streaks, premature leaf or bud drop, stunting, irregular leaf shapes, whitish or black leaf spots, necrotic young leaves, and colored spots, line and ring patterns or stripes on flower petals are other symptoms of TSWV infection. Flowers open late and are commonly distorted.

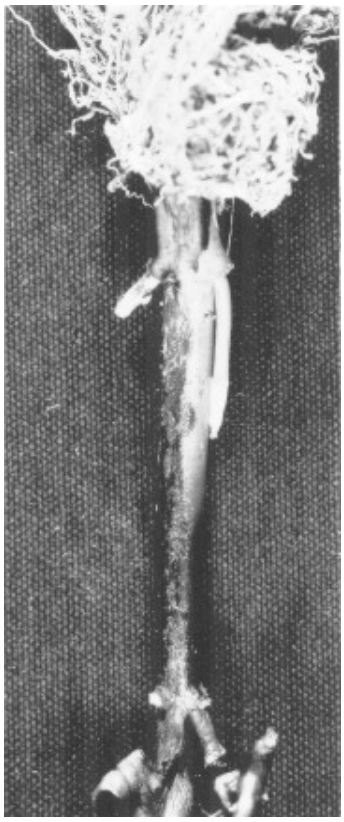

Figure 3. Dark stem lesions on New Guinea impatiens stem caused by TSWV (courtesy Penn. Dept. of Ag.).

Diagnosis of TSWV infection based solely on symptoms is difficult since other biotic agents (e.g., fungi) as well as abiotic factors may mimic TSWV symptoms. The great variability in symptom expression is probably due to a mixture of strains and to differences in the proportion of each strain of virus present. In all hosts the symptoms may be mild under certain conditions and quite different and much more severe in another environment. Even on the same host plant, symptoms vary greatly with the age of the plant, level of nutrition, and particularly with environmental conditions, especially the temperature. Some infected plants may be symptomless. Specific examples are given for a number of crops.

Figure 4. Symptoms of tomato spotted wilt virus (TSWV) on a single cyclamen plant. Left, withering, wilting and dying of leaves; center, brown spots and rings on a leaf; right, whitish blotches, spots, streaks, and a ringspot on a leaf.

Impatiens – On impatiens small, dark purple-brown, papery ringspots are often present on leaves (Figure 1); flowers may also show white ringspots. Dark streaks appear on stems (Figure 3) and leaves, especially on or near the midrib. Leaf yellowing, leaf distortion, leaf drop, and stunting may occur. As the virus becomes systemic, faint purplish ring patterns develop on the lower leaves. Young infected impatiens plants, or older affected plants, may drop many of their leaves, appear "leggy" and are generally unthrifty. Some cultivars of New Guinea impatiens die; others exhibit uneven growth which reduces their value.

Gloxinia - Young gloxinia plants develop symptoms similar to a fungal root or crown rot. New leaves may be stunted or the lower and central parts of the plant may turn brown followed by collapse and death of the plant. Older plants, when first infected, may have malformed leaves with brown or yellowish ringspots (Figure 2), large circular areas of dying tissue, line patterns, browning of the midrib, and terminal bud necrosis. Flowering is delayed and flowers show concentric ringspots, color break, and distortion.

Cyclamen - On cyclamen the most distinctive symptom of TSWV is the yellow ringspots and whitish blotches, spots and streaks on the leaves (Figure 4, center and right). Brown streaks, in addition to rings, may be present on the petioles. Flowers are often malformed. Corms may be elongated and, when cut, the vascular tissues appear as brown streaks (resembling the discoloration caused by Fusarium wilt). Affected plants stop growing and brown spots appear on leaves and leaf edges (Figure 4, center). Eventually plants wilt and die (Figure 4, left). It may take 3 months or longer from the time of infection for symptoms to appear. During this time plants look healthy and grow normally.

Florist's chrysanthemum - Chrysanthemums develop brown to purple-black stem lesions and leaf necrosis followed by dieback of plants. Chlorotic ring symptoms may be evident on the leaves during the early stages of infection. Following a period of stress, flowering plants develop a blighted appearance similar to those associated with Fusarium wilt.

Cineraria - Cineraria plants infected with TSWV show chlorotic ringspots and rough, wrinkled and curled leaves. Necrotic areas on the petioles and stems may be large and girdle (constrict) the affected tissues. At bloom, the leaves are wilted, rolled, and yellowed.

Zebra plant - Infected zebra plants (*Aphelandra squarrosa*) develop dark necrotic areas along the midrib and lateral veins of leaves followed by leaf distortion and death (Figure 5). These symptoms closely resemble those of Phytophthora stem rot, requiring that plants with roots and soil be submitted for analysis to make a proper diagnosis.

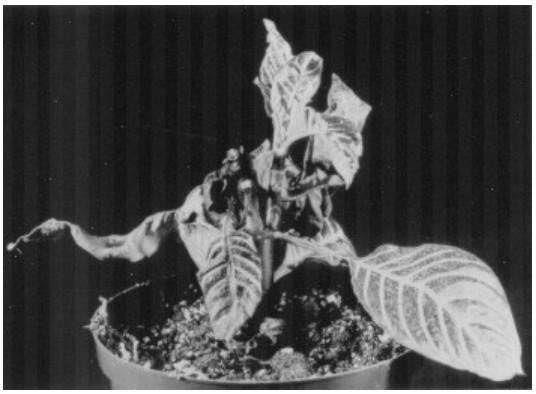

Figure 5. Zebra plant showing severe leaf distortion caused by TSWV (courtesy Pennsylvania Department of Agriculture).

Other ornamentals - Leaf enations (tissue malforations or overgrowths) occur in dahlia, while flower deformations and color breaking are common in dahlia, zinnia and other flowers. China-asters have dead tan areas in the leaves and brown surface blotches on the stems. Calla lilies develop whitish, then brown leaf streaks (Figure 6). On sweet pea, reddish brown to purple streaks may extend the full length of the stem. Circular to oval spots with diffuse margins are followed by yellowing and death of the leaves and stems. Blossoms sometimes develop circular patterns in the pigment. Delphiniums may have numerous distinct double rings. Oakleaf and ringspot symptoms in dahlia are probably also caused by strains of TSWV. Begonia plants are often stunted with deformed leaves that develop chlorotic to necrotic rings which may have concentric zones (Figure 7).

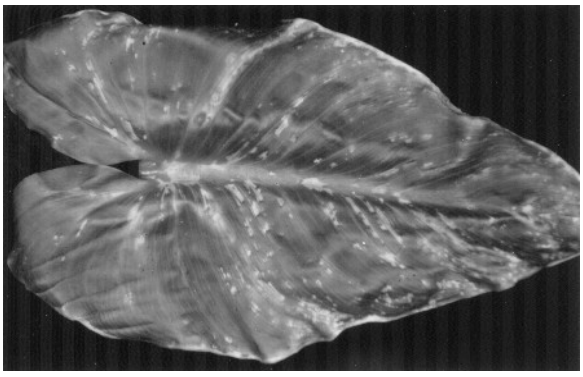

Figure 6. Calla lily leaf showing whitish and brown leaf streaks caused by TSWV (courtesy A.H. McCain).

Tomato - In tomato leaves the TSWV virus causes characteristic bronzing or purpling, one-sided growth, downward curling of leaves; leaf distortion; premature leaf or bud drop; black, brown, reddish, bronze-colored, or yellowish concentric rings; irregular whitish or necrotic leaf spots and flecking (Figure 8); complete plant stunting and yellowing; dark purplish or black stem streaks; and colored spots or stripes on flower petals. Although not always present, ringspots are almost certain symptoms of virus infection. The bronzing of plants may extend to the petiole, stem, pedicel, and calyx. Upward marginal rolling and stiffening of the leaflets follow and small circular dead spots commonly appear on the leaves under optimum conditions. The tips of growing shoots turn brown, wilt, and die. As new spots appear, the older leaves turn brown, die, or droop and later die.

Figure 8. Tomato spotted wilt virus (TSWV) on greenhouse tomatoes. Leaves showing downward curling, distortion, and dark necrotic spotting.

At a later stage, a fairly bold yellowish mosaic mottling, spotting, and malformation of leaves may develop. Growth may be checked permanently or only temporarily. Entire plants may become dwarfed and with the drooping leaves resemble a plant affected by a wilt disease.

Tomato fruit formed prior to infection appear normal while fruit that develop later may have pronounced symptoms. Green tomato fruit often develop pale green, white or yellowish blotches and spots (often with concentric zones of different colors), or small bumps on the surface. Paler red, orange, often yellow, green, or more rarely, white areas form in the normal red skin of mature fruit. Vertical cracks, corky patches or lines, black spots, ringspots, or lumps also may occur. The paler areas vary greatly in shape, ranging from an irregular mottling or blotchiness to distinct concentric circles (Figure 9). Severely affected plants may not form fruit or the fruit may be very small and unmarketable.

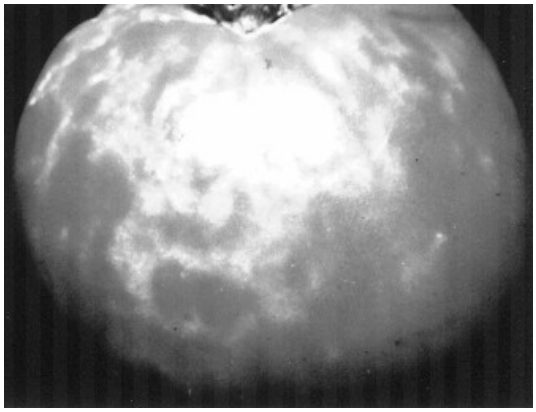

Figure 9. Nearly ripe fruit with white and yellowish mottling, blotching, and irregular patterns (courtesy R.E. Partyka).

Other vegetables - Potatoes have zonate dead spots on the upper leaves and streaks form on the stems, which cause a collapse of the shoot tips; plants are stunted and the yield is much reduced. Lettuce plants are yellowed, growth is stunted, and parchment-like blemishes with brown margins form on the central leaves. Peas develop purplish dead spots on the stem and leaves, followed by mottling, circular spots and wavy lines on the pods. Yellow then dead spots form on the outer stalks of celery with pockets of dead tissue inside the petioles; plants are stunted and worthless.

DISEASE CYCLE

The TSW virus can "survive" only in living plants. In the Midwest, reservoirs of the virus consist of plants growing in greenhouses or outdoor perennial plants, bulbs and corms or roots, and weeds. Dahlia is an important overwintering host. In the southern states, winter annuals are common reservoirs. With a wide host range among ornamental plants and weeds (Table 1), home-grown flowers are often the source of infection for commercial crops.

The thrips vectors are tiny (1/16 to 1/25 of an inch long) winged insects that feed by sucking sap from cells of leaves and flowers. Thrips can retain the virus for at least 4 days and often for life. The cycle begins with an adult thrips laying eggs on an infected plant. The larvae hatch, feed and acquire the virus, then as adults feed on healthy plants, transmitting the virus. The virus multiplies within the plant and may exist systemically even though some parts of the plant appear perfectly healthy. Symptoms begin to appear 7 to 20 days after virus transmission occurs.

Of the nine known species of virus-transmitting thrips, probably the most important in the Midwest is the western flower thrips (*Frankliniella occidentalis*). This insect is sometimes found in greenhouses but is not often present in garden or field situations.

CONTROL

Disease control measures depend upon the setting in which the disease occurs. TSWV is difficult to control where there is a source of the virus, where many susceptible host plants are present, and where there is an abundance of thrips vectors. Prevention, early detection, and quick action are required to reduce losses.

1. **In greenhouses** infected plants which, though only mildly infected, should be promptly destroyed and a routine thrips control program put into practice. Attempts to control thrips vectors with contact insecticides have been rather unsuccessful, probably because viruliferous thrips are constantly being blown into greenhouses, beds, and fields form external virus reservoirs. In addition, immature and adult thrips live deep within flowers or under developing foliage—areas difficult to reach with insecticides applied by ground or air equipment.

   Ornamental and vegetable plants may be treated for thrips with insecticides concentrating on opening flowers and leaves where the thrips tend to congregate and where it is difficult to get insecticide into contact with the thrips. As with all insecticide applications, apply only to plants that are listed on the label, and test spray a few plants to check for phytotoxicity against the cultivars and the best spraying conditions in your situation. Screening all openings into the greenhouse may help keep virus-carrying thrips out. Due to the thrips small size, fine screening (400 mesh) is needed on doors, vents, air intakes, and screens.

   Monitoring thrips in the greenhouse using yellow sticky cards placed near vents and above crop level allows detection of increasing populations of thrips. The insects are attracted to the yellow cards and become trapped on the sticky surface. The cards should be checked at least once a week and the number of thrips counted and recorded. When the number of trapped thrips increases, an insecticidal spray may be warranted. A second application should be made 4 days after the first. University of Illinois insecticide suggestions for thrips control are given in the Illinois Homeowner's Guide to Pest Management which is updated annually and available at all Illinois Extension offices. Follow all label directions for application and harvest intervals.

   Thrips, especially the western flower thrips, have been found to develop populations resistant to certain insecticides that are used repeatedly. It is important to rotate the class of insecticides used. For example pyrethroids, carbamates, chlorinated hydrocarbons, organophorphates, and soaps should be used in rotation instead of constantly applying just one chemical class. Pesticide regulations change frequently, so consult your local Extension Service to obtain current control suggestions. Insecticides are best applied early in the morning, when thrips are most active and when the potential for phytotoxicity is minimized.

Keep the greenhouse area free of weeds since they may harbor both thrips and the virus. Do not use known infected plants for propagation, even if some parts of the plant appear normal and healthy. Inspect incoming crops carefully for thrips infestations or unusual symptoms. Accept only healthy, insect-free plants.

2. **In outdoor culture**, in severe form, some control is achieved by destroying overwintering host plants (Table 1). Do not accept uncertified transplants or seedlings that have ringspots, streaks, bronze or purple flecks on leaves, off-color and drooping leaves, and generally appear unthrifty. There is no cure for infected plants. The disease will spread within a bed, garden or field and to other areas if thrips that transmit the virus are present.

   Roguing diseased plants has proven ineffective in preventing spread of the disease. The primary and best means of control is to start with disease-free plants.

3. Strict weed host control and wide separation of flower hosts from vegetable crops will help to reduce but will not eliminate the spotted wilt problem.

4. If you suspect TSWV, plants should be checked serologically using the ELISA technique. Contact the Plant Clinic at the University of Illinois, 1401 W. St. Mary's Road, Urbana, Il 61802 (may through September 15) or a private laboratory for assistance. ELISA diagnostic kits are available for TSWV and a wide range of other viruses.

Host Range of the Tomato Spotted Wilt Virus (TSWV)

The tomato spotted wilt virus infects some 200 plant species in 34 families including 7 monocotyledonous families. Six strains of the virus have been reported.

Table 1. Some common hosts of the tomato spotted wilt virus

African violet
Acanthospermum spp.
Agaonema
ageratum
Amaranthus spp.
amaryllis
Amazon lily (*Eucharis*)
anemone
apple-of-Peru or shooflyplant
artichoke, globe
aster
baby's-breath
barberry bean, snap
begonia
bindweed
blackberry-lily
boxthorn
broad bean
broccoli
Browallia
bur clover
burdock
bur-marigold
buttercup or crawfoot
cabbage, white stem
Calceolaria
Calendula
calla (arum) lily
Campanula spp.
cape-gooseberry
carnation
cactus (*Opuntia*)
catnip
cauliflower
celery
celeriac
Celosia (cockscomb)
Centranthus
cheeseweed
Chelone
chicory
chickweed
China-aster
Chondrilla spp.
chrysanthemum, florists' and garland
cineraria (*Senecio*)
clovers
cocklebur
Coleus
columbine
Columnea
coriander
cosmos
cowpea
Crepis spp. (hawkweed)
crownbeard, golden
cucumber
cyclamen
dahlia
Datura spp.
delphiniums
Dracaena
Duboisia spp.
dusty miller or mullein pink (*Centaurea*)
eggplant
endive
Erigeron bonariensis
escarole
evening primrose
Exacum (Persian violet)
fern, birdsnest
figmarigold
forget-me-not
foxglove
fuchsia
gaillardia
Galinsoga (Flora's paintbrush or Peruvian daisy)
geranium, florist's and ivy
Gerbera
Gladiolus
Gloxinia
Godetia
goldenrod
Gomphrena (globe amaranth) goosefoot, nettleleaf
Heliptreum spp.
henbane
horehound
horseweed, hairy
Hydrangea
Impatiens spp.
Indian-lettuce
Jerusalem-cherry, false jimsonweed
Kalanchoe (panda plant)
laceflower, blue
lamb's-quarters
Lantana (shrub verbena)
larkspur
lettuce (cos, crisphead, leaf, romaine)
lilies (*Lilium* spp.)
lion's-ear
lipstick vine (*Aeschynanthus*)
Lisianthus
Lobelia
lupines (*Lupinus* spp.)
Lychnis
mallows (*Malva* spp.)
marigolds
Mexican tea
monkey flower (*mimulus*)
Monarda (bee balm)
Morning-glory, blue and common
Nasturtium
Nettles
Nightshades, black, deadly, woody, etc.
Ocimum (Sweet basil)
oleander
orchids

Table 1. Some common hosts of the tomato spotted wilt virus (Cont)

Osteospemum (Vanstadens River daisy)
Oxalis spp.
pawpaw or papaya
pea, garden
peanut
Penstemon (beard tongue)
peony
peperomia peppers
periwinkle
petunia
phlox
Physalis spp.
Physostegia (Virginia lion's heart)
pigweed
pineapple
Plectranthus (Swedish ivy)
Polemonium (Jacob's ladder)
poppies (*Papaver* spp.)
Portulaca
potato
primroses (*primula* spp.)
purslane
Ranunculus spp.
rattleweed, fuzzy and smooth
rockcress, purple (*Aubrietta*)
Rohdea (sacred lily of India)
Salpiglossus, painted-tongue
Salvia (scarlet sage)
saxifrage
Scabiosa
Schizanthus, (Butterfly-flower)
Sedum spp.
shepherd's-purse
Schlumbergera (Christmas cactus)
snapdragon
soapwort
sowthistle, common
Spanish clover
Spanish needle
spinach
Stachys spp.
staggerweed
statice
Stephanotis
stock
strawflower (*Helichrysum*)
Streptocarpus
Streptosolen jamesonii
Swan River daisy (*Brachycome*)
sweet clover, yellow
sweet pea
swinecress
Syngonium spp.
tarragon (*Artemisia*0
tasselflower
thistle (*Circium* spp.)
tickseed
tidy-tips
tiger lily
tobaccos (30 species of *nicotiana*)
Tolmeia (piggyback plant)
tomatoes
Torenia
Trachelium spp.
Troximon sp.
Verbena
Veronica
Virginia stock
wallflower
wandering Jew (*Tradescantia*)
waxplant (*Hoya*)
winter cherry
zebra plant (*Aphelandra*)
zinnia