The Prevalence of tomato spotted wilt virus in weeds and crops in southwestern British Columbia

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A survey was conducted to determine the prevalence of tomato spotted wilt virus (TSWV) in southwestern British Columbia. Over 2600 samples from 38 commercial operations were collected and tested by enzyme-linked immunosorbent assay (ELISA). Twenty-five of the 38 sites had plants infected with TSWV. The incidence of the lettuce and impatiens strains of TSWV was equal outside the greenhouses, but the impatiens strain was more prevalent inside the greenhouses. TSWV was detected in four perennial weeds (*Trifolium* spp., *Cirsium arvense, Rumex acetosella,* and *Oxalis* sp.), one biennial weed *(C. vulgare),* three winter annuals *(Sfellaria media, Senecio vulgaris, Capsella bursa-pastoris)* and five annual weeds *(Cardamine oligosperma, Medicago lupulina, Galium* sp., *Geranium molle* and *Sonchus oleraceus*). Nine of the infected weed species grew outside the greenhouses. The only viruliferous thrips species collected during the survey was the western flower thrips *(Frankliniella occidentalis)* and it was the only thrips species collected inside greenhouses. TSWV is widespread in southwestern British Columbia and appears to be established in weeds outside the greenhouse operations.

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Une etude a ete menée afin de determiner l'importance du virus de la maladie bronzee de la tomate (TSWV) dans le sud-ouest de la Colombie-Britannique. Plus de 2600 echantillons provenant de 38 entreprises commerciales ont ete recueillis et evalues a l'aide du test immuno-enzymatique ELISA. Vingt-cinq des 38 sites présentaient des plants infectes par le TSWV. L'incidence des souches de TSWV a été egale sur la laitue et les impatientes a l'exterieur des serres, mais elle a ete plus marquee sur les impatientes a l'interieur des serres. Le TSWV a ete decouvert sur quatre mauvaises herbes vivaces *(Trifolium* spp., *Cirsium arvense, Rumex acetosella* et *Oxalis* sp.), sur une mauvaise herbe bisannuelle *(C. vulgare),* sur trois annuelles d'hiver *(Sfellaria media, Senecio vulgaris, Capsella bursa-pastoris)* et sur cinq mauvaises herbes annuelles *(Cardamine oligosperma, Medicago lupulina, Galium* sp., *Geranium molle* et *Sonchus oleraceus).* Neuf de ces especes de mauvaises herbes infectees ont pousse a l'exterieur des serres. Mais la seule espece de thrips virulente capturee a l'interieur des serres, durant l'évaluation, a ete le thrips des petits fruits *(Frankliniella occidentalis).* Le TSWV est largement repandu dans le sud-ouest de la Colombie-Britannique et il semble s'être etabli dans les mauvaises herbes a l'exterieur des operations serricoles.

Introduction

Tomato spotted wilt virus (TSWV) was first detected in British Columbia about 20 years ago (1). It is vectored by thrips, particularly the western flower thrips *(Frankhiella occidentalis)* which is native to British Columbia. These thrips did not become pests on greenhouse crops until after 1983, (R.A. Costello, personal communication) although they had infested field crops earlier. The occurrence of thrips on greenhouse crops and the greater movement of plant material into British Columbia have contributed to the increasing incidence of TSWV. Between 1987 and May 1991, TSWV was identified at 35 sites and caused significant losses to greenhouse crops. Many of the over 200 plant species listed as hosts are grown commercially or occur naturally in southwestern British Columbia (2).

While both the vector and hosts are present in British Columbia, it is unclear which hosts are potential sources of TSWV. Weeds were identified as reservoirs of TSWV in Hawaii (3) and because of the relatively mild winters in southwestern British Columbia it seemed possible that weeds could harbour TSWV. There are two predominant strains of TSWV in North America; the lettuce strain (L-strain) which is more common on vegetables and the impatiens strain (I-strain) which occurs more often on ornamental crops. However, both strains can infect vegetables or ornamental plants.

The results of this study in southwestern British Columbia show the range and incidence of TSWV, its presence in native weeds and the species of thrips that transmit the virus.

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Materials and methods

One or more samples of crop and weed species were collected at 38 greenhouse sites between May 1991 and January 1992. At each site, at least one sample of the main weed and crop species were collected. Two or more samples were taken when plant species were present in large numbers or were ones previously identified as hosts. Of the 38 greenhouses surveyed, twenty-one had a history of TSWV; seven had crops which previously tested negative for TSWV; and ten sites had not been surveyed before. Any plants with ring spots, stunting and necrosis were also collected. Most plant samples were collected from within 5 m of the greenhouse but some plants were collected up to 100 m from the greenhouse. Plants were tested for TSWV by double antibody sandwich enzyme-linked immunosorbent assay (DAS-ELISA) using a polyclonal antibody against the impatiens strain and a monoclonal antibody developed against the lettuce strain. The antibodies were developed and supplied by D.J. MacKenzie and P.J. Ellis, Agriculture and Agri-Food Canada, Research Station, Vancouver.

Thrips were collected from different plant species in the greenhouse and the surrounding area. The protocol used by Cho *et al.* (4) was used to test the thrips.

Results

There were 176 different plant species among the 2600 samples collected from the 38 commercial greenhouse ranges. Plants were infected with TSWV at 25 of the 38 sites (Table 1). TSWV had been previously diagnosed by the Plant Diagnostic Lab on crops at 14 of the 25 sites which had plants that tested positive during the survey. The 11 locations which had plants test positive during the survey had not been tested for TSWV before 1991. The virus was detected in weeds growing outside the greenhouse at 13 of the 38 sites surveyed. Seven of these 13 had a history of TSWV on crops, while plants from the other six sites had not been tested before. TSWV was detected in plants from Vancouver Island, the Fraser Valley, and Kelowna.

From the weed samples collected from the 38 sites, 2337 were tested for TSWV. TSWV was detected in 13 weed species and infected weeds were found at 20 sites (Table 2). Chickweed *(Sfellaria media)* was the most commonly infected weed. Over 13% of the 567 chickweed samples were TSWV positive and these plants were collected from 14 different sites. Infected plants and site distribution included clover (*Trifolium* ***spp.)*** plants from four of 30 sites, bull thistle *(Cirsium vulgare)* plants from three of 11 sites and black medick *(Medicago lupulina*) plants from two of 12 sites. TSWV also was detected in annual sowthistle *(Sonchus oleraceus),* bitter cress *(Cardamine oligosperma),* Canada thistle *(Cirsium arvense),* shepherd's purse *(Capsella bursa-pasforis)* and wood sorrel *(Oxalis* sp.) collected in the greenhouse. Seven of these weeds overwinter every year and three others survive most winters in the region. Infected plants of chickweed, clovers, bull thistle, cleavers (*Galium* sp.), bitter cress, common groundsel *(Senecio vulgaris),* dove's foot geranium *(Geranium molle*), and black medick were collected outside the greenhouse. These outdoor infected weeds were symptomless and could be a source of infection in the spring. All of the 115 dandelion (*Taraxacum officinale*) plants tested were negative for TSWV.

The results did not show any relationship between weed species and virus strain. However, when only one strain was present on a crop, the infected weed(s) at the same site had the same strain. The I-strain was detected in 26 weed samples, the L-strain in 11 weed samples and both strains in three weed samples. At the sites surveyed, growers had good weed control within the greenhouse, but few growers were concerned with weeds around the greenhouse. Growers often had piles of culled plants beside the greenhouse which could facilitate the spread of TSWV to nearby weeds.

TSWV was detected in 16 ornamental or vegetable crops collected in the greenhouse while two samples of infected impatiens (*Impatiens wallerana*) were from outside (Table 3). In the ornamental crops, 381 crop plants were tested for TSWV and the most commonly infected plants were the impatiens, including the New Guinea varieties, where 26% of the plants were infected. TSWV was detected on impatiens at seven of 18 greenhouses surveyed and in 18 of the 68 samples tested. Tomato *(Lycopersicon esculentum*) plants were infected at five of nine sites and peppers *(Capsicum annuum*) at three of seven greenhouses. Infected tomatoes were found at three greenhouses at very low levels, in what appeared to be healthy crops. This could be because thrips do not seem to multiply quickly on tomatoes grown in a well managed greenhouse. Even though the virus was present, the vector was not numerous enough to spread it. Brachycome *(Brachycome iberidifolia)* plants were infected with TSWV at two sites.

The impatiens strain was the most prevalent strain detected in the floriculture crops (Table 3) with 19 plants infected with only the I-strain, eight with only TSWV-L, and two with both strains. The tomato strain was more prevalent in the vegetable crops, with 12 plants infected with the L-strain, two with the I-strain, and two with both. Approximately two-thirds of the infected crop species exhibited symptoms associated with TSWV. In pepper, the lettuce strain was detected at one site and the impatiens strain at two sites. All of the tomatoes were infected with the lettuce strain, but two also had the impatiens strain.

Mixed operations, where vegetables and ornamental crops were both grown, had both strains present more frequently than one crop operations (Table 4). In addition, the percentage of mixed operations with TSWV was 75% while ornamental operations, or greenhouse vegetable operations with TSWV were 62% and 60%, respectively (Table 4).

Where TSWV was detected, both weeds and crops were infected at 60% of the sites. Weeds only were infected at 20% of the sites and crop plants only at the remaining 20%.

Thrips were observed at 35 of the 38 locations during the collection of plant samples (Table 5). Ninety-four samples of thrips were collected at 23 locations for identification and to test for the presence of TSWV. The ELISA test used for plants is also effective on individual thrips and results showed that 13% of thrips collected were carrying TSWV. All of the viruliferous thrips were collected from inside the greenhouse and were identified as western flower thrips by R.A. Costello. Viruliferous thrips were collected from chrysanthemum (*Dendranthema grandiflora*), lobelia (*Lobelia erinus),* geranium *(Pelargonium* x *hortorum),* spathiphyllum (*Spathiphyllum* sp.), alstroemeria *(Alstroemeria* sp.), pepper, chickweed and spiny annual sowthistle (Sonchus *asper*). Few thrips were found outside of greenhouses.

Discussion

TSWV is established in southwestern British Columbia. Since 1987, TSWV has been detected at 47 sites overall. Of 38 commercial sites surveyed in 1991, TSWV was detected at 25. TSWV had been diagnosed at 14 of these sites prior to 1991 and the virus was still present in these sites when this survey was conducted. This is in contrast to only seven sites with a history of TSWV where it was not detected. Mixed operations, where both vegetables and ornamentals were produced, had a higher incidence of TSWV. This may be due to more movement of plant material and greater difficulty in controlling thrips in production schedules where the greenhouse cannot be completely emptied between crops. An average of 62 weed and 10 crop plants were tested per site. TSWV was detected in at least one and up to seven plants at each of the 25 operations. TSWV is more common than previously realized.

It is probable that TSWV overwinters in certain weeds. Seven of the weed species found to be infected with TSWV have no difficulty overwintering in this region. TSWV was detected in weeds located within 15 m of the greenhouse at 10 sites. These weeds will remain infected until they die. It is impossible to rely on the appearance of symptoms in weeds to determine if they are infected with TSWV, since all infected weeds in the survey had no symptoms. This shows the importance of maintaining a weed free buffer zone around the greenhouse.

The most common thrips were the western flower thrips and all of the viruliferous thrips were of this species. Thrips feeding on infected overwintering weeds are probably the main source for spread of the virus into the greenhouse in the spring.

In the instances where TSWV was only detected in weeds, it is probable that TSWV also was present in crops which may have been shipped to market or, the virus was present but not detected in the tests. TSWV is difficult to detect because it is located in discrete pockets within the plant and is unstable outside of the plant. As a result, it may not always be detected even though it is present, so that a negative result is not entirely reliable. The ELISA tests used are very specific, so positive test results indicate the virus is present.

TSWV puts British Columbia's $84 million floriculture, $21 million greenhouse vegetable and $56 million field vegetable (5) industry at risk. Good weed control, effective sanitation, use of healthy transplants, and access to insecticides effective against thrips are essential to avoid major losses from TSWV.

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Table 1. Site histories and survey results for 1991.

History of site since 1987	Number of positive sites	Number of negative sites
No previous infections	11	6
Previous infections	14	7
Total from 1991 survey	25	13

Table 2. Summary of weed species infected with TSWV, 1991.

Weed	Growth habit[a]	TSWV strain[b]	Positive site/ total sites	No. infected/ total # tested	Location[c]
Annual sowthistle (*Sonchus oleraceus)*	A	L	1/5	1/6	I
Bitter cress (*Cardamine oligosperma)*	A	I	2/14	41128	I,O
Black medick (*Medicago lupulina*)	A	I,L	2/12	3/50	O
Bull thistle (*Cirsium vulgare)*	B	I,L	3/11	5/132	I,O
Canada thistle (*Cirsium arvense*)	P	L	1/7	1/20	I
Chickweed (*Stellaria media)*	ANVA	I,L,IL	14/34	39/567	I,O
Cleavers (*Galium sp.)*	A	L	1/1	1/1	O
Clover (*Trifolium spp.)*	P	I,L	4/30	61262	I,O
Common groundsel (*Senecio vulgaris)*	ANVA	I	1/9	51160	O
Dove's foot geranium (*Geranium molle)*	A	I	1/1	31240	O
Sheep sorrel (*Rumex acetosella*)	P	0	1/1	1/4	O
Shepherd's purse (*Capsella bursa-pastoris)*	A/WA	L	1/6	1/6	I
Wood sorrel (*Oxalis sp.)*	P	I	1/10	1/11	I

[a] **A** = annual, B = biennial, **P** = perennial and **WA** =winter annual.
[b] I = impatiens, **L** = lettuce, IL = both strains.
[c] Location where samples were collected. **I** = inside greenhouse, **O** = outside.

Table 3. Summary of crop species infected with TSWV, 1991.

Crop	TSWV strain[a]	Positive sites/ total sites tested	# infected/ total #tested	Symptoms[b]
Pepper *(Capsicum annuum)*	I,L	3/7	5/27	+
Tomato *(Lycopersicon esculentum)*	L,IL	5/9	11/35	+
Begonia *(Begonia x hiemalis)*	I	1/10	1/17	+
Brachycome (*Brachycome iberidifolia*)	I,L	2/4	2/6	
Chrysanthemum (*Dendranthema grandiflora*)	L	1/10	3/79	+
Episicia dianthiflora	I	1/1	1/1	+
Exacum *(Exacum affine)*	I	1/2	1/2	+
Fig (*ficus elastica*)	I	1/5	1/7	+
Fuchsia (*Fuchsia* **sp.**)	I	1/6	1/16	
Gloxinia *(Sinningia speciosa)*	I	1/3	1/4	+
Impatiens *(Impatiens wallerana)*	I,L,IL	5/12	9/21	+
Impatiens, New Guinea var.	I,L	3/14	4/21	+
Lantana *(Lantana* sp.)	I	1/1	2/2	
Laurentia fluviatillis	I	1/1	1/2	
Geranium *(Pelargonium x hortorum)*	L	1/6	1/25	
Spathiphyllum *(Spathiphyllum* **sp.**)	I	1/1	1/1	+

[a] I = impatiens, L = lettuce, IL = both strains

[b] + = indicates the plants had leaf spots, stunting, tip dieback or fruit mottling.
- = indicates no symptoms.

Table 4. Occurrence of TSWV on crops and weeds at vegetable, ornamental and mixed operations.

TSWV strain	Ornamental greenhouse	Vegetable greenhouse	Mixed greenhouse	Total sites
I	7	1	2	10
L	4	1	1	6
I + L	2	1	6	9
No TSWV	8	2	3	13
Total sites	21	5	12	38

Table 5. Summary of TSWV detected in thrips collected from 23 sites.

Collection area	No. of sites	No. of positive sites	Total samples	% WFT[a]	No. TSWV	I strain	L strain
Inside	20	5	56	100	44	10	2
Outside	16	0	38	97	38	0	0
Total	23	5	94	99	82	10	2

[a] The percentage of thrips that were western flower thrips.