EPPO Datasheet: *Orthotospovirus tomatomaculae*

Last updated: 2021-08-30

IDENTITY

Preferred name: *Orthotospovirus tomatomaculae*
Taxonomic position: Viruses and viroids: Riboviria: Orthornavirae: Negarnaviricota: Polyploviricotina: Bunyaviricetes: Elliovirales: Tospoviridae
Other scientific names: *TSWV*, *Tomato spotted wilt orthotospovirus*, *Tomato spotted wilt tospovirus*, *Tomato spotted wilt virus*
Common names: bronze leaf of tomato, kromnek virus, spotted wilt of tomato, yellow spot of pineapple
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EPPO Categorization: A2 list
view more categorizations online...
EU Categorization: RNQP ((EU) 2019/2072 Annex IV)
EPPO Code: TSWV00



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Notes on taxonomy and nomenclature

Tomato spotted wilt disease was first described in Australia in 1915 and was later identified as a viral disease caused by tomato spotted wilt virus (TSWV) (Samuel *et al.*, 1930). In 1990, TSWV was assigned to the genus *Tospovirus*, which was later renamed *Orthotospovirus* (family *Tospoviridae*, order Bunyavirales; ICTV online: https://talk.ictvonline.org/taxonomy/; Abudurexiti *et al*., 2019). Species demarcation within the genus is based on nucleoprotein (N) sequence (new species are defined as having less than 90% amino acid sequence similarity to all other described species within the genus); in addition, species are often biologically distinguished by their host range and vector specificity (Plyusnin *et al*., 2011; Kormelink *et al*., 2021).

HOSTS

TSWV has one of the largest known host ranges of any plant virus, with more than 1000 plant species recorded as hosts. The host range includes dicotyledons and monocotyledons, crop plants, ornamentals and weeds. Most of the plant species susceptible to TSWV belong to the *Asteraceae* and *Solanaceae* families (Parrella *et al.*, 2003).

In the EPPO region, the main crop hosts are artichokes (*Cynara scolymus*), eggplants (*Solanum melongena*), peppers (*Capsicum annuum*), chicory (*Cichorium* spp.), cucurbits (Cucurbitaceae), faba beans (*Vicia faba*), lettuce (*Lactuca sativa*), potatoes (*Solanum tuberosum*), tobacco (*Nicotiana tabacum*), tomatoes (*Solanum lycopersicum*); the main ornamental hosts are *Anemone*, *Aster*, *Begonia hybrids*, *Calceolaria*, *Callistephus*, chrysanthemum (*Dendranthema x grandiflorum*), *Cyclamen*, *Dahlia*, *Gerbera*, *Pelargonium*, *Pericallis cruenta*, *Ranunculus*, *Sinningia* spp., *Symphyotrichum*, *Tagetes patula* and *Zinnia*. Wild species such as *Senecio vulgaris*, *Solanum nigrum*, *Sonchus* spp. and *Stellaria media* can be important reservoirs for TSWV.

Host list: *Acalypha australis*, *Acanthospermum hispidum*, *Acanthus mollis*, *Achimenes sp.*, *Aconitum carmichaelii*, *Adenium obesum*, *Aegopodium podagraria*, *Aeschynanthus pulcher*, *Aeschynanthus speciosus*, *Agapanthus praecox subsp. orientalis*, *Agapanthus praecox*, *Agastache foeniculum*, *Ageratum houstonianum*, *Aglaonema commutatum*, *Agrostemma githago*, *Ajania pacifica*, *Alcea rosea*, *Alkekengi officinarum*, *Alliaria petiolata*, *Allium ascalonicum*, *Allium cepa*, *Allium porrum*, *Allium sativum*, *Alstroemeria aurea*, *Alstroemeria hybrids*, *Alternanthera sessilis*, *Althaea officinalis*, *Amaranthus albus*, *Amaranthus blitum*, *Amaranthus caudatus*, *Amaranthus cruentus*, *Amaranthus graecizans*, *Amaranthus hybridus*, *Amaranthus palmeri*, *Amaranthus powellii*, *Amaranthus retroflexus*, *Amaranthus spinosus*, *Amaranthus thunbergii*, *Amaranthus viridis*, *Amaryllis belladonna*, *Ambrosia artemisiifolia*, *Ambrosia psilostachya*, *Ambrosia trifida*, *Ammi majus*, *Ananas comosus*, *Anchusa azurea*, *Anchusa capensis*, *Anchusa officinalis*, *Anchusa undulata*, *Anemone coronaria*, *Antennaria neglecta*, *Anthemis arvensis*, *Anthurium andraeanum*, *Anthurium hookeri*, *Anthurium scherzerianum*, *Antirrhinum majus*, *Aphelandra squarrosa*, *Apium graveolens var. dulce*, *Apium graveolens*, *Aquilegia vulgaris*, *Arabis sp.*, *Arachis batizocoi*, *Arachis duranensis*, *Arachis hypogaea*

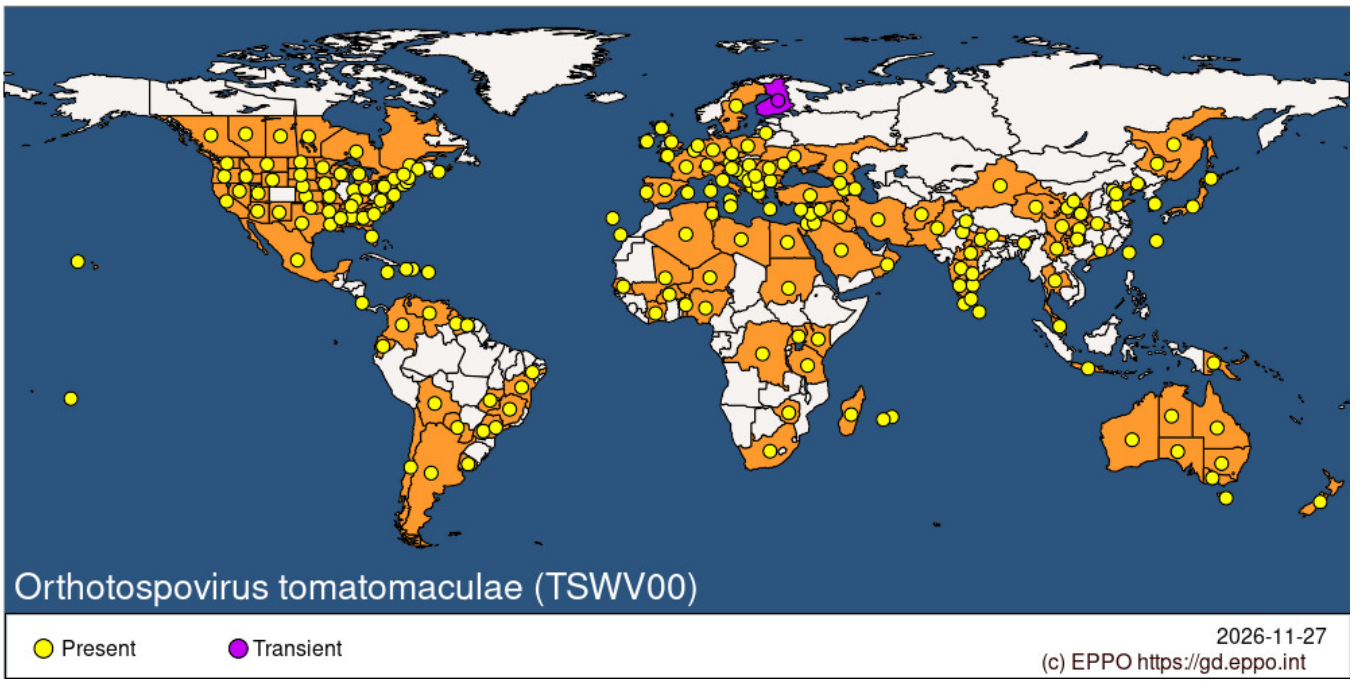
, Arachis monticola, Arachis pusilla, Arachis stenosperma, Arachis villosulicarpa, Arctium lappa, Arctium minus, Arctotheca calendula, Arctotis x hybrida, Ardisia sp., Argyranthemum frutescens, Aristolochia clematitis, Aristolochia elegans, Artemisia absinthium, Artemisia dracunculus, Artemisia princeps, Arum maculatum, Arum palaestinum, Asarum canadense, Asclepias curassavica, Asparagus setaceus, Asplenium nidus, Aster amellus, Aubrieta deltoidea, Avena fatua, Ballota nigra, Barbarea vulgaris, Begonia gracilis, Begonia semperflorens hybrids, Begonia tuberhybrida hybrids, Begonia x hiemalis, Bellis caerulescens, Berberis sp., Beta vulgaris, Betonica officinalis, Bidens discoidea, Bidens pilosa, Bidens subalternans, Bidens vulgata, Blitum capitatum, Blitum virgatum , Bothriocline longipes, Bouvardia sp., Brachyscome iberidifolia, Brassica juncea, Brassica napus, Brassica oleracea var. botrytis, Brassica oleracea, Brassica perviridis, Brassica rapa subsp. chinensis, Brassica rapa subsp. pekinensis, Brassica rapa subsp. sylvestris, Browallia americana, Browallia speciosa, Brugmansia arborea, Brugmansia aurea, Brugmansia suaveolens, Buddleja davidii, Cajanus cajan, Calceolaria crenatiflora, Calceolaria herbeohybrida hybrids, Calectasia cyanea, Calendula arvensis, Calendula officinalis, Calla palustris, Callistephus chinensis, Calotropis gigantea, Calystegia sepium, Campanula americana, Campanula glomerata, Campanula grandis subsp. grandis, Campanula isophylla, Campanula medium, Campanula persicifolia, Campanula pyramidalis, Campanula rapunculoides, Canavalia ensiformis, Canavalia gladiata, Canna sp., Capsella bursa-pastoris, Capsicum annuum, Capsicum chinense, Capsicum frutescens, Cardamine flexuosa, Cardamine hirsuta, Cardamine oligosperma, Cardamine parviflora, Carduus acanthoides, Carduus nutans, Carica papaya, Carthamus tinctorius, Carum carvi, Catharanthus roseus, Celosia argentea, Centaurea cineraria, Centaurea cyanus, Centella asiatica, Centranthus ruber, Cerastium glomeratum, Cerastium holosteoides, Cestrum aurantiacum, Cestrum elegans , Cestrum nocturnum, Cestrum parqui, Chaerophyllum temulum, Chamaedorea costaricana, Chamaedorea elegans, Chelone sp., Chenopodiastrum murale, Chenopodiastrum simplex, Chenopodium album, Chenopodium ficifolium, Chenopodium giganteum, Chenopodium vulvaria, Chondrilla juncea, Chrysanthemum indicum, Chrysanthemum x morifolium, Cicer arietinum, Cichorium endivia var. latifolia, Cichorium endivia, Cichorium intybus, Cineraria sp., Cirsium arvense, Cirsium japonicum, Cirsium palustre, Cirsium setidens, Cirsium vulgare, Citrullus lanatus, Clarkia amoena subsp. lindleyi, Claytonia perfoliata, Clematis flammula, Clematis vitalba, Cleretum clavatum, Clerodendrum thomsoniae, Clivia sp., Codonanthe crassifolia, Codonopsis pilosula, Coffea arabica, Coleus australis , Coleus scutellarioides, Columnea hirta, Commelina communis, Commelina cyanea, Conium maculatum, Convolvulus althaeoides, Convolvulus arvensis, Convolvulus cantabrica, Coprosma repens, Cordyline fruticosa, Coreopsis basalis, Coreopsis lanceolata, Coreopsis tinctoria, Coriandrum sativum, Cornus sanguinea, Cosmos bipinnatus, Cota tinctoria, Crepis capillaris, Crepis divaricata, Crepis foetida subsp. rhoeadifolia, Crepis occidentalis subsp. pumila, Crepis pulchra, Crinum jagus, Crinum moorei, Crotalaria incana, Crotalaria juncea, Crotalaria pallida var. obovata, Crotalaria spectabilis, Croton glandulosus, Cucumis melo, Cucumis sativus, Cucurbita maxima, Cucurbita moschata, Cucurbita pepo, Cyanus montanus, Cyclamen persicum, Cymbidium sp., Cynanchum rostellatum, Cynara cardunculus, Cynara scolymus, Cynodon dactylon, Cynoglossum sp., Cyperus esculentus, Cyperus rotundus, Cyrtanthus sp., Cytisus scoparius, Dahlia hybrids, Dahlia pinnata, Datura ferox, Datura innoxia, Datura metel, Datura stramonium var. tatula, Datura stramonium, Datura wrightii, Delphinium hybrids, Dendrobium sp., Desmodium tortuosum, Desmodium uncinatum, Dianthus chinensis, Diascia barberae, Dieffenbachia sp., Digitalis sp., Digitaria sanguinalis, Dimorphotheca ecklonis, Dimorphotheca fruticosa, Dimorphotheca pluvialis, Dimorphotheca sinuata, Diplotaxis erucoides, Diplotaxis muralis, Dracaena draco, Dracaena fragrans, Dracaena marginata, Duboisia leichhardtii, Duboisia myoporoides, Dysphania ambrosioides, Echinacea purpurea, Echinochloa colonum, Echinocystis lobata, Eclipta prostrata, Eleusine indica, Emilia coccinea , Emilia sonchifolia, Epilobium hirsutum, Epipremnum pinnatum, Erigeron bonariensis, Erigeron canadensis, Erigeron strigosus, Erodium ciconium, Erodium moschatum, Erysimum cheiranthoides, Erysimum x cheiri, Eupatorium capillifolium, Eupatorium maculatum, Euphorbia heterophylla, Euphorbia peplus, Euphorbia pulcherrima, Euphorbia tithymaloides, Euryops sp., Eustoma russellianum, Exacum affine, Fagopyrum esculentum, Fallopia convolvulus, Farfugium japonicum, Fatshedera lizei, Fatsia japonica, Felicia amelloides, Felicia bergeriana, Felicia fruticosa, Ficus benjamina, Ficus cyathistipula, Ficus elastica, Ficus lyrata, Flaveria bidentis, Forsythia koreana, Fragaria vesca, Freesia hybrids, Fuchsia hybrids, Fumaria muralis, Fumaria officinalis, Gaillardia aristata, Gaillardia x grandiflora, Galinsoga parviflora, Galinsoga quadriradiata, Galium aparine, Galium lucidum, Galium parisiense, Galium spurium, Galium tricornutum, Galium verum, Gamochaeta falcata, Gamochaeta pensylvanica, Gamochaeta purpurea, Gardenia jasminoides, Gazania rigens, Geranium carolinianum, Geranium robertianum, Geranium rotundifolium, Gerbera jamesonii, Gerbera x hybrida, Gesneria sp., Gladiolus grandiflorus, Glaucium flavum, Glebionis coronaria, Gleditsia triacanthos, Gloriosa superba, Gloxinia sp., Glycine max, Glycine soja, Gnaphalium uliginosum, Gomphrena globosa, Goniolimon tataricum, Gossypium hirsutum, Guzmania sp., Gymnema sylvestre, Gynura aurantiaca, Gypsophila elegans, Gypsophila paniculata, Helianthus annuus, Helichrysum sp., Heliotropium europaeum, Helminthotheca echioides, Hemistepta lyrata, Heptapleurum actinophyllum, Heptapleurum arboricola, Hesperis matronalis, Hibiscus trionum, Hippeastrum aulicum, Hippeastrum hybrids, Hippeastrum reginae, Hippeastrum striatum, Hirschfeldia incana, Holcus lanatus, Hoya australis

, Hoya bella, Hoya carnosa, Hoya linearis, Humulus scandens, Hydrangea macrophylla, Hymenocallis occidentalis, Hyoscyamus niger, Hypericum triquetrifolium, Iberis semperflorens, Impatiens New Guinea hybrids, Impatiens balsamina, Impatiens capensis, Impatiens hybrids, Impatiens walleriana, Inula helenium, Ipomoea batatas, Ipomoea indica, Ipomoea lacunosa, Ipomoea purpurea, Iris domestica, Iris ensata, Iris x hollandica, Jacobaea maritima, Jacobaea vulgaris, Jacquemontia tamnifolia, Jasminum odoratissimum, Justicia brandegeana, Kalanchoe blossfeldiana, Kalanchoe daigremontiana, Kalanchoe synsepala, Kalanchoe thyrsiflora, Lablab purpureus, Lactuca canadensis, Lactuca floridana, Lactuca indica, Lactuca saligna, Lactuca sativa var. capitata, Lactuca sativa var. crispa, Lactuca sativa var. longifolia, Lactuca sativa, Lactuca serriola, Lagascea mollis, Lagenaria siceraria, Lamium amplexicaule, Lamium purpureum, Lantana camara, Lathyrus odoratus, Lathyrus sativus, Lavandula angustifolia subsp. pyrenaica, Layia elegans, Leonotis nepetifolia, Lepidium didymum, Lepidium draba, Lepidium sativum, Lepidium virginicum, Leptochiton quitoensis, Leucanthemum maximum, Leucanthemum vulgare, Leucanthemum x superbum, Ligustrum vulgare, Lilium lancifolium, Lilium longiflorum, Limonium perezii, Limonium platyphyllum, Limonium sinuatum, Limonium vulgare, Lisianthius sp., Lobelia dortmanna, Lobelia erinus, Lobelia valida, Lobularia maritima, Lolium perenne, Luffa aegyptiaca, Lupinus albus, Lupinus angustifolius, Lupinus leucophyllus, Lupinus polyphyllus, Lupinus subcarnosus, Lychnis chalcedonica, Lycianthes rantonnetii, Lycium chinense, Lycium ferocissimum, Lycopus europaeus, Lysimachia arvensis, Lysimachia congestiflora, Lysimachia loeflingii, Lysimachia nummularia, Macrotyloma uniflorum, Maianthemum canadense, Malcolmia maritima, Malva neglecta, Malva nicaeensis, Malva parviflora, Malva pusilla, Malva sylvestris, Malva verticillata, Maranta leuconeura, Marrubium vulgare, Martynia annua, Matricaria chamomilla, Matricaria discoidea, Matthiola incana, Mazus pumilus, Medicago lupulina, Medicago polymorpha, Medinilla magnifica, Melampodium sp., Melilotus indicus, Melilotus officinalis, Melissa officinalis, Mentha arvensis, Mentha microphylla, Mentha spicata, Mentha suaveolens, Mentha x piperita, Mercurialis annua, Mimulus sp., Mirabilis jalapa, Mollugo verticillata, Moluccella laevis, Monarda didyma, Monarda fistulosa, Montia sp., Morus alba, Myosotis alpestris, Myosoton aquaticum, Nasturtium officinale, Nepeta cataria, Nepeta nuda, Nerine bowdenii, Nerium oleander, Nicandra physalodes, Nicotiana acuminata, Nicotiana alata, Nicotiana benthamiana, Nicotiana bonariensis, Nicotiana debneyi , Nicotiana excelsior, Nicotiana exigua, Nicotiana glauca, Nicotiana goodspeedii, Nicotiana langsdorffii, Nicotiana longiflora, Nicotiana maritima, Nicotiana megalosiphon, Nicotiana nudicaulis, Nicotiana paniculata, Nicotiana pauciflora, Nicotiana plumbaginifolia, Nicotiana quadrivalvis, Nicotiana solanifolia, Nicotiana suaveolens, Nicotiana sylvestris, Nicotiana tabacum, Nicotiana tomentosiformis, Nicotiana undulata, Nicotiana velutina, Nicotiana wigandioides, Nicotiana x edwardsonii, Nicotiana x sanderi, Nolana sp., Notobasis syriaca, Nuttallanthus canadensis, Ocimum basilicum, Oenanthe javanica, Oenothera biennis, Oenothera laciniata, Oenothera sp., Oncidium sp., Onopordum acanthium, Onopordum illyricum, Opuntia sp., Orlaya sp., Ornithogalum thyrsoides, Orobanche sp., Osteospermum sp., Oxalis acetosella, Oxalis corniculata, Oxalis latifolia, Oxalis stricta, Oxalis tuberosa, Oxybasis glauca, Oxybasis urbica, Oxypetalum sp., Pachypodium lamerei, Paederia foetida, Paeonia lactiflora, Panax notoginseng, Papaver dubium, Papaver nudicaule, Papaver orientale, Papaver rhoeas, Papaver somniferum, Parietaria officinalis, Passiflora edulis, Pelargonium crispum, Pelargonium grandiflorum, Pelargonium peltatum, Pelargonium x hortorum, Pelargonium zonale, Penstemon hartwegii, Penstemon hirsutus, Peperomia fraseri, Peperomia obtusifolia, Peperomia rotundifolia, Pericallis cruenta, Pericallis x hybrida, Persicaria hydropiper, Persicaria lapathifolia, Persicaria longiseta, Persicaria maculosa, Persicaria pensylvanica, Petasites japonicus, Petroselinum crispum, Petunia hybrids, Petunia integrifolia, Phalaenopsis sp., Phaseolus lunatus, Phaseolus vulgaris, Philodendron sagittifolium, Phlox drummondii, Physalis acutifolia, Physalis alkekengi var. franchetii, Physalis angulata, Physalis heterophylla, Physalis ixocarpa, Physalis minima, Physalis peruviana, Physalis pruinosa, Physalis pubescens, Physostegia virginiana, Phytolacca americana, Pilea pumila, Pinus sp., Pisum sativum subsp. arvense, Pisum sativum, Pittosporum tobira, Plantago lanceolata, Plantago major, Plantago rugelii, Platycerium superbum, Platycodon grandiflorus, Plumeria rubra f. acutifolia, Poa annua, Polygonum aviculare, Portulaca grandiflora, Portulaca oleracea, Portulaca pilosa, Potentilla reptans, Primula malacoides, Primula obconica, Primula sinensis, Primula vulgaris, Prunella vulgaris, Pyrrhopappus carolinianus, Ranunculus abortivus, Ranunculus acris, Ranunculus arvensis, Ranunculus asiaticus, Ranunculus bulbosus, Ranunculus hybridus , Ranunculus muricatus, Ranunculus sardous, Raphanus raphanistrum, Raphanus sativus, Rhamnus sp., Rhaponticum carthamoides, Rhodanthe chlorocephala subsp. rosea, Rhodanthe manglesii, Rhododendron sp., Richardia scabra, Ricinus communis, Robinia pseudoacacia, Rohdea sp., Rorippa indica, Rorippa palustris, Rosa sp. , Rubus idaeus, Rubus ulmifolius, Rudbeckia amplexicaulis, Rudbeckia hirta, Rudbeckia nitida, Rudbeckia occidentalis, Rumex conglomeratus, Rumex crispus, Ruscus hypoglossum, Salpiglossis sinuata, Salsola kali subsp. ruthenica, Salvia officinalis, Salvia pratensis, Salvia sclarea, Salvia splendens, Salvia verbenaca, Sambucus nigra, Sanguisorba minor, Saponaria officinalis, Saxifraga stolonifera, Scabiosa atropurpurea, Schizanthus pinnatus, Schlumbergera truncata, Schlumbergera x buckleyi, Scutellaria sp., Sedum sarmentosum, Seemannia sylvatica, Senecio doria, Senecio vulgaris, Senna obtusifolia, Senna occidentalis, Senna tora, Sesamum indicum, Setaria viridis , Sicyos edulis, Sida rhombifolia, Sida spinosa, Sigesbeckia orientalis, Silene coronaria, Silene firma, Silene latifolia subsp. alba

, Silene vulgaris, Sinapis arvensis, Sinningia speciosa, Sisymbrium irio, Smilax sieboldii, Solanum aculeatissimum, Solanum americanum, Solanum aviculare, Solanum betaceum, Solanum capsicoides, Solanum carolinense, Solanum chenopodioides, Solanum chilense, Solanum dulcamara, Solanum grandiflorum, Solanum habrochaites, Solanum hieronymi, Solanum laciniatum, Solanum lycocarpum, Solanum lycopersicum, Solanum mammosum, Solanum marginatum, Solanum melongena, Solanum muricatum, Solanum neorickii, Solanum nigrum, Solanum palinacanthum, Solanum pennellii, Solanum pimpinellifolium, Solanum pseudocapsicum, Solanum quitoense, Solanum robustum, Solanum seaforthianum, Solanum triflorum, Solanum trifolium, Solanum tuberosum, Solanum tweedieanum, Solanum viarum, Solanum villosum subsp. miniatum, Solanum violaceum, Solidago altissima , Solidago canadensis, Sonchus asper, Sonchus oleraceus, Sonchus tenerrimus, Sorbus aucuparia, Spathiphyllum floribundum, Spergula arvensis, Spinacia oleracea, Stachys arvensis, Stapelia sp., Stellaria media, Stellaria uliginosa, Stephanotis floribunda, Stevia rebaudiana, Streptocarpus ionanthus, Streptosolen jamesonii, Symphoricarpos albus, Symphyotrichum cordifolium, Symphyotrichum ericoides, Symphyotrichum lateriflorum, Symphyotrichum novae-angliae, Symphytum tuberosum, Syngonium podophyllum, Tagetes erecta, Tagetes minuta, Tagetes patula, Taraxacum officinale, Tephrosia purpurea, Tetragonia tetragonoides, Thymus vulgaris, Tithonia rotundifolia, Tolmiea menziesii, Torilis arvensis, Trachelium caeruleum, Trachymene coerulea, Tradescantia albiflora, Tragopogon dubius, Tragopogon porrifolius, Tragopogon pratensis, Tragopogon x mirus, Tragopogon x miscellus, Trevesia palmata, Tribulus terrestris, Trichosanthes kirilowii, Trifolium incarnatum, Trifolium repens, Trifolium sp., Trifolium subterraneum, Trifolium tembense, Triodanis perfoliata, Tripleurospermum inodorum, Tropaeolum majus, Tulbaghia violacea, Tussilago farfara, Urceolina x grandiflora, Urtica dioica, Valeriana fauriei, Valeriana officinalis, Valerianella locusta, Verbascum blattaria, Verbascum thapsus, Verbena brasiliensis, Verbena hastata, Verbena hybrids, Verbena litoralis, Verbena officinalis, Verbena rigida, Verbesina encelioides, Veronica agrestis, Veronica chamaedrys, Veronica hederifolia, Veronica officinalis, Veronica persica, Vicia amoena, Vicia faba, Vicia hirsuta, Vicia lens, Vigna angularis, Vigna mungo, Vigna radiata, Vigna unguiculata subsp. sesquipedalis , Vigna unguiculata subsp. unguiculata, Vigna unguiculata, Vinca minor, Viola cornuta, Viola sororia, Viola x wittrockiana, Wahlenbergia marginata, Weigela florida, Xanthium orientale subsp. saccharatum, Xanthium spinosum, Xanthium strumarium, Xerochrysum bracteatum, Youngia japonica, Yucca aloifolia, Yucca baccata, Zantedeschia aethiopica, Zantedeschia albomaculata subsp. albomaculata, Zantedeschia albomaculata, Zantedeschia elliottiana, Zantedeschia rehmannii, Zinnia elegans

GEOGRAPHICAL DISTRIBUTION

Although tomato spotted wilt disease was reported from Australia more than 100 years ago, it only spread rapidly in the 1980s due to the global spread of *Frankliniella occidentalis*, one of the major thrips vectors (EFSA, 2012b; Kormelink *et al*., 2021). It is now present in almost all countries with temperate, tropical and subtropical climates.



EPPO Region: Albania, Algeria, Armenia, Austria, Azerbaijan, Belgium, Bosnia and Herzegovina, Bulgaria,

Croatia, Cyprus, Czechia, Finland, France (mainland), Georgia, Germany, Greece (mainland, Kriti), Guernsey, Hungary, Ireland, Israel, Italy (mainland, Sardegna, Sicilia), Jordan, Lithuania, Malta, Moldova, Republic of, Montenegro, Netherlands, North Macedonia, Poland, Portugal (mainland, Madeira), Romania, Russian Federation (Far East, Southern Russia), Serbia, Slovenia, Spain (mainland, Islas Baleares, Islas Canárias), Sweden, Switzerland, Tunisia, Türkiye, Ukraine, United Kingdom (Channel Islands, England, Scotland)
Africa: Algeria, Benin, Burkina Faso, Congo, The Democratic Republic of the, Cote d'Ivoire, Egypt, Kenya, Libya, Madagascar, Mali, Mauritius, Niger, Nigeria, Reunion, Senegal, South Africa, Sudan, Tanzania, United Republic of, Tunisia, Uganda, Zimbabwe
Asia: Afghanistan, China (Beijing, Chongqing, Gansu, Guangdong, Guizhou, Heilongjiang, Hubei, Liaoning, Ningxia, Qinghai, Shaanxi, Shandong, Sichuan, Tianjin, Xinjiang, Yunnan), India (Andhra Pradesh, Assam, Haryana, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Tamil Nadu, Telangana, Uttar Pradesh), Indonesia (Java), Iran, Islamic Republic of, Iraq, Israel, Japan (Hokkaido, Honshu, Ryukyu Archipelago), Jordan, Korea, Republic of, Lebanon, Malaysia (West), Nepal, Oman, Pakistan, Saudi Arabia, Sri Lanka, Syrian Arab Republic, Taiwan, Thailand
North America: Canada (Alberta, British Columbia, Manitoba, Nova Scotia, Ontario, Québec, Saskatchewan), Mexico, United States of America (Alabama, Arizona, Arkansas, California, Connecticut, Delaware, Florida, Georgia, Hawaii, Idaho, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, Wisconsin, Wyoming)
Central America and Caribbean: Costa Rica, Dominican Republic, Haiti, Jamaica, Puerto Rico
South America: Argentina, Bolivia, Brazil (Bahia, Goias, Minas Gerais, Parana, Pernambuco, Sao Paulo), Chile, Colombia, Ecuador, Guyana, Paraguay, Suriname, Uruguay, Venezuela
Oceania: Australia (New South Wales, Northern Territory, Queensland, South Australia, Tasmania, Victoria, Western Australia), Cook Islands, New Zealand, Papua New Guinea

BIOLOGY

TSWV exhibits high genetic diversity (Tsompana *et al.*, 2005; Kaye *et al.*, 2011; Batuman *et al.*, 2020; Fontana *et al.*, 2020; Ruark-Seward *et al.*, 2020). However, despite the known diversity of TSWV populations, it can be assumed that all TSWV isolates occurring worldwide are capable of causing similar diseases in plants and that differences in disease symptoms and symptom severity are a function of isolate, host and environment as well as infection time and the age of the plant (EFSA, 2012a). Diverse resistance-breaking isolates of TSWV have been reported from many regions of the world (Lopez *et al.*, 2011; Almási *et al.*, 2020). The ability of the Tsw gene in pepper and the Sw-5 gene in tomato to break resistance to TSWV is attributed to mutations in different viral genes, NSs for Tsw/pepper (Margaria *et al.*, 2007; de Ronde *et al.*, 2019; Almási *et al.*, 2020) and NSm for Sw-5/tomato (Jahn *et al.*, 2000; Hoffmann *et al.*, 2001; Lopez *et al.*, 2011; Olaya *et al.*, 2020).

Orthotospovirus particles are transmitted and spread in natural conditions by thrips - insects of the genera *Frankliniella* and *Thrips* (family Thripidae). Thrips species known to transmit TSWV are *Frankliniella bispinosa, F. cephalica, F. fusca, F. gemina, F. occidentalis, F. intonsa, F. schultzei, Thrips setosus* and *T. tabaci* (Rotenberg & Whitfield, 2018). In the EPPO region, *F. occidentalis, F. intonsa* and *T. tabaci* are widely distributed (https://www.cabi.org/isc/datasheet/; EFSA, 2012a). Most thrips species are very polyphagous. TSWV is transmitted by thrips in a persistent manner. Only individuals which have acquired the virus at the larval stages can transmit it. Virus transmission occurs after a latent period of circulation and multiplication of TSWV in the thrips vector. Once acquired, the virus is transmitted transstadially and thrips remain infectious for life, however there is no evidence of transovarial transmission (Ullman *et al.*, 1993; Wijkamp *et al.*, 1993; Wijkamp & Peters, 1993; Van de Wetering *et al.*, 1996; Gupta *et al.*, 2018; Rotenberg & Whitfield, 2018).

TSWV can be spread through the movement of infected plant tissue used for vegetative propagation (EFSA, 2012a). Whilst the virus can also be transmitted by mechanical inoculation through small wounds on leaves or stems, this mode of transmission is unlikely to happen in the wild (EFSA, 2012a). Although tospoviruses are considered not to be seed-transmitted (Pappu *et al.*, 2009), an as yet unconfirmed first report of seed transmission of a tospovirus (soybean vein necrosis virus) has recently been published by Groves *et al.* (2016).

DETECTION AND IDENTIFICATION

Symptoms

TSWV can cause a variety of symptoms that may vary in the same host species depending on the variety and age as well as the nutritional and environmental conditions of the plant. Symptoms of TSWV infection also vary depending on the developmental stage of the plant at the time of inoculation and on the virus isolate. Most plants respond to TSWV infection with systemic symptoms. Symptoms on the leaves of infected plants include mosaic, mottle, ring spot, and line patterns. Early infections can result in severe stunting, wilting, leaf deformation and necrosis on stems and tips, chlorotic or necrotic spots on leaves, and plant death. Symptoms on fruits usually consist of irregular discolouration, e.g. yellow/orange flecks or, occasionally, rings, or necrotic lesions or rings. Several other orthotospoviruses, as well as even more genetically distinct viruses, can cause symptoms similar to those of TSWV infection. However, it should be noted that infection of host plants by TSWV may be asymptomatic in some host plants, or the symptoms may be mild due to environmental conditions, or the infection may be too recent to reach full symptom expression (Kormelink *et al.*, 2005; EFSA, 2012a,b; Batuman *et al.*, 2020).

On tomatoes, plants show bronzing, curling, necrotic streaks and spots on leaves. Dark brown streaks also appear on leaf petioles, stems and growing tips. Infected plants are small and stunted compared to healthy plants. The ripe fruit shows paler red or yellow areas on the skin. Sometimes infected plants die due to severe necrosis. On pepper, symptoms usually consist of stunting and yellowing of the entire plant. Leaves may show chlorotic line patterns or mosaic with necrotic spots. Necrotic streaks appear on the stems extending to the terminal shoots. On ripe fruits, yellow spots with concentric rings or necrotic streaks have been observed. On lettuces, infection begins on one side of the plant in the leaves, which become chlorotic with brown spots. The discolouration extends to the heart leaves, and growth on the affected side of the plant ceases (Cho *et al.*, 1989; Moriones *et al.*, 1998; Saidi & Warade, 2008; Kamberoglu & Alan, 2011; Salem *et al.*, 2012; Sevik & Arli-Sokmen, 2012; Salamon *et al.*, 2016; Abadkhah *et al.*, 2018; Batuman *et al.*, 2020; Fontana *et al.*, 2020; Kil *et al.*, 2020).

On leaves of ornamentals, the most typical symptoms indicative of TSWV infection are concentric chlorotic to necrotic rings or ring patterns. In some ornamentals (e.g., *Phalaenopsis* spp.), symptoms are restricted to a few leaves, while in others (e.g., chrysanthemums) systemic infection with spots and rings on leaves and systemic necrosis is observed. On chrysanthemums, there is a wide variation of symptoms among cultivars. In other ornamentals, black stem streaks and wilting are usually observed (Cho *et al.*, 1989; Verhoeven and Roenhorst, 1994; Baker *et al.*, 2007; Zheng *et al.*, 2008).

Morphology

TSWV virions are spherical, enveloped particles approximately 80-120 nm in diameter (Kormelink, 2005). The lipid envelope of orthotospoviruses contains transmembrane tips composed of two glycoproteins that form oligomeric structures on the outside of the envelope (Butkovi? *et al.*, 2021). The cytoplasmic tails of the glycoproteins interact with the nucleoproteins encapsulating at least one copy of the three linear ssRNA segments (Butkovi? *et al.*, 2021).

Detection and inspection methods

The plants, especially the leaves and fruits, should be examined for symptoms. Particular attention should be paid if thrips are present. If necessary, samples should be taken for laboratory testing for definitive identification of the pest. Procedures have been developed for the inspection of potatoes (EPPO, 2007) and vegetable plants for planting (EPPO, 2016).

The tests recommended for the detection and identification of TSWV are described in EPPO Standard PM7/139 (EPPO, 2020). Electron microscopy can be used for the detection of TSWV and other viruses of the same genus, as they share a typical morphology. Mechanical inoculation of test plants can be used for its detection and subsequent identification by other methods. Several ELISA kits and serological tests for on-site detection are commercially available and can be used as screening tools for TSWV. Several conventional and real-time RT-PCR tests have been described for the detection of TSWV, and some for identification. Sequence analysis of amplicons obtained by the generic conventional PCR assays can also be used for TSWV identification. The de?nite identi?cation should be based on the sequence of the complete N gene according to the species demarcation criteria of ICTV. In addition, high-throughput sequencing is a technology that can obtain (nearly) complete genome sequences, and analysis of

these sequences can be used to identify a virus isolate.

In 2020, 76 tests for TSWV diagnosis were evaluated in the EU VALITEST project (www.valitest.eu) after an extensive search of scientific papers and commercial providers of tests for the detection of plant pathogens. After a thorough literature search, in silico analyses, in-house testing and test performance study, the most suitable tests for the detection and identification of TSWV in symptomatic tomato leaves were identified (Vu?urovi? *et al.*, 2021), and they are listed in the **EPPO Diagnostic Expertise Database**.

PATHWAYS FOR MOVEMENT

TSWV is a systemic pathogen and as such it is transmitted very efficiently by all vegetative propagation techniques. In international trade, TSWV can be transmitted by susceptible host plants for planting (whether potted or not), and is particularly able to spread if these plants also carry vectors. Thrips are easily transported on above-ground fresh plant parts (e.g. cut foliage, cut flowers and cut branches) hidden under bracts, in buds and leaf bases. Insect vectors that have acquired TSWV and that invade new areas can transmit TSWV to new hosts. Short distance spread of thrips vectors by natural means within and between adjacent greenhouses, orchards, and other production sites is likely, but long-distance spread, even in strong winds is less common. Weeds play an important role in the spread and survival of TSWV through the year; they provide a virus reservoir from which thrips vectors can migrate into crop fields, which then become heavily infected. Mechanical transmission of TSWV is inefficient in the wild and has little impact on agriculture, and transmission through seeds is considered not to be a pathway or to be a highly unlikely pathway (see Biology) (Mound, 1983; Kirk and Terry, 2003; Kormelink, 2005; EFSA, 2012a; Macharia *et al.*, 2016; Batuman *et al.*, 2020).

PEST SIGNIFICANCE

Economic impact

TSWV ranks second in the list of the ten most economically important plant viruses (Scholthof *et al.* 2011; Rybicki, 2015). TSWV became a major agricultural pest in the 1980s with global losses estimated at over one billion USD annually (Goldbach and Peters, 1994). The continued economic importance of TSWV results from its global distribution and wide host range, including many food and ornamental crops important to the EPPO region, significant crop losses due to infection, and the difficulty in controlling thrips and thus the virus (Adkins, 2000; Pappu *et al.*, 2009; Scholthof *et al.*, 2011).

Severe yield and quality losses in tomato were reported by Moriones *et al.* (1998) in trials with TSWV infection in experimental fields in northern Spain. Field trials of tomato in Turkey with TSWV infection in experimental fields resulted in yield losses of up to 42 % with almost complete loss of marketable tomato due to unsightly fruit (Sevik & Arli-Sokmen, 2012). Although it is difficult to draw an inference for actual field situations from studies in experimental fields, TSWV is considered a very serious pathogen of tomato, and severe losses in tomato production have been recorded in Italy, Spain, Bulgaria and Greece (EFSA, 2012a). A similar high impact on a number of other crops, such as peppers, potatoes, eggplants, lettuce and broad beans (*Vicia faba*), has been observed elsewhere (EFSA, 2012a). In Hawaii, for example, TSWV destroyed 50-90% of lettuce crops in some years (Cho *et al.*, 1987). In India, TSWV was reported to be the major viral disease of groundnut (*Arachis hypogaea*) - crop losses ranged from 5 to 80% (Ghanekar *et al.*, 1979). In California, high incidence of TSWV was observed in fields of radicchio (*Cichorium intybus*) (up to 90%), lettuce (15-100%) and peppers (>70%) (Batuman *et al.*, 2020). TSWV infections can also have a major impact on the ornamental industry as the virus is commonly found in greenhouse flower crops (Verhoeven and Roenhorst, 1994). Severe symptoms on leaves and stem necrosis affect the quality of potted plants of Pelargonium, Begonia, Impatiens, Streptocarpus and Chrysanthemum, making them unsaleable (Verhoeven and Roenhorst, 1994). For example, the disease incidence of TSWV on chrysanthemum plants was estimated at 40% in Serbia (Stankovi? *et al.*, 2013), and at 30% in India (Renukadevi *et al.*, 2015).

Control

The use of healthy planting material and a management strategy based on a combination of thrips and weed control, the use of resistant plant varieties and other measures are considered crucial for TSWV control (EFSA, 2012a;

Batuman *et al.*, 2020).

TSWV is included in the certification scheme for potatoes (EPPO, 1999) and for herbaceous ornamentals (EPPO, 2008), among which there are specific certification schemes for chrysanthemums, pelargoniums, begonias, New Guinea hybrids of impatiens, kalanchoe and petunias (EPPO, 2000a-f). This reduces the impact and spread associated with the plants for the planting pathway.

Seedling beds should be separated from flowering ornamental plants or susceptible crops and surrounding areas kept free of weeds. Greenhouse and outdoor crops should be inspected regularly and as often as possible after planting, and can be tested during the entire propagation scheme. The presence of thrips in crops should be monitored with yellow sticky card traps. If the disease appears in a crop, infected plants should be immediately uprooted and destroyed, and the greenhouse/ field treated with an insecticide against thrips (EFSA, 2012a; EPPO, 2008; Batuman *et al.*, 2020).

Thrips are difficult to control because they can become resistant to several insecticides used (Gao *et al.*, 2012). To avoid the development of resistance mechanisms, it is important to rotate insecticides with different active ingredients (Bielza, 2008). The prevalence of thrips vectors in some crops (e.g. pepper and tomato) under protected conditions can be reduced by introducing biocontrol agents. These include predatory mites, entomopathogenic fungi and nematodes, parasitic wasps and generalist predators (Sánchez and Lacasa, 2002; Blaeser *et al.*, 2004; Ansari *et al.*, 2008; Messelink *et al.*, 2008; Cloyd, 2009). To prevent infestation of a new crop with a thrips population, it is recommended that greenhouses be kept completely free of crop residues and weeds for at least six weeks prior to planting and that seedlings be treated with insecticides before planting (EFSA, 2012a). In addition, fine-mesh netting can be potentially useful to exclude thrips in greenhouses (EFSA, 2012a).

Cultivation of TSWV resistant (tolerant/immune) cultivars will reduce the incidence of the disease (Pico *et al.*, 2002; Saidi and Warade, 2008; Dianese *et al.*, 2011; de Oliveira *et al.*, 2018; Padmanabhan *et al.*, 2019). Unfortunately, resistant varieties of the vast majority of TSWV host plants are not available (EFSA, 2012a), and there is a risk of selection for virulent resistance-breaking strains, as in the case of the dominant gene Sw-5 for TSWV resistance in tomato and the gene Tsw for TSWV resistance in pepper (see Biology).

Phytosanitary risk

TSWV is reported in many European and Mediterranean countries and has one of the largest known host ranges of any plant virus, including cultivated and wild plants. In addition, its thrips vector species are widely distributed in these countries. Spread can occur through thrips vector activity and through movement of infected hosts. The only major limiting factors are climatic conditions in Northern Europe which appear to limit the capacity of thrips vectors to develop and persist in the open environment. Since TSWV can cause both yield and quality losses in a wide range of hosts, without appropriate control measures, significant impact is expected, under protected conditions, or in open fields in Southern Europe (EFSA, 2012a).

PHYTOSANITARY MEASURES

To prevent the introduction and spread of TSWV, most countries apply import requirements to some host species. These requirements vary depending on the crop and the virus prevalence at the point of origin. Following deregulation as an EU quarantine pest, TSWV was recommended for regulation as a regulated non-quarantine pest for seed potatoes, propagating and planting material (other than seeds) of some vegetables (pepper, lettuce, tomato and eggplant), for tobacco and for some ornamentals (*Begonia x hiemalis*, *Gerbera*, Pelargonium, *Capsicum annuum* , *Chrysanthemum* and Impatiens New Guinea hybrids) (Picard *et al.*, 2018).

EPPO countries where TSWV does not occur or is not widespread may consider regulation. If they do so, these countries may require that plants have been produced in a pest free area, in a pest-free place/site of production or be subject to inspection and/or testing (EFSA, 2012a) e.g. as performed in certification schemes. In particular, EPPO recommends that seed potatoes to be imported should meet the requirements of EPPO Standard PM 4/28 *Certification scheme for seed potatoes* (or equivalent) (EPPO, 1999) and be shown free from insects by visual inspection (EPPO, 2017). Post-entry quarantine programmes are established to allow the safe movement of germplasm for research and breeding purposes. During post-entry quarantine for potatoes, it is recommended that

testing for viruses be carried out on microplants and/or greenhouse-grown plants; in exceptional cases, tubers (tuber sap or sprouts) may also be tested (EPPO, 2019).

Before starting the propagation and/or production of plants, it should be ensured that the planting material is free from TSWV (TSWV is included in certification schemes for potatoes and various ornamental plants, see Control section). During the EU Quality pest project, in addition to the testing of nuclear stock (or the stipulation that it is derived from tested mother plants), recommended measures for all other plants for planting categories consisted of zero-tolerance based on symptom and/or testing, and active control of the vectors at the place of production.

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CABI resources used when preparing this datasheet

CABI Datasheet on *Frankliniella occidentalis* (western flower thrips) (https://www.cabi.org/isc/datasheet/24426; date of the last modification: 22 September 2020; accessed on June 2021)

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