EPPO Datasheet: *Crinivirus tomatichlorosis*

Last updated: 2021-07-09

IDENTITY

Preferred name: *Crinivirus tomatichlorosis*
Taxonomic position: Viruses and viroids: Riboviria: Orthornavirae: Kitrinoviricota: Alsuviricetes: Martellivirales: Closteroviridae
Other scientific names: *ToCV*, *Tomato chlorosis closterovirus*, *Tomato chlorosis crinivirus*, *Tomato chlorosis virus*
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EPPO Categorization: A2 list
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EPPO Code: TOCV00

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HOSTS

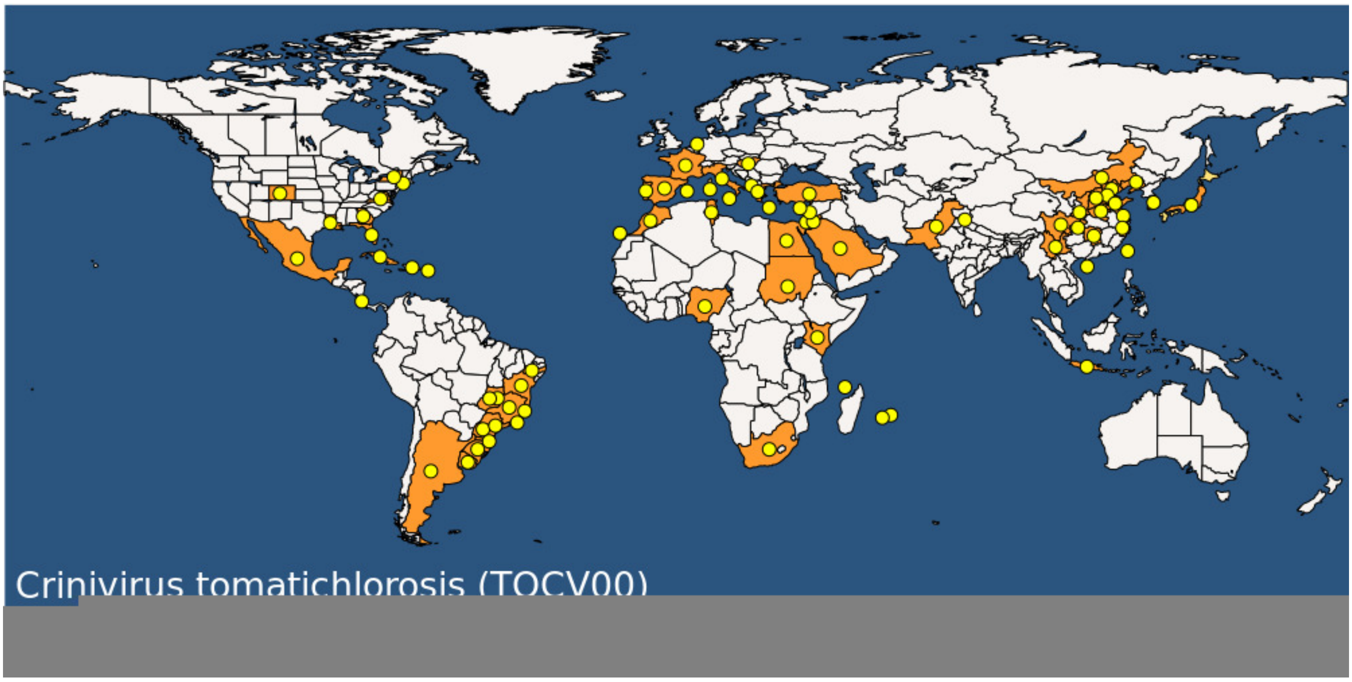
ToCV has been found to infect 84 dicotyledonous plant species belonging to 25 botanical families, including economically important crops (Fiallo-Olivé *et al*., 2019). ToCV naturally infects tomato (*Solanum lycopersicum*) (Wisler *et al*., 1998a) pepper (*Capsicum annuum*) (Lozano *et al*., 2004) and potato (*Solanum tuberosum*) (Fortes & Navas-Castillo, 2012). Transmission experiments have shown the presence of ToCV in potato tubers from infected plants, which subsequently produced infected plants themselves, and that this species served as virus source for tomato infection via *B. tabaci* transmission (Fortes, Navas-Castillo, 2012). The studies showed that tomato is a better source of inoculum than potato (Mituti *et al*., 2018). In Taiwan, *Zinnia* was also reported as a host (Tsai *et al*., 2004). The weeds *Datura stramonium* and *Solanum nigrum* have been identi?ed as hosts in Portugal. The experimental host range includes species in the families Aizoaceae, Amaranthaceae, Apocynaceae, Asteraceae, Chenopodiaceae, Plumbaginaceae, Solanaceae. ToCV infects a wide range of weeds, but information of the importance of these weeds to the occurrence of epidemics of ToCV is still lacking, but these plants likely serve as reservoirs of ToCV in the absence of susceptible cultivated hosts (Souza *et al*., 2020).

Host list: *Abelmoschus esculentus*, *Abutilon theophrasti*, *Acaciella glauca*, *Alcea rosea*, *Alternanthera philoxeroides* , *Amaranthus graecizans subsp. sylvestris*, *Amaranthus retroflexus*, *Amaranthus viridis*, *Ammi majus*, *Anadendrum affine*, *Aralia nudicaulis*, *Bauhinia variegata*, *Bidens bipinnata*, *Brassica oleracea var. capitata*, *Brassica*, *Calotropis procera*, *Capsicum annuum*, *Cardamine flexuosa*, *Cerastium glomeratum*, *Cestrum elegans*, *Cestrum nocturnum*, *Chenopodiastrum murale*, *Chenopodium album*, *Chenopodium opulifolium*, *Cirsium arvense*, *Codiaeum variegatum*, *Convolvulus arvensis*, *Conyza sp.*, *Corchorus olitorius*, *Coriandrum sativum*, *Cucumis melo*, *Cucumis sativus*, *Cucurbita moschata*, *Cucurbita pepo*, *Cynanchum rostellatum*, *Datura stramonium*, *Eranthemum pulchellum* , *Erigeron annuus*, *Erigeron canadensis*, *Eruca vesicaria*, *Euphorbia heterophylla*, *Ficus benjamina*, *Ficus carica*, *Fumaria officinalis*, *Galium aparine*, *Glebionis coronaria*, *Glycine max*, *Gomphrena globosa*, *Gossypium barbadense*, *Gossypium hirsutum*, *Heliotropium lasiocarpum*, *Heptapleurum arboricola*, *Hibiscus cannabinus*, *Hibiscus rosa-sinensis*, *Ipomoea batatas*, *Ipomoea cholulensis*, *Ipomoea coccinea*, *Ipomoea hederacea*, *Jatropha integerrima*, *Lactuca saligna*, *Lactuca sativa*, *Lactuca serriola*, *Luffa aegyptiaca*, *Lysimachia foemina*, *Malva parviflora*, *Malva sylvestris*, *Mazus pumilus*, *Momordica charantia*, *Morus alba*, *Nicandra physalodes*, *Nicotiana benthamiana*, *Nicotiana tabacum*, *Oxalis pes-caprae*, *Pelargonium auritum*, *Pentas lanceolata*, *Phaseolus vulgaris*, *Physalis angulata*, *Physalis ixocarpa*, *Physalis peruviana*, *Physalis pubescens*, *Phytolacca americana*, *Phytolacca icosandra*, *Plantago major*, *Portulaca oleracea*, *Raphanus raphanistrum*, *Ricinus communis*, *Ruta chalepensis*, *Sisymbrium irio*, *Solanum aethiopicum*, *Solanum americanum*, *Solanum arcanum*, *Solanum chilense*, *Solanum chmielewskii*, *Solanum corneliomulleri*, *Solanum elaeagnifolium*, *Solanum galapagense*, *Solanum habrochaites*, *Solanum huaylasense*, *Solanum jamaicense*, *Solanum lycopersicum*, *Solanum mammosum*, *Solanum melongena*, *Solanum neorickii*, *Solanum nigrescens*, *Solanum nigrum*, *Solanum paniculatum*, *Solanum pennellii*, *Solanum peruvianum*, *Solanum pimpinellifolium*, *Solanum retroflexum*, *Solanum scuticum*, *Solanum sessiliflorum*, *Solanum sisymbriifolium*, *Solanum stramoniifolium*, *Solanum subinerme*, *Solanum tuberosum*, *Solanum velleum*, *Sonchus asper*, *Sonchus oleraceus*, *Stellaria media*, *Tectona grandis*, *Tribulus terrestris*, *Trigonotis peduncularis*, *Veronica hederifolia*

, *Vicia faba*, *Vicia sativa subsp. nigra*, *Vicia tetrasperma*, *Vigna unguiculata*, *Withania somnifera*, *Youngia japonica*, *Zinnia*

GEOGRAPHICAL DISTRIBUTION

ToCV was first identified in North-Central Florida (USA) in 1996 in the greenhouse on tomato plants with symptom yellow leaf disorder. This symptom was previously thought to be not virus-related but physiological or nutritional disturbances and has been reported in tomato plants since 1989. Shortly after this the symptoms of ToCV were detected in Spain. Since then, the virus has been detected infecting tomato in many areas around the world (Fiallo-Olivé *et al*., 2019).



EPPO Region: Albania, Cyprus, France (mainland), Greece (mainland, Kriti), Hungary, Israel, Italy (mainland, Sardegna, Sicilia), Jordan, Morocco, Netherlands, Portugal (mainland), Spain (mainland, Islas Baleares, Islas Canárias), Tunisia, Türkiye
Africa: Egypt, Kenya, Mauritius, Mayotte, Morocco, Nigeria, Reunion, South Africa, Sudan, Tunisia
Asia: China (Beijing, Chongqing, Hainan, Hebei, Henan, Hunan, Jiangsu, Liaoning, Neimenggu, Shaanxi, Shandong, Shanxi, Sichuan, Yunnan, Zhejiang), India (Himachal Pradesh), Indonesia (Java), Israel, Japan (Honshu), Jordan, Korea, Republic of, Lebanon, Pakistan, Saudi Arabia, Taiwan
North America: Mexico, United States of America (Colorado, Connecticut, Florida, Georgia, Louisiana, New York, Virginia)
Central America and Caribbean: Costa Rica, Cuba, Dominican Republic, Puerto Rico
South America: Argentina, Brazil (Bahia, Distrito Federal, Espirito Santo, Goias, Minas Gerais, Parana, Pernambuco, Rio de Janeiro, Rio Grande do Sul, Santa Catarina, Sao Paulo), Uruguay

BIOLOGY

ToCV is one of two criniviruses that are transmitted locally by whiteflies of the genera *Bemisia* and *Trialeurodes* . Since 1998 the number of studies have been carried out (Navas-Castillo *et al*., 2000; Wisler *et al*., 1998b, Shi *et al*., 2018; Wintermantel, Wisler, 2006), that showed that the virus is transmitted by several species of the whitefly: *B. tabaci*, *T. vaporariorum*, and *T. abutiloneus*. The efficiency of transmission differs among whitefly species and is associated to differences in virus acquisition and accumulation rate (Fiallo-Olivé *et al*., 2019) and differs following the order *B. tabaci* MED> *B. tabaci* MEAM1 ? *T. abutiloneus* > *B. tabaci* NW > *T. vaporariorum* (Shi *et al.*, 2018; Wintermantel, Wisler, 2006). *T. vaporariorum* is common in glasshouses throughout the EPPO region and is also found outdoors in the summer months. *B. tabaci*, which is on the EPPO A2 List (EPPO/CABI, 1997), is present in glasshouses in many EPPO countries. It is also found in the ?eld in Southern Europe in the summer months. *T. abutiloneus* is found in the USA and Cuba (CABI, 2000). Older tomato crops are probably the most important sources of ToCV inoculum to tomato crops (Souza *et al.,* 2020). ToCV is unlikely to be seedborne (www.cabi.org, 2021).

DETECTION AND IDENTIFICATION

Symptoms

Tomato plants infected with ToCV show an irregular chlorotic mottle that develops first on lower leaves and gradually advances toward the growing point. In the initial stage of the infection, chlorotic areas are frequently polygonal in shape, and are limited by main veins (Fiallo-Olivé *et al*., 2019). In advanced stages, interveinal yellow areas on leaves also develop red and brown necrotic flecks. No obvious symptoms develop on fruit and flowers, but fruit ripening is affected and ?ower abortion occurs (Fortes *et al*., 2012), fruit size and numbers are reduced due to a loss of photosynthetic area. Significant yield losses occur as a result. Other symptoms include rolling of lower leaves and thickened crispy leaves, while the upper leaf canopy appears normal. Symptoms of ToCV are very similar to those of *Tomato infectious chlorosis virus* (TICV) (Wisler *et al*., 1998a, 1998b).

N. physalodes, C. coronarium, G. globosa and *N. physalodes* infected with ToCV have no obvious symptoms of viral infection, whereas infected *A. viridis, N. benthamiana, P. angulata, P. pubescens, S. americanum* exhibit symptoms of interveinal chlorosis, *D. stramonium* and *N. tabacum* cv. TNN develop chlorotic spots (Souza *et al*., 2020).

Symptoms caused by ToCV, are easily attributed to other causes, such as physiological or nutritional disorders, or phytotoxicity of plant protection products.

Morphology

ToCV particles are filamentous and slightly flexuous with a normal length of about 850 nm (Wisler *et al*., 1996). Virions encapsidate two molecules of positive-sense and single-stranded RNA denoted RNA-1 and RNA-2, whose complete nucleotide sequence has been determined *(Martelli et al., 2008).* Cross-banding patterns seen are typical of members of the family *Closteroviridae* (Wisler *et al*., 1998b). ToCV RNAs 1 and 2 are 8595nt and 8247nt, respectively. RNA1 contains four open reading frames (ORFs), which encode proteins for replication. RNA2 codes nine ORFs comprising theHSP70 homolog, a 59 kDa protein, CP, and CPm, that express proteins involved in viral encapsidation, movement and broad vector transmissibility of the virus (*Martelli et al., 2008,* Lee *et al.*, 2018).

Detection and inspection methods

Fully developed leaves, showing mild interveinal yellowing, should be sampled (EPPO, 2013). For bioassay using whitefly, efficient transmission of ToCV is obtained by allowing adult insects (*T. vaporariorum*) a 48 h acquisition access period on samples and a 48 h inoculation access period on test plants of tomato, *Nicotiana benthamiana* or *Physalis wrightii*. Subsequently, the positive reaction on the indicator plants need to be assigned to the responsible virus using suitable identification tests (EPPO, 2013). ToCV can be distinguished from TICV by symptoms on the indicator plants *Nicotiana benthamiana* and *N. clevelandii*. Whereas both species show interveinal yellowing when infected with either virus, only TICV causes necrotic ?ecking in these hosts (Wisler *et al*., 1998b). Antisera to ToCV have been produced mainly for research purposes and may be used for screening tests for ToCV (EPPO, 2013).

Conventional RT-PCR and real-time RT-PCR can be used for both detection and identification. In addition, sequence analysis of amplicons can be used for identification (EPPO, 2013). Several real-time RT-PCR tests have been developed to test for ToCV. Protocol based on the best ToCV primers and ToCV probes by Morris *et al.* (2006), were validated in a test performance study involving five laboratories (EPPO, 2013).

Nucleic acid hybridization has proved to be reliable and sensitive in particular for mass screening of samples but this is not commonly used, and for routine diagnosis the method can be replaced by RT-PCR tests (EPPO, 2013).

Guidance for detection and identification of this virus are given in the EPPO Diagnostic Protocol PM 7/118 (1) *Tomato chlorosis virus* and *Tomato infectious chlorosis* virus (EPPO, 2013).

PATHWAYS FOR MOVEMENT

In international trade, ToCV may be carried by infected plants for planting. The high number of natural plant hosts and ready transmission by several whitefly species have contributed to emergence of ToCV worldwide. In Spain, outbreaks of ToCV have been associated with the main spread of *B. tabaci* populations during the summer months (Navas-Castillo *et al*., 2000). Field investigations conducted in Brazil on tomato have shown that the main dispersal mechanism of the disease caused by ToCV is primary spread, with epidemics being caused by successive influxes of viruliferous whiteflies (Macedo *et al.*, 2019). Viruliferous white?ies could be carried long distances on plants of hosts or non-hosts.

PEST SIGNIFICANCE

Economic impact

Criniviruses emerged as a major problem for world agriculture at the end of the twentieth century with the establishment of some of their whitefly vectors in temperate climate (Fiallo-Olivé *et al*., 2019).

There are no estimates of yield losses, although since To?V discovery, the virus represents a serious problem for tomato production in many parts of the world (Martelli *et al*., 2008). ToCV is very important in tomatoes, in peppers and potatoes (Mituti T. *et al*., 2018). New cases of virus detection on these crops in new regions are noted every year. Outbreaks in tomato fields in Málaga and Almería provinces in Southern Spain in 1998 and 1999 were associated with high populations of *B. tabaci* and were described as epidemics. Incidences of over 30% symptomatic plants in individual ?elds were frequent (Navas-Castillo & Moriones, 2000; Navas-Castillo *et al*., 2000). Hana? (2002) reports that ToCV caused signi?cant damage in tomato glasshouses in Spain. The severity of symptoms and damage vary according to the cultivar.

It is known that with a mixed virus infection ToCV and Tomato spotted wilt virus (TSWV) synergism is observed, that leads to the rapid death of plants (Fiallo-Olivé *et al*., 2019).

Control

As with other virus diseases, once a plant is infected with a virus there is no cure, and measures should be taken to eradicate sources of inoculum and eliminate the presence of vectors to minimise the risk of further transmission therefore, control of whitefly vectors is key.

Regarding chemical control, *B. tabaci* appears to develop resistance to all groups of insecticides. A rotation of insecticides that offer no cross resistance must therefore be used to control *B. tabaci* infestations. The biocontrol agent *Encarsia formosa* (parasitic wasp) is used to control *T. vaporariorum*, but it is less efficient against *B. tabaci.* Repeated releases of large numbers of *E. formosa* against *B. tabaci* are necessary if eradication is required. The predatory beetle *Delphastus pusillus* is very effective against *B. tabaci* (MAFF, 2000). Roguing of severely infested plants reduces whitefly populations.

Using containment structures, for example adding nets to the greenhouse ventilation windows limiting the access of the whitefly vectors to the plants, results in an efficient protection of the crop from ToCV infection (Fiallo-Olivé *et al*., 2019).

Tomato seedlings for transplanting should be kept free from infection. There are no resistant tomato cultivars as no resistance to ToCV has yet been identi?ed in tomato. No differences in the incidence of yellowing due to ToCV in ?elds containing different cultivars of tomato were observed in southern Spain (Navas-Castillo *et al*., 2000).

Eradication of isolated outbreaks in glasshouse-grown tomatoes can probably be achieved by destruction of affected hosts and of the vector(s). However, it is difficult to envisage that eradication could be achieved for outbreaks in the field in Southern Europe. Weed hosts may act as reservoirs for ToCV.

Phytosanitary risk

ToCV presents a significant risk of further spread in the EPPO region. The risk to the tomato industry is high since *T. vaporariorum*, a known vector, is present and widespread in glasshouses and in the field in Northern and Southern Europe in summer (CABI, 2000). In addition, *B. tabaci*, another known vector of ToCV, occurs in many EPPO countries. This whitefly is found on outdoor crops in Southern Europe in summer and in glasshouses in Northern Europe. It is frequently intercepted on plants and plant products. The recent detection of ToCV in Northern Europe (in the Netherlands and the United Kingdom) and in Africa (in Nigeria, Kenya, Egypt) raises serious concerns because the climatic conditions in these countries were not thought to be conducive to the transmission of the virus. ToCV would be expected to cause considerable damage to glasshouse tomato crops in EPPO countries. Outdoor crops in Mediterranean countries are also at risk.

PHYTOSANITARY MEASURES

At present, there are no specific measures against ToCV in Europe and in particular there are no restrictions on the movement of tomato seedlings from areas where the disease occurs. Possible measures would be equivalent to those proposed for CVYV (EPPO, 2005).

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CABI resources used when preparing this datasheet

CABI. Crop protection compendium. https://www.cabi.org/isc/datasheet/54069#todistributionDatabaseTable [accessed on 4 May 2021]

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Datasheet history

This datasheet was first published in the EPPO Bulletin in 2005 and revised in 2021. It is now maintained in an electronic format in the EPPO Global Database. The sections on 'Identity', ‘Hosts’, and 'Geographical distribution' are automatically updated from the database. For other sections, the date of last revision is indicated on the right.

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