

Tomato chlorosis virus (ToCV) and Tomato infectious chlorosis virus (TICV)



Figures 1a and b. Leaves showing characteristic yellowing in a TICV-infected tomato plant

Background

Tomato chlorosis virus (ToCV) and *Tomato infectious chlorosis virus* (TICV) are whitefly-transmitted criniviruses in the family *Closteroviridae*. Both viruses can have serious, yield-reducing effects upon tomato production if suitable control is not administered. Recent outbreaks in other countries have caused extensive economic damage to the production of tomatoes.

Both viruses were discovered in the USA as recently as the 1990s. TICV was first detected in the Irvine region of Orange County, California in 1993. ToCV was first detected in Florida in 1998. The viruses have since spread worldwide into all major tomato-growing areas. Before the discovery of these viruses as causal agents of viral leaf yellowing (chlorosis), the symptoms they

induced on tomatoes were often attributed to nutritional and physiological disorders or pesticide phytotoxicity, as they appear very similar. As viruses that are known to be present but distributed locally within the region covered by the European and Mediterranean Plant Protection Organisation (EPPO), they are included on the EPPO A2 list and it is recommended that they are regulated as quarantine pests in the EPPO region.

Both viruses are spread by the greenhouse whitefly (*Trialeurodes vaporariorum*), but ToCV may also be transmitted by other whitefly species including several biotypes of *Bemisia tabaci*. Although both viruses are considered to have only tomato as their major economic host, they can infect a broader range of plant species including a range of common weeds.

Symptoms

Two to three weeks after being infected with either TICV or ToCV, tomato plants start showing symptoms in their lower leaves. Irregular chlorotic mottling and interveinal yellowing (chlorosis) occurs, with the yellowing gradually intensifying and the veins remaining green (Figures 1 and 2).



Figure 2a and b. Leaf chlorosis and rolling in a ToCV-infected tomato plant

Over time, the symptoms move further up the plant towards the growing point, with the newest, uppermost leaves often seeming unaffected. As the infection progresses, affected leaves thicken, become brittle and start to roll. The older leaves start to bronze and redden with necrosis, with the plant showing reduced vigour (Figure 3) and, ultimately, a reduction in fruit size and number can be expected.



Figure 3. Reduced vigour and chlorosis in ToCV-infected tomato plants

The symptoms of infection from these viruses can be confused with other causes of leaf yellowing. Nutritional deficiencies, such as lack of Magnesium, or other causes of phytotoxicity may induce similar symptoms. Due to the similarities in virus-symptoms, TICV and ToCV cannot easily be distinguished in infected tomatoes and can only be determined through diagnostic testing.

Spread

Once either virus infects a host plant, its movement is restricted solely to the phloem tissue and, consequently, neither ToCV or TICV can be mechanically transmitted. These viruses are not known to be seedborne. The viruses are spread via insect vector transmission by whiteflies and transmission is in a semi-persistent manner, where the insect effectively acts like a flying syringe. Once carrying virus, the insect may transmit the virus for up to 3 to 5 days. *Tomato infectious chlorosis virus* is transmitted exclusively by the greenhouse whitefly (*Trialeurodes vaporariorum*) (Figure 4).



Figure 4. The greenhouse whitefly, *Trialeurodes vaporariorum*, a vector of both TICV and ToCV

By comparison, *Tomato chlorosis virus* can be transmitted by several species of whitefly. ToCV can also be transmitted by greenhouse whitefly (*T. vaporariorum*) (Figure 4), as well as Silverleaf Whitefly (*Bemisia tabaci* biotype B) (Figure 5) and *B. tabaci* biotype Q, the predominant biotype in the Mediterranean region. The virus is also passed on by sweet-potato whitefly (*B. tabaci* biotype A) and the banded-wing whitefly (*Trialeurodes abutilonea*), although less efficiently than by *T. vaporariorum*, and *B. tabaci* biotypes B and Q.

Hosts

Although tomato, *Solanum lycopersicum*, is the only host where infection is thought to be of major importance, both viruses have quite a wide host range.

TICV has been reported to infect 19 species, from 4 botanical families including the Solanaceae (9 species), the Asteraceae (7 species), Amaranthaceae (2 species), and Ranunculaceae (1 species). The virus has been reported to infect other commodity crops including sweet pepper (*Capsicum annum*), lettuce (*Lactuca sativa*) and globe artichoke (*Cynara scolymus*). TICV has also been found infecting ornamental species such as *Petunia* hybrids and *Zinnia*. However, the vast proportion of hosts of this virus



Figure 5. – *Bemisia tabaci*, a vector of ToCV

are classified as wild or weed species (47%) including common UK field weeds such as fat-hen (*Chenopodium album*) and black nightshade (*Solanum nigrum*).

ToCV is known to affect 34 species from 12 botanical families. The majority of these are from the Solanaceae (13 species), the Asteraceae (5 species) and the Fabaceae (3 species). Again, the majority of recognised host species are classified as weeds (67%) including common UK field weeds such as fat-hen (*Chenopodium album*), common chickweed (*Stellaria media*), greater plantain (*Plantago major*), and black nightshade (*Solanum nigrum*). The virus has been recorded from several commodity crops including sweet pepper (*C. annum*) and aubergine (*Solanum melongena*). However, unlike its counterpart, ToCV has been recorded from potato (*S. tuberosum*) though this record is from Brazil.

With a broad range of potential hosts, should an outbreak occur outside a glasshouse environment, there is potential for the virus to be harboured and spread among the wild plant species if the whitefly could persist for long enough periods.

Distribution

Transmission of TICV and ToCV is exclusively by whiteflies in the genera *Trialeurodes* and *Bemisia*. These virus vectors are pests that are naturally found affecting crops in tropical and subtropical regions. The general distribution of these viruses, therefore, reflects the distribution of their vectors. However, in cooler temperate regions, glasshouse growing conditions can prove to be favourable for the introduced pests and there have been sporadic outbreaks recorded in Northern Europe as a result of infected plants, and vectors, entering glasshouses.

Since their discovery/confirmation in the USA in the 1990s, both TICV and ToCV have spread across the world into major areas of tomato production. Tomato infectious chlorosis virus has a relatively narrow range of global distribution. It has been reported on both the East and West coast of the USA, Mexico, Japan, Indonesia, Taiwan, and from several countries around Europe and the Mediterranean Basin including Italy, Greece, Bulgaria, France, Jordan and Tunisia.

By contrast, *Tomato chlorosis virus* has a much broader distribution, possibly a reflection of the broader geographic range of the vectors that can transmit the virus. The virus has been recorded across all major tomato-growing regions, with the exception of Australia. It has also been recorded across the USA, central and south America, East Asia and the Middle East, as well as North, sub-Saharan and South Africa. In Europe and the Mediterranean Basin, the virus has been widely reported as being present within glasshouse environments and also with a presence in field-grown tomatoes in Southern Europe where whitefly populations occur naturally in higher numbers during the summer months.

In 2017, ToCV was detected in the Netherlands for the very first time in glasshouses of three fruit-production companies. The status of this outbreak is currently 'transient – under eradication'.

Control

These viruses are both of quarantine significance. Should an outbreak of either of these viruses be suspected, the finding must be reported to the Plant Health and Seeds Inspectorate immediately. *B. tabaci* are also pests of quarantine significance and, should an outbreak of this species be suspected, the finding should also be reported immediately. In England and Wales, call the Plant Health Helpline on 01904 405138 to report suspicion of a quarantine plant pest or disease, or for advice and guidance on plant health regulations. In Scotland, please contact the Horticulture and Marketing Unit at hort.marketing@gov.scot for further advice.

As with other virus diseases, once a plant is infected with a virus there is no cure, and measures should be taken to minimise sources of inoculum and the presence of vectors to minimise the risk of further transmission. Isolated glasshouse outbreaks can probably be eradicated by destruction of both the vectors and the affected host plants.

There is no recognised resistance to these viruses in commercial tomato varieties and, therefore, control of whitefly vectors is key. Silverleaf whiteflies (*B. tabaci* biotype B) are reportedly capable of developing resistance to all groups of insecticides. Parasitic Chalcid wasp *Encarsia formosa* can be used as a biocontrol agent against the Greenhouse Whitefly (*T. vaporariorum*) but is less effective against the Silverleaf Whitefly species.

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Further information

EPPO Data Sheet on Tomato infectious chlorosis virus
gd.eppo.int/taxon/TICV00/documents

EPPO Data Sheet on Tomato chlorosis virus
gd.eppo.int/taxon/TOCV00/documents

More information on the diseases and further photographs of symptoms:

Emerging Virus Diseases of Greenhouse Crops. British Columbia Ministry of Agriculture, 2016.

www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/animal-and-crops/plant-health/phu-emergingvirusdiseases-greenhousetomatoeesss.pdf

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