European and Mediterranean Plant Protection Organization
Organisation Européenne et Méditerranéenne pour la Protection des Plantes

Data sheets on pests recommended for regulation
Fiches informatives sur les organismes recommandés pour réglementation

Tomato infectious chlorosis virus

Identity

Name: *Tomato infectious chlorosis virus*
Synonym: Tomato infectious chlorosis crinivirus (TICV)
Taxonomic position: Virus, *Closteroviridae*, *Crinivirus*
Common name of the disease: Infectious chlorosis of tomato
EPPO code: TICV00
Phytosanitary categorization: EPPO A2 list no. 348.

Hosts

Lycopersicon esculentum (tomato) is the major host of TICV. The following cultivated plants have also been recorded as natural hosts of TICV in California (US) (Wisler *et al*., 1998a): *Lactuca sativa* (lettuce), *Physalis ixocarpa* (tomatillo), *Cynara scolymus* (artichoke), *Petunia hybrida* (petunia), *Ranunculus* sp., *Callistephus chinensis* (China aster). *Zinnia elegans* (zinnia) has been found to be a natural host in Taiwan, but not apparently tomato (Tsai *et al*., 2004). In Italy, tomato and artichoke have been identified as crop hosts (Caciagli, 2001), but in Spain only tomato (Font *et al*., 2002).

The same authors have noted the weeds *Picris echioides*, *Nicotiana glauca* and *Cynara cardunculus* as natural hosts in California, *Chenopodium album* and *Chenopodium murale* in Spain.

Species recorded as experimentally susceptible by Duffus *et al*. (1996) were *Chenopodium capitatum*, *C. murale* (Chenopodiaceae), *C. cardunculus*, *C. scolymus*, *L. sativa*, *P. echioides*, *Senecio vulgaris*, *Sonchus oleraceus*, *Z. elegans* (Asteraceae), *Capsella bursa-pastoris* (Brassicaceae), *Erodium cicutarium*, *Geranium dissectum* (Geraniaceae), *Trifolium subterraneum* (Fabaceae), *Anoda cristata* (Malvaceae), *L. esculentum*, *Nicotiana benthamiana*, *Nicotiana clevelandii*, *P. hybrida*, *Physalis alkekengi*, *Physalis floridana*, *P. ixocarpa*, *Physalis wrightii*, *Solanum tuberosum* (Solanaceae), *Conium maculatum* (Apiaceae). Many other species were tested and found not to be susceptible.

Geographical distribution

EPPO region: Greece (Dovas *et al*., 2002); Italy (Calabria, Campania, Lazio, Liguria, Sardegna) (Wisler *et al*., 1998a; Caciagli, 2001; Vaira *et al*., 2002; Parrella & Scassillo, 2006); Jordan (Anfoka & Abhary, 2007); Spain (Castellón and Alicante provinces in Comunidad Valenciana; Murcia) (Font *et al*., 2002, 2003, 2004). In 2003, TICV was detected in two tomato samples collected near Nice, but the virus was not considered as established in France (Dalmon *et al*., 2005).
Asia: Indonesia (Verhoeven *et al*., 2003); Japan (Hartono *et al*., 2003); Jordan (Anfoka and Abhary, 2007); Taiwan (Tsai *et al*., 2004).
North America: USA (California, North Carolina) (Wisler *et al*., 1998a).
EU: Greece, Italy, Spain.

Biology

TICV is found in both field and glasshouse crops of tomato. It is transmitted by the whitefly *Trialeurodes vaporariorum*. In experiments, the virus was acquired by *T. vaporariorum* after feeding for 1 h, but was transmitted with greater efficiency after longer feeding periods. Similarly, *T. vaporariorum* could transmit TICV to healthy plants after feeding for 1 hour, but efficiency of transmission increased after longer feeding times. TICV was not found to be transmitted by *Bemisia tabaci*, *Trialeurodes abutilonea* or *Myzus persicae* (Duffus *et al*., 1996).

TICV has been detected in various weeds (see Hosts) and these may serve as a reservoir of inoculum.

Detection and identification

Symptoms

Interveinal yellowing, necrosis and yield reduction are symptoms of infected tomato plants in the field. In inoculated plants, the first indication of infection is a bright interveinal yellowing symptom on the older leaves. As the disease progresses, the yellowing develops acropetally and the leaves thicken, become brittle and roll. Bronzing and necrosis of older leaves is accompanied by a decline in vigour and a reduction in fruit yield (Duffus *et al*., 1996). These symptoms are very similar to those caused by *Tomato chlorosis virus* (ToCV) (Wisler *et al*., 1998a) (EPPO A2 list no. 323).

Symptoms in other crop hosts and weeds are reported to be similar. Severe yellowing and/or reddening symptoms, stunting rolling and brittleness have been noted (Duffus *et al*., 1996).

Morphology

TICV has flexuous, filamentous particles of variable lengths. Measurements of over 200 particles indicated that the average

length was in the 800–850 nm range with some in the 1550–1600 nm range. Particles were estimated to be 12 nm wide. Sap from TICV infected leaves of *Nicotiana clevelandii* contained long flexuous rod-shaped particles with an average length of 850–900 nm (Duffus *et al*., 1996).

Detection and inspection methods

Polyclonal antibodies have been produced against TICV (Duffus *et al*., 1996). TICV-specific probes have also been used for diagnosis (Tian *et al*., 1996; Wisler *et al*., 1998b). Methods used in a comparison of diagnostics have been indirect ELISA, Western blot, dot-blot hybridization and RT-PCR assays. RT-PCR was found to be 100-fold more sensitive than ELISA, Western blot and dot-blot hybridization assays. The highest concentrations of TICV in infected plants were found to be in the young tomato leaves just before the onset of yellowing (Li *et al*., 1998).

TICV can also be detected by vector transmission to indicator plants but is not transmitted mechanically. It can be distinguished from ToCV by symptoms on the indicator plants *N. benthamiana* and *N. clevelandii*. Whereas both species show interveinal yellowing when infected with either virus, only TICV causes necrotic flecking in these hosts (Wisler *et al*., 1998b). TICV induces cytoplasmic vesicles characteristic of closterovirus infection in the phloem of infected plants (Li *et al*., 1998).

Pathways for movement

Over short distances, TICV can be carried by its vector *T. vaporariorum*. Over longer distances and in international trade, it can be carried in young plants for planting of tomato, and possibly other crop hosts which are traded in this form. These plants may also carry viruliferous whiteflies. Like almost all viruses in the *Closteroviridae*, TICV is unlikely to be seed-borne.

Pest significance

Economic impact

When TICV was first found in the Irvine area of Orange County, California (US) in 1993, symptoms of the disease affected virtually 100% of tomato plants in every field. The disease was associated with a high incidence of *T. vaporariorum* (Duffus *et al*., 1996). In one season in Orange County, growers suffered 2 million USD in losses (Wisler *et al*., 1998a). Losses by some growers have been estimated to be 20–50%. However, TICV is now described as generally causing only minor losses.

In Liguria (IT), TICV was found in back-garden tomato crops at the end of the growing season in 1995 and 1997, but damage was not very high. Incidence was associated with high populations of *T. vaporariorum*. Although TICV has also been reported in artichokes in the same area (Caciagli, 2001), the pathogen is not regarded as a serious problem on this crop. Tomato is not grown commercially on a year round basis in Liguria, there is a host-free period in the winter and populations of *T. vaporariorum* are slow to build up in the summer after being reduced significantly in open fields during the winter. These factors are believed to have diminished the impact TICV has on the tomato industry in this locality. More recently, TICV has been found in tomato in Lazio, Campania and Sardegna. Yellowing and reddening leaf symptoms have been reported to be severe and widespread. Plants were said to be less vigorous, with fruits that sometimes showed delayed ripening. TICV was described as a severe threat to tomato crops in Europe (Vaira *et al*., 2002). In Greece, 80–100% infection incidence was reported in some glasshouse tomato crops (Dovas *et al*., 2002).

Control

Control of TICV is centred on the control of *T. vaporariorum*, its whitefly vector. It is particularly important to protect young plants for transplanting. Many insecticides give some control of *T. vaporariorum* (Heungens & Buysse, 1991), but strains of *T. vaporariorum* resistant to one or other of them have become established. Imidacloprid, fenpropathrin, bifenthrin (Zhu & Ju, 1990), buprofezin (Stenseth & Singh, 1990), deltamethrin, fenvalerate, dimethoate, endosulfan, methamidophos and pymetrozine are all currently used in many countries for whitefly control, dependent on resistance levels. Most insecticides used are only effective against adults, so that repeated treatments at 3–5-day intervals are necessary for several weeks before control can be achieved.

Biological control has been widely used against *T. vaporariorum* in glasshouses, especially since the development of insecticide-resistant whiteflies. It is chiefly based on the chalcid wasp *Encarsia formosa* (Osborne & Landa, 1992), and gives very successful control if the parasite is established on plants when natural infestations are minor. Other biological control agents used for pest control in glasshouses (the predatory beetle *Delphastus pusillus* and the lacewings *Chrysoperla* spp.) also consume whiteflies. It is important to choose insecticides and methods of application in glasshouses that are not damaging to biological control agents (Hayashi, 1996).

The fungal pathogen *Verticillium lecanii* attacks whiteflies and thrips and can be a useful control agent in situations where the crop is grown under high humidity conditions (Masuda & Kikuchi, 1993). The fungus attacks young as well as adults, taking about 1–2 weeks to develop. Commercial preparations are available (Ravensberg *et al*., 1990, 1994). Microbial insecticides based on the entomopathogenic fungus *Paecilomyces fumosoroseus* have also been used for the control of *T. vaporariorum* (Sterk *et al*., 1996).

Cultural measures may also be used to reduce and delay initial infestation of the crop. It is important, for glasshouse tomatoes, to ensure that young plants are not infested with *T. vaporariorum* before being taken into the glasshouse. A suitable insecticide can be applied as a routine precaution. Ensuring a crop-free period for some time during the year may break the cycle of the vector. *T. vaporariorum* can survive on weeds, in and around glasshouses or in the field, so adequate

weed control reduces the risk that crops become infested with the vector of TICV. There are currently no commercial cultivars of tomato or other host species with TICV resistance.

Phytosanitary risk

TICV is absent from most of the EPPO region. It causes a serious disease of tomato crops under glass or in the field. Tomato is among the most important vegetable crops of the EPPO region, grown in and out of doors in the south, and in glasshouses in the north. Other hosts (lettuce, artichoke) are less affected by the disease, but are also of considerable economic importance. The vector of TICV, *T. vaporariorum*, is a very widespread pest of glasshouse crops in the EPPO region and also occurs on field crops in the summer months. The possibility thus exists that TICV can establish and spread practically throughout the EPPO region.

Where TICV already occurs in the EPPO region (Greece, Italy, Jordan, Spain), severe symptoms and high incidences have been reported in some tomato crops. However, trials to determine yield reduction or quality losses have not yet been reported, so no figure can be put on the potential of TICV to cause damage. Spread of the pest into new areas within the EPPO region is most likely to occur with young plants of tomato, but natural spread with the vector is also possible over shorter distances. Conditions thus exist which may allow the existing infestations to be contained.

Phytosanitary measures

TICV was added in 2007 to the EPPO A2 action list, and endangered EPPO member countries are thus recommended to regulate it as a quarantine pest. Suitable measures would be to require that young tomato plants for planting should be produced in a crop or place of production free from the pest, under conditions which exclude the vector. Eradication of isolated outbreaks in glasshouse-grown tomatoes could be achieved by destruction of affected hosts and of the vector *T. vaporariarum*.

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