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Data Sheets on Quarantine Pests

Tomato mottle bigeminivirus

Tomato mottle bigeminivirus is the most distinctive, the best characterized and probably the most economically important of a number of geminiviruses which have very recently been described on tomatoes and *Capsicum* in Mexico and some southern states of the USA. This sudden rise in importance of a previously insignificant group is associated with the spread of biotype B of *Bemisia tabaci*, their common vector. It is at present impossible to establish clearly which of these recently described viruses are important, what is their true geographical distribution, which are possibly synonymous with each other and which could qualify as quarantine pests for the EPPO region. Provisionally, therefore, tomato mottle bigeminivirus has been singled out and documented as a quarantine pest, while the situation of the others is reviewed. In due course, when the true status of these various taxa has been worked out, a revised data sheet will be produced.

IDENTITY

Name: Tomato mottle bigeminivirus
Taxonomic position: Viruses: Geminiviridae: Bigeminivirus
Common names: ToMoV (acronym)
Notes on taxonomy and nomenclature: Tomatoes in Florida (USA) have been epidemically affected by a new virus disease since 1989 (Simone *et al*., 1990; Kring *et al*., 1991). The agent was only later characterized and named as tomato mottle geminivirus by Abouzid *et al*. (1992). The epidemic in Florida drew attention elsewhere in the world, where the virus was provisionally referred to as the "Florida tomato virus". This provisional name can now be replaced by the correct name.

Chino del tomate bigeminivirus (CdTV) (Brown & Hine, 1984; Brown & Nelson, 1988) causes a leaf curl disease of tomatoes in Sinaloa and Tamaulipas states in Mexico. Tomato leaf crumple bigeminivirus (TLCrV) is a very recently characterized new virus from tomato in the Culiacan valley of Sinaloa state (northwestern Mexico) (Paplomatas *et al*., 1994). Tomato necrotic dwarf virus (ToNDV) is a poorly characterized whitefly-transmitted virus from California (USA) (Larsen *et al*., 1984). Several other geminiviruses infect tomatoes in tropical America (Brazil, Costa Rica, Venezuela): tomato golden mosaic bigeminivirus (TGMV) (Hamilton *et al*., 1981) and the very similar tomato yellow mosaic bigeminivirus (TYMV) (Uzcátegui & Lastra, 1978). These have been known for many years and are not considered of any significant economic importance.

Another group of viruses has been described primarily from *Capsicum*: pepper mild tigré bigeminivirus (PepMTV), associated with CdTV in causing tigré disease of *Capsicum* (Brown *et al*., 1989); serrano golden mosaic bigeminivirus (SGMV) (Brown & Poulos, 1990); Pepper Texas bigeminivirus (TPGV) (Stenger *et al*., 1990); PV-WA and PV-WB from Weslaco in the Rio Grande valley in Texas, USA (Brown, 1990); pepper hausteco bigeminivirus (PHV) and another geminivirus, together involved in "rizado amarillo" disease in Tamaulipas state, Mexico, and considered by the authors to have a possible involvement in tigré disease also, as non-mechanically transmissible geminiviruses of *Capsicum* in the same part of the country (Garzon Tiznado *et al*., 1993).

Finally, it should be noted that tomato yellow leaf curl bigeminivirus (TYLCV) (EPPO/CABI, 1996), the Old World virus which has caused great problems in the

Mediterranean Basin since the spread of biotype B of *Bemisia tabaci* and was recently added to the EPPO A2 list, has recently been recorded in tropical America (Dominican Republic; Nakhla *et al*., 1994). It is considered distinct from ToMoV and the other American geminiviruses of tomato, and is thought to have appeared in America as a result of introduction. However, it shows similarities to CdTV.
EPPO computer code: TMMOXX
EPPO A1 list: No. 225
EU Annex designation: I/A1 (as "Florida tomato virus")

HOSTS

The only natural host of ToMoV is tomatoes (*Lycopersicon esculentum*). When inoculated artificially into hosts of several families, only *Lycopersicon*, *Nicotiana* and *Physalis* spp. were infected, besides a symptomless infection of *Phaseolus vulgaris* (Polston *et al*., 1993). In practice, this means that many familiar hosts of other geminiviruses in tropical America were not infected (Cucurbitaceae, Euphorbiaceae, Fabaceae, Malvaceae), and that ToMoV probably does not infect common weeds. It is notable also that it does not infect *Capsicum annuum*.

CdTV infects tomatoes and *C. annuum*, as well as weeds like *Datura stramonium* and *Malva parviflora*. TLCrV artificially infects *Nicotiana benthamiana* and *Phaseolus vulgaris* as well as its natural host, tomato, but not *C. annuum*.

C. annuum is the only known natural host of PepMTV, PHV, PV-WA and PV-WB (Brown, 1990). PepMTV has been artificially inoculated to tomatoes. SGMV infects tomatoes, *C. annuum*, *C. frutescens* and other Solanaceae, while TPGV infects *C. annuum* and other Solanaceae.

GEOGRAPHICAL DISTRIBUTION

Although ToMoV, in USA (Florida), is the virus which has caused greatest concern, the various geminiviruses of tomato and *Capsicum* in Mexico and USA seem to be fairly closely related and have not been fully characterized or distinguished from each other. For this reason, it is useful to specify geographical distribution details for all.
EPPO region: Absent.
North America: Mexico (CdTV in both Sinaloa and Tamaulipas states, PepMTV and PHV in Tamaulipas state, SGMV in Sinaloa state, TLCrV in Sinaloa state), USA (ToMoV in Florida, South Carolina, Tennessee, Virginia; SGMV in Arizona; ToNDV in California; PV-WA, PV-WB and TPGV in the Rio Grande valley, Texas).
Central America and Caribbean: Symptoms suggestive of geminivirus infection have been seen in many countries (Brown, 1990): Cuba, Guatemala, Honduras, Nicaragua, Puerto Rico, Trinidad.
EU: Absent.

BIOLOGY

ToMoV, like all the other geminiviruses mentioned in this data sheet, is transmitted in the persistent manner by the whitefly *Bemisia tabaci*, and especially its biotype B. It is sap-transmissible, as are TLCrV, SGMV, PV-WA and TPGV but not CdTV or PepMTV. None of these viruses is transmitted by seed. Detailed information on the period during which infectivity is retained seems to be lacking, but it is at least 7 days for CdTV (Brown & Nelson, 1988).

While ToMoV alone causes a serious disease of tomato, the situation is less clear for the *Capsicum* viruses. So-called tigré disease is induced by a virus complex which includes

CdTV and PepMTV, which together cause only mild symptoms. Authentic tigré disease is attributed to a putative third whitefly-transmitted geminivirus, the disease being whitefly-transmitted.

ToMoV is closely related to abutilon mosaic geminivirus and to bean dwarf mosaic geminivirus (these two now being regarded as synonymous) as indicated by pseudorecombination between infectious cloned DNA components (Gilbertson *et al*., 1993). They are also closely related to each other, and to TLCrV, on the basis of alignments of nucleotide sequences (Paplomatas *et al*., 1994). CdTV is similar in many respects to the Old World TYLCV.

DETECTION AND IDENTIFICATION

Symptoms

ToMoV causes yellow mottling on tomato leaves, with upward leaf curling, stunting and distorted growth. TLCrV causes leaf crumpling, epinasty and mottling. CdTV causes severe stunting, downward curling of leaves, interveinal chlorosis and reduced fruit set (Brown, 1990). The Spanish word "chino" means "curl", so the English equivalent would be "tomato leaf curl". SGMV causes interveinal chlorosis, poor fruit set and blossom-end fruit necrosis (Brown, 1990).

The symptoms of tigré disease are bright-yellow tiger-striping of the leaves. PepMTV alone causes a mild foliar chlorosis, developing in 10-12 days, followed by more subdued interveinal chlorosis and mild stunting. CdTV is symptomless in *Capsicum annuum*. PV-WA, isolated from *C. annuum* showing tigré-like symptoms, causes vein etching and bright, splotchy, but mild, chlorosis. PV-WB causes bright-yellow splotches. TPGV causes leaf curl and distortion. SGMV causes bright-yellow mosaic. PHV causes "rizado amarillo", i.e. yellow striping, which resembles tigré disease.

Morphology

ToMoV has been sequenced (Abouzid *et al*., 1992), but no particular details on its morphology seem to be available beyond the fact that it is a geminivirus. TLCrV has similarly been characterized only molecularly. TPGV is the best characterized of the *Capsicum* viruses (Stenger *et al*., 1990). No details are available on CdTV or SGMV. In general, characteristic nuclear inclusions have been seen with many of these geminiviruses. All are typical bipartite geminiviruses.

Detection and inspection methods

DNA probes to components of several well characterized whitefly-transmitted geminiviruses are available (Brown & Nelson, 1989), and can be used to detect geminiviruses in many hosts. Tests to differentiate the different American geminiviruses in tomato are not yet fully established. TGMV is moderately immunogenic, but serological data on the other viruses does not seem to be available.

Host range on indicator plants provides some basis for identification: ToMoV does not infect *Datura stramonium*; CdTV and SGMV infect *D. stramonium* and also *Capsicum annuum*, on which they are distinguished from each other by their symptoms.

MEANS OF MOVEMENT AND DISPERSAL

ToMoV and the other viruses move only in their vector *Bemisia tabaci*, which can spread them between fields (and presumably glasshouses) in infested areas. In international trade, they are very unlikely to be carried by tomato or *Capsicum* plants, since these are annual vegetable crops not normally moved except as seedlings. Young seedlings for transplanting might constitute a pathway, but would still be unlikely to be moved in intercontinental

trade. Tomato or *Capsicum* fruits would not be likely to carry *B. tabaci*, and none of the viruses is seed-transmitted. So the main risk of movement is in *B. tabaci* on other host plants (e.g. ornamentals), given the fact that the vector moves readily from one host to another and that such viruses are known to persist in the vector for several weeks after acquisition.

PEST SIGNIFICANCE

Economic impact

ToMoV, now found in all tomato-producing areas of Florida, is widespread and damaging. Incidences as high as 95% have been reported, and the virus was estimated to have reduced the value of the 1990/91 southwestern Florida tomato crop by 125 million USD. The epidemic was clearly associated with the first appearance in Florida (1988) of biotype B of *Bemisia tabaci*. Although TLCrV is in many ways very similar to ToMoV, there is no indication that, on the basis of currently published information, it has any economic importance at all.

CdTV has been found on tomato in the western coastal valleys of Sinaloa state (Mexico) since the 1970s. It reached epidemic proportions in 1982/83, and spread to the eastern coastal Tamaulipas state by 1988. It seems possible that this epidemic too could be associated with *B. tabaci* biotype B. SGMV has infected *Capsicum annuum* on an epidemic scale in Sinaloa state since 1989; its incidence on tomatoes is secondary.

Brown (1990) records that geminiviruses became an economic problem on *Capsicum annuum* following severe infestation of *B. tabaci* (presumably biotype B) in eastern coastal Mexico and the Rio Grande valley, Texas, USA. Several previously unknown diseases were observed during the mid-1980s, especially tigré disease. Then serrano golden mosaic became epidemic in western coastal Mexico a few years later. Since the viruses concerned may occur as a complex and have not yet been clearly characterized, it is difficult at present to rate them for importance. It is clear, nevertheless, that there is a whitefly-transmitted virus disease problem on *C. annuum* in Mexico and southern USA.

Control

Only ToMoV and CdTV have required control measures. Planting times should be adjusted in order to avoid heavy whitefly infestations. Chemical control of *B. tabaci* has not proved very practical. In theory, resistant cultivars should provide a good means of control, but little work has yet been done. Transgenic tobacco plants genetically engineered to carry an antisense DNA sequence of the AL1 gene of TGMV were resistant to the virus (Day *et al*., 1991), so genetic engineering techniques may have promise against these geminiviruses.

Phytosanitary risk

ToMoV has recently been added to the EPPO A1 list, but otherwise the American geminiviruses of tomato and *Capsicum* remain to be evaluated as quarantine pests. It should be noted that TYLCV is an A2 quarantine pest for EPPO, but does not appear in EU Directive 77/93. Individually, the American geminiviruses of tomato are about as important as TYLCV (ToMoV, CdTV) or much less so (TLCrV). For the EPPO region, it seems clear that ToMoV is a damaging virus, favoured by the outbreaks of *B. tabaci* biotype B now prevalent in Europe, which should be classed as an A1 quarantine pest. CdTV is also important, but its identity is less clearly defined and its characterization incomplete. The other viruses do not seem important enough individually to merit specific listing. It is also debatable whether there is any sense in taking phytosanitary measures against ToMoV unless similar measures are taken against the much more immediately threatening TYLCV (EPPO/CABI, 1996).

Of the *Capsicum* viruses, PepMTV has been included in EU Annex I/A1, but it (like CdTV) causes only a "mild" disease by comparison with another supposed geminivirus principally responsible for tigré disease. It cannot thus be considered a significant quarantine pest for the EPPO region. TPGV and SGMV appear better characterized and individually more important as pests, but the situation remains confused, and none of the *Capsicum* viruses can be singled out as quarantine pests at the present time.

PHYTOSANITARY MEASURES

Host plants of *Bemisia tabaci* from areas where ToMoV or other American geminiviruses of tomato and *Capsicum* occur should come from a place of production free from ToMoV and other geminivirus-induced diseases of tomato and *Capsicum*, and also from *B. tabaci* (or treated against *B. tabaci*), during the last growing season. This applies especially to the ornamental *Euphorbia pulcherrima*, which is notorious for carrying *B. tabaci* inconspicuously.

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