# EPPO Datasheet: *Ipomovirus lycopersici*

Last updated: 2024-01-04

## IDENTITY

**Preferred name:** *Ipomovirus lycopersici*
**Taxonomic position:** Viruses and viroids: Riboviria: Orthornavirae: Pisuviricota: Stelpaviricetes: Patatavirales: Potyviridae
**Other scientific names:** *Eggplant mild leaf mottle virus*, *TMMoV*, *Tomato mild mottle virus*
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**EU Categorization:** Quarantine pest ((EU) 2019/2072 Annex II A)
**EPPO Code:** TOMMOV

### Notes on taxonomy and nomenclature

Tomato mild mottle virus (TMMoV) is a positive-sense single stranded RNA virus of the genus *Ipomovirus* in the family *Potyviridae*. Ipomoviruses differ from members of other genera in that they are transmitted by whiteflies and branch separately in phylogenetic analyses (Inoue-Nagata *et al.*, 2022).

The isolate from eggplant, eggplant mild leaf mottle virus (EMLMV), is considered a TMMoV strain. Sequence comparisons of the complete genomes of EMLMV (HQ840786) and the TMMoV isolate from tomato (HE600072) revealed identities of 81% at the nucleotide level and 92% at the amino acid level; similar identity values were determined for the nucleotide and amino acid sequences of the coat protein of these viruses. In addition, the serological analysis clearly showed that EMLMV is closely related to the TMMoV isolate from tomato. In the literature, EMLMV is sometimes also referred to as the Israeli isolate of TMMoV (TMMoV-IL). (Dombrovsky *et al* ., 2013; Inoue-Nagata *et al*., 2022)

## HOSTS

TMMoV was first reported from Yemen, where it infected *Solanum lycopersicum* (tomato) and weeds *Datura stramonium* (jimson weed) and *Solanum nigrum* (black night-shade) which were growing adjacent to the infected tomato plants (Walkey *et al*., 1994). Natural infection with TMMoV has also been reported for *Nicandra physalodes*, another weed species growing near infected tomato plants (Hiskias *et al*., 1999), and *Solanum betaceum* (tamarillo) (Monger and Nixon, 2010; Kinoga *et al*., 2023). *Solanum melongena* (eggplant) has been found to be infected with the EMLMV strain of TMMoV (Dombrovsky *et al*., 2012).

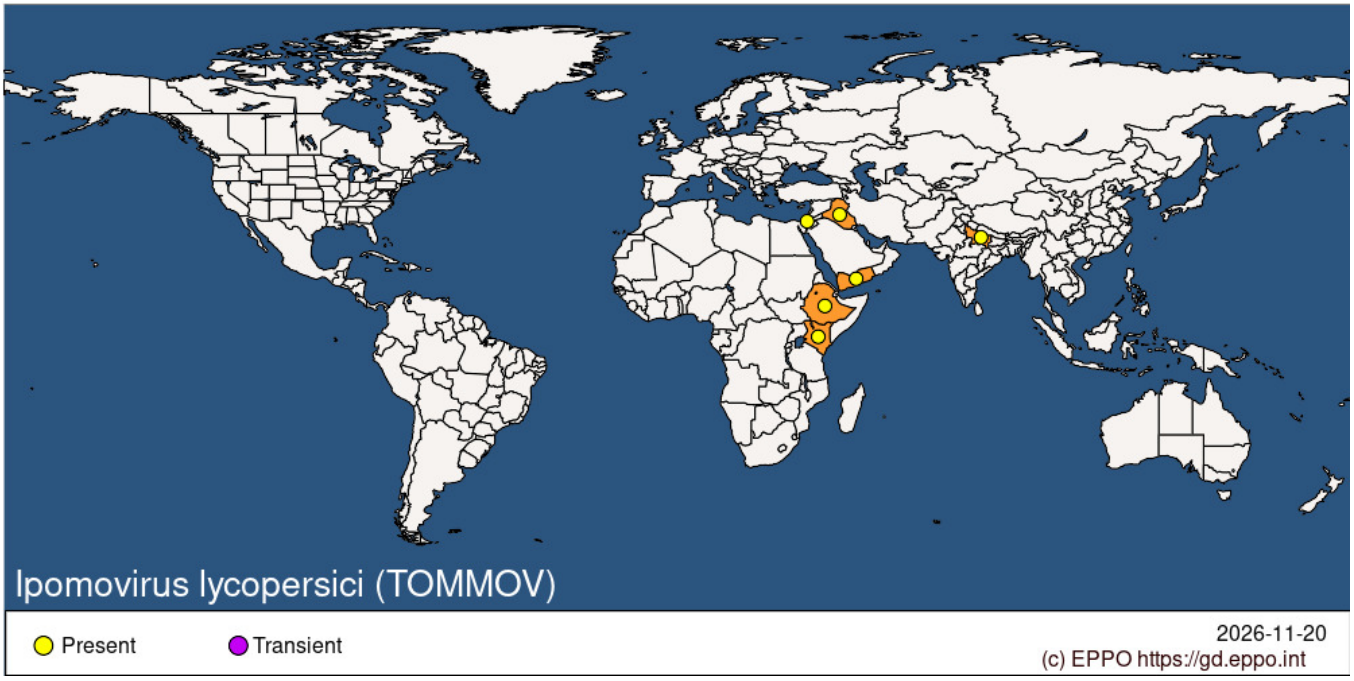
Under experimental conditions, TMMoV, including the isolate from eggplant (EMLMV), was also transmitted by mechanical sap inoculation to the following test plants: *Nicotiana benthamiana, N. clevelandii, N. glutinosa, N. occidentalis, N. rustica, N. sylvestris* and *N. tabacum* (Walkey *et al*., 1994; Hiskias *et al*., 1999; Dombrovsky *et al*., 2013. In addition, the isolate from tomato was mechanically transferred to *Datura metel* (Walkey *et al*., 1994; Hiskias *et al*., 1999), and the isolate from eggplant was transferred to *Physalis floridana*, and *Petunia* sp. (Dombrovsky *et al*., 2013).

**Host list:** *Datura stramonium*, *Nicandra physalodes*, *Solanum betaceum*, *Solanum lycopersicum*, *Solanum melongena*, *Solanum nigrum*

## GEOGRAPHICAL DISTRIBUTION

The tomato disease caused by TMMoV was first observed in Yemen in 1990 (Walkey *et al*., 1994), and later, based on a survey of tomato fields in 1994, TMMoV was found to be the predominant and most widespread virus on tomato in Ethiopia (Hiskias *et al.*, 1999). In 2009, TMMoV was also found on tamarillo in Kenya (Monger and Nixon, 2010; Kinoga *et al*., 2023).

EMLMV has been shown to be the causal agent of a viral disease of eggplant that has been spreading in Israel since 2003 (Dombrovsky *et al*., 2012). Analysis of samples from the 2020-2021 survey confirmed that EMLMV also infects eggplants in Iraq (Khaffajah *et al*., 2022) and India (Mishra *et al*., 2023). Khaffajah *et al*. (2022) suggested that EMLMV was probably present on eggplant in Iraq before 2020, as a similar virus called eggplant blister mottled virus had been detected in earlier studies (Al-Ani *et al*., 2011). However, this assumption would need to be verified.




**EPPO Region:** Israel
**Africa:** Ethiopia, Kenya
**Asia:** India (Uttar Pradesh), Iraq, Israel, Yemen

## BIOLOGY

All ipomoviruses are transmissible experimentally by mechanical inoculation and by grafting (Inoue-Nagata *et al*., 2022). These viruses are also transmitted by the whitefly (*Bemisia tabaci*) in a non-circulative, semi-persistent manner, the virions being retained on the external surface of the vectors' mouth parts for a few days or weeks (Dombrovsky *et al*., 2014).

The first detected TMMoV isolates were reported as a nonpersistent aphid-borne potyvirus (Walkey *et al*., 1994; Hiskias *et al*., 2001). However, the sequence of TMMoV shows no relationship with any of the aphid-transmitted genera (Monger *et al*., 2001), furthermore, repeated vector transmission studies failed to demonstrate transmission of TMMoV by aphids (Abraham *et al*., 2012). A possible explanation for the discrepancy between these reports is that in the Walkey *et al*. (1994) and Hiskias *et al*. (2001) studies, TMMoV unknowingly occurred in a mixed infection with an aphid-transmitted potyvirus, e.g., potato virus Y (PVY), which may have lead to opportunistic transmission of TMMoV by aphids (Abraham *et al*., 2012; Dombrovsky *et al*., 2014). When whitefly transmission was attempted with TMMoV using approximately 100 whiteflies per plant, one of five transmission trials with *B. tabaci* resulted in successful transmission of TMMoV to one plant of *N. tabacum* cv. Samsun (transmission of TMMoV to other plants included in the same trial failed) (Abraham *et al*., 2012).

Similar results were reported for the TMMoV isolate from eggplant, EMMLV, which also lacks the motifs in the viral polyprotein that are essential for aphid-vectored transmission of potyviruses but not for transmission by whiteflies (Dombrovsky *et al*., 2012). Therefore, transmission experiments with aphids failed as expected, whereas EMMLMV was successfully transmitted from infected to healthy eggplant plants or from infected to healthy tobacco plants (*N. tabacum* cv. Samsun plants) in transmission experiments with whiteflies (*B. tabaci*) (Dombrovsky *et al*., 2013). However, the transmission efficiency of *B. tabaci* was poor and a large number of *B. tabaci* individuals (a few hundred per plant) were required for successful transmission (Dombrovsky *et al*., 2013). The transmission of

EMLMV by whiteflies occurred in five out of seven independent transmission experiments, yielding the following transmission rates (infected/inoculated test plants): 6/6, 6/8, 0/7, 5/7, 0/6, 8/8 and 6/8. Independent serial transmission experiments on eggplant revealed that the virus was able to persist in the whitefly vector for at least 5 days but was no longer infective after 9 days (Dombrovsky *et al*., 2013).

## DETECTION AND IDENTIFICATION

### Symptoms

The naturally infected tomato plants from which the TMMoV isolate from Yemen was obtained were slightly stunted with mild but distinct mottle symptoms on the leaves (Walkey *et al*., 1994). In Ethiopia, TMMoV was detected in tomato plants with mottling symptoms on the leaves, whereas severe mosaic, leaf deformation, and plant stunting were observed only when tomato plants were also infected with PVY (Hiskias *et al*., 1999). No symptoms occur on tomato plants, cvs Marmande and Linda, artificially infected with the TMMoV isolate from eggplant, EMLMV (Dombrovsky *et al*., 2013).

Mixed infection with TMMoV and PVY in tamarillo from Kenya resulted in leaf mosaic, mottling, and malformation (Kinoga *et al*., 2023). No sample of tamarillo had a single infection with either virus, making it difficult to associate the observed symptoms with TMMoV or PVY individually.

*Solanum nigrum* plants infected with TMMoV were just under half the normal size, and the leaves showed distinct mottle symptoms (Walkey *et al*., 1994). *Datura stramonium* from Yemen infected with TMMoV was also stunted, and leaves were reduced in size and showed interveinal chlorosis symptoms (Walkey *et al*., 1994). Virus-like symptoms have also been observed in naturally infected *Nicandra physalodes* (Hiskias *et al.,* 1999).

In eggplant (*Solanum melongena*), EMLMV causes mild mottling of leaves and varying degrees of fruit distortion, sometimes accompanied by the formation of blisters on the fruit surface (Dombrovsky *et al*., 2013). Leaves of eggplant plants infected with EMLMV may also show mosaic, blistered areas, and downward curving leaves (Khaffajah *et al*., 2022; Mishra *et al*., 2023).

### Morphology

TMMoV particles have a flexible, filamentous morphology and are approximately 720 nm long (Walkey *et al*., 1994; Dombrovsky *et al.,* 2013). The ssRNA genome of virions comprises approximately 9280 nucleotides (excluding the 3’ poly(A) tail) and encodes a polyprotein of 3011 amino acids (Abraham *et al*., 2012; Dombrovsky *et al*., 2012).

Transmission electron microscopy analysis of ultrathin sections from infected leaf tissue revealed the presence of cytoplasmic inclusion bodies with pinwheel and crystalline structures typical of those induced by potyviral infection (Walkey *et al*., 1994; Dombrovsky *et al*., 2013).

### Detection and inspection methods

The plants, especially the leaves, should be examined for symptoms. Particular attention should be paid if the whitefly *B. tabaci* is present. If necessary, samples should be taken for laboratory testing for definitive identification of the pest.

Electron microscopy can be used for the detection of Ipomoviruses, as they share a typical morphology, but cannot distinguish TMMoV from the other viruses in the genus. Mechanical inoculation of test plants can be used for detection and subsequent identification by other methods. On mechanically inoculated test plants such as *D. stramonium, N. benthamiana, N. clevelandii, N. glutinosa, N. sylvestris* and *N. tabacum* ‘White Burley’, TMMoV can cause vein clearing followed by leaf mottle and deformation or stunting (Hiskias *et al*., 1999; Dombrovsky *et al*., 2013).

Antisera prepared against the coat protein of TMMoV have been used in Western blot or ELISA in some studies (Walkey *et al*., 1994; Hiskias *et al*., 1999 and 2001; Monger *et al*., 2001; Abraham *et al*., 2012; Dombrovsky *et al*.,

2013) but are not currently commercially available. Reverse transcription PCR tests with TMMoV specific primers have also been used for research purposes (Dombrovsky *et al*., 2013; Kinoga *et al*., 2023; Mishra *et al*., 2023), but it should be noted that validation data (performance characteristics according to EPPO Standard PM 7/98) are currently not available for any of these PCR-based tests.

High-throughput sequencing (HTS) analysis can also be used as a screening test for TMMoV. HTS is a technology that can be used to obtain (nearly) complete genome sequences, and analysis of these sequences can be used to identify a virus isolate. Several HTS platforms and sample preparation protocols are available. The performance characteristics of sequencing on the MinION sequencer (Oxford Nanopore Technologies) using the cDNA-PCR protocol for sequencing ribosomal RNA- depleted total RNA to detect TMMoV in tomato leaves are available in the EPPO database on diagnostic expertise (section validation data https://dc.eppo.int/validation_data/validationlist).

## PATHWAYS FOR MOVEMENT

In international trade, TMMoV is most likely to be carried by infected vegetative host material, such as seedlings. *B. tabaci* will spread TMMoV locally.

TMMoV is semipersistent in its white?y host, and it has been shown that the virus was able to persist in the whitefly vector for at least 5 days but was no longer infective after 9 days(Dombrovsky *et al*., 2013). This means that *B. tabaci* can probably spread TMMoV over long distances when carried on infected host material, but when carried on non-host plants, it may not remain virulent long enough to transmit the virus.

In addition, in the case of a mixed infection with an aphid-transmitted potyvirus, local spread of TMMoV by aphids cannot be excluded (see Biology). Mechanical transmission by wounding, although possible under experimental conditions, is highly unlikely to occur (EFSA, 2013). TMMoV is not known to be transmitted by seed.

## PEST SIGNIFICANCE

### Economic impact

The disease caused by TMMoV was first observed on tomato in June 1990 at a site in Yemen, but there was no evidence of economic impact, except that the virus slightly stunted many plants of cv. Roma and that these plants showed mild mottle symptoms on the leaves (Walkey *et al*., 1994). Later, the results of the survey of tomato fields conducted in 1994 in the main growing areas in the Rift Valley and the west of Ethiopia showed that TMMoV is the predominant and most widespread virus in tomato in Ethiopia (Hiskias *et al*., 1999). Hiskias *et al*., 1999 reported that in Ethiopia, a single infection with TMMoV resulted in mottle symptoms, while in cases where a mixed infection with PVY was detected, severe mosaic, leaf deformation and plant stunting were observed.

The effects of TMMoV on tamarillo are not assessable as it has only been detected in mixed infections with PVY. However, this mixed infection has been reported to cause mosaic, mottling and malformations on tamarillo leaves (Kinoga *et al*., 2023).

The TMMoV strain, EMLMV, could have a serious impact on eggplant production, as the fruits of EMLMV-infected plants were deformed to varying degrees, accompanied by hardening of the flesh, making them unmarketable (Dombrovsky *et al*., 2013). In some cases, complete yield loss was observed in Israel (Dombrovsky *et al*., 2013). Based on the survey conducted in Iraq in 2020, the infection rate with EMLMV in the eggplant fields surveyed was estimated at 1 to 80 % (Khaffajah *et al*., 2022).

### Control

Control should be based on preventive and cultural practices. The use of healthy seedlings and measures against *B. tabaci* can help contain the spread. Care should be taken to protect host plant seedlings from infection before transplanting in the field or greenhouse. In regions where *B. tabaci* occurs in open fields, control should both exclude the insect from entering the area that the host crops are grown (physical barriers, protected cultivation) and reduce whitefly populations using integrated pest management practices, combining biological and chemical control

strategies (EPPO, 2023) to suppress the spread of the virus. Crop rotation and planting outside periods of high vector population can also help to reduce the impact of viral diseases. The removal of virus-infected plants, and the removal of the weeds, which are a potential virus reservoir, is also important and would help to prevent further spread of the virus.

### Phytosanitary risk

TMMoV has been present in Yemen and Ethiopia since 1990 and 1994 respectively; later it was found in Israel, Iraq, Kenya and India (see Geographical distribution). It can become established in areas where *B. tabaci*, its white?y vector, is present. *B. tabaci* occurs outdoors in coastal areas with a Mediterranean climate and is a greenhouse pest in many EPPO countries (EFSA, 2013; EPPO, 2023). Tomato and eggplant are grown throughout the EPPO region, while tamarillo prefers a subtropical climate but can be grown in Mediterranean climates.

## PHYTOSANITARY MEASURES

Host plants for planting should only be imported from pest-free areas for the virus. They may also come from areas where the virus occurs if they are produced in pest-free sites of production e.g. under isolation or where measures are implemented to avoid the presence of *B. tabaci* (e.g. greenhouses, trapping) and no symptoms of the virus are observed during the cycle of vegetation. Surveillance (visual inspection followed by laboratory testing) contributes to early detection of TMMoV infected plants and assessment of vectors for targeted insecticide application. Eradication measures for TMMoV would need to involve both destruction of the affected hosts and target the vector *B. tabaci*.

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**Datasheet history**

This datasheet was first published online in 2024. It is 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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