EPPO Datasheet: *Potexvirus pepini*

Last updated: 2021-03-19

IDENTITY

Preferred name: *Potexvirus pepini*
Taxonomic position: Viruses and viroids: Riboviria: Orthornavirae: Kitrinoviricota: Alsuviricetes: Tymovirales: Alphaflexiviridae
Other scientific names: *PepMV*, *Pepino mosaic potexvirus*, *Pepino mosaic virus*
view more common names online...
EPPO Categorization: A2 list
view more categorizations online...
EU Categorization: Emergency measures (formerly), RNQP ((EU) 2019/2072 Annex IV)
EPPO Code: PEPMV0



more photos...

HOSTS

The reported host range of Pepino mosaic virus (PepMV) appears to be relatively broad with plants from different families including both cultivated and wild hosts, but has not been reported to infect plants from the Cucurbitaceae or Fabaceae. Most systemically infected plant species reported belong to the Solanaceae, and *Solanum* spp. appear to be its main hosts.

PepMV was originally reported from *Solanum muricatum* (pepino) and cultivated *S. lycopersicum* (tomato) but surveys showed infection with PepMV of several related wild *Solanum* spp. Infections in these wild species were generally symptomless.

Apart from pepino and tomato, PepMV was also reported to infect other solanaceous crops and test plants; *Solanum melongena* (eggplant), *S. nigrum*, *S. tuberosum* (potato), *Datura stramonium*, *D. metel*, *D. innoxia*, *Nicotiana benthamiana*, *N. occidentalis*, *N. glutinosa* and *N. tabacum* cv. xanthi. *Capsicum annuum* (pepper) does not seem to be a suitable host since most PepMV strains were not able to induce a systemic infection, with the exception of the US1 strain which could induce systemic necrotic lesions.

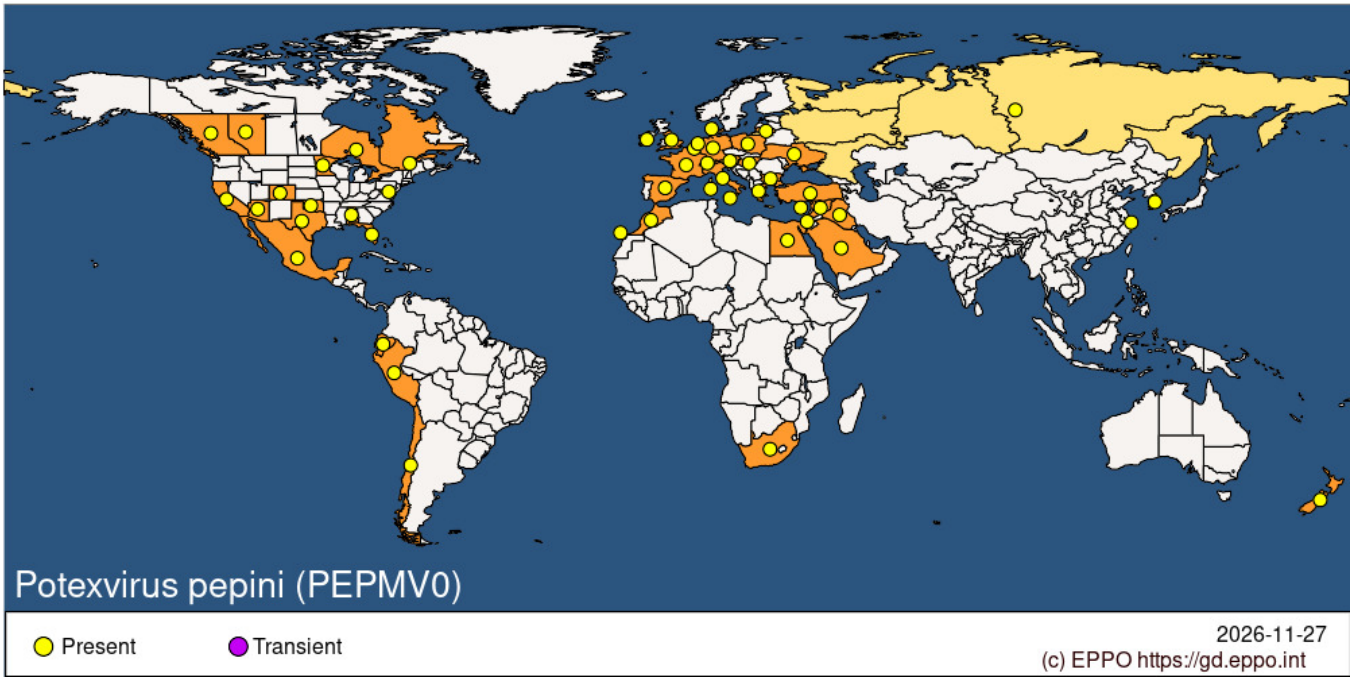
Weed hosts from various plant families (e.g. Convolvulaceae, Brassicaceae, Boraginaceae, Asteraceae, Plantaginaceae and Polygonaceae) were also found to be hosts for PepMV. The original virus description (Jones *et al* ., 1980) reports weed hosts in Peru including *D. stramonium*, *Nicandra physaloides* and *Physalis peruvianum.*

Host list: *Amaranthus graecizans*, *Amaranthus retroflexus*, *Amaranthus sp.*, *Amaranthus viridis*, *Bassia scoparia*, *Calendula arvensis*, *Calystegia sepium*, *Capsicum*, *Chenopodiastrum murale*, *Convolvulus althaeoides*, *Convolvulus arvensis*, *Convolvulus humilis*, *Datura innoxia*, *Diplotaxis erucoides*, *Echium creticum*, *Echium humile*, *Erigeron sumatrensis*, *Glebionis segetum*, *Heliotropium europaeum*, *Lepidium sp.*, *Malva neglecta*, *Malva nicaeensis*, *Malva parviflora*, *Malva sylvestris*, *Moricandia arvensis*, *Nicotiana glauca*, *Oloptum miliaceum*, *Onopordum cyprium*, *Onopordum sp.*, *Plantago afra*, *Plantago lagopus*, *Plantago major*, *Rumex sp.*, *Sisymbrium irio*, *Solanum americanum*, *Solanum chilense*, *Solanum chmielewskii*, *Solanum dulcamara*, *Solanum lycopersicum*, *Solanum melongena*, *Solanum muricatum*, *Solanum nigrum*, *Solanum peruvianum*, *Solanum pimpinellifolium*, *Solanum tuberosum*, *Sonchus asper*, *Sonchus oleraceus*, *Sonchus tenerrimus*, *Taraxacum officinale*

GEOGRAPHICAL DISTRIBUTION

Since its first scientific description from Peru (Jones *et al.*, 1980), PepMV remained agriculturally insignificant until its first finding in commercial protected tomato crops in the United Kingdom and the Netherlands (Van der Vlugt *et al*., 2000). Since then, PepMV has spread rapidly and can now be regarded to be spread worldwide in commercial

tomato crops both protected and outdoors. However there have been limited reports from Africa and Asia and it has not been reported so far from Oceania.



EPPO Region: Austria, Belgium, Bulgaria, Cyprus, Denmark, France (mainland), Germany, Greece (mainland), Hungary, Ireland, Israel, Italy (mainland, Sardegna, Sicilia), Lithuania, Morocco, Netherlands, Poland, Russian Federation, Spain (mainland, Islas Canárias), Switzerland, Türkiye, Ukraine, United Kingdom (England)
Africa: Egypt, Morocco, South Africa
Asia: China (Shanghai), Iraq, Israel, Korea, Republic of, Saudi Arabia, Syrian Arab Republic
North America: Canada (Alberta, British Columbia, Ontario, Québec), Mexico, United States of America (Alabama, Arizona, California, Colorado, Florida, Maryland, Minnesota, Oklahoma, Texas)
South America: Chile, Ecuador, Peru
Oceania: New Zealand

BIOLOGY

As a potexvirus, PepMV is a mainly mechanically transmitted virus and is fairly stable at room temperature. The virus can survive and remain infectious for several weeks in plant debris and on contaminated surfaces (see section ‘Pathways for movement’ for more information on transmission).

Since its first finding in commercial tomato crops many different isolates of PepMV have been described, either isolated from commercial tomato crops or tomato seed lots or from wild *Solanum* spp. Most isolates show relatively mild symptoms, typical of the tomato strain, but a number of isolates show more severe symptoms (including leaf and stem necrosis and severe fruit symptoms) in tomato or wild *Solanum* sp. There is considerable biological variation between isolates and severity of symptoms is not related to the virus strain: in most strains, both mild and severe isolates have been described.

Based on biological data (i.e. symptoms on host and indicator plants), serological relationships and multiple nucleotide sequence alignments, at least five clusters of PepMV isolates are now considered as separate genotypes or strains:

1. The Peruvian pepino strain (LP)
2. The European tomato strain (EU)
3. The Chile-2 strain (CH2)
4. The US1 strain (US1)
5. The PES strain, identified from wild *Solanum* species in Peru

Nucleotide sequence identity between isolates of the same strain is high (above 98%) and full genome nucleotide sequence comparisons between multiple isolates of the different strains show that LP and EU strains are most closely related with around 95% sequence identity. The US1 and PES strains share around 86% identity to each other and around 81% identity to the LP and EU strain. The CH2 strain is the most divergent as it generally shares around 78% sequence identity with the four other strains.

DETECTION AND IDENTIFICATION

Symptoms

Symptoms of PepMV may be very variable ranging from latent infections (no visible symptoms) to very severe leaf and fruit symptoms.

The original Peruvian PepMV isolate caused a distinct yellow mosaic on young leaves of pepino and most infected plant also showed dark green enations on the lower surface of some leaves (Jones *et al.*, 1980). *Solanum* spp. showed a symptomless systemic infection as was shown by back-inoculation on sensitive indicator plants such as *N. glutinosa* . Only a limited number of plant species (*D. metel*, *D. stramonium* and a number of *Nicotiana* spp.) showed distinct symptoms upon systemic infection.

The EU-tomato virus isolate found in 1999 in commercial tomato crops in the United-Kingdom and the Netherlands did cause generally mild although distinct symptoms in commercial tomato crops which consisted of small yellow spots on the leaves. In general, PepMV symptoms depend on the particular virus isolate in combination with the tomato cultivar, the age of the plant when first infected and environmental conditions with low light conditions and low temperatures favouring more pronounced symptoms. Mild symptoms may vary from small yellow leaf spots to a slight reduction in fruit production. More pronounced symptoms may consist of yellow-green mosaic, mottle on the older leaves and/or slight curling in the top leaves (nettle-head symptom) or a greyish appearance of the top of the plant. Fruit symptoms may range from discolouration in the form of blotchy ripening or flaming, fruit marbling, mild sometimes concentric yellow/orange mottling and uneven ripening to netting and cracking (‘open fruits’) and shape distortion.

Inoculation studies of three PepMV strains (EU, CH2 and US1), clearly showed a number of differences between reactions on tomato and other solanaceous crops and test plants (Blystadt *et al.*, 2015). Tomato is susceptible to all three strains, whereas sweet pepper (*C. annuum*) is generally not a systemically susceptible host for the three strains. Eggplant is susceptible to all three strains however local symptoms are seldom seen and systemic leaf symptoms may depend on locality and virus isolate. In potato systemic infections may develop in a sensitive cultivar but local and systemic symptoms are seldom seen. The virus however can infect the tubers and can thus be transmitted to the progeny crop.

Particular point mutations in the genomes of PepMV isolates have been identified as being involved in the severity of symptoms (Hasiów-Jaroszewska & Borodynko, 2012; Hasiów-Jaroszewska *et al*., 2009).

Morphology

PepMV is a member of the genus *Potexvirus* within the virus family *Alphaflexiviridae* and as such has the typical filamentous particles with a normal length of 510 nm. Particles are comprised of a single capsid protein (CP) of approximately 26 kDa. Inclusion bodies, consisting of arrays of filamentuous virus-like particles may be observed in Transmission Electron Microscope (TEM) images of ultrathin sections of infected leaf material.

The genome organisation of PepMV is typical of potexviruses. For all strains its positive single-stranded RNA is around 6 410 nt long, capped at the 5’-end, polyadenylated at the 3’-end and contains 5’- and 3’-untranslated regions. It encodes five putative partly overlapping open reading frames (ORFs 1 to 5) whereby the overlapping ORFs 2,3 and 4 are referred to as the Triple Gene Block (TGB) (Van der Vlugt & Stijger, 2008).

Detection and inspection methods

Inspection of plants and plant material for the presence of PepMV may be unreliable as symptoms of PepMV range from latent infections (e.g. on young plants) to very severe leaf and fruit symptoms. Symptoms may also depend on environmental conditions such as light and temperature. Depending on the moment of infection plants may be systemically infected while not (yet) showing symptoms. Additional guidance for the inspection of places of production of vegetable plants for planting are available in EPPO Standard PM 3/77 (EPPO, 2016a).

When sampling for seed testing, the recommended minimum sample size is 3000 seeds with a maximum sub-sample size of 250 seeds, except for small seed lots (EPPO, 2013). Additional guidance for the sampling of a tomato seed consignment is given in EPPO Standard PM 3/80 *Consignment inspection of seed of* Solanum lycopersicum (EPPO, 2016b).

Specific detection of PepMV is possible either through serological or molecular methods. Antisera from different suppliers are available for use in DAS-ELISA. In addition, 'quick strip tests' (lateral flow tests; LFDs) are available. Molecular detection of PepMV can be done either using conventional Reverse-Transcriptase (RT)-PCR or through real-time RT-PCR ('TaqMan-assay').

An EPPO diagnostic protocol for the detection and identi?cation of PepMV describes serological, molecular and biological detection tests to be used on infected plant material (leaves and fruits) as well as on tomato seeds (EPPO, 2013, under revision).

PATHWAYS FOR MOVEMENT

Because of its persistent nature, the most important routes of transmission of PepMV are mechanical through virus contaminated tools, clothes and surfaces. The virus was also shown to be efficiently transmitted between tomato plants in closed recirculating hydroponic systems as well as by bumblebees (Shipp *et al*., 2008). The latter two transmission routes are likely to contribute to the spread of the virus in commercial closed greenhouse production systems in which bumblebees are used for pollination.

Infected fruits and seeds are likely to contribute to long distance virus transmission. Fruits harvested from infected plants may contain high concentrations of virus and do not necessarily show symptoms. PepMV is also transmitted by tomato seed at low levels (0.005% - 0.057%; Hanssen *et al.*, 2010) whereby infection levels of the seeds appear to correlate with the time period between plant infection and seed harvest. The virus is probably located on or in the seed coat and not in the embryo (Ling, 2008). The virus has been detected many times in consignments of traded tomato seed since 2001 (Clark & Crook, 2012). Persons installing and fixing greenhouses as well as trellising workers may travel internationally and were suspected to be a source of contamination for PepMV in the EU (EPPO, 2020).

PEST SIGNIFICANCE

Economic impact

Although PepMV is now reported worldwide, the overall economic impact of the virus appears to be limited with only occasional reports on severe fruit damage.

An important direct economic impact the virus can have is direct yield loss and reduced fruit quality (i.e. symptoms on fruits and fruit size) in affected tomato crops (Spence *et al.*, 2006). However, given the expression of symptoms is a combination of virus isolate, tomato cultivar, environmental conditions, the presence of other pathogens and timing of infection, the level of possible damage following infection is impossible to predict. In addition, in some countries 'weak' isolates of PepMV are employed in a cross-protection strategy (see section on 'Control') which results in (near)-symptomless infections. In rare instances complete crops losses have been reported due to the clearing of infected tomato production sites.

In addition, routine measures during seed production (e.g. production under Good Seed and Plant Practices (GSPP), see section on 'Control'; or compulsory testing of seed lots to ensure virus-free seed), as well as control measures

(e.g. to disinfect infected production sites, tools, crates etc.) are costly.

Control

Under practical conditions in greenhouses and fields the virus may easily survive for several weeks in plant debris and on surfaces (e.g., tools, clothes, containers) that have come in contact with virus-infected leaves or fruits. Implementation of strict hygiene protocols during the growing season and thorough cleaning of greenhouses at the end of the growing season have shown to effectively control the introduction and spread of the virus. In endpoint dilution studies, sap from infected *N. glutinosa* was always infectious at dilutions of 10^{-4}, occasionally at 10^{-5} but never at 10^{-6}. Sap lost most of its infectivity after 10 minutes at 65^{o}C and was no longer infectious after 10 minutes at 70^{o}C. Sap stored at 20^{o}C still shows some infectivity after 3 months while leaves of *N. glutinosa* desiccated over silica gel were still infectious after 6 months. Good hygiene practices which would for most of them also be valid for PepMV have been compiled in the EPPO PRA for tomato brown rugose fruit virus (EPPO, 2020). The GSPP system already sets a number of standards for the production of tomato seed and plants for planting which contribute to decreasing the risk of PepMV infection (e.g. isolation of the seed and seedling production location from the environment; prevention of infection by managing different risk factors: water, people, propagation material, materials; constant monitoring during the growing season; checks before delivery; independent audits; training of the staff; traceability requirements).

To prevent infection, it is essential to produce healthy planting material. This implies that the absence of PepMV in mother plants or nuclear stock has to be confirmed by testing, as recommended in the Standard for the production of pathogen-tested herbaceous ornamentals (for Solanaceae; EPPO, 2008).

No resistance genes to PepMV are available in commercial tomato cultivars. Screening of wild *Solanum* sp. has identified only a very limited number of potential resistance sources (Soler *et al*., 2011). Some accessions of *S. lycopersicoides* and *S. chilense* are resistant to isolates of the EU strain. Whether this resistance holds against the other PepMV strains remains to be investigated.

One method currently applied in various countries to control the negative effects of PepMV infections is cross-protection i.e., the use of attenuated virus isolates. Cross-protection implies the inoculation of a mild virus isolate onto a crop in an early growth stage. The resulting systemic infection protects the plant against more severe isolates of the virus. Cross-protection is based on the sequence specific activation of the RNA-Induced Silencing Complex (RISC). This general antiviral defence mechanism is sequence homology-dependent and is therefore not virus isolate- but virus strain-specific. Protection against severe EU-strain isolates requires an attenuated EU isolate while an attenuated CH2 isolate is required to protect against aggressive CH2 isolates (De Nayer *et al.*, 2011). In many instances isolates of the CH2 and EU strains occur in mixed infections so for adequate protection mild isolates of both strains are required.

Since isolates of different strains do not exclude each other, mixed infections of isolates of different strains in one plant can occur. Co-infection of one plant with isolates of both the EU-tomato and Ch2 strains not only leads to more severe symptoms but could also lead to genetic recombinants between the two strains (Hanssen *et al.*, 2008).

Phytosanitary risk

Tomato is the main host and the crop at risk in the EPPO region. Tomato is widely grown in the EPPO region outdoors and under protected conditions, commercially and in gardens. PepMV has already been reported in several EPPO countries. The potential geographical distribution of PepMV is the whole of the EPPO region. However, given the relatively low economic impact, the phytosanitary risk of PepMV is considered to be low.

PHYTOSANITARY MEASURES

Phytosanitary measures to prevent the introduction of PepMV in countries where the virus fulfils criteria for being listed as a quarantine pest are recommended for tomato (EPPO, 2012), based on a PRA developed during the PEPEIRA Project (Werkman & Sansford, 2010). These measures for tomato seeds and plants for planting include testing, growing the crop in specified conditions (strict hygiene measures, testing of the mother plants), production in

a certification scheme, in a pest free place of production or a pest free area. Tomato fruits should be produced either in a pest free area, in a pest free place of production, under good hygiene conditions, should be tested, or should not be imported to packing houses that are also sites of production. Standard PM 8/1 (EPPO, 2017) also recommends that seed potatoes (except micropropagative material and minitubers) from countries where PepMV is known to occur should be, where appropriate, subject to transitional arrangements (pest-free area for PepMV and origin from a pest-free potato production and distribution system for the pest, according to EPPO Standard PM 3/61 (EPPO, 2019)).

When not regulated as a quarantine pest, PepMV was regulated by some EPPO countries as a regulated non-quarantine pest (RNQP) for tomato seeds e.g in the European Union with a zero-tolerance threshold (EU, 2020). One important phytosanitary measure to control unwanted spread of PepMV is to only use virus-free seeds and planting material. Seed production should take place under virus-free conditions (e.g. under GSPP) and seed batches should be rigorously tested for the absence of any virus using validated protocols and methods (PM 7/113).

Given the persistent nature of PepMV particles and the usually very high virus concentrations in infected plant material and fruits, disinfection of contaminated surfaces can be very difficult. Numerous claims have been made with regards to the efficacy of disinfecting compounds. These should however be treated with caution. Very strict hygiene measures to avoid infections are recommended (see Control section).

REFERENCES

Blystad D-R, Van der Vlugt R, Alfaro-Fernández A, Carmen Córdoba M, Bese G, Hristova D, Pospieszny H, Mehle N, Ravnikar M, Tomassoli L, Varveri C & Nielsen SL (2015) Host range and symptomatology of Pepino mosaic virus strains occurring in Europe. *European Journal of Plant Pathology* **143**, 43-56.

Clark S & Crook K (2012) 'Import risk analysis: tomato and capsicum seed for sowing from all countries', *Ministry of Agriculture and Forestry*, Wellington (NZ) https://www.mpi.govt.nz/dmsdocument/2887 [accessed on 16 March 2021].

De Nayer F, Goen K, Paeleman A, Parra NO, Vanachter ACRC, Hanssen IM, Wittemans L & Vandewoestijne (2011) Cross-protection as a control strategy for Pepino mosaic virus (PepMV) in greenhouse tomato. *Acta Horticulturae* **194**, 163-170.

EPPO (2008) EPPO Standard PM 4/34 Production of pathogen-tested herbaceous ornamentals. *EPPO Bulletin* **38**, 31-52. Available at https://gd.eppo.int/taxon/PEPMV0/documents [accessed on 16 March 2021].

EPPO (2012) Report of a Pest Risk Management for Pepino mosaic virus. Available at https://pra.eppo.int/getfile/53afe954-9f70-4cf2-9249-12140d8f10dd [accessed on 16 March 2021].

EPPO (2013) EPPO Standard PM7/113 (1) Pepino mosaic virus. *EPPO Bulletin* **43**, 94–104. Available at https://gd.eppo.int/taxon/PEPMV0/documents [accessed on 16 March 2021].

EPPO (2016a) EPPO Standard PM 3/77(1) Vegetable plants for planting under protected conditions – Inspection of places of production. *EPPO Bulletin* **46**, 40-48. Available at https://gd.eppo.int/taxon/PEPMV0/documents [accessed on 16 March 2021].

EPPO (2016b) EPPO Standard PM 3/80(1) Consignment inspection of seed of *Solanum lycopersicum*. *EPPO Bulletin* **46**, 68-72. Available at https://gd.eppo.int/taxon/PEPMV0/documents [accessed on 16 March 2021].

EPPO (2017) EPPO Standard PM 8/1(2) Potato. Commodity-specific phytosanitary measures. *EPPO Bulletin* **47**, 487-503. Available at https://gd.eppo.int/taxon/ PEPMV0/documents [accessed on 16 March 2021].

EPPO (2019) EPPO Standards PM 3/61(2) Pest-free areas and pest-free production and distribution systems for quarantine pests of potato. *EPPO Bulletin***49**, 480–481. Available at https://doi.org/10.1111/epp.12617 [accessed on 16 March 2021].

EPPO (2020) Pest risk analysis for tomato brown rugose fruit virus. EPPO, Paris. Available at https://gd.eppo.int/taxon/TOBRFV/documents

[accessed on 16 March 2021].

EU (2020) Commission Implementing Regulation (EU) 2019/2072 of 28 November 2019 establishing uniform conditions for the implementation of Regulation (EU) 2016/2031 of the European Parliament and the Council, as regards protective measures against pests of plants, and repealing Commission Regulation (EC) No 690/2008 and amending Commission Implementing Regulation (EU) 2018/2019. Last consolidated 2020-12-23. *Journal of the European Union* **319**, 02019R2072. Available at: https://eur-lex.europa.eu/eli/reg_impl/2019/2072/oj [accessed on 16 March 2021].

Hanssen IM, Mumford R, Blystad D_R, Cortez I, Hasiów-Jaroszewska B, Hristova D, Pagán I, Pereira A-M, & Peters L, Pospieszny H, Ravnikar M, Stijger I, Tomassoli L, Varveri C, Van der Vlugt R & Steen Lykke Nielsen SL (2010) Seed transmission of Pepino mosaic virus in tomato. *European Journal of Plant Pathology* **126**, 145-152.

Hanssen IM, Paeleman A, Wittemans L, Goen K, Lievens B, Bragard C, Vanachter ACRC & Thomma BPHJ (2008) Genetic characterization of Pepino mosaic virus isolates from Belgian greenhouse tomatoes reveals genetic recombination. *European Journal of Plant Pathology* **121**, 131-146.

Hasiów-Jaroszewska B & Borodynko N (2012) Characterization of the necrosis determinant of the European genotype of pepino mosaic virus by site-specific mutagenesis of an infectious cDNA clone. *Archives of Virology* **175** , 337.

Hasiów-Jaroszewska B, Pospieszny H & Borodynko N (2009) New Necrotic Isolates of Pepino mosaic virus Representing the Ch2 Genotype. *Journal of Phytopathology* **175**, 494-496.

Jones RAC, Koenig R & Lesemann D-E. (1980) Pepino mosaic virus, a new potexvirus from pepino (*Solanum muricatum*). *Annals of Applied Biology* **94**, 61.

Ling K-S. (2008) Pepino mosaic virus on tomato seed: virus location and mechanical transmission. *Plant Disease* **92**, 1701–1705.

Shipp JL, Buitenhuis R, Stobbs L, Wang K, Kim WS & G. Ferguson G (2008) Vectoring of Pepino mosaic virus by bumble bees in tomato greenhouses. *Annals of Applied Biology* **153**, 149-155.

Soler S, López, Prohens J & Nuez F (2011) New sources of resistance to PepMV in tomato *Journal of Plant Diseases and Protection* **118**, 149-155.

Spence N, Basham J, Mumford RA, Hayman G, Edmondson R & Jones DR (2006) Effect of Pepino mosaic virus on the yield and quality of glasshouse-grown tomatoes in the UK. *Plant Pathology* **55**, 595-606.

Van der Vlugt RAA, Stijger CCMM, Verhoeven JThJ & Lesemann DE (2000) First report of Pepino mosaic virus on tomato. *Plant Disease* **84**, 103.

Van der Vlugt RAA & Stijger CCMM (2008) Pepino Mosaic Virus. Encyclopedia of Virology, 5 vols. (B.W.J. Mahy and M.H.V. Van Regenmortel, Editors), pp. 108 Oxford: Elsevier.

Werkman AW & Sansford CE (2010) Pest Risk Analysis for Pepino mosaic virus for the EU. Deliverable Report 4.3. EU Sixth Framework Project PEPEIRA Available from https://pra.eppo.int/getfile/d07d4218-01f0-48fa-ad32-d251c8d21e99 [accessed on 16 March 2021].

ACKNOWLEDGEMENTS

This datasheet was prepared in 2020 by Prof. dr.ir. R.A.A. van der Vlugt (Wageningen University and Research, the Netherlands). His valuable contribution is gratefully acknowledged.

How to cite this datasheet?

EPPO (2026) *Potexvirus pepini*. EPPO datasheets on pests recommended for regulation. Available online. https://gd.eppo.int

Datasheet history

This datasheet was first published online in 2021. 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.


Co-funded by the
European Union