

California Pest Rating Proposal for

Tomato mosaic tobamovirus

Current Pest Rating: C

Proposed Pest Rating: C

Realm: Riboviria; Phylum: incertae sedis
Family: Virgaviridae; Genus: *Tobamovirus*

Comment Period: 07/28/2023 through 09/11/2023

Initiating Event:

This pathogen has not been through the pest rating process. The risk to California from Tomato mosaic virus (ToMV) is described herein and a permanent rating is proposed.

History & Status:

Background:

Tomatoes are the most economically important vegetable crop worldwide and are California's 8th highest valued commodity worth \$1.18B in 2022 (CDFA Ag Stats, 2022). California is responsible for 90 to 95% of the processed tomato products consumed in the United States and over 30% of the world market. Most are field grown as processing tomatoes in four main areas: Sacramento Valley (Colusa, Sutter, Yolo, Solano, and Sacramento counties), Northern San Joaquin Valley (San Joaquin, Stanislaus, and Merced counties), Fresno and Kings counties, and Kern County. High value fresh market tomatoes are field grown, mainly in San Joaquin, Merced, Fresno, San Diego, Kern, Stanislaus, Kings, Tulare, and Sacramento counties, with additional production in greenhouses or other protected structures, mainly on the coast in Santa Barbara, Ventura, and San Diego counties. Crops are started in nurseries and taken to the field or greenhouse as transplants (Le Strange et al., 2000; Hartz et al., 2008).

Tomato mosaic virus is a member of the genus *Tobamovirus* in the family Virgaviridae (Lefkowitz et al., 2018). The family Virgaviridae contains several genera of important plant viruses including *Tobamovirus*, *Potexvirus*, and *Carlavirus*, each with distinct characteristics and host ranges (Adams et al., 2017). *Tobamovirus* are non-enveloped and possess a rigid rod-shaped or filamentous morphology, with a single-stranded, positive-sense RNA genome. Transmission is primarily mechanical through direct physical contact, and in some cases, they can also be transmitted by insect vectors. They are

highly stable viruses that can cause severe disease symptoms. Members of the genus are best known for causing serious diseases on plants in the Cucurbitaceae, Solanaceae and Chenopodiaceae families. Some have wide host ranges, affecting vegetables and ornamentals and they are easily transmitted by seed (Smith and Dombrovsky, 2019).

ToMV was initially documented in the United States over a century ago (Clinton, 1909; Allard, 1916), with reports from Europe closely following (Westerdijk, 1910). Since then, ToMV has been extensively studied worldwide as infection leads to reduced yields and quality in tomatoes. Initially, it was considered a strain of Tobacco mosaic tobamovirus (Brunt, 1988). However, the distinction between the two viruses became apparent as differences in host range, serological affinities, protein and nucleic acid sequences, and compositions. Consequently, ToMV has been recognized as a separate virus since 1971 (Harrison et al., 1971), and is presently classified within the *Tobamovirus* genus with over a dozen other viral species (van Regenmortel and Meshi, 1995).

Numerous naturally occurring strains of ToMV have been described based on the distinct symptoms they induce in tomato plants. These strains have been extensively characterized, including aucuba or yellow mosaic, common, corky ringspot, crusty fruit, dahlemense, enation, black fleck, rosette, summer necrosis, yellow atypical, yellow ringspot, and winter necrosis (Brunt, 1988).

Hosts: Tomato (*Solanum lycopersicum*) is the most important host of ToMV and is particularly susceptible. Besides tomatoes, ToMV can infect other members of the Solanaceae family as well as other plant families. These are common hosts: pepper (*Capsicum* spp.), potato (*S. tuberosum*), eggplant (*S. melongena*), petunia (*Petunia* spp.), and tobacco (*Nicotiana* spp.). Weeds are also important hosts including groundcherries (*Physalis* spp.), henbane (*Hyoscyamus niger*), jimsonweed (*Datura stramonium*), black nightshade (*S. nigrum*) and horsenettle (*S. carolinense*) (CABI, 2023).

ToMV also has a very wide experimental host range. It is reported to be transmissible to at least 127 other species in 23 families (Edwardson and Christie, 1997). Different strains or isolates of ToMV may exhibit varying levels of infectivity on different plants. While some strains might infect a wide range of hosts, others may have a more limited host range. Resistance or tolerance to the virus can vary among different cultivars and varieties within a given plant species.

Symptoms: ToMV can cause a variety of symptoms. The severity and appearance of symptoms can vary depending on factors such as the virus strain, host cultivar, and environmental conditions. One of the hallmark symptoms of ToMV infection is the appearance of mosaic patterns on the leaves of tomatoes. The mosaic patterns are irregular, with alternating light green or yellow areas and normal green areas. The mosaic patterns can be blotchy or more distinct, depending on the severity of the infection. Infected leaves may show mottling, which is the presence of light and dark patches or spots on the leaf surface. Chlorosis, or yellowing of the leaf tissue, can also occur, especially in the light green areas of the mosaic patterns. The severity of chlorosis can vary from mild yellowing to complete yellowing of the leaf (Broadbent, 1976; CABI, 2023).

ToMV-infected leaves may exhibit distortion or curling. The edges of the leaves can become crinkled or puckered, and the overall shape of the leaf may be abnormal. Symptoms can be described as “fern-like,

or shoestring-like”. Severe leaf distortion can affect the plant's ability to photosynthesize and grow properly. Infected plants may exhibit reduced overall growth and stunted development compared to healthy plants. The affected plants may be smaller in size, with shorter internodes and a general lack of vigor. ToMV infection can impact the quality of fruit. Symptoms such as mosaic patterns, mottling, or yellowing can appear on the fruit as well. Additionally, infected fruits may exhibit uneven ripening, be smaller in size, and have a less desirable appearance (CABI, 2023; Davis et al., 2013).

Transmission: The primary means of transmission involve direct contact with infected plants, seeds, or insect vectors. Mechanical transmission is the most common mode of transmission for ToMV. The virus can be easily spread from infected plants to healthy ones through physical contact. When a person or a tool touches an infected plant, the virus can adhere to their hands, clothing, or equipment. If they subsequently touch a healthy plant, the virus can be transferred, leading to infection. This mode of transmission can occur during routine farming activities, such as pruning, harvesting, or handling infected plants. Rapid spread within crops from primary foci is largely attributable to mechanical transmission of virus by insects, small mammals, birds and, most importantly, by horticultural workers on contaminated hands, clothing, and tools during routine horticultural operations. When infected plants are found in a greenhouse, the virus can persist for many months on greenhouse structures and in debris of infected plants in soil from which it can only be eradicated with great effort or long rotations to non-host species (Broadbent, 1976; CABI, 2023).

ToMV can be readily transmitted through infected seeds usually carrying the virus externally, in low concentrations, but also it can be found in external mucilage, testa and endosperm, but not in the embryo. When infected seeds are planted, the resulting seedlings are infected (Broadbent, 1965). It is crucial to use certified disease-free seeds or employ treatments like hot water treatment or chemical treatments to eliminate the virus from seeds (CABI, 2023).

ToMV can also be transmitted through grafting or vegetative propagation methods. When infected plant material, such as stem cuttings or scions, is used to graft or propagate new plants, the virus can be transferred to the healthy plant (Yadav and Yadav, 2017).

Damage Potential: The damage caused by ToMV can vary depending on various factors such as the severity of the strain, the susceptibility of the tomato cultivar, and the cultural and environmental conditions. In tomato, the most important and vulnerable host plant of this virus, ToMV causes mosaic, stunting and leaf distortion. Infected plants may exhibit stunted growth, reduced fruit size, and decreased overall productivity, leading to 15%–25% plant loss (Broadbent, 1976).

ToMV can significantly reduce tomato fruit yields. In severe cases, yield losses can exceed 30%. ToMV-infected tomatoes may develop symptoms such as mosaic patterns, mottling, yellowing, or distorted fruit shape. These visual symptoms can make the affected fruits unmarketable or downgraded in quality, resulting in financial losses for growers. ToMV can cause delayed ripening of tomatoes, affecting their timing of harvest, market value and shelf life (Di Candilo et al., 1992).

ToMV can cause general debilitation in infected plants, resulting in reduced vigor, overall plant health, and vitality. Weakened plants are more vulnerable to other stressors such as environmental conditions, pests, and diseases, which can further impact crop productivity (CABI, 2023).

Worldwide Distribution: Tomato mosaic virus is highly prevalent around the world, with a broad geographical distribution. It has been reported in various regions worldwide, and it is likely present wherever commercial tomato cultivation takes place, primarily due to the unintentional introduction of the virus through contaminated seed stocks (CABI, 2023).

Official Control: Although ToMV is not officially classified as a quarantine pest by any regional plant protection organization, its potential to inflict considerable damage to fruit yield and quality is widely acknowledged. As a precautionary measure, it is strongly advised to utilize only disease-free or treated seeds when engaging in international trade. This practice helps minimize the risk of introducing or spreading ToMV through seed shipments. It is on the USDA PCIT's harmful organisms list for Georgia and Japan (USDA PCIT, 2023).

California Distribution: Statewide (French, 1989; CDFA PDR database, 2023).

California Interceptions: none

The risk Tomato mosaic tobamovirus would pose to California is evaluated below.

Consequences of Introduction:

1) Climate/Host Interaction:

ToMV is likely to found anywhere its hosts can grow

Evaluate if the pest would have suitable hosts and climate to establish in California.

Score: 3

- Low (1) Not likely to establish in California; or likely to establish in very limited areas.
- Medium (2) may be able to establish in a larger but limited part of California.
- **High (3) likely to establish a widespread distribution in California.**

2) Known Pest Host Range:

The host range includes plants in multiple families, including vegetables, ornamentals, and weeds.

Evaluate the host range of the pest.

Score: 3

- Low (1) has a very limited host range.
 - Medium (2) has a moderate host range.
 - **High (3) has a wide host range.**
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3) Pest Reproductive Potential:

This virus is very stable and easily transmitted mechanically and with seed.

Evaluate the natural and artificial dispersal potential of the pest.

Score: 2

- Low (1) does not have high reproductive or dispersal potential.
- **Medium (2) has either high reproductive or dispersal potential.**
- High (3) has both high reproduction and dispersal potential.

4) Economic Impact:

Tobamoviruses are destructive pathogens, especially of tomatoes and cucurbits, causing serious symptoms on plants and their fruits.

Evaluate the economic impact of the pest to California using the criteria below.

Economic Impact: A, B

- A. The pest could lower crop yield.**
- B. The pest could lower crop value (includes increasing crop production costs).**
- C. The pest could trigger the loss of markets (includes quarantines).
- D. The pest could negatively change normal cultural practices.
- E. The pest can vector, or is vectored, by another pestiferous organism.
- F. The organism is injurious or poisonous to agriculturally important animals.
- G. The organism can interfere with the delivery or supply of water for agricultural uses.

Economic Impact Score: 2

- Low (1) causes 0 or 1 of these impacts.
- **Medium (2) causes 2 of these impacts.**
- High (3) causes 3 or more of these impacts.

5) Environmental Impact:

Tobamoviruses have a significant impact on cultural methods. Their presence requires seed disinfestation and strict sanitation protocols to prevent epidemics, especially in greenhouses.

Evaluate the environmental impact of the pest to California using the criteria below

Environmental Impact: E

- A. The pest could have a significant environmental impact such as lowering biodiversity, disrupting natural communities, or changing ecosystem processes.
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- B. The pest could directly affect threatened or endangered species.
- C. The pest could impact threatened or endangered species by disrupting critical habitats.
- D. The pest could trigger additional official or private treatment programs.
- E. **The pest significantly impacts cultural practices, home/urban gardening or ornamental plantings.**

Environmental Impact Score: 2

- Low (1) causes none of the above to occur.
- **Medium (2) causes one of the above to occur.**
- High (3) causes two or more of the above to occur.

Consequences of Introduction to California for: Medium

Add up the total score and include it here. **12**

- Low = 5-8 points
- Medium = 9-12 points**
- High = 13-15 points

- 6) **Post Entry Distribution and Survey Information:** Evaluate the known distribution in California. Only official records identified by a taxonomic expert and supported by voucher specimens deposited in natural history collections should be considered. Pest incursions that have been eradicated, are under eradication, or have been delimited with no further detections should not be included.

This pathogen has been present in California for decades and is widespread.

Evaluation is 'high'.

Score: -3

- Not established (0) Pest never detected in California or known only from incursions.
- Low (-1) Pest has a localized distribution in California or is established in one suitable climate/host area (region).
- Medium (-2) Pest is widespread in California but not fully established in the endangered area, or pest established in two contiguous suitable climate/host areas.
- High (-3) Pest has fully established in the endangered area, or pest is reported in more than two contiguous or non-contiguous suitable climate/host areas.**

- 7) **The final score is** the consequences of introduction score minus the post entry distribution and survey information score: (Score)

Final Score: Score of Consequences of Introduction – Score of Post Entry Distribution and Survey Information = 9

Uncertainty:

The symptoms of ToMV can resemble those caused by other viral infections, herbicide damage, or physiological disorders. Tomatoes can be co-infected with multiple Tobamoviruses including Tomato brown rugose fruit virus, which is a Federal Quarantine Pest (Ling et al., 2019). Proper laboratory testing is required to confirm the presence of ToMV in suspected infected plants to avoid misdiagnosis.

Conclusion and Rating Justification:

Based on the evidence provided above the proposed rating for **Tomato mosaic tobamovirus is C.**

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Responsible Party:

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***Comment Period: 07/28/2023 through 09/11/2023**

*NOTE:

You must be registered and logged in to post a comment. If you have registered and have not received the registration confirmation, please contact us at [permits\[@\]cdfa.ca.gov](mailto:permits[@]cdfa.ca.gov).

Comment Format:

- ❖ Comments should refer to the appropriate California Pest Rating Proposal Form subsection(s) being commented on, as shown below.

Example Comment:

Consequences of Introduction: 1. Climate/Host Interaction: [Your comment that relates to “Climate/Host Interaction” here.]

- ❖ Posted comments will not be able to be viewed immediately.
 - ❖ Comments may not be posted if they:
 - Contain inappropriate language which is not germane to the pest rating proposal;
 - Contains defamatory, false, inaccurate, abusive, obscene, pornographic, sexually oriented, threatening, racially offensive, discriminatory or illegal material;
 - Violates agency regulations prohibiting sexual harassment or other forms of discrimination;
 - Violates agency regulations prohibiting workplace violence, including threats.
 - ❖ Comments may be edited prior to posting to ensure they are entirely germane.
 - ❖ Posted comments shall be those which have been approved in content and posted to the website to be viewed, not just submitted.
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Proposed Pest Rating: C
