cdfa CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

California Pest Rating Proposal for

Apple mosaic virus

Current Pest Rating: C

Proposed Pest Rating: C

Realm: Riboviria, Kingdom: Orthornavirae

Phylum: Kitrinoviricota, Class: Alsuviricetes

Order: Martellivirales, Family: Bromoviridae

Genus: Ilarvirus

Comment Period: 10/13/2020 through 11/27/2020

Initiating Event:

On August 9, 2019, USDA-APHIS published a list of "Native and Naturalized Plant Pests Permitted by Regulation". Interstate movement of these plant pests is no longer federally regulated within the 48 contiguous United States. There are 49 plant pathogens (bacteria, fungi, viruses, and nematodes) on this list. California may choose to continue to regulate movement of some or all these pathogens into and within the state. In order to assess the needs and potential requirements to issue a state permit, a formal risk analysis for Apple mosaic virus (ApMV) is given herein and a permanent pest rating is proposed.

History & Status:

Background:

The family Bromoviridae contains six genera of viruses: Bromovirus, Cucumovirus, Ilarvirus, Alfamovirus, Anulavirus, and Oleavirus. There are 22 described ilarviruses and they have been found primarily in woody plants. Notable members of the genus and their hosts include Apple mosaic virus (pome fruits and roses), Prunus necrotic ring spot virus and Prune dwarf virus (stone fruits and roses), and Citrus leaf rugose virus and citrus variegation virus (citrus) (Bujarski et al., 2019; Agrios, 2005).

Ilarviruses are named after their description as "**i**sometric **l**abile **r**ingspot viruses," although they are not truly isometric, and many cause symptoms other than ringspots. The type species Ilarvirus is tobacco streak. Several Ilarviruses can be transmitted by thrips, but some are seed and/or pollen transmitted in some hosts. Ilarviruses occur wherever their hosts are grown, and many are distributed worldwide having been spread with infected nursery stock, budwood, or seed. Because ilarviruses are very labile (unstable), they have been more difficult to isolate and characterize. Therefore, the identity of many and relationships with one another have been difficult to establish definitively. ApMV has two genomic RNAs (RNA1 and RNA2) each contained in separate quasi-spherical particles. It also has a third RNA (RNA3) and a sub-genomic RNA (RNA4) contained together in a third particle. ApMV is more closely related to alfalfa mosaic virus than to other ilarviruses (Shiel and Berger, 2000; Agrios, 2005).

ApMV is named after the disease it causes in apples. Apple was the first host from which it was recorded, with work done in Michigan (Bradford and Joly, 1933). The preferred scientific name is Apple mosaic virus; other names in literature are Chestnut mosaic, Birch line pattern virus, Birch ringspot virus, Dutch plum line pattern virus, European plum line pattern virus, Hop A virus, Hop virus A, Hop virus C, Horse chestnut yellow mosaic virus, and Mountain ash variegation virus. Roses are often co-infected with Apple mosaic virus and Prunus necrotic ringspot virus: the resulting disease is called Rose mosaic virus complex (CABI-CPC, 2020).

Hosts: Aesculus sp. (buckeye), *Aesculus flava* (yellow buckeye), *Aesculus hippocastanum* (horse-chestnut), *Aesculus parviflora* (bottle brush buckeye), *Aesculus x carnea* (red horse chestnut), *Artemisia vulgaris* (mugwort), *Betula alleghaniensis* (swamp birch), *Betula papyrifera* (paper birch), *Betula pendula* (silver birch), *Campanula* (bell flower), *Clematis vitalba* (old man's beard), *Corylus avellana* (hazel), *Crataegus* (hawthorn), *Fragaria x ananassa* (strawberry), *Galeopsis* (hemp nettle), *Humulus lupulus* (hop), *Malus domestica* (apple), *Prunella* (heal-all), *Prunus armeniaca* (apricot), *Prunus avium* (cherry), *Prunus cerasifera* (cherry plum), *Prunus domestica* (plum), *Prunus domestica* subsp. *insititia* (damson plum), *Prunus dulcis* (almond), *Prunus mahaleb* (mahaleb cherry), *Prunus persica* (peach), *Prunus salicina* (Chinese plum), *Prunus serrulata* (Japanese cherry), *Prunus spinosa* (blackthorn), *Prunus triloba* (flowering plum), *Pyrus communis* (pear), *Ribes rubrum* (red currant), *Rosa* (rose), *Rubus* (brambles), *Rubus canescents, Rubus idaeus* (red raspberry), *Rubus occidentalis* (black raspberry), *Rubus ursinus* (pacific blackberry), *Salvia verbenaca* (wild clary), *Scandix, Sorbus aucuparia* (mountain ash).

Symptoms: The symptoms caused by ApMV are variable on different host plants and with different virus strains. Some strains cause severe "shock" symptoms on the spring growth of their hosts with leaves, blossoms, and young twigs killed. Necrotic cankers may sometimes develop on twigs and branches. Leaves and shoots produced later in the spring may show mild or no symptoms. Although most apple cultivars remain asymptomatic after infection, sensitive varieties show symptoms mostly on the foliage and blossoms in the form of line patterns, ring spots, and mosaics, which are sometimes accompanied by leaf malformation and distortions. Trees affected with some strains of ApMV may show symptoms for only one or a few years, with the virus becoming latent and symptomless in subsequent years.

The distribution of symptomatic leaves may be erratic on individual trees or limited to a single limb. The number and severity of symptomatic leaves also depends on temperature, with more severe symptoms in years with moderate spring temperatures (Posnette and Cropley, 1956).

Leaves of stone fruit trees show yellow line patterns, bright yellow blotches in the form of patchy or widespread mottling, rings, bright yellow vein clearing, and oak-leaf patterns. The symptoms generally appear at the beginning of summer and in some cases are present only on a limited number of leaves randomly distributed on affected plants. However, the symptomatology is generally not of diagnostic significance, because similar symptoms may be produced on *Prunus* spp. by other ilarviruses (Ritchie et al., 1995).

ApMV has been associated with yellow mosaic disease of horse chestnuts. The symptoms occur throughout the canopy on some trees, but flowering was not substantially affected by ApMV infection (Sweet and Barbara, 1979). Brambles can show symptoms of yellow flecking, line patterns and/or yellow speckling of the leaves or they can be symptomless. Leafroll symptoms observed in strawberries have also been attributed to ApMV infection (Tzanetakis and Martin, 2005). Symptoms of ApMV in hop range from chlorotic ringspots that can become necrotic to oak-leaf line patterns (Pethybridge et al., 2002).

Golino et al. (2007) describe ApMV symptoms on *Rosa* spp. as line patterns, chlorotic ringspots, chlorotic mottle, and vein banding. These symptoms can occur on different leaves of individual plants. Line pattern symptoms forming oak-leaf designs, irregular rings, or linear flecks sometimes accompanied by a mild mosaic were observed in white (*B. papyrifiera*) and yellow birches (*B. alleghaniensis*) (Gotlieb and Berbee, 1973).

Transmission: ApMV is graft-transmissible and the main source of inoculum is virus in vegetative propagation material taken from infected trees (Grimova et al., 2016). The virus can be sap-transmitted in hop by mechanical inoculation with pruning (Pethybridge et al., 2002). Transmission by dodder plants has not been confirmed. Although ApMV has a wide host range, no insect vectors of ApMV are known. Other species from the genus Ilarvirus are commonly transmitted in association with thrips (Jones, 2005).

ApMV transmission through root grafting was studied in California with roses by Golino et al., 2007. They demonstrated that healthy bushes that were planted near virus-infected bushes became infected over two years. The rate of virus spread within the rootstock *R. multiflora* was greater than in other varieties tested. Other experiments showed that pruning and hedging could spread ApMV in roses. Transmission of ApMV was also shown to occur via plant to plant contact by hop shoot intertwining (Pethybridge et al., 2002).

No evidence was found for seed and pollen transmission in apples and roses (Golino et al., 2007). Cameron and Thompson (1986) demonstrated seed transmission of ApMV in hazelnuts. ApMV was detected in unripe seeds of *A. hippocastanum* and *A. carnea* but was lost during maturation and no evidence of seed transmission was found. ApMV was present in the anthers of *A. carnea* with the possibility of pollen transmission undetermined (Sweet and Barbara, 1979).

Damage Potential: For fruit and nut trees, the use of certified virus-tested (and found to be free of all known viruses) planting material eliminates ApMV and provides durable protection from this disease. ApMV has been shown to reduce tree growth and fruit yield and to adversely affect fruit quality. Most varieties of apple are susceptible to ApMV but symptoms are variable. Fruit yields may be reduced 25 to 50% (Ohlendorf, 1999). Large losses have been reported for hazelnuts and almonds (25%) but are variable with varieties and environmental conditions (Martelli and Savino, 1997; Aramburu and Rovira, 1995).

Infection by ApMV or another ilarvirus, Prunus necrotic ringspot virus, on roses causes rose mosaic complex disease. Virus-infected plants may grow more slowly, produce delayed or fewer flowers, and become more susceptible to frost damage. The severity of damage varies with the host cultivar. Some infected roses exhibit no damage symptoms (Karlick et al., 2020).

Worldwide Distribution: Africa: *Algeria, Kenya, Morocco, South Africa, Tunisia, Zimbabwe.* Asia: *Azerbaijan, Bangladesh, China, India, Japan, Jordan, Lebanon, Syria, Turkey*. Europe: *Albania, Austria, Belarus, Belgium, Bosnia, Bulgaria, Cyprus, Czechia, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Latvia, Netherlands, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, United Kingdom*. North America: *Canada, Mexico, United States* (Alabama, Alaska, Arizona, California, Colorado, Connecticut, Delaware, Florida, Idaho, Indiana, Iowa, Kansas, Kentucky, Maine, Maryland, Massachusetts, Michigan, Mississippi, Missouri, Montana, Nevada, New Hampshire, New Jersey, New York, Ohio, Oregon, Pennsylvania, South Carolina, Tennessee, Texas, Utah, Vermont, Virginia, Washington, Wisconsin, Wyoming. Oceania: *Australia, New Zealand*. South America: *Argentina, Brazil, Chile Uruguay*. (CABI-CPC, 2020).

Official Control: USDA PCIT harmful organism list for Canada, Colombia, Ecuador, Egypt, Georgia, Guatemala, Honduras, Indonesia, Israel, Japan, Mexico, Morocco, Norway, Sri Lanka, Taiwan, Timor-Leste, and Turkey (USDA PCIT, 2020). EPPO has ApMV on the A2 list for Egypt, Jordan and Turkey, quarantine pest for Morocco, Mexico, USA, Israel, and Norway (EPPO, 2020).

California Distribution: Alameda, Contra Costa, Fresno, Glenn, Humboldt, Kern, Kings, Marin, Merced, Monterey, Orange, Sacramento, San Joaquin, San Mateo, Santa Barbara, Santa Clara, Santa Cruz, Solano, Sonoma, Sutter, Tehama, Tulare, and Yolo counties

California Interceptions: None

The risk Apple mosaic virus would pose to California is evaluated below.

Consequences of Introduction:

1) **Climate/Host Interaction:** This pathogen lives entirely inside of its host and can establish everywhere its hosts are grown

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 pome fruit, stone fruit, brambles, and nut trees

Evaluate the host range of the pest.

Score: 2

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

3) **Pest Reproductive Potential:** ApMV does not have a vector and spreads primarily through vegetative propagation of infected hosts. In some hosts, it spreads with pruning and root grafting. Seed and pollen transmission are possible in some hosts but do not seem to occur in apples or roses.

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:** Virus-testing and clean stock programs utilizing thermal therapy for fruit and nut trees reduces the incidence of ApMV in commercial production. The damage it causes to roses reduce the value of the plants.

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:** Although the virus has a moderate host range, it does not have a known vector, thus movement into native plants is not likely.

Environmental Impact:

A. The pest could have a significant environmental impact such as lowering biodiversity, disrupting natural communities, or changing ecosystem processes.
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: 1
- 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 Apple mosaic virus*:* Medium

Add up the total score and include it here. **10**
-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.

Evaluation is 'high'. ApMV is widespread in California, almost exclusively as a part of Rose mosaic disease complex.

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* **= 7**

Uncertainty:

Although no thrips vector has been identified for ApMV, this could be made in the future, as closely related virus species have thrips vectors.

Conclusion and Rating Justification:

Based on the evidence provided above the proposed rating for Apple mosaic virus is C.

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Responsible Party:

Heather J. Scheck, Primary Plant Pathologist/Nematologist, CDFA/PHPPS ECOPERS, 2800 Gateway Oaks Suite 200, Sacramento, CA 95833 Phone: (916) 654-1017, permits[@]cdfa.ca.gov.

***Comment Period: 10/13/2020 through 11/27/2020**

***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.

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.

Proposed Pest Rating: C
