California Pest Rating Proposal for

Tomato ringspot virus

Current Pest Rating: C

Proposed Pest Rating: C

Realm: Riboviria; Phylum: incertae sedis

Family: Secoviridae; Subfamily: Comovirinae

Genus: Nepovirus

Comment Period: 6/2/2020 through 7/17/2020

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 Tomato ringspot virus (ToRSV) is given herein and a permanent pest rating is proposed.

History & Status:

Background:

Tomato ringspot virus is widespread in North America. Despite the name, it is of minor importance to tomatoes. However, it infects many other hosts and causes particularly severe losses on perennial woody plants including fruit trees and brambles. ToRSV is a nepovirus; "nepo" stands for **ne**matode-transmitted **po**lyhedral. It is part of a large group of more than 30 viruses, each of which may attack many annual and perennial plants and trees. They cause severe diseases of trees and vines. ToRSV is vectored by dagger nematodes in the genus *Xiphinema* and sometimes spreads through seeds or can be transmitted by pollen to the pollinated plant and seeds. ToRSV is often among the most important diseases for each of its fruit tree, vine, or bramble hosts, which can suffer severe losses in yield or be

killed by the virus. The diseases caused by ToRSV are often named after the symptoms they cause, for example, prunus stem pitting and decline, apple graft union necrosis and decline, and grapevine yellow vein disease and grapevine decline (Agrios, 2005).

Nematode-vectored spread occurs in areas where there are moderate to high populations of nematodes (Stace-Smith, 1984). The nematode vector is most often *Xiphinema americanum* sensu lato, the American dagger nematode. This is a species complex and may contain more than 20 distinct species with different host ranges making it very difficult to provide a definitive list of vector species. The following have been suggested as being possible vectors of ToRSV: *X. americanum*, *X. californicum*, *X. incognitum*, *X. occidium*, *X. rivesi*, *X. thornei*, *X. utahense* (Brown, 1989). *Xiphinema americanum* appears to be the most important vector in California and has been recently reviewed and rated (CDFA Pest Ratings, 2020; Chitambar et al., 2018).

Hosts: Buddleja davidii (butterfly bush), *Capsicum* spp. (peppers), *Capsicum frutescens* (chili), *Cornus* (dogwood), *Cucumis sativus* (cucumber), *Cydonia oblonga* (quince), *Daphne mezereum* (mezereon), *Dipsacus fullonum* (Fuller's teasel), *Erigeron glaucus* (seaside fleabane), *Fragaria x ananassa* (strawberry), *Fragaria chiloensis* (Chilean strawberry), *Fraxinus americana* (white ash), *Gladiolus hybrids* (sword lily), *Hydrangea* (hydrangeas), *Lilium* spp. (lily), *Lotus corniculatus* (bird's-foot trefoil), *Malus domestica* (apple), *Nicotiana tabacum* (tobacco), Orchidaceae (orchids), *Pelargonium* spp. (pelargoniums), *Peperomia* sp. (peperomia), *Picris echioides* (bristly ox tongue), *Plantago* sp. (plantain), *Prunus* (stone fruit), *Prunus armeniaca* (apricot), *Prunus avium* (sweet cherry), *Prunus cerasus* (sour cherry), *Prunus domestica* (plum), *Prunus dulcis* (almond), *Prunus persica* (peach), *Prunus salicina* (Japanese plum), *Punica granatum* (pomegranate), *Ribes* (currants), *Rubus* (blackberry, raspberry), *Rubus idaeus* (raspberry), *Rubus procerus* (Himalayan blackberry), *Sambucus* (elderberry), *Solanum lycopersicum* (tomato), *Solanum melongena* (eggplant), *Taraxacum officinale* complex (dandelion), *Vaccinium corymbosum* (blueberry), and *Vitis vinifera* (grapevine) (CABI-CPC, 2020; EPPO, 2020; French, 1989).

Symptoms: Nepovirus-infected plants often show severe shock symptoms initially or in early spring but later in the season partially recover and the symptoms become milder or disappear completely. On annuals and some perennials, ToRSV causes mosaic and ring spot symptoms on the leaves, sometimes accompanied by various degrees of systemic necrosis. In grapevines, strawberries, and raspberries, the leaves may show mottling, rings, or yellow veins, the vines become stunted, fruit clusters develop poorly or not at all, and berry size may be uneven. On grapevines, removing the bark from trunks and stems may reveal thickened, spongy phloem tissue with numerous necrotic pits (Uyemoto, 1975).

On most perennial hosts, ToRSV usually causes no distinctive symptoms on the foliage; rather, it affects the graft unions causing stem pitting or necrosis. In several hosts including apples, grafting a variety scion onto a ToRSV infected rootstock causes a hypersensitive response in the scion and the graft can fail. The disease is called apple union necrosis. This can also occur if the rootstock is infected by nematodes after planting. Affected trees without the hypersensitive reaction often show yellowing of foliage, twig dieback, and general decline and death within 3 to 5 years of the appearance of symptoms at the graft union (Agrios, 2005).

In stone fruit there can be extensive and severe pitting of the scion, rootstock, or both on either side of the graft union. The union will show various degrees of necrosis at the graft plate. Foliage symptoms slowly spread throughout the canopy as the virus moves up into scion wood and there is a general decline. On cherries, the limbs can look bare as leaves drop from the bottom of branches. The dieback moves upward as the virus kills spurs, twigs, and small branches. Affected leaves have an elm leaf-like appearance with prominent, whitish veins at right angles to the midrib. Leaflike growths called enations develop along the midrib on the underside of these leaves (Adaskaveg and Caprile, 2009; Agrios, 2005).

Prunus stem pitting affects peaches, nectarines, plums, and cherries. Symptoms are similar to those from water stress and can be confused with fungal root pathogens and trunk girdling or root damage from rodents. Infected trees leaf out later than normal and the foliage may appear pale green or yellowish and wilted in early summer. In late summer, foliage may prematurely develop reddish or purplish coloration. A distinguishing characteristic of this disease is an abnormally thick and spongy bark at the base of the tree just above and below the soil line. The wood underneath is deeply grooved and pitted. The wood may be weakened to the point that the tree falls over (Adaskaveg and Caprile, 2009; Uyemoto and Scott, 1992).

Transmission: TomRSV is occasionally transmitted to seed from the mother plant and pollen transmission to seed has been demonstrated in pelargonium (Scarborough & Smith, 1977). The virus is readily transmissible by grafting and by sap inoculation to herbaceous hosts, and by grafting in woody hosts. Spread by root grafts may occur, but nematode vectors are the most important field transmission agents. Disease spread in an orchard follow the movement of soil water, which moves nematodes. Cultivation and irrigation may assist in the spread of both the nematode and the disease (Agrios, 2005).

Dagger nematode adults, as well as three larval stages, can transmit the virus to susceptible hosts through their normal feeding, Dagger nematodes require at least 1 year to complete their life cycle and can mature and survive in soil in the absence of a host plant. They do not survive long periods in frozen soil, and their numbers decline at high and low moisture levels. The optimum temperature range for reproduction is 20-24°C (Bitterlin and Gonsalves, 1987).

Damage Potential: ToRSV is widespread in perennial tree fruit and small fruit. Because it causes such severe decline in productivity, it is one of the most damaging plant viruses in North America. The virus can infect dandelion and other weeds and may be disseminated over considerable distances in windblown dandelion seeds (Rosenberger et al., 1983). Furthermore, dandelion and other perennial weeds provide reservoirs for virus acquisition by nematode vectors. ToRSV causes serious disease problems in areas where the nematode vectors also occur. Yellow bud mosaic occurs on peaches, nectarines, and cherries in the Sacramento and northern San Joaquin valleys. Trees grown on peach, almond, Mahaleb or Mazzard cherry, and Myrobalan plum rootstocks become unproductive and need to be removed to prevent disease spread (Adaskaveg and Caprile, 2009; Uyemoto and Scott, 1992; Uyemoto, 1975).

Grapes will show many winter-killed buds and stunted shoot growth that weakens the vines. Fruit clusters are reduced in size with many berries aborting (Uyemoto, 1975). On raspberries, canes are stunted, and both fruit size and yield are reduced. By the third year of infection, 10-80% of fruiting canes may be killed (Smith, 1972). Fruit size and yield are reduced greatly, and fruit may fall prematurely. Foliage and fruit symptoms are caused by a reaction at the graft union that interferes with the flow of water and nutrients.

Worldwide Distribution:

ToRSV is endemic in North America and widespread in temperate regions where the vector occurs. It is primarily seen in the major apple and stone fruit growing regions: along the Pacific coast from southern British Columbia to California, in the Niagara Peninsula in Ontario, New York, and Pennsylvania. It is also in Belarus, Brazil, Chile, China, Colombia, Croatia, Egypt, France, Fiji, Germany, Iran, Italy, Japan, Jordan, Lithuania, New Zealand, Oman, Pakistan, Poland, Peru, Russia, Serbia, Slovenia, Slovakia, South Korea, Togo, Turkey, and Venezuela (CABI-CPC, 2020).

Official Control:

EPPO A1 list: Argentina, Bahrain, Brazil, China, Egypt, Georgia, Kazakhstan, Paraguay, Ukraine, and Uruguay; EPPO A2 list: Jordan, Russia, and Turkey; Quarantine pest: Canada, Israel, Mexico, Morocco, and Norway (EPPO, 2020).

California Distribution: There are many 20th century records of ToRSV in apples, grapevines, and stone fruit in the Central and Sacramento valleys and along the North Coast. There are a few recent records, and they are only on grapevines (M. Al Rwahnih, Foundation Plant Services, pers. comm.)

California Interceptions: None

The risk **Tomato ringspot virus** would pose to California is evaluated below.

Consequences of Introduction:

1) **Climate/Host Interaction:** ToRSV stays in close association with its hosts or its nematode vectors. The nematodes are widespread in California as are the hosts including tree fruit, vines, small fruit, and many weeds.

   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 is large and includes tomatoes but also many other woody and herbaceous species, including small fruit and tree fruit, plus 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.**

3) **Pest Reproductive Potential:** ToRSV multiplies inside its hosts but not inside its nematode vectors.

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-free planting stock is the key for the prevention of nepovirus epidemics. In California, there is extensive testing of mother blocks and seed stocks prior to propagation. If any are found positive for ToRSV, the germplasm can be cleaned up with thermotherapy and shoot-tip culture which eliminate the virus. There is additional testing of budwood prior to export. It is important to use clean planting stock, plant resistant rootstocks where possible, remove diseased trees, control the nematode vectors, and use strict sanitation to avoid spreading nematodes with infested soil (Adaskaveg and Caprile, 2009).

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

Economic Impact: A, B, C, E, G

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: **3**

- 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:** There are native plants on the host list for ToRSV. The virus and the vectors likely have a north American origin; however, it has been spread to new areas with agriculture and negative environmental impacts have not been reported.

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 Tomato ringspot virus*:* 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.

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:

Because of similarities in symptoms, overlapping host ranges, and shared vectors, Tomato ringspot virus and Tobacco ringspot virus were once difficult to separate and there is some uncertainty regarding older records of either virus. At the present time, diagnosis can be made with RT-PCR and RNA sequencing.

Conclusion and Rating Justification:

Based on the evidence provided above the proposed rating for **Tomato ringspot virus is C.**

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Responsible Party:

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***Comment Period:** 6/2/2020 through 7/17/2020

***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