CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

California Pest Rating Proposal for

Beet curly top virus
Curly top

Current Pest Rating: C

Proposed Pest Rating: C

Kingdom: Viruses and viroids, Category: Monodnaviria,
Category: Shotokuvirae, Phylum: Cressdnaviricota,
Class: Repensiviricetes, Order: Geplafuvirales,
Family: Geminiviridae, Genus: Curtovirus

Comment Period: 01/25/2024 through 03/10/2024

Initiating Event:

This pathogen has not been through the pest rating process. The risk to California from Beet curly top virus is described herein and a permanent rating is proposed.

History & Status:

Background:

Geminiviruses are a large family of plant-infecting viruses with circular single-stranded DNA genomes that are encapsidated within twinned-icosahedral virions. Viruses in this family are divided into four genera; *Mastrevirus, Curtovirus, Topocuvirus*, and *Begomovirus* based on the characteristics of their genomes, host range, and type of insect vector. The genus *Curtovirus* contains viruses that cause curly top diseases of various vegetable and field crops, including Beet curly top virus (BCTV). Dicotyledonous plants serve as natural hosts for these viruses (Rojas et al., 2005). Curtoviruses are transmitted in a persistent circulative manner by the beet leafhopper *Circulifer tenellus* Baker (Bennett, 1971). This is a widespread C-rated insect in California.

Curtovirus isolates and strains with greater than 94% sequence identity are considered variants of the same species and those with 77% or less sequence identity are considered different species (Varsani et al., 2014). Some widely recognized *Curtovirus* spp. affecting sugar beets and vegetables that were previously treated as separate species are now classified as strains of BCTV. These strains include California/Logan, Colorado, Mild, Pepper curly top, Pepper yellow dwarf, Severe, Spinach curly top, and Worland. Two additional *Curtovirus* spp., Spinach severe curly top virus and Horseradish curly top virus,

have similar symptoms and partially overlapping host ranges, and have the same vector (Hernandez and Brown, 2010; Klute et al., 1996; Varsani et al., 2014).

Beet leafhoppers are small phloem-feeding insects. The adults overwinter in the foothills of the Coastal Range, west of the Central Valley, and their nymphs are thought to acquire curly top viruses from infected weeds. This can include infected annual weeds, e.g., filaree and buckhorn plantain, and perennial weeds, e.g., Russian thistle, perennial pepperweed, and saltbrush, all of which act as reservoir hosts. When these hosts dry down in the spring, viruliferous adult beet leafhoppers migrate to the valley floor in search of new food sources. They can transmit BCTV through feeding to crops, e.g., tomatoes, peppers, sugarbeets, spinach, and cucurbits, or weeds, e.g., mustards, broadleaf plantain, London rocket, lambsquarter, redroot pigweed, and Russian thistle. They migrate between weeds and crops, and over multiple generations continue to spread BCTV, until they return as adults to the foothills to overwinter (Lawson et al., 1951; Chen et al., 2010; Creamer et al., 1996).

BCTV has been reported as causing damage in California since 1899, and the epidemiology in the San Joaquin Valley has been extensively studied for over a century (Carsner and Stahl, 1924). The California Department of Food and Agriculture's Integrated Pest Control branch runs a Beet curly top virus control program. The program was established in 1943 to manage the economic impact of BCTV throughout the State. The program is funded by assessments and program activities reduce BCTV outbreaks with monitoring and control of beet leafhoppers. Most operations are in the San Joaquin Valley, but virus damage and vector populations are monitored at multiple locations in the state. Although the occurrence of curly top disease is sporadic, it has the potential to cause significant economic losses, especially in tomatoes. Control methods include targeting insecticide treatments to prevent the movement of vectors. https://www.cdfa.ca.gov/plant/ipc/curlytopvirus/ctv_hp.htm

Hosts: BCTV has a very wide host range and infects approximately 300 crop and weed plant species (Thomas and Milk, 1979). Economically important hosts include sugar beet (*Beta vulgaris*), tomato (*Solanum lycopersicum*), pepper (*Capsicum* spp.), bean (*Phaseolus* spp.), spinach (*Spinacea oleraceae*), and several cucurbit species. Data on the incidence of the virus in weeds from 14 different plant families and disease epidemiology involving weeds has been studied in California (Creamer et al., 1996).

Symptoms: The symptoms of curly top include stunted and distorted plant growth, leaf curling, crumpling, yellowing, vein swelling, and distortion, and necrosis and hyperplasia of the phloem. Plants infected with curly top are stunted. Plant stunting and thickened curled leaves are similar throughout the host range (Bennett, 1971). Plants can turn bronze with purple-tinged leaves, becoming stiff and rapidly dying. Green fruit turns red, regardless of age (Chen et al., 2010; Davis et al., 2013).

In tomatoes, leaflets roll inward along the midrib, and the petiole and midrib curve down. Leaves appear to be drooping but not wilted. Leaves become thickened and crisp and may later turn yellow with purple veins. If fruits are formed, they ripen prematurely, and the seeds are aborted. If the plants are infected at an early age, there is a marked stunting that leads to whole plant chlorosis and sometimes death. In peppers, leaves are chlorotic and brittle, with stiff stems. If infected early, they set

fewer fruit and the fruit are small and rounded. Post-infection, the plants stop growing in height (EPPO, 2023; Creamer et al., 1997). In cucurbits, leaves are stunted and there is a poor fruit set and sometimes an increase in vertical growth. Some bean varieties show chlorosis and reduced fruit set. Spinach and other leafy vegetables show stunting and curling of leaves and chlorosis. Hemp symptoms include thickened, bushy, and stunted plants with thin curled leaves, chlorosis, and mottling (Giladi et al., 2020). Weed hosts rarely show distinctive symptoms of BCTV infection (Creamer et al., 1996).

Transmission: BCTV is moved locally by beet leafhoppers. BCTV is not seed-borne or tuber-borne and has limited ability to transmit mechanically. Infected sugarbeet roots for planting could potentially be a pathway (EPPO, 2023). Tomato and pepper transplants are poor sources for virus acquisition by the leafhopper vectors because they are not preferred hosts (Hudson et al., 2010). Higher rates of BCTV infection are positively correlated with exposure of plants to higher numbers of viruliferous beet leafhoppers. Also, BCTV titer in beet leafhoppers can influence disease development in certain hosts. Monitoring beet leafhopper populations and BCTV incidence and titer in beet leafhoppers early in the season can be a predictor of disease development in the field (Chen et al., 2010).

Damage Potential: Curly top has been an economic problem in California and the Western United States for over a century, causing significant annual losses to irrigated agriculture (Creamer, 2020). The occurrence of curly top epidemics has been sporadic, and the factors that lead to severe curly top outbreaks are not completely understood. It is difficult to predict the relative disease incidence and severity in a given year (Creamer et al., 1996; Chen et al., 2010). In 2013, an outbreak of curly top disease led to ~$100 million in losses to the processing tomato industry in California (Chen and Gilbertson, 2016; Chen et al., 2017).

Worldwide Distribution: Argentina, Bolivia, Canada, Costa Rica, Cote d'Ivoire, Cyprus, Egypt, India, Iran, Italy, Japan, Mexico, Türkiye, United States of America (Arizona, California, Colorado, Hawaii, Idaho, Illinois, Iowa, Kansas, Maryland, Michigan, Minnesota, Montana, Nebraska, Nevada, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, South Dakota, Texas, Utah, Virginia, Washington, Wisconsin, Wyoming), Uruguay (EPPO, 2023).

Official Control: BCTV is on the EPPO's A1 list for Brazil, Chile, the European Plant Protection Organization, European Union, Jordan, Switzerland, Turkey, United Kingdom, the A2 list for Comite Regional de Sanidad Vegetal del Cono Sur, and a quarantine pest in Canada, Israel, and Mexico (EPPO, 2023). BCTV is on the USDA PCIT's harmful organism list for Albania, Brazil, Canada, Chile, Colombia, European Union, French Polynesia, Georgia, Guatemala, Indonesia, Israel, Japan, Mexico, Namibia, Panama, Peru, Philippines, Republic of North Macedonia, South Africa, Sri Lanka, Taiwan, The Republic of Korea, Timor-Leste, Turkey, and United Kingdom (USDA PCIT, 2023).

California Distribution: Widespread in the coastal foothills and the Central Valley and listed as a widely prevalent virus in California https://www.prevalentviruses.org/state.cfm?id=us_CA

California Interceptions: none

The risk that Beet curly top virus would pose to California is evaluated below.

Consequences of Introduction:

1) **Climate/Host Interaction: BCTV is likely to occur anywhere that its hosts and beet leafhoppers can occur. This includes most agricultural areas.**

   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 be established 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 of BCTV is very large including plants from many families, both annuals and perennials.

   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:** The virus replicates inside host plants and is spread by the migration and feeding of the beet leafhopper.

   Evaluate the natural and artificial dispersal potential of the pest.

   Score: 3
   - 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:** BCTV can have a large impact on crop yield, specifically for tomatoes. It is a quarantine pest and is vectored by a pestiferous insect.

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

   Economic Impact: A, C, E
   A. The pest could lower crop yield.
   B. The pest could lower crop value (including increasing crop production costs).
   C. The pest could trigger the loss of markets (including 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:** BCTV is largely asymptomatic in non-crop plants. It is the subject of an official control program.

Evaluate the environmental impact of the pest on California using the criteria below.

Environmental Impact: D

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: 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 Beet curly top virus*:* High

Add up the total score and include it here. **14**
-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 the 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* ***= 11***

Uncertainty:

None

Conclusion and Rating Justification:

Based on the evidence provided above the proposed rating for **Beet curly top virus is C.**

References:

Bennett, C. W. 1971. The Curly Top Disease of Sugarbeet and Other Plants. American Phytopathological Society, St. Paul, MN

CABI digital library. 2023. Beet curly top virus. https://www.cabidigitallibrary.org/doi/10.1079/cabicompendium.10239

Carsner, E. and Stahl, C. F. 1924. Studies on curly-top disease of the sugar beet. J. Agric Res. 28:297-320

Chen, L.F., Brannigan, K., Clark, R., and Gilbertson, R.L., 2010. Characterization of curtoviruses associated with curly top disease of tomato in California and monitoring for these viruses in beet leafhoppers. Plant Disease, 94(1), pp.99-108.

Chen, L.-F., and Gilbertson, R. L. 2016. Page 243 in: Vector-Mediated Transmission of Plant Pathogens. APS Press, St. Paul, MN.

Chen, L.-F., O. Batuman, B. J. Aegerter, and R. L. G. J. Willems (2017). First report of curly top disease of pepper and tomato in California caused by the spinach curly top strain of beet curly top virus.Plant Disease 101(7), 1334

Creamer, R., Luque-Williams, M. and Howo, M., 1996. Epidemiology and incidence of beet curly top geminivirus in naturally infected weed hosts. Plant disease (USA), 80(5).

Creamer, R., 2020. Beet curly top virus transmission, epidemiology, and management. In Applied Plant Virology (pp. 521-527). Academic Press.

EPPO Database. https://gd.eppo.int/taxon/ BCTV00. Accessed 12/27/23

French, A. M. 1989. California plant disease host index. CA Division of Plant Industry. 2nd Ed. 394 pg

Giladi, Y., Hadad, L., Luria, N., Cranshaw, W., Lachman, O. and Dombrovsky, A., 2020. First report of beet curly top virus infecting Cannabis sativa in western Colorado. Plant Disease, 104(3), pp.999-999.

Hernandez, C., and Brown, J. K. 2010. First report of a new curtovirus species, Spinach severe curly top virus, in commercial spinach plants (*Spinacia oleracea*) from south-central Arizona. Plant Dis. 94:917.

Klute, K. A., Nadler, S. A., and Stenger, D. C. 1996. Horseradish curly top virus is a distinct subgroup II geminivirus species with rep and C4 genes derived from a subgroup III ancestor. J. Gen. Virol. 77:1369-1378.

Lawson, F. R., Chamberlin, J. C., and York, G. T. 1951. Dissemination of the beet leafhopper in California. U.S. Dep. Agric. Tech. Bull. 59.

Rojas, M. R., Hagen, C., Lucas, W. J., and Gilbertson, R. L. 2005. Exploiting chinks in the plant's armor: Evolution and emergence of geminiviruses. Annu. Rev. Phytopathol. 43:361-394

Thomas, P. E., and Mink, G. I. 1979. Beet curly top virus. CMI-AAB Descriptions of Plant Viruses, No. 210. Association of Applied Biologists, Wellesbourne, Warwick, U.K.

Varsani, A., Martin, D. P., Navas-Castillo, J., Moriones, E., Hernández-Zepeda, C., Idris, A., Zerbini, F. M., and Brown, J. 2014. Revisiting the classification of curtoviruses based on genome-wide pairwise identity. Arch. Virol. 159:1873-1882.

USDA Phytosanitary Certificate Issuance and Tracking System, Phytosanitary Export Database (PExD) Harmful Organisms Database Report. Beet curly top virus. Accessed 12/27/23.

Responsible Party:

Heather J. Scheck, Primary Plant Pathologist/Nematologist, CDFA/PHPPS ECOPERS, 1220 N St Rm 221, Sacramento, CA 95814 Phone: (916) 654-1017, permits[@]cdfa.ca.gov.

***Comment Period: 01/25/2024 through 03/10/2024**

***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
