CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

California Pest Rating Proposal for

Hop Latent Viroid

Current Pest Rating: Z

Proposed Pest Rating: C

Kingdom: incertae sedis; Phylum: incertae sedis

Class: incertae sedis; Order: incertae sedis

Family: Pospiviroidae; Genus: Cocadviroids

Comment Period: 6/1/2020 through 7/16/2020

Initiating Event:

In September 2011, a Sutter County ranch that grows stone fruit and walnuts submitted samples of volunteer hop plants found in a ditch bank. It had been 30 years since commercial hops were grown on the ranch. In order to send the hop to the state of Washington for a genetics study, they had to be tested and found free-from Hop stunt viroid, which is of quarantine significance. CDFA plant virologist Tongyan Tian tested the hop and they were negative for Hop stunt viroid, but positive for Hop latent viroid (HpLVd). Due to the age of the plants and the known methods of transmission, it's likely they were infected during propagation, decades earlier. Hop latent viroid is ubiquitous worldwide in hop and is generally latent or asymptomatic. It was given a temporary Z rating.

In August of 2019, two independent reports of HpLVd in California were published by Bektaş et al. and Warren et al. Both papers described a disease causing damage in commercial cannabis. Both had identified HpLVd with high-throughput sequencing and RT-PCR from symptomatic, but not from asymptomatic plants, from multiple growers. These are the first reports of HpLVd in cannabis. The risk to California from HpLVD is described herein and a permanent rating is proposed.

History & Status:

Background:

Viroids are the smallest known plant pathogens and are composed of only a short, circular, single-stranded RNA. Although viroids are composed of nucleic acid, they do not encode any protein and have no protein coats. All viroids are inhabitants of higher plants, and some cause diseases while others are asymptomatic. Hop latent viroid replicates using RNA polymerase II, a host cell enzyme normally associated with synthesis of messenger RNA from plant DNA, instead using "rolling circle" synthesis to make new RNA from the negative strand viroid RNA. Only viroids in Pospiviroidae replicate this way in the nuclei. The other viroid family, Avsunviroidae, replicates by the single-unit nuclear-encoded polymerase in chloroplasts.

After Hop stunt viroid was discovered in the early 1970s in Japanese hops (Yamamoto et al., 1973), surveys of hops were made in Spain (Pallas et al., 1987) and Germany (Puchta et al., 1988). Although they did not find Hop stunt viroid, these surveys revealed the presence of a second viroid, initially termed “hop viroid-like RNA fast, or HV-f”. It was subsequently described and renamed HpLVd in reference to its largely latent nature. HpLVd is a covalently closed single stranded RNA of 256 nucleotides, distinct from Hop stunt viroid with only 45% sequence homology. Although viroids generally form complex populations of natural sequence variants called quasispecies, no variants have been reported for HpLVd (Pethybridge et al., 2008).

Hosts: Cannabis (*Cannabis sativa*), hop (*Humulus lupulus*), and Japanese hop (*H. japonicus*) in the family Cannabaceae and stinging nettle (*Urtica dioica*) in the family Urticaceae (Knabel et al., 1999; Pallus et al., 1987; Bektaş et al., 2019).

Symptoms: Symptoms caused by infection with HpLVd in hops are often minimal or absent in hop. They have been described in hop cv. Omega as leaf chlorosis, slow growth, and the production of fewer laterals with smaller cones (Barbara et al., 2005). HpLVd infection is reported to be associated with changes in the production of secondary metabolites and alpha acids that play a role in beer production in some Belgian hop varieties (De Jonghe et al., 2016). In cannabis, HpLVd does cause symptoms include stunting, malformation or chlorosis of leaves, brittle stems, and reduction in yields. Cuttings showed a reduced rooting success rate (Warren et al., 2019). Additional symptoms in cannabis are brittle stems, an outwardly horizontal plant structure, and reduced flower mass and trichomes (Bektaş et al., 2019).

Transmission: The worldwide distribution of HpLVd is probably due to its efficient mechanical transmission and dissemination in infected propagation material, moving latently and without symptoms in hops. Low transmission efficiency has been reported through pollen transfer or by seed, with seed transmission not considered important for the spread of HpLVd in hop (Adams and Barbara, 1982). The role of these transmission pathways with seed or pollen have not been studied in cannabis. The spread of HpLVd in a hop yard or cannabis grow is predominantly localized to adjacent plants, through mechanical means including pruning and harvesting, rarely through physical contact between plants (Adams et al., 1996). No evidence has been seen to support long-distance spread by encapsidation in co-infecting viruses or aphid vectoring (Adams et al., 1992).

Damage Potential: Viroids are generally very stable and long lasting in the environment compared to other types of pathogens. Hop yards are generally very long lived (50 yrs +) and there are no remedial treatments for viroids. Symptom development and damage is dependent on cultivar susceptibility but is generally low to negligible. Effects of HpLVd on cone yield and levels of brewing organic acids have been reported but are also strongly dependent upon genotype (Pethybridge et al., 2008).

Damage from HpLVd is more significant in cannabis, causing a stunting disease and hypothesized to have detrimental effects on the commercially valuable secondary metabolites of the plants (Bektaş, et al., 2019), although these effects have not been quantified. From preliminary reports from commercial labs in California, the viroid is already widespread in cannabis, and requires strict sanitation, testing, and rouging to eliminate it from commercial greenhouses.

Worldwide Distribution: Australia, Brazil, Czech Republic, Germany, Japan, Korea, New Zealand, Poland, Slovenia, Spain, United Kingdom, and United States (Adams et al., 1992; Barbara et al., 1990; Knabel et al., 1999; Hay, 1989; Lee et al., 1990; Solarska et al., 1995; Pallas et al., 1987; Hataya et al., 1994; Matousek et al., 1992; Fonseca et al., 1993; Nelson et al., 1998; Knapick et al., 1998).

Official Control: Hop latent viroid is on the USDA's harmful organism list for China, Georgia, and India. It currently has a Z rating in California.

California Distribution: There is one official hop sample from Sutter County but there are reports in the literature that it is more widespread in California in cannabis

California Interceptions: None

The risk Hop latent viroid would pose to California is evaluated below.

Consequences of Introduction:

1) **Climate/Host Interaction:**

Viroids survive inside their hosts and for a short time on contaminated equipment. Only limited areas of California are suitable for hop production and the planted acreage is very low. Cannabis is grown widely, indoors and outdoors, and climate will not be a limiting factor for HpLVd.

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 limited to *Cannabis*, *Humulus*, and *Urtica*. It is unknown if industrial hemp can be a symptomatic host.

Evaluate the host range of the pest.

Score: 1

- 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:** HpLVd spreads through vegetative propagation and mechanically with infected sap. Seed transmission is not important in hop but the significance of this mode of transmission is unknown for cannabis. It is not airborne, waterborne, or soilborne and is not vector-transmitted.

Evaluate the natural and artificial dispersal potential of the pest.

Score: 1

- 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:** In 2019, California harvested only 130 acres of hops (USAHops, 2019) which makes it an extremely minor crop. This is contrast with cannabis which had an estimated retail value in 2017 of over $10 billion (UC AIC 2017). Although reports on cannabis are relatively recent, it does seem to have a negative impact on yield. Strict sanitation is required to prevent transmission in a grow or hopyard

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

Economic Impact: A, D

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:** Stinging nettles are a host and are common weeds in fields and greenhouses, but since the viroid requires transmission of sap to spread, they are unlikely to be a risky pool of inoculum for crops.

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 Hop latent viroid is low:

Add up the total score and include it here. **8**
-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 'medium'. There is an official record from Sutter County in hop (2011) and published literature of the pathogen in Santa Barbara County and "northern" California. Since it is easily transmitted mechanically, and plants can be latently infected, often without symptoms, it is difficult to survey.

Score: 2
-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* **= 6**

Uncertainty:

The susceptibility of industrial hemp to HpLVd is unknown. Hemp and cannabis production are increasing rapidly in California and this viroid could pose a risk to yield for both.

Conclusion and Rating Justification:

Based on the evidence provided above the proposed rating for Hop latent viroid is C.

References:

Adams, A. N., Barbara, D. J., Morton, A., & Darby, P. 1996. The experimental transmission of hop latent viroid and its elimination by low temperature treatment and meristem culture. Annals of applied biology, 128(1), 37-44.

Adams, A. N., and Barbara, D. J. 1982. Host range, purification and some properties of two carlaviruses from hop (Humulus lupulus): Hop latent and American hop latent. Ann.Appl. Biol. 101:483-494.

Adams, A. N., Morton, A., Barbara, D. J., and Ridout, M. S. 1992. The distribution and spread of hop latent viroid within two commercial plantings of hop (Humulus lupulus). Ann. Appl. Biol. 121:585-592.

Bektaş, A., Hardwick, K.M., Waterman, K. and Kristof, J., 2019. Occurrence of Hop Latent Viroid in Cannabis sativa with Symptoms of Cannabis Stunting Disease in California. Plant Disease, 103(10), p.2699.

Barbara, D. J., Morton, A., Adams, A. N., and Green, C. P. 1990. Some effects of hop latent viroid on two cultivars of hop (*Humulus lupulus*) in the UK. Ann. Appl. Biol. 117:359-366. Barbara, D. J., & Adams, A. N. (2003). Hop latent viroid. Viroids. A. Hadidi, R. Flores, JW Randles, and JS Semancik, eds. CSIRO Publ., Collingwood, Australia, 213-217.

De Jonghe, K., Van Bogaert, N., Vandierendonck, S., Smagghe, G., and Maes, M. 2016. First report of Hop latent viroid in Belgian hops. Plant Disease, 100(9), 1956-1956.

Fonseca, M. E. N., Marinho, V. L. A., and Nagata, T. 1993. Hop latent viroid in hop germ plasm introduced into Brazil from the United States. Plant Dis. 77:952.

Eastwell, K. C., & Nelson, M. E. 2007. Occurrence of viroids in commercial hop (*Humulus lupulus* L.) production areas of Washington State. Plant health progress, 8(1), 1.

Hay, F. S. 1989. Studies on the viruses of hop (*Humulus lupulus* L.) in New Zealand. Ph.D. thesis. Lincoln University, Christchurch, New Zealand

Hataya, T., Hikage, K., Sunda, N., Nagata, T., Li, S., Itoga, Y., Tanikoshi, T., and Shikata, E. 1992. Detection of hop latent viroid (HLVd) using reverse transcription and polymerase chain reaction (RT-PCR). Ann. Phytopathol. Soc. Jpn. 58:677-684.

Knabel, Von S., Seigner, L., and Wallnofer, P.R. 1999. Detection of hop latent viroid (HLVd) using the polymerase chain reaction (PCR). Gesunde Pflanzen 51:234-239.

Lee, J. Y., Lee, S. H., and Sänger, H. L. 1990.Viroid diseases occurring on Korean hop plants. Korean J. Plant Pathol. 6:256-260.

Knapic, V., and Javornik, B. 1998. ViroidiPovročitelji Rastlinskih Bolezni. Sodobno Kmetijstvo 31:462-465. Solarksa, E., Skomra, U., Kitlinksa, J., and Wojcierowski, J. 1995. The occurrence of hop latent viroid (HLVd) in hop plants in Poland. Phytopathol. Polonica 10:55-59.

Matousek, J., Trnena, L., Svoboda, P., and Ruzkova, P. 1994. Analysis of hop latent viroid (HLVd) in commercial hop clones in Czech Republic. Rost. Vyr. 40:973-983.

Nelson, M. E., Klein, R. E., and Skrzeczkowski, L. J. 1998. Occurrence of hop latent viroid (HLVd) in hops in Washington State. (Abstr.) Phytopathology 88: S108.

Pallas, V., Navarro, A., and Flores, R. 1987. Isolation of a viroid-like RNA from hop different from hop stunt viroid. J. Gen. Virol. 68:3201-3205.

Puchta, H., Ramm, K., and Sanger, H. L. 1989. Hop latent viroid (HLVd), a new viroid occurring worldwide in hops. Pages 181-191 in: Proc. Int. Workshop Hop Virus Dis. Giessen.

Pethybridge, S. J., Hay, F. S., Barbara, D. J., Eastwell, K. C., & Wilson, C. R. 2008. Viruses and viroids infecting hop: Significance, epidemiology, and management. Plant disease, 92(3), 324-338.

Solarksa, E., Skomra, U., Kitlinksa, J., and Wojcierowski, J. 1995. The occurrence of hop latent viroid (HLVd) in hop plants in Poland. Phytopathol. Polonica 10:55-59.

[UC AIC] UC Agricultural Issues Center. 2017. Economic Costs and Benefits of Proposed Regulations for the Implementation of the Medical Cannabis Regulation and Safety Act (MCRSA). Standardized Regulatory Impact Analysis. www.dof.ca.gov/Forecasting/Economics/Major_Regulations/Major_Regulations_Table/documents/SRIAandAppendix.2.28.17.pdf

USAHops. 2019 HGA Statistical Packet. USAHops.org. 2019. Retrieved 5/6/2020.

Warren, J. G., Mercado, J., & Grace, D. 2019. Occurrence of Hop Latent Viroid Causing Disease in *Cannabis sativa* in California. Plant Disease, 103(10), 2699-2699.

Yamamoto H, Kagami Y, Kurukawa M, Nishimura S, and Kubo S. 1973. Studies on hop stunt disease in Japan. Report of the Research Laboratories of Kirin Brewery Co., Ltd, 16. 49-62

Responsible Party:

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***Comment Period: 6/1/2020 through 7/16/2020**

***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